2019 MAGELLAN® CLINICAL GUIDELINES
FOR
MEDICAL NECESSITY REVIEW

HARVARD PILGRIM

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Guidelines for Clinical Review Determination

Preamble
Magellan is committed to the philosophy of supporting safe and effective treatment for patients. The medical necessity criteria that follow are guidelines for the provision of diagnostic imaging. These criteria are designed to guide both providers and reviewers to the most appropriate diagnostic tests based on a patient’s unique circumstances. In all cases, clinical judgment consistent with the standards of good medical practice will be used when applying the guidelines. Guideline determinations are made based on the information provided at the time of the request. It is expected that medical necessity decisions may change as new information is provided or based on unique aspects of the patient’s condition. The treating clinician has final authority and responsibility for treatment decisions regarding the care of the patient.

Guideline Development Process
These medical necessity criteria were developed by Magellan Healthcare for the purpose of making clinical review determinations for requests for diagnostic tests. The developers of the criteria sets included representatives from the disciplines of radiology, internal medicine, nursing, and cardiology and other specialty groups. They were developed following a literature search pertaining to established clinical guidelines and accepted diagnostic imaging practices.

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All guidelines were reviewed between January 1, 2018 and September 15, 2018.

Prepared October 31, 2018
CPT Code: 70336

INTRODUCTION:

Temporomandibular joint (TMJ) dysfunction causes pain and dysfunction in the jaw joint and muscles controlling jaw movement. Symptoms may include: jaw pain, masticator muscle stiffness, limited movement or locking of the jaw, clicking or popping in jaw joint when opening or closing the mouth, and a change in how the upper and lower teeth fit together. The cause of the condition is not always clear but may include acute or chronic trauma to the jaw or temporomandibular joint, e.g., grinding of teeth, clenching of jaw, or impact in an accident. Osteoarthritis or rheumatoid arthritis may also contribute to the condition. The modality of choice for the evaluation of temporomandibular joint dysfunction is magnetic resonance imaging (MRI) which provides tissue contrast for visualizing the soft tissue and periarticular structures of the TMJ.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR TEMPOROMANDIBULAR JOINT (TMJ) MRI (Bag, 2014; Gauer, 2015; Ohnuki, 2003):

- For evaluation of dysfunctional temporomandibular joint after unsuccessful conservative therapy for at least four (4) weeks with bite block or splint and anti-inflammatory medicine.
- For pre-operative evaluation of dysfunctional temporomandibular joint in candidates for orthognathic surgery.
- For evaluation of locked or frozen jaw.
- For persistent temporomandibular joint dysfunction after surgical repair.
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
REFERENCES


CPT Codes: 70450 70460 70470

INTRODUCTION:

Computed tomography (CT) is an imaging technique used to view the structures of the brain and is useful in evaluating pathologies in the brain. It provides more detailed information on head trauma, brain tumors, stroke, and other pathologies in the brain than regular radiographs.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR BRAIN CT:

For evaluation of known or suspected seizure disorder (Krumholz, 2007; Gaillard, 2009; Ramli, 2015):
- New onset of seizures or newly identified change in seizure activity/pattern AND cannot have a Brain MRI.

For evaluation of neurologic symptoms or deficits (ACR, 2012a):
- Acute, new or fluctuating neurologic symptoms or deficits such as sensory deficits, limb weakness, speech difficulties, lack of coordination or mental status changes.

For evaluation of clinical assessment documenting cognitive impairment of unclear cause (AAN; Narayanan, 2016; HQO, 2014):
- Change in mental status with a mental status score of either MMSE or MoCA of less than 26 or other similar mental status instruments showing at least mild cognitive impairment AND a completed basic metabolic workup (such as thyroid function testing, liver function testing, complete blood count, electrolytes, and B12).

For evaluation of known or suspected trauma (Alrajhi, 2015; Jagoda, 2008; Menditto, 2012; Lee, 2005):
- Known or suspected trauma or injury to the head with documentation of one or more of the following acute, new, or fluctuating:
  - Focal neurologic findings
  - Motor changes
  - Mental status changes
  - Amnesia
  - Vomiting
  - Seizures
  - Headache
  - Signs of increased intracranial pressure
- Known coagulopathy
- Known or suspected skull fracture by physical exam and/or positive x-ray.
- Repeat scan 24 hours post head trauma for anticoagulated patients with suspected diagnosis of delayed subdural hematoma.

For evaluation of headache (Frischberg, 2000; Graham, 2000; Schafer, 2007; Edlow, 2008; Silberstein, 2000; Gunner, 2007; ACR, 2017a; Kerjnick, 2008):
• Chronic headache with a change in character/pattern (e.g., more frequent, increased severity or duration) and MRI is contraindicated or cannot be performed.
• New onset (< 48 hours) of “worst headache in my life” or “thunderclap” headache. Note: The duration of a thunderclap type headache lasts more than 5 minutes. Sudden onset new headache reaching maximum intensity within 2-3 minutes.
• New onset of headache with any acute, new, or fluctuating neurologic deficits such as sensory deficits, limb weakness, speech difficulties, lack of coordination, or mental status changes.
• Once in patients with cluster headaches to eliminate secondary causes
• Patient with history of cancer, or significantly immunocompromised, with new onset headache.
• New headache in individual > 55 years old.
• New temporal headache in person > 55, with sedimentation rate (ESR) > 55 with tenderness over the temporal artery and MRI is contraindicated or cannot be performed.
• With history or suspicion of aneurysm or AVM with new onset of headache.

For evaluation of known or suspected brain tumor, mass, or metastasis (NCCN, 2017; Chase, 2011):
• Follow up for known tumor.
• Suspected tumor with any acute, new, or fluctuating neurologic symptoms or deficits such as sensory deficits, limb weakness, speech difficulties, lack of coordination or mental status changes.
• Known lung cancer or rule out metastasis and/or preoperative evaluation.
• Metastatic melanoma (not all melanomas).
• For patient with history of cancer with suspected recurrence or metastasis [based on symptoms or examination findings (may include new or changing lymph nodes)].
• Patient with history of cancer that had a recent course of chemotherapy, radiation therapy (to the brain), or has been treated surgically within the last two (2) years.
• Bone tumor or abnormality of the skull.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated, OR evaluation of suspected metastases (Sanellia, 2014):
• ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine, or Lumbar Spine

For evaluation of known or suspected stroke (Jauch, 2013; Tunkel, 2008; Smith, 1998):
• Patient with history of a known stroke with new and sudden onset of severe headache.
• Known or suspected stroke with any acute, new, or fluctuating symptoms or deficits such as sensory deficits, limb weakness, speech difficulties, lack of coordination, or mental status changes or with a family history (brother, sister, parent or child) of aneurysm.
• Symptoms of transient ischemic attack (TIA) (episodic neurologic symptoms.)

For evaluation of known or suspected inflammatory disease or infection (e.g., meningitis or abscess) and MRI is contraindicated or cannot be performed (Tarrant, 2009):
• Suspected increased intracranial pressure or meningitis.
• Intracranial abscess or brain infection with acute altered mental status OR positive lab findings (such as elevated WBC’s) OR follow up assessment during or after treatment completed.
• Meningitis with positive physical findings (such as fever, stiff neck) and positive lab findings (such as elevated white blood cells or abnormal lumbar puncture fluid exam.)
• Suspected encephalitis with a severe headache, altered mental status, OR positive lab finding, (such as elevated WBC’s).
• Endocarditis with suspected septic emboli.
- Central Nervous System (CNS) involvement in patients with known or suspected vasculitis or autoimmune disease with positive lab findings.

**For evaluation of known or suspected congenital abnormality (such as hydrocephalus, craniosynostosis)** (Ashwal, 2009; Vinocur, 2010; Marchese, 2017; Lieb, 2015; Labuguen, 2006):
- Known or suspected congenital abnormality with any acute, new, or fluctuating neurologic, motor, or mental status changes.
- Microcephaly and MRI is contraindicated or cannot be performed
- Follow up shunt evaluation within six (6) months of placement or one (1) year follow up and/or with neurologic symptoms.
- Craniosynostosis and other head deformities.
- Suspected or known hydrocephalus.
- Prior or planned treatment for congenital abnormality.

**Suspected normal pressure hydrocephalus, (NPH) with symptoms** (Wilbrink, 2009).

**Pre-operative evaluation for brain/skull surgery.**

**Post-operative/procedural evaluation:**
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

**Other indications for a Brain CT** (Tunkel, 2008; Thust, 2014; Arkuszewski, 2010; Agostoni, 2009; DeFeer, 2006; ACR, 2017b):
- Suspected acute subarachnoid hemorrhage (SAH).
- Follow up for known hemorrhage, hematoma, or vascular abnormalities.
- Developmental delay where MRI cannot be performed.
- Vertigo associated with headache, blurred or double vision, or a change in sensation after full neurologic examination and initial work-up and MRI is contraindicated or cannot be performed.
- Abnormal eye findings on physical or neurologic examination (papilledema, nystagmus, ocular nerve palsies, visual field deficit etc).
- Anosmia (loss of smell) (documented by objective testing).
- Known or suspected cerebrospinal fluid (CSF) leakage.
- Immunocompromised patient (e.g., transplant recipients, HIV with CD4<200, primary immunodeficiency syndromes, hematologic malignancies) with focal neurologic-symptoms, headaches, behavioral, cognitive, or personality changes.
- Suspected central venous thrombosis
- Neurological findings in sickle cell disease
- Prior to lumbar puncture in patients with suspected increased intracranial pressure or at risk for herniation.
- Suspected cholesteatoma.

**Indication for Brain CT/Cervical CT combination studies:**
- For evaluation of Arnold Chiari malformation where MRI cannot be performed.

**Brain CT/Orbit CT:**
- For approved indications as noted above and being performed in a child under 3 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent intracranial tumor (e.g. “trilateral retinoblastoma”)

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• Unilateral papilledema: to distinguish a compressive lesion on the optic nerve or optic disc swelling associated with acute demyelinating optic neuritis in multiple sclerosis from nonarteritic anterior ischemic optic neuropathy (NAION), central retinal vein occlusion, or optic nerve infiltrative disorders.

**Brain CT/Neck CTA:**
• Confirmed carotid stenosis >60%, surgery, or angioplasty candidate

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**ADDITONAL INFORMATION RELATED TO BRAIN CT:**

**CT scan for congenital abnormalities** - While MRI is preferred to CT for evaluation of most congenital CNS abnormalities, in some clinical situations CT is preferred (craniosynostosis) or equivalent to MRI. CT is appropriate in the follow up of hydrocephalus or VP shunt function where the etiology of hydrocephalus has been previously determined or in patients for which MRI evaluation would require general anesthesia.

**CT scan for Headache** - Generally, magnetic resonance imaging is the preferred imaging technique for evaluating the brain parenchyma and CT is preferable for evaluating subarachnoid hemorrhage. CT is faster and more readily available than MRI and is often used in urgent clinical situations. Neurologic imaging is warranted in patients with headache disorders along with abnormal neurologic examination results or predisposing factors for brain pathology.

**CT scan for Head Trauma** - Most types of head injury are minor injuries; clinical signs and symptoms help predict the need for brain CT following injury. CT has advantages in evaluating head injury due to its sensitivity for demonstrating mass effect, ventricular size and configuration, bone injuries and acute hemorrhage. A patient who presents with certain clinical risk factors may be more likely to benefit from CT imaging. Some of the clinical risk factors that may be used as a guide to predict the probability of abnormal CT following minor head injury are vomiting, skull fracture and age greater than 60 years. Patients with a Glasgow Coma Scale of 15 or less who also have vomiting or suspected skull fracture are likely to show abnormal results on CT scan. CT is also useful in detecting delayed hematoma, hypoxic-ischemic lesions, or cerebral edema in the first 72 hours after head injury.

**CT scan for Stroke** – Patients presenting with symptoms of acute stroke should receive prompt imaging to determine whether they are candidates for treatment with tissue plasminogen activator. Non-contrast CT can evaluate for hemorrhage that would exclude the patient from reperfusion therapy. Functional imaging can be used to select patients for thrombolytic therapy by measuring the mismatch between “infarct core” and “ischemic penumbra” which is a target for therapy. Contrast enhanced CT angiography (CTA) may follow the non-contrast CT imaging and may define ischemic areas of the brain with the potential to respond positively to reperfusion therapy.

**CT scan and Meningitis** – In suspected bacterial meningitis, contrast CT may be performed before lumbar puncture to show beginning meningeal enhancement. It may rule out causes for swelling. CT may be used to define the pathology of the base of the skull and that may require therapeutic intervention and surgical consultation. Some causes of the infection include fractures of the paranasal sinus and inner ear infection.

**CT for Macrocephaly** - Consider ultrasound for child <6 months of age for macrocephaly.
REDUCING RADIATION EXPOSURE:
Brain MRI is preferred to Brain CT in most circumstances where the patient can tolerate MRI and sufficient time is available to schedule the MRI examination. Assessment of subarachnoid hemorrhage, acute trauma or bone abnormalities of the calvarium (fracture, etc) may be better imaged with CT.
REFERENCES


CPT Codes: 70480, 70481, 70482

INTRODUCTION:

Computed tomography's use of thin sections with multi-planar reconstruction, (e.g., axial, coronal and sagittal planes) along with its three-dimensional rendering permits thorough diagnosis and management of ocular and orbital disorders. Brain CT is often ordered along with CT of the orbit for head injury with orbital trauma.

Temporal bone, mastoid, and internal auditory canal computed tomography (CT) is a unique study performed for problems such as conductive hearing loss, chronic otitis media, mastoiditis, cholesteatoma, congenital hearing loss and cochlear implants. It is a modality of choice because it provides 3D positional information and offers a high degree of anatomic detail. It is rarely used for evaluation of VIIth of VIIIth nerve tumors.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR ORBIT CT (Kennedy, 2017; Hande, 2012):

- Orbital asymmetry, exophthalmos (proptosis), or enophthalmos.
- Vision loss with etiology not identified on ophthalmologic examination and laboratory tests.
- Diplopia or ophthalmoplegia (paralysis or weakness of the eye muscles).
- Evaluation of ocular tumor.
- Suspected hyperthyroidism (such as Graves’ disease).
- Orbital trauma.
- Unilateral visual deficit.
- Suspected orbital pseudotumor (inflammatory orbital syndrome).
- Papilledema.
- Orbital infection.
- Known or suspected optic neuritis if MRI is contraindicated or is unable to be performed (Voss, 2011).

COMBINATION OF STUDIES WITH ORBIT CT:

- Brain CT/Orbit CT
  - For approved indications as noted above and being performed in a child under 8 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent intracranial pathology (Lawson, 2000).
  - Unilateral papilledema: to distinguish a compressive lesion on the optic nerve or optic disc swelling associated with acute demyelinating optic neuritis in multiple sclerosis from nonarteritic anterior ischemic optic neuropathy (NAION), central retinal vein occlusion or optic nerve infiltrative disorders.

INDICATIONS FOR SELLA CT:
• Evaluation of sellar and parasellar masses (Donovan, 1996).

**INDICATIONS FOR TEMPORAL/MASTOID/INTERNAL AUDITORY CANAL CT:**

**Hearing loss (documented on audiogram):**
- Sensorineural hearing loss with contraindication to MRI (Sharma, 2018).
- Conductive or mixed hearing loss (Sharma, 2018).
- Congenital hearing loss (Sharma, 2018; Baek, 2003; Ma, 2008; Westerhof, 2001).
- Cochlear implant evaluation (Sharma, 2018; Jain, 2003; Whiting, 2008).

**Tinnitus:**
- Pulsatile tinnitus (Kessler, 2017; Yew, 2014)
- Unilateral tinnitus with contraindication to MRI (Kessler, 2017; Yew, 2014)

**Other indications:**
- Acoustic neuroma or peripheral cranial nerve palsy with contraindication to MRI (Wu, 1986).
- Chronic otitis media (O’Reilly, 1991).
- Mastoiditis (Vazquez, 2003).
- Dehiscence of the jugular bulb or carotid canal (Bozek, 2016).
- Aberrant blood vessels or malformations (Bozek, 2016).
- Episodic vertigo (peripheral vertigo) with abnormal neurologic findings (Sharma, 2018; Muncie, 2017).
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

**Pre-operative/procedural evaluation:**
- Pre-operative evaluation for a planned surgery or procedure.

**Post-operative/procedural evaluation:**
- When imaging, physical, or laboratory findings indicate surgical or procedural complications.
REFERENCES


CPT Codes: 70486, 70487, 70488, 76380

INTRODUCTION:

Computed tomography (CT) primarily provides information about bony structures, but may also be useful in evaluating soft tissue masses. It can help document the extent of facial bone fractures, facial infections and abscesses, and can aid in diagnosing salivary stones. Additionally, CT may be useful in characterizing and identifying tumor extent in the face and may be used in the assessment of chronic osteomyelitis.

CT scans can provide more detailed information about the anatomy and abnormalities of the paranasal sinuses than plain films. A CT scan provides greater definition of the sinuses and is more sensitive than plain radiography for detecting sinus pathology, especially within the sphenoid and ethmoid sinuses. CT scan findings can be nonspecific, however, and should not be used routinely in the diagnosis of acute sinusitis. The primary role of CT scans is to aid in the diagnosis and management of recurrent and chronic sinusitis, or to define the anatomy of the sinuses prior to surgery.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

A single authorization for CPT codes 70486, 70487, 70488, or 76380 includes imaging of the entire maxillofacial area including face and sinuses. Multiple authorizations are not required.

INDICATIONS FOR SINUS & MAXILLOFACIAL CT:

For evaluation of known or suspected infections or inflammatory disease:
- Unresolved sinusitis after four (4) consecutive weeks of medication, e.g., antibiotics, steroids or antihistamines (Rosenfeld, 2015; Kaplan, 2013).
- Immunocompromised patient (including but not limited to AIDS, transplant patient or patient with genetic or acquired deficiencies,) or conditions predisposed to sinusitis (e.g., cystic fibrosis and immotile cilia syndrome/Kartagener's syndrome).
- Known or suspected osteomyelitis (Pincus, 2009; Lee, 2016)
- Suspected orbital or intracranial complication of sinusitis (Kirsch, 2017)
- Suspected invasive fungal sinusitis (Kirsch, 2017)
- Known or suspected facial abscess.

For evaluation of known or suspected tumor:
- For known or suspected tumor based on exam or prior imaging (Das, 2005).

For evaluation of trauma (Echo, 2010):
- Suspected fracture AND prior imaging was nondiagnostic or equivocal.
- Complications of known fracture.
- Suspected post-traumatic CSF leak with suspected CSF rhinorrhea or otorrhea (Snetty, 2015).

Pre-operative/procedural evaluation:
- Pre-operative evaluation for a planned surgery or procedure.
Post-operative/procedural evaluation:
- When imaging, physical, or laboratory findings indicate surgical or procedural complications.

Other indications for Sinus and Maxillofacial CT:
- Asthma refractory to treatment (Sahay, 2016).
- Deviated nasal septum, polyp, or other structural abnormality seen on imaging or direct visualization that may be causing significant airway obstruction (Kirsch, 2017).
- New onset anosmia or hyposmia with contraindication to MRI (Policeni, 2017).
- Other conditions such as granulomatosis with polyangiitis (Wegener's granulomatosis) that may present as rhinosinusitis.
- Parotid or other salivary stones (Gadodia, 2011).

COMBINATION OF STUDIES WITH SINUS & MAXILLOFACIAL CT:

Sinus CT/Chest CT:
- For poorly controlled asthma associated with upper respiratory tract infection. May be performed without failing 4 consecutive weeks of treatment with medication.
- Granulomatosis with polyangiitis (Wegener's granulomatosis) disease (GPA) (Lohrmann, 2006).

ADDITIONAL INFORMATION RELATED TO SINUS & MAXILLOFACIAL CT:

Choosing Wisely: American Academy of Allergy, Asthma & Immunology (2012)

Don’t order sinus computed tomography (CT) or indiscriminately prescribe antibiotics for uncomplicated acute rhinosinusitis. Viral infections cause the majority of acute rhinosinusitis and only 0.5 percent to 2 percent progress to bacterial infections. Most acute rhinosinusitis resolves without treatment in two weeks. Uncomplicated acute rhinosinusitis is generally diagnosed clinically and does not require a sinus CT scan or other imaging. Antibiotics are not recommended for patients with uncomplicated acute rhinosinusitis who have mild illness and assurance of follow-up. If a decision is made to treat, amoxicillin should be first-line antibiotic treatment for most acute rhinosinusitis.

CT instead of MRI – MRI allows better differentiation of soft tissue structures within the sinuses. It is used occasionally in cases of suspected tumors or fungal sinusitis. Otherwise, MRI has no advantages over CT scanning in the evaluation of sinusitis. Disadvantages of MRI include high false-positive findings, poor bony imaging, and higher cost. MRI scans take considerably longer to accomplish than CT scans and may be difficult to obtain in patients who are claustrophobic.
REFERENCES


**CPT Codes:** 70490, 70491, 70492

**INTRODUCTION:**

High resolution CT can visualize both normal and pathologic anatomy of the neck. It is used in the evaluation of neck soft tissue masses, abscesses, and lymphadenopathy. For neck tumors, it defines the extent of the primary tumor and identifies lymph node spread. CT provides details about the larynx and cervical trachea and its pathology. Additional information regarding airway pathology is provided by three-dimensional images created from the CT dataset. Neck CT can also accurately depict and characterize tracheal stenoses.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

**INDICATIONS FOR NECK CT:**

**Known tumor or cancer of skull base, tongue, larynx, nasopharynx, pharynx, or salivary glands**
- Initial staging (Kuno, 2014)
- Restaging during treatment
- Suspected recurrence or metastases based on symptoms or examination findings
  - New mass
  - Change in lymph nodes (King 2007)
- Diagnosed Primary Hyperparathyroidism when surgery planned
  - Previous nondiagnostic ultrasound or nuclear medicine scan (Keogh, 2008; Alexander, 2002)

**Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:**
- ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.

**Suspected tumor or cancer:**
- Suspicious mass/tumor found on an imaging study and needing clarification or found by physical exam and remains non-diagnostic after x-ray or ultrasound is completed (Kuno, 2014).
- Palpable suspicious lesions in mouth or throat (Kuno, 2014).
- Non-thyroid neck mass
  - Increased risk for malignancy
    - No known infection and unknown duration with no fluctuation on exam OR
    - Any of these:
      - fixation to adjacent tissues
      - firm consistency
      - size>1.5 cm
      - ulceration of overlying skin (Pynnonen, 2017)
    - Failed 2 weeks of treatment for suspected infectious cause (Schwetschenau, 2002)

**Known or suspected deep space infections or abscesses of the pharynx or neck (Meyer, 2009).**
Pre-operative evaluation.

Post-operative/procedural evaluation (e.g. post neck dissection):
• A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

Other indications for a Neck CT:
• Vocal cord lesions or vocal cord paralysis (Dankbaar, 2014).
• Salivary gland stones or suspected gland abscess (Burke, 2011).
• For evaluation of tracheal stenosis (LoCicero, 1996)
• Brachial plexus dysfunction (Brachial plexopathy/Thoracic Outlet Syndrome) (Ferrante, 2012; Tharin, 2014).
REFERENCES


INTRODUCTION:

Computed tomography angiography (CTA) is recognized as a valuable diagnostic tool for the management of patients with cerebrovascular disease. With its three-dimensional reconstructions, CTA can simultaneously demonstrate the bony skull base and its related vasculature. CTA use of ionizing radiation and an iodine-based intravascular contrast medium is a disadvantage when compared to magnetic resonance angiography (MRA) but it is quicker and requires less patient cooperation than MRA. CTA is much less invasive than catheter angiography which involves injecting contrast material into an artery.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR BRAIN CTA:

For evaluation of known intracranial vascular disease (ACR, 2017; Sanelli, 2014; Colen, 2007; Khan, 2007; Zuccoli, 2011):
- Known intracranial aneurysm or arteriovenous malformation (AVM).
- Known vertebrobasilar insufficiency (VBI).
- Vascular abnormality visualized on previous brain imaging.
- Known vasculitis.

For evaluation of suspected intracranial vascular disease (Chalouhi, 2011; Villablanca, 2002; Jager, 2000; Leker, 1999; Hofmann, 2013):
- To screen for suspected intracranial aneurysm in patient whose parent, brother, sister, or child has history of intracranial aneurysm. Note: If there is a first degree familial history, repeat study is recommended every 5 years.
- Screening for aneurysm in polycystic kidney disease, Ehlers-Danlos syndrome, fibromuscular dysplasia, neurofibromatosis, or known aortic coarctation.
- Previously diagnosed subarachnoid hemorrhage (SAH).
- Suspected vertebrobasilar insufficiency (VBI) in patients with symptoms such as, vision changes, vertigo, or abnormal speech.
- Suspected arteriovenous malformation (AVM) in patient with previous or indeterminate imaging study.
- Suspected venous thrombosis (dural sinus thrombosis).
- Distinguishing benign intracranial hypertension (pseudotumor cerebri) from dural sinus thrombosis.
- Pulsatile tinnitus to identify vascular etiology.
- Suspected vasculitis with abnormal lab results suggesting acute inflammation or autoimmune antibodies.

Pre-operative evaluation for brain/skull surgery (Farsad, 2009):

Post-operative/procedural evaluation (Sanelli, 2004; Wallace, 2007):
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
Indications for Brain CTA/Neck CTA combination studies:

- Patients who have had a stroke or transient ischemic attack (TIA) within the past 2 weeks.
- Known or suspected vertebrobasilar insufficiency (VBI) in patients with symptoms such as vision changes, vertigo, or abnormal speech.
- Known or suspected carotid or cerebral artery occlusion in patients with a sudden onset of one-sided weakness, abnormal speech, vision defects, or severe dizziness.
- Head trauma in a patient with closed head injury for suspected carotid or vertebral artery dissection.
- Pulsatile tinnitus to identify vascular etiology.

ADDITIONAL INFORMATION RELATED TO BRAIN CTA:

CTA for Evaluation of Aneurysm – CTA is useful in the detection of cerebral aneurysms. The sensitivity of CTA to detect cerebral aneurysms ≤ 5 mm is higher than that with digital subtraction angiography (DSA). Most aneurysms missed with CTA are ≤ 3 mm. Aneurysms in the region of the anterior clinoid process may extend into the subarachnoid space where they carry the threat of hemorrhage. CTA can help delineate the borders of the aneurysm in relation to the subarachnoid space and may help detect acute ruptured aneurysms. It may be used in the selection of patients for surgical or endovascular treatment of ruptured intracranial aneurysms.

CTA for Screening of Patients with first degree relative (parent, brother, sister or child) have a history of aneurysm – Data has suggested that individuals with a parent, brother, sister, or child harboring an intracranial aneurysm are at increased risk of aneurysms. It is likely that multiple genetic and environmental risk factors contribute to the increased risk.

CTA for Evaluation of Vertebrobasilar Insufficiency (VBI) – Multidetector CT angiography (MDCTA) may be used in the evaluation of vertebral artery pathologies. The correlation between MDCTA and color Doppler sonography is moderate. CTA is used for minimally invasive follow-up after intracranial stenting for VBI. It enables visualization of the patency of the stent lumen and provides additional information about all brain arteries and the brain parenchyma.

CTA for evaluation of Arteriovenous Malformation (AVM) – A good correlation has been found between catheter angiography and CTA in the detection of arteriovenous malformations. CTA allows calculation of the volume of an AVM nidus and identifies and quantifies embolic material within it. CTA may be used for characterization and stereotactic localization before surgical resection or radiosurgical treatment of arteriovenous malformations.
REFERENCES


CPT Code: 70498

INTRODUCTION:

Neck computed tomography angiography (CTA) uses a computerized analysis of x-ray images enhanced by contrast material injected into a peripheral vein. Neck CTA may be performed after initial carotid duplex imaging that does not provide adequate information or shows abnormal results. Neck CTA may be used for the evaluation of carotid body tumors and for post-operative evaluation of carotid endarterectomy.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR NECK CTA:

Suspected or known vascular disease:
- Asymptomatic patients with an abnormal ultrasound of the neck or carotid duplex imaging (e.g. carotid stenosis ≥ 70%, technically limited study, aberrant direction of flow in the carotid or vertebral arteries) (Marquardt, 2010; Brott, 2011).
- Symptomatic patients with an abnormal ultrasound of the neck or carotid duplex imaging (e.g. carotid stenosis ≥ 50%, technically limited study, aberrant direction of flow in the carotid or vertebral arteries) (Rerkasem, 2011; Rothwell, 2003; Brott, 2011).
- Head or neck blunt injury with suspected carotid or vertebral artery dissection.
  - Focal or lateralizing neurological deficits
  - Face or cervical fractures
  - Cervical hematomas
  - Injury by severe cervical hyperextension/rotation or hyperflexion, or “clothesline”
  - Thoracic injury
  (Franz, 2012; Mundinger, 2013)
- Findings of Takayasu arteritis in other blood vessels on previous imaging and Neck MRA cannot be done (Keenan, 2009).

Known of suspected tumor/mass
- Carotid body tumors, or other paraganglioma (Persky, 2002).
- Pulsatile neck mass after ultrasound has been performed when there is reasonable suspicion that it is not a vascular lesion (Pegge, 2017).

Pre-operative evaluation.

Post-operative/procedural evaluation (e.g. carotid endarterectomy):
A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

**Indications for combination studies:**

**Neck CTA/Brain CTA:**
- New onset stroke or transient ischemic attack (TIA) (Easton, 2009)
- Known or suspected vertebrobasilar insufficiency (VBI) in patients with symptoms such as vision changes, vertigo, or abnormal speech (Searls, 2012).
- Head or neck blunt injury with suspected carotid or vertebral artery dissection.
  - Focal or lateralizing neurological deficits
  - Face or cervical fractures
  - Cervical hematomas
  - Injury by severe cervical hyperextension/rotation or hyperflexion, or “clothesline”
  - Thoracic injury
  (Franz, 2012; Mundinger, 2013)
- Pulsatile tinnitus for vascular etiology (Pegge, 2017).

**Neck CTA/Brain CT:**
- Asymptomatic patients with an abnormal ultrasound of the neck or carotid duplex imaging (e.g. carotid stenosis ≥ 70%, technically limited study, aberrant direction of flow in the carotid or vertebral arteries) and patient is surgery or angioplasty candidate. (Marquardt, 2010; Brott, 2011).
- Symptomatic patients with an abnormal ultrasound of the neck or carotid duplex imaging (e.g. carotid stenosis ≥ 50%, technically limited study, aberrant direction of flow in the carotid or vertebral arteries) and patient is surgery or angioplasty candidate. (Rerkasem, 2011; Rothwell, 2003; Brott, 2011).
REFERENCES


CPT Codes: 70540, 70542, 70543

INTRODUCTION:

Magnetic resonance imaging (MRI) is used in the evaluation of face and neck region masses, trauma, and infection. The soft-tissue contrast between normal and abnormal tissues provided by MRI is sensitive for differentiating between inflammatory disease and malignant tumors and permits the precise delineation of tumor margins. MRI is used for therapy planning and follow-up of face and neck neoplasms. It is also used for the evaluation of neck lymphadenopathy and vocal cord lesions.

CT scanning remains the study of choice for the imaging evaluation of acute and chronic inflammatory diseases of the sinonasal cavities. MRI is not considered the first-line study for routine sinus imaging because of limitations in the definition of the bony anatomy and length of imaging time. MRI for confirmation of diagnosis of sinusitis is discouraged because of hypersensitivity (overdiagnosis) in comparison to CT without contrast. MRI, however, is superior to CT in differentiating inflammatory conditions from neoplastic processes. MRI may better depict intraorbital and intracranial complications in cases of aggressive sinus infection, as well as differentiating soft-tissue masses from inflammatory mucosal disease. MRI may also identify fungal invasive sinusitis or encephaloceles.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

A single authorization for CPT code 70540, 70542, or 70543 includes imaging of the Orbit, Face, Sinuses, and Neck. Multiple authorizations are not required.

INDICATIONS FOR ORBIT MRI (Kennedy, 2017; Hande, 2012):
- Orbital asymmetry, exophthalmos (proptosis), or enophthalmos.
- Vision loss with etiology not identified on ophthalmologic examination and laboratory tests.
- Ophthalmoplegia (paralysis or weakness of the eye muscles) or diplopia.
- Evaluation of ocular tumor.
- Suspected hyperthyroidism (such as Graves’ disease).
- Orbital trauma.
- Unilateral visual deficit.
- Suspected orbital pseudotumor (inflammatory orbital syndrome).
- Papilledema.
- Orbital infection.
- Known or suspected optic neuritis (Voss, 2011).

INDICATIONS FOR FACE/SINUS MRI:
- Acute rhinosinusitis with suspected orbital or intracranial complications (Kirsch, 2017).
- Suspected invasive fungal sinusitis (Kirsch, 2017).
- Sinonasal obstruction (Kirsch, 2017).
- Known or suspected mass based on exam or previous imaging (Kirsch, 2017).
- Known or suspected osteomyelitis (Pincus, 2009; Lee, 2016).
INDICATIONS FOR NECK MRI:
- Vocal cord lesions or vocal cord paralysis (Dankbaar, 2014).
- Sialography for salivary gland stones.
- Suspected salivary gland abscess (Burke, 2011).
- Parotid or other salivary tumors.
- Brachial plexus dysfunction (Brachial plexopathy/Thoracic Outlet Syndrome) (Ferrante 2012; Tharin, 2014)
- Palpable suspicious lesions in mouth or throat (Kuno, 2014).
- Known or suspected inflammatory disease, infection, or abscess.
- Primary hyperparathyroidism with nondiagnostic ultrasound or nuclear medicine scan and surgery is planned (Keogh, 2008; Alexander 2002).
- Evaluation of non-thyroid neck mass
  - Present on physical exam after abnormal or non-diagnostic x-ray or ultrasound (Kuno, 2014; Kransdorf, 2017).
  - Increased risk of malignancy suggested by size > 1.5 cm, firm consistency, fixation to adjacent tissues, or ulceration of overlying skin (Pynnonen, 2017).
  - Failed 2 weeks of treatment for suspected infectious adenopathy (Haynes, 2015).

OTHER INDICATIONS FOR ORBIT/FACE/NECK MRI

Evaluation of known cancer
- Initial staging (Kuno, 2014)
- Restaging during treatment
- Suspected recurrence or new metastases based on symptoms or examination findings (King, 2009)

Pre-operative/procedural evaluation:
- Pre-operative evaluation for a planned surgery or procedure.

Post-operative/procedural evaluation:
- When imaging, physical, or laboratory findings indicate surgical or procedural complications.

INDICATIONS FOR COMBINATION STUDIES: ORBIT/FACE/NECK MRI WITH BRAIN MRI.
- Anosmia on objective testing (Policeni, 2017)
- Trigeminal neuralgia (Policeni, 2017)
- Cranial neuropathy (weakness or sensory abnormalities of the head and neck) (Policeni, 2017)
- Unilateral papilledema: to distinguish a compressive lesion on the optic nerve or optic disc swelling associated with acute demyelinating optic neuritis in multiple sclerosis from nonarteritic anterior ischemic optic neuropathy (NAION), central retinal vein occlusion or optic nerve infiltrative disorders.
- For approved indications as noted above and being performed in a child under 8 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent intracranial pathology (Lawson, 2000).

INDICATIONS FOR COMBINATION STUDIES: Initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:
- ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.
REFERENCES


CPT Codes: 70544, 70545, 70546

INTRODUCTION:

Magnetic resonance angiography (MRA) or magnetic resonance venography (MRV) can be used as a first line investigation of intracranial vascular disease. It is an alternative to invasive intra-catheter angiography that was once the mainstay for the investigation of intracranial vascular disease. MRA/MRV may use a contrast agent, gadolinium, which is non-iodine-based, for better visualization. It can be used in patients who have history of contrast allergy and who are at high risk of kidney failure. A single authorization covers both MRA and MRV.

Three different techniques of MRA/MRV are: time of flight (both 2D and 3D TOF), phase contrast (PC), and contrasted enhanced angiography. Time of flight MRA takes advantage of the phenomena of flow related enhancement and is the preferred MRA technique due to the speed at which the exam can be acquired.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR BRAIN (HEAD) MRA/MRV:

For evaluation of known intracranial vascular disease (ACR, 2017; Sanelli, 2014; Obusez, 2014; Jageer, 2000):
- Known intracranial aneurysm or arteriovenous malformation (AVM).
- Known vertebrobasilar insufficiency (VBI).
- Vascular abnormality visualized on previous brain imaging.
- Known vasculitis.

- To screen for suspected intracranial aneurysm in patient whose parent brother, sister, or child has history of intracranial aneurysm. Note: If there is a first degree familial history, repeat study is recommended every 5 years.
- Screening for aneurysm in polycystic kidney disease, Ehlers-Danlos syndrome, fibromuscular dysplasia, neurofibromatosis, or known aortic coarctation.
- Previously diagnosed subarachnoid hemorrhage (SAH).
- Suspected vertebrobasilar insufficiency (VBI) in patients with symptoms such as vision changes, vertigo, or abnormal speech.
- Suspected arteriovenous malformation (AVM) in patient with previous or indeterminate imaging study.
- Suspected venous thrombosis (dural sinus thrombosis).
- Distinguishing benign intracranial hypertension (pseudotumor cerebri) from dural sinus thrombosis.
- Pulsatile tinnitus to identify vascular etiology.
- Suspected vasculitis with abnormal lab results suggesting acute inflammation or autoimmune antibodies.
- Stroke risk in sickle cell patients (2 - 16 years of age) with a transcranial doppler velocity >200.
Neurological findings in sickle cell disease

**Pre-operative evaluation for brain/skull surgery.**

**Post-operative/procedural evaluation (Wong, 2007; Lee, 2009):**

- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

**Indications for Brain MRA/Neck MRA combination studies:**

- Patients who have had a stroke or transient ischemic attack (TIA) within the past 2 weeks.
- Known or suspected vertebrobasilar insufficiency (VBI) in patients with symptoms such as vision changes, vertigo, or abnormal speech.
- Known or suspected carotid or cerebral artery occlusion in patients with a sudden onset of one-sided weakness, abnormal speech, vision defects, or severe dizziness.
- Head trauma in a patient with closed head injury for suspected carotid or vertebral artery dissection.
- Pulsatile tinnitus to identify vascular etiology.

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**ADDITIONAL INFORMATION RELATED TO BRAIN (HEAD) MRA**

**MRA and Cerebral Aneurysms** – Studies that compared MRA with catheter angiography in detecting aneurysms found that MRA could find 77% - 94% of the aneurysms previously diagnosed by catheter angiography that were larger than 5 mm. For aneurysms smaller than 5 mm, MRI detected only 10% - 60% of those detected with catheter angiography. On the other hand, aneurysms that were missed by catheter angiography in patients with acute subarachnoid hemorrhage were detected with MRA, due to the much larger number of projections available with MRA.

**MRA and Cerebral Arteriovenous Malformations (AVM)** – Brain arteriovenous malformation (AVM) may cause intracranial hemorrhage and is usually treated by surgery. 3D TOF-MRA is commonly used during the planning of radio-surgery to delineate the AVM nidus, but it is not highly specific for the detection of a small residual AVM after radio-surgery.

**MRV** - A pitfall of the TOF technique, particularly 3D TOF, is that in areas of slowly flowing blood, turbulence or blood which flows in the imaging plane there can be regions of absent or diminished signal. The signal loss can be confused with vascular occlusion or thrombi. To avoid this pitfall MRA performed after the intravenous administration of gadolinium based contrast agents is utilized at many facilities.

Intracranial magnetic resonance venography (MRV) is used primarily to evaluate the patency of the venous sinuses. The study can be performed with TOF, Phase contrast and IV contrast enhanced techniques. Delayed images to allow for enhancement of the venous system are required to obtain images when intravenous gadolinium enhanced studies are undertaken.

Saturation pulses are utilized in studies not undertaken with intravenous contrast to help eliminate flow related signal in a specified direction and thus display the desired arterial or venous structures on their own. In cranial applications, saturation pulses applied at the inferior margin of the imaging field eliminate signal from arterial flow in order to visualize the veins. Conversely, superior saturation pulses are used to eliminate venous flow related enhancement when evaluation of the arterial structures is desired.
REFERENCES


CPT Codes: 70547, 70548, 70549

INTRODUCTION:

Magnetic resonance angiography (MRA) of the neck uses magnetic resonance imaging (MRI) technology and may be performed after abnormal results are found on carotid duplex imaging. MRA is used for the evaluation and imaging of vessels in the head and the neck.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR NECK MRA:

For evaluation of vascular disease:
- For evaluation of asymptomatic patients with an abnormal ultrasound of the neck or carotid duplex imaging (e.g. carotid stenosis ≥ 70%, technically limited study, aberrant direction of flow in the carotid or vertebral arteries) (Brott, 2011).
- For evaluation of symptomatic patients with an abnormal ultrasound of the neck or carotid duplex imaging (e.g. carotid stenosis ≥ 50%, technically limited study, aberrant direction of flow in the carotid or vertebral arteries) (Brott, 2011).
- For evaluation of head or neck blunt injury for suspected carotid or vertebral artery dissection.
  - Focal or lateralizing neurological deficits
  - Face or cervical fractures
  - Cervical hematomas
  - Injury by severe cervical hyperextension/rotation or hyperflexion, or “clothesline”
  - Thoracic injury
  (Franz, 2012; Mundinger, 2013)
- Findings of Takayasu arteritis in other blood vessels (Keenan, 2009)

For evaluation of known or suspected tumor/mass:
- For evaluation of carotid body tumors, or other paragangliomas.
- For evaluation of pulsatile neck mass after ultrasound has been performed when there reasonable suspicion that it is not a vascular lesion (Pegge, 2017).

Pre-operative evaluation.

Post-operative/procedural evaluation (e.g. carotid endarterectomy):
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

Indications for combination studies:

Neck MRA/Brain MRA:
- Evaluation of new onset stroke or transient ischemic attack (TIA)
- For evaluation of known or suspected vertebrobasilar insufficiency (VBI) in patients with symptoms such as vision changes, vertigo, or abnormal speech.
- For evaluation of known or suspected carotid or cerebral artery occlusion in patients with a sudden onset of one-sided weakness, abnormal speech, vision defects or severe dizziness.
- For evaluation of head or neck blunt injury for suspected carotid or vertebral artery dissection.
  - Focal or lateralizing neurological deficits
  - Face or cervical fractures
  - Cervical hematomas
  - Injury by severe cervical hyperextension/rotation or hyperflexion, or “clothesline”
  - Thoracic injury
  (Franz 2012; Mundinger 2013)
- For evaluation of pulsatile tinnitus for vascular etiology (Pegge, 2017).

**Neck MRA/Brain MRI:**
- For evaluation of asymptomatic patients with an abnormal ultrasound of the neck or carotid duplex imaging (e.g. carotid stenosis ≥ 70%, technically limited study, aberrant direction of flow in the carotid or vertebral arteries) and patient is surgery or angioplasty candidate (Brott, 2011).
- For evaluation of symptomatic patients with an abnormal ultrasound of the neck or carotid duplex imaging (e.g. carotid stenosis ≥ 50%, technically limited study, aberrant direction of flow in the carotid or vertebral arteries) and patient is surgery or angioplasty candidate (Brott, 2011).

**ADDITIONAL INFORMATION RELATED TO NECK MRA:**

**MRA and Carotid Body Tumor** – Carotid body tumors are found in the upper neck at the branching of the carotid artery. Although most of them are benign they may be locally aggressive with a small malignant potential. MRA may be used to identify a carotid body tumor due to its ability to define the extension of the tumor in relation to the carotid arteries, involvement of the base of the skull and bilateral tumors.

**Post-operative evaluation of carotid endarterectomy** – Carotid endarterectomy is a vascular surgical procedure that removes plaque from the carotid artery. MRA with multiprojection volume reconstruction is a non-invasive imaging modality that is an alternative to postoperative angiography following carotid endarterectomy. It allows the surgeon to get informative and comparative data.
REFERENCES


INTRODUCTION:

Brain (head) MRI is the procedure of choice for most brain disorders. It provides clear images of the brainstem and posterior brain, which are difficult to view on a CT scan. It is also useful for the diagnosis of demyelinating disorders (disorders such as multiple sclerosis (MS) that cause destruction of the myelin sheath of the nerve). The evaluation of blood flow and the flow of cerebrospinal fluid (CSF) is possible with this non-invasive procedure.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR BRAIN MRI:

For evaluation of suspected multiple sclerosis (MS) (Traboulsee, 2016):
- For evaluation of patient with neurologic symptoms or deficits within the last four (4) weeks.

For evaluation of known multiple sclerosis (MS) (Traboulsee, 2016):
- Stable condition with no prior imaging within the past ten (10) months or within the past six (6) months if patient has relapsing disease
- Exacerbation of symptoms or change in symptom characteristics such as frequency or type and demonstrated compliance with medical therapy.

For evaluation of known or suspected seizure disorder (Krumholz, 2007; Gaillard, 2009; Ramli, 2015):
- New onset of a seizure.
- Medically refractory epilepsy.

For evaluation of suspected Parkinson’s disease (Pyatigorskaya, 2014):
- For evaluation of suspected Parkinson’s disease as a baseline study.

For evaluation of known Parkinson’s disease (Pyatigorskaya, 2014):
- For evaluation of new non-Parkinson symptoms complicating the evaluation of the current condition.

For evaluation of neurologic symptoms or deficits (ACR, 2012a):
- Acute, new, or fluctuating neurologic symptoms or deficits such as sensory deficits, limb weakness, speech difficulties, lack of coordination, or mental status changes.

For evaluation of clinical assessment documenting cognitive impairment of unclear cause (Narayanan, 2016; HQO, 2014):
- Change in mental status with a mental status score of either MMSE or MoCA of less than 26 or other similar mental status instruments showing at least mild cognitive impairment AND a completed basic metabolic workup (such as thyroid function testing, liver function testing, complete blood count, electrolytes, and B12).
For evaluation of known or suspected trauma (Lee, 20015; Jagoda, 2008):
- Known or suspected trauma or injury to the head with documentation of one or more of the following acute, new, or fluctuating:
  - Focal neurologic findings
  - Motor changes
  - Mental status changes
  - Amnesia
  - Vomiting
  - Seizures
  - Headache
  - Signs of increased intracranial pressure
- Known coagulopathy
- Known or suspected skull fracture by physical exam and positive x-ray.

For evaluation of headache (Holle, 2013; Edlow, 2008; Schaefer, 2007; Silberstein, 2000; Wilbrink, 2009; ACR, 2012b; Gunner, 2007):
- Chronic headache with a change in character/pattern (e.g., more frequent, increased severity, or duration).
- New onset (< 48 hours) of “worst headache in my life” or “thunderclap” headache. Note: The duration of a thunderclap type headache lasts more than 5 minutes. Sudden onset new headache reaching maximum intensity within 2-3 minutes.
- New onset of headache with any acute, new or fluctuating neurologic deficits such as sensory deficits, limb weakness, speech difficulties, lack of coordination, or mental status changes
- MRI is indicated once in patients with cluster headaches to eliminate secondary causes.
- Patient with history of cancer, or significantly immunocompromised, with new onset headache.
- New headache in individual > 55 years old.
- New temporal headache in person > 55, with sedimentation rate (ESR) > 55 with tenderness over the temporal artery.
- Acute, sudden onset of headache with a family history (brother, sister, parent or child) of brain aneurysm or AVM (arteriovenous malformation).
- New severe unilateral headache with radiation to or from the neck. Associated with suspicion of carotid or vertebral artery dissection.
- New onset of headache in pregnancy.

For evaluation of known or suspected brain tumor, mass or metastasis (Kerjnick, 2008):
- Known tumor and new onset of headache.
- Follow up for known tumor.
- Evaluation of suspected tumor with any acute, new or fluctuating neurologic symptoms or deficits such as sensory deficits, limb weakness, speech difficulties, lack of coordination, or mental status changes.
- Known lung cancer or rule out metastasis and/or preoperative evaluation.
- Evaluation of metastatic melanoma (not all melanomas).
- Known or suspected pituitary tumor with corroborating physical exam (galactorrhea) neurologic findings and/or lab abnormalities.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated, OR evaluation of suspected metastases (NCCN, 2017):
- ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.
For evaluation of known or suspected stroke (Jauch, 2013):
- To evaluate patient with history of a known stroke with new and sudden onset of severe headache.
- Known or suspected stroke with any acute, new or fluctuating symptoms or deficits such as sensory deficits, limb weakness, speech difficulties, lack of coordination or mental status changes or with a family history (brother, sister, parent, or child) of aneurysm.
- Symptoms of transient ischemic attack (TIA) (episodic neurologic symptoms).

For evaluation of known or suspected inflammatory disease or infection (e.g., meningitis or abscess) (Lummel, 2016; Oliveira, 2014; Tarrant, 2009):
- Intracranial abscess or brain infection with acute altered mental status OR positive lab findings (such as elevated WBC's) OR follow up assessment during or after treatment completed.
- Meningitis with positive physical findings (such as fever, stiff neck) and positive lab findings (such as elevated white blood cells or abnormal lumbar puncture fluid exam.)
- Suspected encephalitis with a severe headache, altered mental status OR positive lab finding, (such as elevated WBC's).
- Endocarditis with suspected septic emboli.
- Evaluation for Central Nervous System (CNS) involvement in patients with known or suspected vasculitis or autoimmune disease with positive lab findings.

For evaluation of known or suspected congenital abnormality (such as hydrocephalus, craniosynostosis) (Ashwal, 2009; Vinocur, 2010):
- Known or suspected congenital abnormality with any acute, new, or fluctuating neurologic, motor, or mental status changes.
- Evaluation of macrocephaly with child >6 months of age.
- Evaluation of microcephaly.
- Follow up shunt evaluation within six (6) months of placement or one (1) year follow up and/or with neurologic symptoms.
- Evaluation of craniosynostosis and other skull deformities. CT is preferred imaging to assess bony structures; MRI imaging is preferred to assess intracranial soft tissue.
- To evaluate patient for suspected or known hydrocephalus.
- To evaluate patient for prior treatment OR treatment planned for congenital abnormality.

Suspected normal pressure hydrocephalus (NPH) with symptoms (Valvassori, 2000).

Pre-operative evaluation for brain/skull surgery:

Post-operative/procedural evaluation:
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

Indications for a Brain MRI with Internal Auditory Canal (IAC) (Labuguen, 2006):
- Unilateral non-pulsatile tinnitus.
- Pulsatile tinnitus.
- Suspected acoustic neuroma (Schwannoma) or cerebellar pontine angle tumor with any of the following signs and symptoms: unilateral hearing loss by audiometry, headache, disturbed balance or gait, unilateral tinnitus, facial weakness, or altered sense of taste.
- Suspected cholesteatoma.
- Suspected glomus tumor.
- Asymmetric sensorineural hearing loss on audiogram.
Other indications for a Brain MRI (Meadows, 2000; Thust, 2014; Agostoni, 2009; ACR, 2017b; ACR, 2017a; Mackin, 2014; Silva, 2009p; Strickberger, 2006):

- Evaluation of suspected acute subarachnoid hemorrhage (SAH).
- Follow up for known hemorrhage, hematoma or vascular abnormalities.
- Suspected central venous thrombosis.
- Evaluation of neurological findings in sickle cell disease.
- Developmental delay.
- Vertigo associated with headache, blurred or double vision, or a change in sensation after full neurologic examination and initial work-up.
- Abnormal eye findings on physical or neurologic examination (papilledema, nystagmus, ocular nerve palsies, visual field deficit etc).
- Anosmia (loss of smell) (documented by objective testing).
- Evaluation of known or suspected cerebrospinal fluid (CSF) leakage.
- Immunocompromised patient (e.g., transplant recipients, HIV with CD4<200, primary immunodeficiency syndromes, hematologic malignancies) with focal neurologic-symptoms, headaches, behavioral, cognitive or personality changes.
- Initial imaging of a suspected or known Arnold Chiari malformation (ACM)
- Optic neuritis.
- Initial evaluation for a known syrinx or syringomyelia.
- Suspected cholesteatoma.

Indications for combination studies:

- **Brain MRI/Neck MRA** –
  o Confirmed carotid occlusion >60%, surgery or angioplasty candidate.

- **Brain MRI/Cervical MRI** –
  o For evaluation of Arnold Chiari Malformation.
  o For follow-up of known multiple sclerosis (MS).

- **Brain MRI/Orbit MR** –
  o For approved indications as noted above and being performed in a child under 3 years of age who will need anesthesia for the procedure and there is a suspicion of concurrent intracranial tumor (e.g. “trilateral retinoblastoma”).
  o Unilateral papilledema: to distinguish a compressive lesion on the optic nerve or optic disc swelling associated with acute demyelinating optic neuritis in multiple sclerosis from nonarteritic anterior ischemic optic neuropathy (AION), central retinal vein occlusion or optic nerve infiltrative disorders.

**ADDITIONAL INFORMATION RELATED TO BRAIN MRI:**

**MMSE**: The Mini Mental State Examination (MMSE) is a tool that can be used to systematically and thoroughly assess mental status. It is an 11-question measure that tests five areas of cognitive function: orientation, registration, attention and calculation, recall, and language. The MMSE has been the most commonly used measure of cognitive function in dementia research, but researchers have recognized that it is relatively insensitive and variable in mildly impaired individuals. The maximum score is 30. A score of 23 or lower is indicative of cognitive impairment. The MMSE takes only 5-10 minutes to administer and is therefore practical to use repeatedly and routinely.
MoCA - The Montreal Cognitive Assessment (MoCA) was designed as a rapid screening instrument for mild cognitive dysfunction. It assesses different cognitive domains: attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. MoCA differs from the MMSE mainly by including tests of executive function and abstraction, and by putting less weight on orientation to time and place. Ten of the MMSE's 30 points are scored solely on the time-place orientation test, whereas the MoCA assigns it a maximum of six points. The MoCA also puts more weight on recall and attention-calculation performance, while de-emphasizing language skill. Time to administer the MoCA is approximately 10 minutes. The total possible score is 30 points; a score of 26 or above is considered normal.

Combination MRI/MRA of the Brain – This is one of the most misused combination studies and these examinations should be ordered in sequence, not together. Vascular abnormalities can be visualized on the brain MRI.

MRI for Headache - Generally, magnetic resonance imaging is the preferred imaging technique for evaluating the brain parenchyma and CT is preferable for evaluating subarachnoid hemorrhage. CT is faster and more readily available than MRI and is often used in urgent clinical situations. Neurologic imaging is warranted in patients with headache disorders along with abnormal neurologic examination results or predisposing factors for brain pathology. Contrast enhanced MRI is performed for evaluation of inflammatory, infectious, neoplastic and demyelinating conditions.

MRI for Macrocephaly - Consider ultrasound for child <6 months of age for macrocephaly.

MRI and Positron Emission Tomography (PET) for Chronic Seizures – When MRI is performed in the evaluation of patients for epilepsy surgery, almost a third of those with electrographic evidence of temporal lobe epilepsy have normal MRI scans. Interictal positron emission tomography (PET) may be used to differentiate patients with MRI-negative temporal lobe epilepsy.

MRI and Multiple Sclerosis – Current advances in MRI improve the ability to diagnose, monitor and understand the pathophysiology of MS. Different magnetic resonance methods are sensitive to different aspects of MS pathology and by the combining of these methods, an understanding of the mechanisms underlying MS may be increased.

MRI and Vertigo – Magnetic resonance imaging is appropriate in the evaluation of patients with vertigo who have neurologic signs and symptoms, progressive unilateral hearing loss or risk factors for cerebrovascular disease. MRI is more appropriate than CT for diagnosing vertigo due to its superiority in visualizing the posterior portion of the brain, where most central nervous system disease that causes vertigo is found. MRI is helpful in diagnosing vascular causes of vertigo.
REFERENCES


CPT Codes: 70554, 70555

INTRODUCTION:

Functional MRI (fMRI) of the brain is a non-invasive imaging technique, using radio waves and a strong magnetic field, to image the brain activity of a patient prior to undergoing brain surgery for tumors or epilepsy. It is based on the increase in blood flow to the local vasculature when parts of the brain are activated and helps to determine the location of vital areas of brain function. fMRI images capture blood oxygen levels in parts of the brain that are responsible for perception, cognition, and movement allowing neurosurgeons to operate with less possibility of harming areas that are critical to the patient’s quality of life.

fMRI is also used to image and localize abnormal brain function in patients with seizures.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR FUNCTIONAL BRAIN MRI (ACR, 2017; ACR, 2014; Carmichael, 2007; Chakraborty, 2008; Hall, 2009; Owen, 2007; Petrella, 2006; Chandrasekharan, 2008):

Pre-operative Evaluation:
- With brain tumors where fMRI may have a significant role in mapping lesions.
- With seizures where fMRI may have a significant role in mapping lesions.

Post-operative Evaluation:
- To assess progress after surgery. A documented medical reason must clearly explain the medical necessity for the post-operative follow up.

ADDITIONAL INFORMATION RELATED TO FUNCTIONAL BRAIN MRI:

fMRI and Brain Tumors – fMRI may significantly affect therapeutic planning in patients who have potentially resectable brain tumors. Due to its non-invasiveness, its relatively high spatial resolution, and its pre-operative results, fMRI is used before surgery in the evaluation of patients with brain tumors. fMRI may have a significant role in mapping lesions that are located in close proximity to vital areas of brain function (language, sensory motor, and visual). It can determine the precise spatial relationship between the lesion and adjacent functionally essential parenchyma, allowing removal of as much pathological tissue as possible during resection of brain tumors without compromising essential brain functions. fMRI provides an alternative to other invasive tests such as the Wada test and direct electrical stimulation.

fMRI and Seizures – Brain fMRI can influence the diagnostic and therapeutic decisions of the seizure team, thereby affecting the surgical approach and outcomes. Brain surgery is often the treatment for patients with epilepsy, especially patients with a single seizure focus. fMRI may have a significant role in mapping lesions that are located in close proximity to vital areas of brain function (language, sensory motor, and visual).
fMRI can determine the location of the brain functions of areas bordering the lesion, resulting in better outcomes with less neurologic deficit.

**fMRI as an Alternative to the Invasive WADA test and Direct Electrical Stimulation** – fMRI is considered an alternative to the Wada test and direct electrical stimulation as it is a non-invasive method for location of vital brain areas. The Wada test is used for the pre-operative evaluations of patients with brain tumors and seizures to determine which side of the brain is responsible for vital cognitive functions, e.g., speech and memory. It can assess the surgical risk of damaging the vital areas of the brain. The Wada test is invasive, involving an angiography procedure to guide a catheter to the internal carotid where a barbiturate is injected, putting one hemisphere of the brain to sleep. Direct electrical stimulation mapping is invasive requiring the placement of electrodes in the brain. The electrodes are used to stimulate multiple cortical sites in the planned area of resection to allow the surgeons to identify and mark which areas can be safely resected.
REFERENCES


CPT Codes: 71250, 71260, 71270, G0297

INTRODUCTION:

Computed tomography (CT) scans provide greater clarity than regular x-rays and are used to further examine abnormalities found on chest x-rays. They may be used for detection and evaluation of various disease and conditions in the chest, e.g., tumor, inflammatory disease, vascular disease, congenital abnormalities, trauma and symptoms such as hemoptysis.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR CHEST CT:

For annual lung cancer screening:
The use of low-dose, non-contrast spiral (helical) multi-detector CT imaging as an annual screening technique for lung cancer is considered medically necessary ONLY when used to screen for lung cancer for certain high-risk asymptomatic individuals when ALL of the following criteria are met:

- Individual is between 55-77 years of age; AND
- There is at least a 30 pack-year history of cigarette smoking; AND
- If the individual is a former smoker, that individual had quit smoking within the previous 15 years (Medicare, ACCP).

For evaluation of known tumor, cancer or mass:
- Initial evaluation of diagnosed cancer.
- Evaluation of known tumor or cancer for patient undergoing active treatment to assess impact of treatment.
- Evaluation of known tumor or cancer or history of prior cancer presenting with new signs (i.e., physical, laboratory, or imaging findings) or new symptoms.
- Active monitoring for recurrence as clinically indicated.

Evaluation of suspicious mass/tumor (unconfirmed cancer diagnosis):
- Initial evaluation of suspicious mass/tumor found on an imaging study and needing clarification or found by physical exam and remains non-diagnostic after x-ray or ultrasound is completed.
- Known distant cancer with suspected chest/lung metastasis based on a sign, symptom, imaging study or abnormal lab value.
- For the follow-up evaluation of a nodule with a previous CT (follow-up intervals approximately 3, 6, 12 and 24 months):
  - f/u evaluation of ground glass > 5mm up to 36 months.
  - no further f/u of solid nodules < 6mm if unchanged at 12 month

Known or suspected interstitial lung disease (e.g. idiopathic interstitial lung diseases, idiopathic pulmonary fibrosis, hypersensitivity pneumonitis, pneumoconiosis, sarcoidosis, silicosis and asbestosis) and initial x-ray has been performed:
- With abnormal physical, laboratory, and/or imaging findings requiring further evaluation.
Known or suspected infection or inflammatory disease (i.e., complicated pneumonia not responding to treatment, abscess, tuberculosis (TB), empyema or immunosuppression post-organ transplant with new symptoms or findings) and initial x-ray has been performed:

- With abnormal physical, laboratory, and/or imaging findings requiring further evaluation.
- For evaluation of known inflammatory disease:
  o Initial evaluation
  o During treatment
  o With new signs and symptoms
- For evaluation of non-resolving pneumonia documented by at least two imaging studies:
  o Unimproved with 4 weeks of antibiotic treatment OR
  o Not resolved at 8 weeks
- For evaluation of lung abscess, cavitary lesion, or empyema, demonstrated or suggested on prior imaging.

Suspected vascular disease, (e.g., aneurysm, dissection):

- For evaluation of known or suspected superior vena cava (SVC) syndrome.
- Suspected thoracic/thoracoabdominal aneurysm or dissection (documentation of clinical history may include hypertension and reported “tearing or ripping type” chest pain) when contrast is contraindicated.

Known vascular disease:

- For follow up of known vascular disease (aneurysm) and contrast is not appropriate for the clinical indication

Suspected Pulmonary Embolism (PE):

Patients at intermediate risk for PE and positive D-dimer or at high risk for PE

Patients with intermediate risk for PE with negative D-dimer or low risk for PE should be directed to Chest CTA although this is controversial and Chest CT optimized as to enhancement of the pulmonary vessels may be acceptable in select circumstances

Patients can be excluded from imaging with low risk for PE and negative D-dimer results

D-dimer is a blood test that measures fibrin degradation products that are increased when increased clotting and clot degradation is going on in the body.

*Low risk defined as NO to ALL of the following questions with intermediate and high risk defined based on the number of positive responses:
1) Evidence of current or prior DVT;
2) HR > 100;
3) Cancer diagnosis;
4) Recent surgery or prolonged immobilization;
5) Hemoptysis;
6) History of PE;
7) Another diagnosis beside PE is less likely.

All patients should have prior Chest x-ray to evaluate other possible causes for the patient symptoms (i.e CHF) and patients in low and intermediate risk groups for PE should have preceding D-dimer level to better stratify patient into risk categories to decide if test is necessary or proper protocol for Chest CT.

Known or suspected congenital abnormality:

- For evaluation of known or suspected congenital abnormality
- Vascular - suggest Chest CTA or Chest MRA depending on age and radiation safety issues.
- Nonvascular - abnormal imaging and/or physical examination finding.

**Hemoptysis:**
- For evaluation of hemoptysis and prior x-ray performed.

**Post-operative/procedural evaluation:**
- Post-surgical follow up when records document medical reason requiring additional imaging

**Other indications for Chest CT:**
- Pre-operative evaluation.
- Re-evaluation after abnormal imaging within past 30 - 60 days and with no improvement on x-ray, (not indicated with known rib fractures).
- Evaluation of persistent unresolved cough of at least four weeks duration, unresponsive to medical treatment and chest x-ray has been performed.
- Evaluation of other chest or thorax adenopathy.
- Evaluation of pneumothorax.
- Evaluation of vocal cord paralysis.
- Suspected thymoma with myasthenia gravis.
- Pre-operative evaluation for Electromagnetic Navigation Bronchoscopy (Khan et al, 2016)

**Combination of studies with Chest CT:**
- Abdomen CT/Pelvis CT/Chest CT/Neck MRI/Neck CT with MUGA – known tumor/cancer for initial staging or evaluation before starting chemotherapy or radiation treatment.

**COMBINATION OF STUDIES WITH CHEST CT/SINUS CT:**
- For poorly controlled asthma associated with upper respiratory tract infection. May be performed without failing 4 consecutive weeks of sinus treatment with medication.
- Granulomatosis with polyangiitis (GPA) (Wegener’s).

**ADDITIONAL INFORMATION RELATED TO CHEST CT:**

**LDCT for Lung Cancer Screening** - Screening should be discontinued once a person has not smoked for 15 years or develops a health problem that substantially limits life expectancy or the ability or willingness to have curative lung surgery

**CT for Management of Hemoptysis** – High-resolution CT (HRCT) is useful for estimating the severity of hemoptysis, localizing the bleeding site and determining the cause of the bleeding. Its results can be related to the severity of bleeding. The volume of expectorated blood and the amount of blood that may be retained within the lungs without being coughed up are important. HRCT is a way to evaluate the amount of bleeding and its severity. It may also help in the localization of bleeding sites and help in detecting the cause of bleeding.

**CT and Solitary Pulmonary Nodules** – Solitary Pulmonary nodules are abnormalities that are solid, semisolid and non solid: another term to describe a nodule is focal opacity. CT makes it possible to find smaller nodules and contrast-enhanced CT is used to differentiate benign from malignant pulmonary modules. When a nodule is increasing in size or has spiculated margins or mixed solid and ground-glass
attenuation, malignancy should be expected. Patients who have pulmonary nodules and who are immunocompromised may be subject to inflammatory processes.

**CT and Empyema** – Contrast-enhanced CT used in the evaluation of the chest wall may detect pleural effusion and differentiate a peripheral pulmonary abscess from a thoracic empyema. CT may also detect pleural space infections and help in the diagnosis and staging of thoracic empyema.

**CT and Superior Vena Cava (SVC) Syndrome** – SVC is associated with cancer, e.g., lung, breast and mediastinal neoplasms. These malignant diseases cause invasion of the venous intima or an extrinsic mass effect. Adenocarcinoma of the lung is the most common cause of SVC. SVC is a clinical diagnosis with typical symptoms of shortness of breath along with facial and upper extremity edema. Computed tomography (CT), often the most readily available technology, may be used as confirmation and may provide information including possible causes.
REFERENCES


Medicare.gov.


INTRODUCTION:

Computed tomography angiography (CTA) is a non-invasive imaging modality that may be used in the evaluation of thoracic vascular problems. Chest CTA (non-coronary) may be used to evaluate vascular conditions, e.g., pulmonary embolism, thoracic aneurysm, thoracic aortic dissection, aortic coarctation, or pulmonary vascular stenosis. CTA depicts the vascular structures as well as the surrounding anatomical structures.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR CHEST CTA:

For evaluation of suspected or known pulmonary embolism (excludes low risk*)

For evaluation of suspected or known vascular abnormalities:
- For evaluation of a thoracic/thoracoabdominal aneurysm or dissection (documentation of clinical history may include hypertension and reported “tearing or ripping type” chest pain).
- Congenital thoracic vascular anomaly, (e.g., coarctation of the aorta or evaluation of a vascular ring suggested by GI study).
- Signs or symptoms of vascular insufficiency of the neck or arms (e.g., subclavian steal syndrome with abnormal ultrasound).
- Follow-up evaluation of progressive vascular disease when new signs or symptoms are present.
- Primary or secondary pulmonary hypertension.

Preoperative evaluation
- Known or suspected vascular abnormalities seen on prior imaging
- Ablation procedure for atrial fibrillation.

Postoperative or post-procedural evaluation
- Physical evidence of post-operative bleeding complication or re-stenosis.
- Post-surgical follow up when records document medical reason requiring additional imaging

Chest CTA and Abdomen CTA or Abdomen/Pelvis CTA or Pelvis CTA combo:
- For evaluation of extensive vascular disease involving the chest and abdominal cavities such as aortic dissection, vasculitic diseases such as Takayasu's arteritis, significant post-traumatic or post-procedural vascular complications, etc.
- For preoperative or preprocedural evaluation such as transcatheter aortic valve replacement (TAVR).

ADDITIONAL INFORMATION RELATED TO CHEST CTA:
CTA and Coarctation of the Aorta – Coarctation of the aorta is a common vascular anomaly characterized by a constriction of the lumen of the aorta distal to the origin of the left subclavian artery near the insertion of the ligamentum arteriosum. The clinical sign of coarctation of the aorta is a disparity in the pulsations and blood pressures in the legs and arms. Chest CTA may be used to evaluate either suspected or known aortic coarctation and patients with significant coarctation should be treated surgically or interventionally.

CTA and Pulmonary Embolism (PE) – Note: D-Dimer blood test in patients at low risk* for DVT is indicated prior to CTA imaging. Negative D-Dimer suggests alternative diagnosis in these patients.

*Low risk defined as NO to ALL of the following questions:
   1) Evidence of current or prior DVT;
   2) HR > 100;
   3) Cancer diagnosis;
   4) Recent surgery or prolonged immobilization;
   5) Hemoptysis;
   6) History of PE;
and another diagnosis is more likely.

CTA has high sensitivity and specificity and is the primary imaging modality to evaluate patients suspected of having acute pulmonary embolism. When high suspicion of pulmonary embolism on clinical assessment is combined with a positive CTA, there is a strong indication of pulmonary embolism. Likewise, a low clinical suspicion and a negative CTA can be used to rule out pulmonary embolism.

CTA and Thoracic Aortic Aneurysms – Computed tomographic angiography (CTA) allows the examination of the precise 3-D anatomy of the aneurysm from all angles and shows its relationship to branch vessels. This information is very important in determining the treatment: endovascular stent grafting or open surgical repair.

CTA and Thoracic Aorta Endovascular Stent-Grafts – CTA is an effective alternative to conventional angiography for postoperative follow-up of aortic stent grafts. It is used to review complications after thoracic endovascular aortic repair. CTA can detect luminal and extraluminal changes to the thoracic aortic after stent-grafting and can be performed efficiently with fast scanning speed and high spatial and temporal resolution.
REFERENCES


CPT Codes: 71550, 71551, 71552

INTRODUCTION:

Magnetic Resonance Imaging (MRI) is a noninvasive imaging technique for detection and evaluation of various disease and conditions in the chest, e.g., congenital anomalies and aneurysms. MRI may be used instead of computed tomography (CT) in patients with allergies to radiographic contrast or with impaired renal function.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR CHEST MRI:

- For evaluation of mediastinal or hilar mass of patient with renal failure or allergy to contrast material (Carter, 2017; Azidad, 2016; Erasmus, 2000).
- For evaluation of chest wall masses (Carter, 2016; Carter, 2015).
- For evaluation of myasthenia gravis with suspected thymoma (Carter, 2015; Conti-Fine, 2006).
- For evaluation of brachial plexus dysfunction (brachial plexopathy/thoracic outlet syndrome) (Amrami, 2005; Demondon, 2006; Dillman, 2006; Medina, 2008; Smith, 2015).
- For evaluation of a thoracic/thoracoabdominal aneurysm or dissection (documentation of clinical history may include hypertension and reported “tearing or ripping type” chest pain (Lau, 2017; Mongeon, 2016; Dudzinski, 2015; Dillman, 2008; Goitein, 2005; Konen, 2004; Russo, 2006; Norenberg, 2016).
- For evaluation of congenital heart disease or cardiac and non-cardiac malformations, [e.g., vascular rings or pulmonary slings, aortic arch anomalies and patent ductus arteriosus (PDA)] (Smith, 2015; Gutierrez, 2002; Konen, 2004; McMahon, 2007; Russo, 2006; Ruano, 2015; Baez, 2015).
- For evaluating whether masses invade into specific thoracic structures (e.g. aorta, pulmonary artery, brachial plexus, subclavian vessels, or thoracic spine) (Zapala, 2017; Mueller, 2015; Cline, 2017; Hazenfield, 2016; Carter, 2016; Carter, 2015).
- To determine the consistency of thoracic masses (cystic vs. solid vs. mixed) (Hansen, 2015).
- Initial evaluation of suspicious abnormality found on an imaging study and needing clarification or found by physical exam and remains non-diagnostic after x-ray or ultrasound is completed.
- Post-surgical follow up when records document medical reason requiring additional imaging.

ADDITIONAL INFORMATION RELATED TO CHEST MRI:

MRI and Myasthenia Gravis – Myasthenia Gravis is a chronic autoimmune disease characterized by weakness of the skeletal muscles causing fatigue and exhaustion that is aggravated by activity and relieved by rest. It most often affects the ocular and other cranial muscles and is thought to be caused by the presence of circulating antibodies. Symptoms include ptosis, diplopia, chewing difficulties, and dysphagia. Thymoma has a known association with myasthenia. Contrast-enhanced MRI may be used to identify the presence of a mediastinal mass suggestive of myasthenia gravis in patients with renal failure or allergy to contrast material.
**MRI and Thoracic Outlet Syndrome** – Thoracic outlet syndrome is a group of disorders involving compression at the superior thoracic outlet that affects the brachial plexus, the subclavian artery and veins. It refers to neurovascular complaints due to compression of the brachial plexus or the subclavian vessels. Magnetic resonance multi-plane imaging shows bilateral images of the thorax and brachial plexus and can demonstrate the compression of the brachial plexus and venous obstruction.

**MRI and Brachial Plexus** · MRI is the only diagnostic tool that accurately provides high resolution imaging of the brachial plexus. The brachial plexus is formed by the cervical ventral rami of the lower cervical and upper thoracic nerves which arise from the cervical spinal cord, exit the bony confines of the cervical spine, and traverse along the soft tissues of the neck, upper chest, and course into the arms.
REFERENCES


CPT Codes: 71555

INTRODUCTION:

Magnetic resonance angiography (MRA) is a noninvasive technique used to provide cross-sectional and projection images of the thoracic vasculature, including large and medium sized vessels, e.g., the thoracic aorta. It provides images of normal as well as diseased blood vessels and quantifies blood flow through these vessels. Successful vascular depiction relies on the proper imaging pulse sequences. MRA may use a contrast agent, gadolinium, which is non-iodine-based, for better visualization. It can be used in patients who have history of contrast allergy and who are at high risk of kidney failure.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR CHEST MRA:

For evaluation of suspicious mass and CTA is contraindicated due to a history of contrast allergy or high risk for contrast induced renal failure.

For evaluation of suspected or known pulmonary embolism (excludes low risk*) (ACCP, 2013; Douma, 2009; Schiebler, 2013; Li, 2009).

For evaluation of suspected or known vascular abnormalities (ACR, 2017):
- Thoracic/thoracoabdominal aneurysm or dissection (documentation of clinical history may include hypertension and reported “tearing or ripping type” chest pain) (Miller, 2008; Bonci, 2017).
- Congenital thoracic vascular anomaly (e.g., coarctation of the aorta or evaluation of a vascular ring suggested by GI study) (Russo, 2006).
- Signs or symptoms of vascular insufficiency of the neck or arms (e.g., subclavian steal syndrome with abnormal ultrasound) (Bauer, 2009).
- Follow-up evaluation of progressive vascular disease when new signs or symptoms are present (Araoz, 2003).
- Primary or secondary pulmonary hypertension (Swift, 2012; Lopez-Costa, 2014).
- Pulmonary sequestration (Xu, 2001).
- Central venous thrombosis (Kim, 2008).

Preoperative Evaluation

- Known vascular abnormalities
- Ablation procedure for atrial fibrillation (Cirillo, 2004).

Postoperative or post-procedural evaluation

- Physical evidence of post-operative bleeding complication or re-stenosis.
- Post-surgical follow up when records document medical reason requiring additional imaging (Araoz, 2003).
ADDITIONAL INFORMATION RELATED TO CHEST MRA:

**MRA and Coarctation of the Aorta** – One of the most common congenital vascular anomalies is coarctation of the aorta which is characterized by obstruction of the juxtaductal aorta. Clinical symptoms, e.g., murmur, systemic hypertension, difference in blood pressure in upper and lower extremities, absent femoral or pedal pulses, may be present. Gadolinium enhanced 3D MRA may assist in preoperative planning as it provides angiographic viewing of the aorta, the arch vessels and collateral vessels. It may also assist in the identification of postoperative complications.

**MRA and Pulmonary Embolism (PE)** – Note: D-Dimer blood test in patients at low risk* for DVT is indicated prior to MRA imaging. Negative D-Dimer suggests alternative diagnosis in these patients.

*Low risk defined as NO to ALL of the following questions:
1) Evidence of current or prior DVT;
2) HR > 100;
3) Cancer diagnosis;
4) Recent surgery or prolonged immobilization;
5) Hemoptysis;
6) History of PE;
and another diagnosis is more likely

Studies show mixed results regarding the value of MRA v CTA in detecting pulmonary embolism. A systematic review and meta-analysis found MRA to be inferior to CTA in detecting PE. Therefore, MRA should be used only if CTA is not available or contraindicated in a specific patient (Li, 2009).

**MRA and Thoracic Aortic Aneurysm** – One of the most common indications for thoracic MRA is thoracic aortic aneurysm, most often caused by atherosclerosis. These aneurysms may also be due to aortic valvular disease. Aneurysms are defined by their enlargement and patients with rapidly expanding aortas, or with aortic diameters greater than five or six centimeters, are at high risk of rupture and may require surgery.

**MRA and Thoracic Aortic Dissection** – The most common clinical symptom of aortic dissection is tearing chest pain and the most common risk factor is hypertension. An intimal tear is the hallmark for aortic dissection and intramural hematoma may also be detected. Unfortunately, patients with aortic dissection may be unstable and not good candidates for routine MR evaluation; MRA may be indicated as a secondary study. 3D MRA is also useful in postoperative evaluation of patients with repaired aortic dissections.

**MRA and Central Venous Thrombosis** – MRA is useful in the identification of venous thrombi. Venous thrombosis can be evaluated by gadolinium enhanced 3D MRA as an alternative to CTA which may not be clinically feasible due to allergy to iodine contrast media or renal insufficiency.

**Other MRA Indications** – MRA is useful in the assessment for postoperative complications of pulmonary venous stenosis.

**MRI and Patent Ductus Arteriosus** – Patent ductus arteriosus (PDA) is a congenital heart problem in which the ductus arteriosus does not close after birth. It remains patent allowing oxygen-rich blood from the aorta to mix with oxygen-poor blood from the pulmonary artery. MRI can depict the precise anatomy
of a PDA to aid in clinical decisions. It allows imaging in multiple planes without a need for contrast administration. Patients are not exposed to ionizing radiation.
REFERENCES


CPT Codes: 72125, 72126, 72127

INTRODUCTION:
Computed tomography (CT) is performed for the evaluation of the cervical spine. CT may be used as the primary imaging modality or it may complement other modalities. Primary indications for CT include conditions, e.g., traumatic, neoplastic, and infectious. CT is often used to study the cervical spine for conditions such as degenerative disc disease when MRI is contraindicated. CT provides excellent depiction of bone detail and is used in the evaluation of known fractures of the cervical spine and for evaluation of postoperative patients.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR CERVICAL SPINE CT:

For evaluation of known fracture (ACR, 2012):
- To assess union of a fracture when physical examination, plain radiographs, or prior imaging suggest delayed or non-healing
- To determine the position of fracture fragments.

For evaluation of neurologic deficits when Cervical Spine MRI is contraindicated or inappropriate (ACR, 2013; Carette, 2005):
- With any of the following new neurological deficits: extremity weakness; abnormal reflexes; or abnormal sensory changes along a particular dermatome (nerve distribution) as documented on physical exam.

For evaluation of suspected myelopathy when Cervical Spine MRI is contraindicated (Behrbalk, 2013; ACR, 2015; Vitzthum, 2007):
- Progressive symptoms including hand clumsiness, worsening handwriting, difficulty with grasping and holding objects, diffuse numbness in the hands, pins and needles sensation, increasing difficulty with balance and ambulation (unsteadiness, broad-based gait, increased muscle tone, weakness and wasting of the upper and lower limbs; diminished sensation to light touch, temperature, proprioception, vibration; bowel and bladder dysfunction in more severe cases).

For evaluation of chronic neck pain, with any of the following when Cervical Spine MRI is contraindicated (ACR, 2013):
- Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*.
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic or cervical spine pain (NASS, 2013)).

For evaluation of new onset of neck pain when Cervical Spine MRI is contraindicated:
• Failure of conservative treatment*, for at least six (6) weeks within the last six (6) months (NASS, 2013).
• With progression or worsening of symptoms during the course of conservative treatment*.
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic or cervical spine pain (NASS, 2013)).

For evaluation of trauma or acute injury (ACR, 2012):
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With progression or worsening of symptoms during the course of conservative treatment*.
• When the patient is clinically unevaluable or there are preliminary imaging findings (X-ray or CT) needing further evaluation.
  (“MRI and CT provide complementary information”. When indicated, “It is appropriate to perform both examinations” (ACR, 2012)).

For evaluation of known tumor, cancer, or evidence of metastasis with any of the following (MRI is usually the preferred study but CT may help characterize solitary indeterminate lesions (Kim, 2012)):
• For staging of known tumor.
• For follow-up evaluation of patient undergoing active cancer treatment.
• Presents with new signs or symptoms (e.g. physical, laboratory, and/or imaging findings) of new tumor or change in tumor.
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
• With evidence of metastasis on bone scan or previous imaging study.

For evaluation of suspected tumor when Cervical Spine MRI is contraindicated or inappropriate (ACR, 2013):
• Prior abnormal or indeterminate imaging that requires further clarification.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:
• < 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine, or Lumbar Spine.

For evaluation of known or suspected infection, abscess, or inflammatory disease when Cervical Spine MRI is contraindicated (ACR, 2013):
• As evidenced by signs/symptoms, laboratory or prior imaging findings.

For evaluation of spine abnormalities related to immune system suppression, e.g., HIV, chemotherapy, leukemia, or lymphoma when Cervical Spine MRI is contraindicated (Nagashima, 2010; Williams, 1999):
• As evidenced by signs/symptoms, laboratory, or prior imaging findings.

As part of initial post-operative/procedural evaluation (“CT best examination to assess for hardware complication, extent of fusion” (ACR, 2013) and MRI for cord, nerve root compression, disc pathology, or post-op infection):
A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

- Changing neurologic status post-operatively.
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
- Surgical infection as evidenced by signs/symptoms, laboratory, or prior imaging findings.
- Continuing or recurring symptoms of any of the following neurological deficits: Lower extremity weakness, lower extremity asymmetric reflexes.

**Other indications for a Cervical Spine CT:**
- For preoperative evaluation and Cervical Spine MRI is contraindicated
- CT myelogram or discogram.
- Suspected cord compression with any of the following neurologic deficits, e.g., extremity weakness, abnormal gait, asymmetric reflexes.
- Suspicious sacral dimple (those that are deep, larger than 0.5 cm, located within the superior portion of the gluteal crease or above the gluteal crease, or associated with other cutaneous markers) when Cervical Spine MRI is contraindicated (D'Alessandro, 2009).
- Known Arnold-Chiari syndrome and Cervical Spine MRI is contraindicated.
- Congenital abnormalities in the presence of neurologic deficit, progressive spinal deformity, or for preoperative planning (Trenga, 2016).
- Syringin or syringomyelia and Cervical Spine MRI is contraindicated.

**Combination of Studies with Cervical Spine CT:**

**Cervical/Thoracic/Lumbar CTs:**
- CT myelogram or discogram.
- Any combination of these for scoliosis survey in infant/child (Strahle, 2015).
- Any combination of these for spinal survey in patient with metastases.
- For evaluation of spinal abnormalities associated with Arnold-Chiari Malformation. (C/T/L spine due to association with tethered cord and syringomyelia) (Milhorat, 2009; Strahle, 2015).

**Cervical MRI/CT - unstable craniocervical junction.**

**Brain CT/Cervical CT – for evaluation of Arnold-Chiari Malformation and Cervical Spine MRI is contraindicated.**

**Additional Information Related to Cervical Spine CT:**

*Conservative Therapy:* (spine) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components such as rest, ice, heat, modified activities, medical devices, acupuncture and/or stimulators, medications, injections (epidural, facet, bursal, and/or joint, not including trigger point), and diathermy can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program** - (HEP) – the following two elements are required to meet guidelines for completion of conservative therapy:
- Information provided on exercise prescription/plan AND
- Follow up with member with documentation provided regarding completion of HEP (after suitable 6 week period), or inability to complete HEP due to physical reason - i.e. increased pain, inability to
physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

**Myelopathy:** Symptom severity varies and a high index of suspicion is essential for making the proper diagnosis in early cases. Symptoms of pain and radiculopathy may not be present. The natural history of myelopathy is characterized by neurological deterioration. The most frequently encountered symptom is gait abnormality (86%) followed by increased muscular reflexes (79.1%), pathological reflexes (65.1%), paresthesia of upper limb (69.8%) and pain (67.4%) (Vitzthum, 2007).

**CT and Infection of the spine** - Infection of the spine is not easy to differentiate from other spinal disorders, e.g., degenerative disease, spinal neoplasms, and non-infective inflammatory lesions. Infections may affect different parts of the spine, e.g., vertebrae, intervertebral discs, and paraspinal tissues. Imaging is important to obtain early diagnosis and treatment to avoid permanent neurologic deficits. When MRI is contraindicated, CT may be used to evaluate infections of the spine.

**CT and Degenerative Disc Disease** – Degenerative disc disease is very common and CT may be indicated, when MRI is contraindicated, when chronic degenerative changes are accompanied by conditions, e.g., new neurological deficits; onset of joint tenderness of a localized area of the spine; new abnormal nerve conductions studies; exacerbation of chronic neck or back pain unresponsive to conservative treatment; and unsuccessful physical therapy/home exercise program.

**Sacral Dimples** - Simple midline dimples are the most commonly encountered dorsal cutaneous stigmata in neonates and indicate low risk for spinal dysraphism. Only atypical dimples are associated with a high risk for spinal dysraphism, particularly those that are large (>5 mm), high on the back (>2.5 cm from the anus), or appear in combination with other lesions (D’ Alessandro, 2009). High-risk cutaneous stigmata in neonates include hemangiomas, upraised lesions (i.e., masses, tails, and hairy patches), and multiple cutaneous stigmata.
REFERENCES


CPT Codes: 72128, 72129, 72130

INTRODUCTION:

Computed tomography is used for the evaluation, assessment of severity, and follow-up of diseases of the spine. Its use in the thoracic spine is limited, however, due to the lack of epidural fat in this part of the body. CT myelography improves the contrast severity of CT, but it is also invasive. CT may be used for conditions, e.g., degenerative changes, infection, and immune suppression, when magnetic resonance imaging (MRI) is contraindicated. It may also be used in the evaluation of tumors, cancer, or metastasis in the thoracic spine and it may be used for preoperative and post-surgical evaluations. CT obtains images from different angles and uses computer processing to show a cross-section of body tissues and organs. CT is fast and is often performed in acute settings. It provides good visualization of cortical bone.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR THORACIC SPINE CT:

For evaluation of known fracture:
- To assess union of a fracture when physical examination, plain radiographs, or prior imaging suggest delayed or non-healing
- To determine the position of fracture fragments.

For evaluation of neurologic deficits when Thoracic Spine MRI is contraindicated or inappropriate:
- With any of the following new neurological deficits: lower extremity weakness; abnormal reflexes; or abnormal sensory changes along a particular dermatome (nerve distribution) as documented on physical exam.

For evaluation of suspected myelopathy when Thoracic Spine MRI is contraindicated (Behrbalk, 2013; ACR, 2015; Vitzthum, 2007):
- Progressive symptoms including unsteadiness, broad-based gait, increased muscle tone, pins and needles sensation, weakness and wasting of the lower limbs, and diminished sensation to light touch, temperature, proprioception, and vibration; bowel and bladder dysfunction in more severe cases.

For evaluation of chronic back pain with any of the following when Thoracic MRI is contraindicated (Jarvik, 2015; Miller, 2006):
- Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*.
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013)).

For evaluation of new onset of back pain when Thoracic Spine MRI is contraindicated (AANSCNS, 2014):
- Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*. 
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013)).

**For evaluation of trauma or acute injury:**
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With progression or worsening of symptoms during the course of conservative treatment*.

**For evaluation of known tumor, cancer, or evidence of metastasis with any of the following (Miller 2006) (MRI is usually the preferred study but CT may help characterize solitary indeterminate lesions (Kim 2012)):**
• For staging of known tumor.
• For follow-up evaluation of patient undergoing active cancer treatment.
• Presents with new signs or symptoms (e.g. physical, laboratory, and/or imaging findings) of new tumor or change in tumor.
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
• With evidence of metastasis on bone scan or previous imaging study.

**For evaluation of suspected tumor when Thoracic Spine MRI is contraindicated or inappropriate (ACR 2015):**
• Prior abnormal or indeterminate imaging that requires further clarification.

**Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated, OR evaluation of suspected metastases:**
• ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine, or Lumbar Spine.

**For evaluation of known or suspected infection, abscess, or inflammatory disease when Thoracic MRI is contraindicated (ACR, 2015; Miller, 2006):**
• As evidenced by signs/symptoms, laboratory or prior imaging findings.

**For evaluation of spine abnormalities related to immune system suppression, e.g., HIV, chemotherapy, leukemia, or lymphoma when Thoracic MRI is contraindicated (ACR, 2015):**
• As evidenced by signs/symptoms, laboratory or prior imaging findings.
• As part of initial post-operative / procedural evaluation (“CT best examination to assess for hardware complication, extent of fusion” (ACR 2015) and MRI for cord, nerve root compression, disc pathology, or post-op infection):
• A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
• Changing neurologic status post-operatively.
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
• Surgical infection as evidenced by signs/symptoms, laboratory, or prior imaging findings.
• Continuing or recurring symptoms of any of the following neurological deficits: Lower extremity weakness, lower extremity asymmetric reflexes.

Other indications for a Thoracic Spine CT:
• For pre-operative evaluation and Thoracic MRI is contraindicated
• CT myelogram or discogram.
• Suspected cord compression with any of the following neurologic deficits, e.g., extremity weakness, abnormal gait, asymmetric reflexes, and Thoracic Spine MRI is contraindicated.
• Suspicious sacral dimples (those that are deep, larger than 0.5 cm, located within the superior portion of the gluteal crease or above the gluteal crease, or associated with other cutaneous markers) when Thoracic Spine MRI is contraindicated (D'Alessandro, 2009).
• Ankylosing Spondylitis/Spondyloarthopathies - For diagnosis when suspected as a cause of insidious onset (usually > 3 month) of back or sacroiliac pain associated with morning stiffness not relieved with rest (usually age at onset <40) AND satisfying any of the following (Akgul, 2011; Bennett, 2010; Ostergaard, 2012; Seiper, 2009):
  o Sedimentation rate and/or C-reactive protein (not an essential criteria).
  o HLA B27 (not an essential criteria).
  o Non-diagnostic or indeterminate x-ray
  o Personal or family history of sacroilitis, peripheral inflammatory arthritis, and/or inflammatory bowel disease.
Known Arnold-Chiari syndrome and Thoracic MRI is contraindicated (Milhorat, 2009; Strahle, 2015).
• Syrinx or syringomyelia and Thoracic Spine MRI is contraindicated.
• Congenital abnormalities when Thoracic Spine MRI is contraindicated or for characterization of boney detail (Trenga, 2016):
  o Back pain and vertebral anomalies (hemivertebrae, hypoplasia, agenesis, butterfly, segmentation defect, bars, or congenital wedging) in a child on preliminary imaging.
  o Scoliosis with progressive spinal deformity, neurologic deficit or pre-operative planning.

COMBINATION OF STUDIES WITH THORACIC SPINE CT:

Cervical/Thoracic/Lumbar CTs:
• CT myelogram or discogram.
• Any combination of these for scoliosis survey in infant/child (Strahle, 2015).
• Any combination of these for spinal survey in patient with metastases.
• For evaluation of spinal abnormalities associated with Arnold-Chiari Malformation and Spine MRI is contraindicated. (C/T/L spine due to association with tethered cord and syringomyelia) (Milhorat, 2009; Strahle, 2015).

ADDITIONAL INFORMATION RELATED TO THORACIC SPINE CT:

*Conservative Therapy*: (spine) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components such as rest, ice, heat, modified activities, medical devices, acupuncture and/or stimulators, medications, injections (epidural, facet, bursal, and/or joint, not including trigger point), and diathermy can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program** - (HEP) – the following two elements are required to meet guidelines for completion of conservative therapy:
• Information provided on exercise prescription/plan AND
• Follow up with member with documentation provided regarding completion of HEP (after suitable 6 week period), or inability to complete HEP due to physical reason - i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

Myelopathy: Symptom severity varies and a high index of suspicion is essential for making the proper diagnosis in early cases. Symptoms of pain and radiculopathy may not be present. The natural history of myelopathy is characterized by neurological deterioration. The most frequently encountered symptom is gait abnormality (86%) followed by increased muscular reflexes (79.1%), pathological reflexes (65.1%), paresthesia of upper limb (69.8%), and pain (67.4%) (Vitzthum, 2007).

CT and Infection of the spine - Infection of the spine is not easy to differentiate from other spinal disorders, e.g., degenerative disease, spinal neoplasms, and non-infective inflammatory lesions. Infections may affect different parts of the spine, e.g., vertebrae, intervertebral discs, and paraspinal tissues. Imaging is important to obtain early diagnosis and treatment to avoid permanent neurology deficits. When MRI is contraindicated, CT may be used to evaluate infections of the spine.

CT and Degenerative Disc Disease – Degenerative disc disease is very common and CT may be indicated when MRI is contraindicated, when chronic degenerative changes are accompanied by conditions, e.g., new neurological deficits; onset of joint tenderness of a localized area of the spine; new abnormal nerve conductions studies; exacerbation of chronic back pain unresponsive to conservative treatment; and unsuccessful physical therapy/home exercise program.

Sacral Dimples - Simple midline dimples are the most commonly encountered dorsal cutaneous stigmata in neonates and indicate low risk for spinal dysraphism. Only atypical dimples are associated with a high risk for spinal dysraphism, particularly those that are large (>5 mm), high on the back (>2.5 cm from the anus), or appear in combination with other lesions (D’Alessandro, 2009). High-risk cutaneous stigmata in neonates include hemangiomas, upraised lesions (i.e., masses, tails, and hairy patches), and multiple cutaneous stigmata.
REFERENCES


CPT Codes: 72131, 72132, 72133

INTRODUCTION:
Computed tomographic scans provide bone detail and define the bony anatomy in multiple planes. It demonstrates the lumbar subarachnoid space and provides moderately good visualization of the vertebral canal. Three-dimensional reconstructions using CT help to demonstrate the anatomy of the vertebral canal.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR LUMBAR SPINE CT:

For evaluation of known fracture:
- To assess union of a fracture where physical examination, plain radiographs, or prior imaging suggest delayed or non-healing
- To determine position of known fracture fragments.

For evaluation of neurologic deficits when Lumbar Spine MRI is contraindicated or inappropriate:
- With any of the following new neurological deficits: lower extremity weakness; abnormal reflexes; abnormal sensory changes along a particular dermatome (nerve distribution) as documented on exam; evidence of Cauda Equina Syndrome; bowel or bladder dysfunction; new foot drop.

For evaluation of chronic back pain with any of the following when Lumbar Spine MRI is contraindicated (ACR, 2015; AAFP, 2012; ACEP, 2014; NASS, 2013; Chou, 2007; Jarvik, 2015; Miller, 2006):
- Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*.
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013)).

For evaluation of new onset of back pain when Lumbar Spine MRI is contraindicated (ACR, 2015; AANSCNS, 2014; ACA, 2017; ACEP, 2014; Chou, 2007):
- Failure of conservative treatment*, for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*.
- With an abnormal electromyography (EMG) or nerve conduction study if (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic, or cervical spine pain (NASS, 2013))

For evaluation of trauma or acute injury (ACR, 2012; Chou, 2007):
- Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes [along a particular dermatome (nerve distribution)].
- With progression or worsening of symptoms during the course of conservative treatment*.
For evaluation of known tumor, cancer, or evidence of metastasis with any of the following (Miller, 2006) (MRI is usually the preferred study but CT may help characterize solitary indeterminate lesions (Kim, 2012)):

- For staging of known tumor.
- For follow-up evaluation of patient undergoing active cancer treatment.
- Presents with new signs or symptoms (e.g. physical, laboratory, and/or imaging findings) of new tumor or change in tumor.
- Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
- With evidence of metastasis on bone scan or previous imaging study.

For evaluation of suspected tumor when Lumbar Spine MRI is contraindicated or inappropriate (ACR, 2015):
- Prior abnormal or indeterminate imaging that requires further clarification

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:

- ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.

For evaluation of known or suspected infection, abscess, or inflammatory disease when Lumbar Spine MRI is contraindicated (ACR, 2015):
- As evidenced by signs/symptoms, laboratory or prior imaging findings.

For evaluation of spine abnormalities related to immune system suppression, e.g., HIV, chemotherapy, leukemia, or lymphoma and Lumbar Spine MRI is contraindicated (ACR, 2015):
- As evidenced by signs/symptoms, laboratory or prior imaging findings.

Post-operative / procedural evaluation (“CT best examination to assess for hardware complication, extent of fusion” (ACR, 2015) and MRI for cord, nerve root compression, disc pathology, or post-op infection):
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
- Changing neurologic status post-operatively.
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
- Surgical infection as evidenced by signs/symptoms, laboratory or prior imaging findings.
- Continuing or recurring symptoms of any of the following neurological deficits: Lower extremity weakness, lower extremity asymmetric reflexes.

Other indications for a Lumbar Spine CT:
- For preoperative evaluation and Lumbar Spine MRI is contraindicated
- CT myelogram or discogram.
- Suspicious sacral dimple (those that are deep, larger than 0.5 cm, located within the superior portion of the gluteal crease or above the gluteal crease, or associated with other cutaneous markers) when Lumbar Spine MRI is contraindicated (D’Alessandro, 2009).
• Tethered cord or spinal dysraphism (known or suspected) based on preliminary imaging, neurological exam, and/or cutaneous stigmata (AANS: Duz, 2008; Milhorat, 2009; NIH) when **Lumbar Spine MRI is contraindicated**.

• Ankylosing Spondylitis/Spondyloarthropathies - For diagnosis when suspected as a cause of insidious onset (usually > 3 month) of back or sacroiliac pain associated with morning stiffness not relieved with rest (usually age at onset <40) AND satisfying any of the following when **Lumbar Spine MRI is contraindicated** (Akgul, 2011; Bennett, 2010; Ostergaard, 2012; Seiper, 2009):
  - Sedimentation rate and/or C-reactive protein (not an essential criteria).
  - HLA B27 (not an essential criteria).
  - Non-diagnostic or indeterminate x-ray
  - Personal or family history of sacroiliitis, peripheral inflammatory arthritis, and/or inflammatory bowel disease.

• Known Arnold-Chiari syndrome and **Lumbar Spine MRI is contraindicated** (Milhorat, 2009; Strahle, 2015).

• Congenital abnormalities when **Lumbar Spine MRI is contraindicated** or for characterization of boney detail (Trenga, 2016):
  - Back pain and vertebral anomalies (hemivertebrae, hypoplasia, agenesis, butterfly, segmentation defect, bars, or congenital wedging) in a child on preliminary imaging.
  - Scoliosis with progressive spinal deformity, neurologic deficit or pre-operative planning.

**COMBINATION OF STUDIES WITH LUMBAR SPINE CT:**

**Cervical/Thoracic/Lumbar CTs:**
- CT myelogram or discogram
- Any combination of these for scoliosis survey in infant/child when MRI is contraindicated (Strahle, 2015).
- Any combination of these for spinal survey in patient with metastasis.
- For evaluation of spinal abnormalities associated with Arnold-Chiari Malformation (C/T/L spine due to association with tethered cord and syringomyelia) (Milhorat, 2009; Strahle, 2015) and **Lumbar Spine MRI is contraindicated**.

**ADDITIONAL INFORMATION RELATED TO LUMBAR SPINE CT:**

* **Conservative Therapy:** (spine) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components, such as rest, ice, heat, modified activities, medical devices, acupuncture and/or stimulators, medications, injections (epidural, facet, bursal, and/or joint, not including trigger point), and diathermy can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program - (HEP)** – the following two elements are required to meet guidelines for completion of conservative therapy:
  - Information provided on exercise prescription/plan AND
  - Follow up with member with documentation provided regarding completion of HEP (after suitable 6 week period), or inability to complete HEP due to physical reason- i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).
**CT and Fracture of the Lumbar Spine** – CT scans of the lumbar spine generate high-resolution spinal images; this and the absence of superimposed structures allow accurate diagnosis of lumbar fractures.

**CT and Radiculopathy** – Lumbar radiculopathy is caused by compression of a nerve root and/or inflammation that has progressed enough to cause neurologic symptoms, e.g., numbness, tingling, and weakness in leg muscles. These are warning signs of a serious medical condition which needs medical attention. Multidetector CT may be performed to rule out or localize lumbar disk herniation before surgical intervention, when MRI is contraindicated. Radiation dose should be kept as low as possible in young individuals undergoing CT of the lumbar spine.

**CT and Infection of the Spine** – Infection of the spine is not easy to differentiate from other spinal disorders, e.g., degenerative disease, spinal neoplasms, and non-infective inflammatory lesions. Infections may affect different parts of the spine, e.g., vertebrae, intervertebral discs, and paraspinal tissues. Imaging is important to obtain early diagnose and treatment to avoid permanent neurology deficits. When MRI is contraindicated, CT may be used to evaluate infections of the spine.

**CT and Degenerative Disease of the Lumbar Spine** – Stenosis of the lumbar canal may result from degenerative changes of the discs, ligaments and facet joints surrounding the lumbar canal. Compression of the microvasculature of the bundle of nerve roots in the lumbosacral spine may lead to significant effects on the cauda equina. This is a surgical emergency and CT may be performed to help assess the problem when MRI is contraindicated or inappropriate. CT scans can provide visualization of the vertebral canal and may demonstrate encroachment of the canal by osteophytes, facets, pedicles or hypertrophied lamina.

**CT and Low Back Pain** – Low back pain by itself is a self-limited condition which does not warrant any imaging studies. One of the “red flags” signifying a more complicated status is focal neurologic deficit with progressive or disabling symptoms. When magnetic resonance imaging (MRI) is contraindicated, CT of the lumbar spine with or without contrast is indicated for low back pain accompanied by a “red flag” symptom. Myelography combined with post-myelography CT is accurate in diagnosing disc herniation and may be useful in surgical planning. CT may be indicated when MRI is contraindicated, and chronic back pain unresponsive to conservative treatment; and unsuccessful physical therapy/home exercise program.

**Tethered spinal cord syndrome** - a neurological disorder caused by tissue attachments that limit the movement of the spinal cord within the spinal column. Although this condition is rare, it can continue undiagnosed into adulthood. The primary cause is myelomeningocele and lipomyelomeningocele; the following are other causes that vary in severity of symptoms and treatment.
- Dermal sinus tract (a rare congenital deformity)
- Diastematomyelia (split spinal cord)
- Lipoma
- Tumor
- Thickened/tight filum terminale
- History of spine trauma/surgery
- Arnold Chiari Malformation

**Sacral Dimples** - Simple midline dimples are the most commonly encountered dorsal cutaneous stigmata in neonates and indicate low risk for spinal dysraphism. Only atypical dimples are associated with a high risk for spinal dysraphism, particularly those that are large (>5 mm), high on the back (>2.5 cm from the anus), or appear in combination with other lesions (D’ Alessandro, 2009). High-risk cutaneous stigmata in
neonates include hemangiomas, upraised lesions (i.e., masses, tails, and hairy patches), and multiple cutaneous stigmata.
REFERENCES


INTRODUCTION:

Magnetic resonance imaging (MRI) produces high quality multiplanar images of organs and structures within the body without radiation. It is the preferred modality for evaluating the internal structure of the spinal cord, providing assessment of conditions such as degenerative disc pathology, osteomyelitis, and discitis.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR CERVICAL SPINE MRI:

For evaluation of known or suspected multiple sclerosis (MS) (ACR, 2015; Filippi, 2016):
- Evidence of MS on recent baseline Brain MRI.
- Suspected MS with new or changing symptoms consistent with cervical spinal cord disease.
- Follow up of known Multiple Sclerosis.
- Follow up to the initiation or change in medication for patient with known Multiple Sclerosis.
- Cervical and/or Thoracic MRI for evaluation of suspected multiple sclerosis (MS) when Brain MRI does not fulfill diagnostic criteria (Filippi, 2016).

For evaluation of neurologic deficits (ACR, 2013; Carette, 2005):
- With any of the following new neurological deficits: extremity weakness; abnormal reflexes; or abnormal sensory changes along a particular dermatome (nerve distribution) as documented on physical exam.

For evaluation of suspected myelopathy (Behrbalk, 2013; ACR, 2015; Vitzthum, 2007):
- Progressive symptoms including hand clumsiness, worsening handwriting, difficulty with grasping and holding objects, diffuse numbness in the hands, pins and needles sensation, increasing difficulty with balance and ambulation (unsteadiness, broad-based gait, increased muscle tone, weakness and wasting of the upper and lower limbs; diminished sensation to light touch, temperature, proprioception, vibration; bowel and bladder dysfunction in more severe cases).

For evaluation of chronic neck pain with any of the following (ACR, 2013; Ahmed, 2007):
- Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*.
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic or cervical spine pain (NASS, 2013))

For evaluation of new onset of neck pain:
- Failure of conservative treatment*, for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*.
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic or cervical spine pain (NASS, 2013)).

For evaluation of trauma or acute injury (ACR, 2012):
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With progression or worsening of symptoms during the course of conservative treatment*.
• When the patient is clinically unevaluable or there are preliminary imaging findings (X-ray or CT) needing further evaluation.
  (“MRI and CT provide complementary information”. When indicated, “It is appropriate to perform both examinations” (ACR, 2012)).

For evaluation of known tumor, cancer, or evidence of metastasis with any of the following (MRI is usually the preferred study but CT may help characterize solitary indeterminate lesions (Kim, 2012)):
• For staging of known tumor.
• For follow-up evaluation of patient undergoing active cancer treatment.
• Presents with new signs or symptoms (e.g. physical, laboratory, and/or imaging findings) of new tumor or change in tumor.
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality
• With evidence of metastasis on bone scan or previous imaging study.

For evaluation of suspected tumor (ACR, 2013):
• Prior abnormal or indeterminate imaging that requires further clarification.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated, OR evaluation of suspected metastases:
• < 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.

For evaluation of known or suspected infection, abscess, or inflammatory disease (ACR, 2013):
• As evidenced by signs/symptoms, laboratory or prior imaging findings.

For evaluation of spine abnormalities related to immune system suppression, e.g., HIV, chemotherapy, leukemia, or lymphoma (Nagashima, 2010; Williams, 1999):
• As evidenced by signs/symptoms, laboratory or prior imaging findings.

As part of initial post-operative / procedural evaluation (“CT best examination to assess for hardware complication, extent of fusion” (ACR, 2013) and MRI for cord, nerve root compression, disc pathology or post-op infection):
• A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
• Changing neurologic status post-operatively.
• With an abnormal electromyography (EMG) or nerve conduction study if radicular symptoms are present.
• Surgical infection as evidenced by signs/symptoms, laboratory or prior imaging findings.
• Continuing or recurring symptoms of any of the following neurological deficits: Lower extremity weakness, lower extremity asymmetric reflexes.

Other indications for a Cervical Spine MRI:
• For preoperative evaluation.
• Suspected cord compression with any of the following neurological deficits: extremity weakness; abnormal gait; asymmetric reflexes.
• Suspicious sacral dimple (those that are deep, larger than 0.5 cm, located within the superior portion of the gluteal crease or above the gluteal crease, or associated with other cutaneous markers).
• Known Arnold-Chiari syndrome.
• Congenital abnormalities in the presence of neurologic deficit, progressive spinal deformity, or for preoperative planning (Trenga, 2016):
• Syrinx or syringomyelia.

COMBINATION OF STUDIES WITH CERVICAL SPINE MRI:
Cervical/Thoracic/Lumbar MRIs:
• Any combination of these for scoliosis survey in infant/child (Strahle, 2015).
• Any combination of these for spinal survey in patient with metastases.
• For evaluation of spinal abnormalities associated with Arnold-Chiari Malformation. (C/T/L spine due to association with tethered cord and syringomyelia) (Milhorat, 2009; Strahle, 2015).

Cervical MRI/CT
• For unstable craniocervical junction.

Brain MRI/Cervical MRI –
• For evaluation of Arnold Chiari malformation.
• For follow-up of known Multiple Sclerosis (MS) (Filippi, 2016).

ADDITIONAL INFORMATION RELATED TO CERVICAL SPINE MRI:

*Conservative Therapy: (Spine) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components, such as rest, ice, heat, modified activities, medical devices, acupuncture and/or stimulators, medications, injections (epidural, facet, bursal, and/or joint, not including trigger point), and diathermy can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program - (HEP) – the following two elements are required to meet guidelines for completion of conservative therapy:
• Information provided on exercise prescription/plan AND
• Follow up with member with documentation provided regarding completion of HEP (after suitable 6 week period), or inability to complete HEP due to physical reason- i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

Cervical myelopathy: Symptom severity varies and a high index of suspicion is essential for making the proper diagnosis in early cases. Symptoms of pain and radiculopathy may not be present. The natural history of myelopathy is characterized by neurological deterioration. The most frequently encountered
symptom is gait abnormality (86%) followed by increased muscular reflexes (79.1%), pathological reflexes (65.1%), paresthesia of upper limb (69.8%), and pain (67.4%) (Vitzthum, 2007).

**MRI for Evaluation of Discitis** – Discitis is a known complication of cervical discography. Postoperative discitis in the cervical spine does not occur frequently but can result from accidental inoculation of bacteria into the disc space intra-operatively by a contaminated spinal needle being used as a radiological marker. There may be other causes for postoperative discitis, e.g., esophageal perforation, hematogenous spread, inoculation of bacteria during surgery. Patients with an alteration in the nature of their symptoms after cervical discectomy and fusion may have discitis. Symptoms may include complaints of mild paresthesia in extremities and neck pain. MRI may be performed to reveal feature of discitis with associated abscesses and may help to confirm the diagnosis and decide on the further management.

**MRI for Cervical Radiculopathy** – MRI is a useful test to evaluate the spine because it can show abnormal areas of the soft tissues around the spine; it addition to the bones, it can also show pictures of the nerves and discs and is used to find tumors, herniated discs or other soft-tissue disorders. MRI has a role both in the pre-operative screening and post-operative assessment of radicular symptoms due to either disc or osteophyte.

**MRI and Multiple Sclerosis (MS)** – MRI is a sensitive method of detecting the white matter lesions of MS. These plaques on MRI generally appear as multiple, well demarcated, homogenous, small ovoid lesions which often lack mass effect and are oriented perpendicular to the long axis of the lateral ventricles. Sometimes they present as large, space occupying lesions that may be misinterpreted as tumors, abscesses, or infarcts.

**MRI and Neck Pain** – Neck pain is common in the general population and usually relates to musculoskeletal causes but it may also be caused by spinal cord tumors. When neck pain is accompanied by extremity weakness, abnormal gait, or asymmetric reflexes, spinal MRI may be performed to evaluate the cause of the pain. MRI may reveal areas of cystic expansion within the spinal cord. Enhancement with gadolinium contrast may suggest that the lesion is neoplastic.

**Back Pain with Cancer History** - Radiographic (x-ray) examination should be performed in cases of back pain when a patient has a cancer history. This can make a diagnosis in many cases. This may occasionally allow for selection of bone scan in lieu of MRI in some cases. When radiographs do not answer the clinical question, then MRI may be appropriate after a consideration of conservative care.

For example, bone metastases occur in a minority of all breast cancer patients. Low stage breast cancer patients are very unlikely to have bone metastases (Coleman, 1985). Radiographic (X-ray) evaluation prior to MRI is appropriate. A trial of conservative care in back pain is also indicated and appropriate in these low stage patients.

Advanced stage breast cancer patients do develop bone metastases in a slight majority of cases (Coleman, 1985). Back pain in advanced stage breast cancer patients should still be initially evaluated with X-ray (which has the chance of demonstrating cause of pain, or identifying multiple metastases and may change the subsequent imaging choice for optimal staging). However, these patients should, in most cases, not undergo a trial of conservative care.”

**Sacral Dimples** - Simple midline dimples are the most commonly encountered dorsal cutaneous stigmata in neonates and indicate low risk for spinal dysraphism. Only atypical dimples are associated with a high risk for spinal dysraphism, particularly those that are large (>5 mm), high on the back (>2.5 cm from the anus), or appear in combination with other lesions (D’ Alessandro, 2009). High-risk cutaneous stigmata in
neonates include hemangiomas, upraised lesions (i.e., masses, tails, and hairy patches), and multiple cutaneous stigmata.
REFERENCES


INTRODUCTION:

Magnetic resonance imaging (MRI) produces high quality multiplanar images of organs and structures within the body without using ionizing radiation. It is used for evaluation, assessment of severity, and follow-up of diseases of the spine and is the preferred modality for imaging intervertebral disc degeneration. High contrast resolution (soft tissue contrast) and multiplanar imaging (sagittal as well as axial planes) are helpful in the evaluation of possible disc herniation and detecting nerve root compression. MRI is one of the most useful techniques to evaluate spine infection and is also used to evaluate tumors, cancer, and immune system suppression.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR THORACIC SPINE MRI:

Cervical and/or Thoracic MRI for evaluation of suspected multiple sclerosis (MS) when Brain MRI does not fulfill diagnostic criteria (Filippi, 2016).

For evaluation of neurologic deficits:
- With any of the following new neurological deficits: extremity weakness; abnormal reflexes; or abnormal sensory changes along a particular dermatome (nerve distribution) as documented on physical exam.

For evaluation of suspected myelopathy (Behrbalk, 2013; ACR, 2015; Vitzthum, 2007):
- Progressive symptoms including unsteadiness, broad-based gait, increased muscle tone, pins and needles sensation, weakness and wasting of the lower limbs, and diminished sensation to light touch, temperature, proprioception, and vibration; bowel and bladder dysfunction in more severe cases.

For evaluation of chronic back pain with any of the following (Jarvik, 2015; Miller, 2006):
- Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*.
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic or cervical spine pain (NASS, 2013)).

For evaluation of new onset of back pain (ANSCNS, 2014):
- Failure of conservative treatment* for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*.
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic or cervical spine pain (NASS 2013)).

For evaluation of trauma or acute injury:

CPT Codes: 72146, 72147, 72157
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With progression or worsening of symptoms during the course of conservative treatment*.

For evaluation of known tumor, cancer, or evidence of metastasis with any of the following (Miller 2006) (MRI is usually the preferred study but CT may help characterize solitary indeterminate lesions (Kim 2012)):
• For staging of known tumor.
• For follow-up evaluation of patient undergoing active cancer treatment.
• Presents with new signs or symptoms (e.g. physical, laboratory and/or imaging findings) of new tumor or change in tumor
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
• With evidence of metastasis on bone scan or previous imaging study.

For evaluation of suspected tumor (ACR 2015):
• Prior abnormal or indeterminate imaging that requires further clarification.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated, OR evaluation of suspected metastases:
• < 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.

For evaluation of known or suspected infection, abscess, or inflammatory disease (ACR 2015; Miller 2006):
• As evidenced by signs/symptoms, laboratory or prior imaging findings.

For evaluation of spine abnormalities related to immune system suppression, e.g., HIV, chemotherapy, leukemia, or lymphoma (ACR 2015):
• As evidenced by signs/symptoms, laboratory or prior imaging findings.

As part of initial post-operative / procedural evaluation (“CT best examination to assess for hardware complication, extent of fusion” (ACR 2015) and MRI for cord, nerve root compression, disc pathology or post-op infection):
• A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
• Changing neurologic status post-operatively.
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
• Surgical infection as evidenced by signs/symptoms, laboratory or prior imaging findings.
• Continuing or recurring symptoms of any of the following neurological deficits: Lower extremity weakness, lower extremity asymmetric reflexes.

Other indications for a Thoracic Spine MRI:
• For preoperative evaluation
• Suspected cord compression with any of the following neurological deficits: extremity weakness; abnormal gait; asymmetric reflexes.
• Suspicious sacral dimples (those that are deep, larger than 0.5 cm, located within the superior portion of the gluteal crease or above the gluteal crease, or associated with other cutaneous markers) (D’Alessandro, 2009).
• Ankylosing Spondylitis/Spondyloarthropathies - For diagnosis when suspected as a cause of insidious onset (usually > 3 month) of back or sacroiliac pain associated with morning stiffness not relieved with rest (usually age at onset <40) AND satisfying any of the following (Akgul, 2011; Bennett, 2010; Ostergaard, 2012; Seiper, 2014):
  o Sedimentation rate and/or C-reactive protein (not an essential criteria).
  o HLA B27 (not an essential criteria).
  o Non-diagnostic or indeterminate x-ray
  o Personal or family history of sacroilitis, peripheral inflammatory arthritis and/or inflammatory bowel disease.
• Known Arnold-Chiari syndrome (Milhorat, 2009; Strahle, 2015).
• Congenital abnormalities (Trenga, 2016):
  o Back pain and vertebral anomalies (hemivertebrae, hypoplasia, agenesis, butterfly, segmentation defect, bars, or congenital wedging) in a child on preliminary imaging.
  o Scoliosis with progressive spinal deformity, neurologic deficit or pre-operative planning.
• Syrinx or syringomyelia.

COMBINATION OF STUDIES WITH THORACIC SPINE MRI:

Cervical/Thoracic/Lumbar MRIs:
• Any combination of these for scoliosis survey in infant/child (Strahle, 2015).
• Any combination of these for spinal survey in patient with metastases.
• For evaluation of spinal abnormalities associated with Arnold-Chiari Malformation. (C/T/L spine due to association with tethered cord and syringomyelia) (Milhorat, 2009; Strahle, 2015).

ADDITIONAL INFORMATION RELATED TO THORACIC SPINE MRI

*Conservative Therapy: (spine) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components, such as rest, ice, heat, modified activities, medical devices, acupuncture and/or stimulators, medications, injections (epidural, facet, bursal, and/or joint, not including trigger point), and diathermy can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program - (HEP) – the following two elements are required to meet guidelines for completion of conservative therapy:
  o Information provided on exercise prescription/plan AND
  o Follow up with member with documentation provided regarding completion of HEP (after suitable 6 week period), or inability to complete HEP due to physical reason- i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

Myelopathy: Symptom severity varies and a high index of suspicion is essential for making the proper diagnosis in early cases. Symptoms of pain and radiculopathy may not be present. The natural history of myelopathy is characterized by neurological deterioration. The most frequently encountered symptom is gait abnormality (86%) followed by increased muscular reflexes (79.1%), pathological reflexes (65.1%), paresthesia of upper limb (69.8%), and pain (67.4%) (Vitzthum, 2007).
**MRI and Spinal Infections** – Infection of the spine is not easy to differentiate from other spinal disorders, e.g., degenerative disease, spinal neoplasms, and noninfectious inflammatory lesions. Infections may affect different parts of the spine, e.g., vertebrae, intervertebral discs and paraspinal tissues. Imaging is important to obtain early diagnose and treatment to avoid permanent neurologic deficits. MRI is the preferred imaging technique to evaluate infections of the spine. With its high contrast resolution and direct multiplanar imaging, it has the ability to detect and delineate infective lesions irrespective of their spinal location.

**MRI and Degenerative Disc Disease** – Degenerative disc disease is very common and MRI is indicated when chronic degenerative changes are accompanied by conditions, e.g., new neurological deficits: onset of joint tenderness of a localized area of the spine; new abnormal nerve conduction studies; exacerbation of chronic back pain unresponsive to conservative treatment; and unsuccessful physical therapy/home exercise program.

**MRI and Multiple Sclerosis (MS)** – MRI is a sensitive method of detecting the white matter lesions of MS. These plaques on MRI generally appear as multiple, well demarcated, homogenous, small ovoid lesions which lack mass effect and are oriented perpendicular to the long axis of the lateral ventricles. Sometimes they present as large, space occupying lesions that may be misinterpreted as tumors, abscesses or infarcts.

**Back Pain with Cancer History** - Radiographic (x-ray) examination should be performed in cases of back pain when a patient has a cancer history. This can make a diagnosis in many cases. This may occasionally allow for selection of bone scan in lieu of MRI in some cases. When radiographs do not answer the clinical question, then MRI may be appropriate after a consideration of conservative care.

For example, bone metastases occur in a minority of all breast cancer patients. Low stage breast cancer patients are very unlikely to have bone metastases (Coleman 1985). Radiographic (X-ray) evaluation prior to MRI is appropriate. A trial of conservative care in back pain is also indicated and appropriate in these low stage patients.

Advanced stage breast cancer patients do develop bone metastases in a slight majority of cases (Coleman 1985). Back pain in advanced stage breast cancer patients should still be initially evaluated with X-ray (which has the chance of demonstrating cause of pain, or identifying multiple metastases, and may change the subsequent imaging choice for optimal staging). However, these patients should in most cases, not undergo a trial of conservative care.”

**Sacral Dimples** - Simple midline dimples are the most commonly encountered dorsal cutaneous stigmata in neonates and indicate low risk for spinal dysraphism. Only atypical dimples are associated with a high risk for spinal dysraphism, particularly those that are large (>5 mm), high on the back (>2.5 cm from the anus), or appear in combination with other lesions (D’ Alessandro, 2009). High-risk cutaneous stigmata in neonates include hemangiomas, upraised lesions (i.e., masses, tails, and hairy patches), and multiple cutaneous stigmata.


CPT Codes: 72148, 72149, 72158

INTRODUCTION:

Magnetic resonance imaging (MRI) is used in the evaluation, diagnosis, and management of spine related conditions, e.g., degenerative disc disease, cauda equine compression, radiculopathy, infections, or cancer in the lumbar spine. MRI provides high quality multiplanar images of organs and structures within the body without the use of x-rays or radiation. In the lumbar area where gonadal exposure may occur, MRI’s lack of radiation is an advantage.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR LUMBAR SPINE MRI:

For evaluation of neurologic deficits:
- With any of the following new neurological deficits: lower extremity weakness; abnormal reflexes; abnormal sensory changes along a particular dermatome (nerve distribution) as documented on exam; evidence of Cauda Equina Syndrome; bowel or bladder dysfunction; new foot drop.

For evaluation of chronic back pain with any of the following (ACR, 2015; AAFP, 2012; ACEP, 2014; NASS, 2013; Chou, 2007; Jarvik, 2015; Miller, 2006):
- Failure of conservative treatment* for at least six (6) weeks within the last six (6) months
- With progression or worsening of symptoms during the course of conservative treatment*
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality. (EMG is not recommended to determine the cause of axial lumbar, thoracic or cervical spine pain (NASS, 2013)).

For evaluation of new onset of back pain (ACR, 2015; AANSCNS, 2014; ACA, 2017; ACEP, 2014; Chou, 2007):
- Failure of conservative treatment*, for at least six (6) weeks within the last six (6) months.
- With progression or worsening of symptoms during the course of conservative treatment*
- With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality (EMG is not recommended to determine the cause of axial lumbar, thoracic or cervical spine pain (NASS, 2013)).

For evaluation of trauma or acute injury (ACR 2012; Chou 2007):
- Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
- With progression or worsening of symptoms during the course of conservative treatment*.

For evaluation of known tumor, cancer, or evidence of metastasis with any of the following (Miller, 2006) (MRI is usually the preferred study but CT may help characterize solitary indeterminate lesions (Kim, 2012)):
- For staging of known tumor.
- For follow-up evaluation of patient undergoing active cancer treatment.
• Presents with new signs or symptoms (e.g. physical, laboratory and/or imaging findings) of new tumor or change in tumor
• Presents with radiculopathy, muscle weakness, abnormal reflexes, and/or sensory changes along a particular dermatome (nerve distribution).
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
• With evidence of metastasis on bone scan or previous imaging study.

For evaluation of suspected tumor (ACR, 2015):
• Prior abnormal or indeterminate imaging that requires further clarification.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated, OR evaluation of suspected metastases:
• ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.

For evaluation of known or suspected infection, abscess, or inflammatory disease (ACR, 2015; Miller, 2006):
• As evidenced by signs/symptoms, laboratory or prior imaging findings.

For evaluation of spine abnormalities related to immune system suppression, e.g., HIV, chemotherapy, leukemia, or lymphoma (ACR, 2015):
• As evidenced by signs/symptoms, laboratory or prior imaging findings.

As part of initial post-operative / procedural evaluation (“CT best examination to assess for hardware complication, extent of fusion” (ACR, 2015) and MRI for cord, nerve root compression, disc pathology, or post-op infection):
• A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
• Changing neurologic status post-operatively.
• With an abnormal electromyography (EMG) or nerve conduction study (if performed) indicating a spinal abnormality.
• Surgical infection as evidenced by signs/symptoms, laboratory or prior imaging findings.
• Continuing or recurring symptoms of any of the following neurological deficits: Lower extremity weakness, lower extremity asymmetric reflexes.

Other indications for a Lumbar Spine MRI:
• For preoperative evaluation.
• Tethered cord, or spinal dysraphism (known or suspected) based on preliminary imaging, neurological exam, and/or cutaneous stigmata (AANS; Duz, 2008; Milhorat, 2009; NIH).
• Suspicious sacral dimple (those that are deep, larger than 0.5 cm, located within the superior portion of the gluteal crease or above the gluteal crease, or associated with other cutaneous markers) (D’Alessandro, 2009).
• Ankylosing Spondylitis/Spondyloarthropathies • For diagnosis when suspected as a cause of insidious onset (usually > 3 month) of back or sacroiliac pain associated with morning stiffness not relieved with rest (usually age at onset <40) AND satisfying any of the following:’ (Akgul, 2011; Bennett, 2010; Ostergaard, 2012; Seiper, 2014):
  o Sedimentation rate and/or C-reactive protein (not an essential criteria).
  o HLA B27 (not an essential criteria).
- Non-diagnostic or indeterminate x-ray
- Personal or family history of sacroilitis, peripheral inflammatory arthritis, and/or inflammatory bowel disease.

- Known Arnold-Chiari syndrome (Milhorat, 2009; Strahle, 2015).
- Congenital abnormalities (Trenga, 2016):
  - Back pain and vertebral anomalies (hemivertebrae, hypoplasia, agenesis, butterfly, segmentation defect, bars, or congenital wedging) in a child on preliminary imaging.
  - Scoliosis with progressive spinal deformity, neurologic deficit, or pre-operative planning.

**COMBINATION OF STUDIES WITH LUMBAR SPINE MRI:**

Cervical/Thoracic/Lumbar MRIs:
- Any combination of these for scoliosis survey in infant/child (Strahle, 2015).
- Any combination of these for spinal survey in patient with metastasis.
- For evaluation of spinal abnormalities associated with Arnold-Chiari Malformation (C/T/L spine due to association with tethered cord and syringomyelia) (Milhorat, 2009; Strahle, 2015).

**ADDITIONAL INFORMATION RELATED TO LUMBAR SPINE MRI:**

*Conservative Therapy* (spine) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components, such as rest, ice, heat, modified activities, medical devices, acupuncture and/or stimulators, medications, injections (epidural, facet, bursal, and/or joint, not including trigger point), and diathermy can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program - (HEP)** – the following two elements are required to meet guidelines for completion of conservative therapy:
- Information provided on exercise prescription/plan AND
- Follow up with member with documentation provided regarding completion of HEP (after suitable 6 week period), or inability to complete HEP due to physical reason- i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

**MRI and Back Pain** – MRI is the initial imaging modality of choice in the evaluation of complicated low back pain. Contrast administration may be used to evaluate suspected inflammatory disorders, e.g., discitis, and it is useful in evaluating suspected malignancy. Radiculopathy, disease of the nerve roots is the most common indication for MRI of patients with low back pain. The nerve roots become irritated and inflamed, due to direct pressure from degenerative changes in the lumbar spine, creating pain and numbness. Symptoms of radiculopathy also include muscle weakness. MRI is indicated for this condition if the symptoms do not improve after conservative treatment over six weeks. MRI is also performed to evaluate Cauda equina syndrome, severe spinal compression.

**Sacral Dimples** - Simple midline dimples are the most commonly encountered dorsal cutaneous stigmata in neonates and indicate low risk for spinal dysraphism. Only atypical dimples are associated with a high risk for spinal dysraphism, particularly those that are large (>5 mm), high on the back (>2.5 cm from the anus), or appear in combination with other lesions (D’ Alessandro, 2009). High-risk cutaneous stigmata in neonates include hemangiomas, upraised lesions (i.e., masses, tails, and hairy patches), and multiple cutaneous stigmata.
**Tethered spinal cord syndrome** - a neurological disorder caused by tissue attachments that limit the movement of the spinal cord within the spinal column. Although this condition is rare, it can continue undiagnosed into adulthood. The primary cause is myelomeningocele and lipomyelomeningocele; the following are other associations that vary in severity of symptoms and treatment.
- Dermal sinus tract (a rare congenital deformity)
- Diastematomyelia (split spinal cord)
- Lipoma
- Tumor
- Thickened/tight filum terminale
- History of spine trauma/surgery
- Arnold Chiari Malformation

Magnetic resonance imaging (MRI) can display the low level of the spinal cord and a thickened filum terminale, the thread-like extension of the spinal cord in the lower back. Treatment depends upon the underlying cause of the tethering. If the only abnormality is a thickened, shortened filum then limited surgical treatment may suffice.

**Back Pain with Cancer History** - Radiographic (x-ray) examination should be performed in cases of back pain when a patient has a cancer history. This can make a diagnosis in many cases. This may occasionally allow for selection of bone scan in lieu of MRI in some cases. When radiographs do not answer the clinical question, then MRI may be appropriate after a consideration of conservative care.

For example, bone metastases occur in a minority of all breast cancer patients. Low stage breast cancer patients are very unlikely to have bone metastases (Coleman, RE). Radiographic (X-ray) evaluation prior to MRI is appropriate. A trial of conservative care in back pain is also indicated and appropriate in these low stage patients.

Advanced stage breast cancer patients do develop bone metastases in a slight majority of cases (Coleman, RE). Back pain in advanced stage breast cancer patients should still be initially evaluated with X-ray (which has the chance of demonstrating cause of pain, or identifying multiple metastases, and may change the subsequent imaging choice for optimal staging). However, these patients should, in most cases, not undergo a trial of conservative care.”
REFERENCES


TOC
CPT Codes: 72159

INTRODUCTION:
Application of spinal magnetic resonance angiography (MRA) allows for more effective and noninvasive screening for vascular lesions than magnetic resonance imaging (MRI) alone. It may improve characterization of normal and abnormal intradural vessels while maintaining good spatial resolution. Spinal MRA may be used for the evaluation of spinal arteriovenous malformations, as well as injuries to blood vessels supplying the spine and cord.

INDICATIONS FOR SPINAL CANAL MRA:
- For the evaluation of spinal arteriovenous malformation (AVM) (Backes, 2008; Mathur, 2017; Mull, 2007; NIH, 2009; Rohany, 2007; Saraf-Lavi, 2002).
- For the evaluation of a known cervical spine fracture, disc herniation, infection or venous thrombosis where there is concern for vascular pathology (compression or thrombosis) compromising spinal cord blood flow or venous drainage (ACR, 2015; Vargas, 2015).
- For the evaluation of known or suspected vertebral artery injury when there is also concern for vascular compromise to the spinal canal and its contents (otherwise Neck MRA or CTA is sufficient to evaluate vertebral artery injury).
- Preoperative evaluation (e.g. localization of the spinal arteries prior to complex spinal surgery, aortic aneurysm repair, or characterization of suspected vascular lesion of the spinal canal and its contents) (Backes, 2008).
- Myelopathy when the suspected etiology is compromise of blood flow or drainage to the spinal cord (ACR, 2015; Vargas, 2015).
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested (Mathur, 2017).

ADDITIONAL INFORMATION RELATED TO SPINAL CANAL MRA:

Spinal Arteriovenous Malformations (AVMs) – Spinal cord arteriovenous malformations are comprised of snarled tangles of arteries and veins which affect the spinal cord. They are fed by spinal cord arteries and drained by spinal cord veins. Magnetic resonance angiography (MRA) can record the pattern and velocity of blood flow through vascular lesions as well as the flow of cerebrospinal fluid throughout the spinal cord. MRA defines the vascular malformation and may assist in determining treatment.

Spinal MRA/MRV (Backes, 2008; Vargas, 2015; Mathur, 2017):
Typically, contrast enhanced 3 D time of flight techniques and contrast enhanced CT angiography (CTA) are used for evaluation of the spinal arteries and veins as a non-invasive alternative to catheter angiography. The detection rate of the Adamkiewicz artery (AKA) by MRA is in the range of 69-100% but with modern equipment both MRA and CTA detection rates should approach 100% (Backes, 2008). Magnetic resonance angiography is well suited to patients who cannot receive iodinated contrast and undergo CTA. CTA has the advantage over MRA of providing greater spatial resolution, can image the entire spine during one contrast bolus, and provides for a faster exam time that is less prone to motion artifact. MRA is limited by a finite field of view typically <= 50 cm (Backes, 2008). MRI has the
advantage over CT of being able to detect areas of ischemia through the use of diffusion weighted imaging. Mathur et al showed a 100% sensitivity in detecting recurrent spinal arteriovenous fistulas post treatment (Mathur, 2017).

**Spinal Arteries/Veins (Vargas, 2015):**

Vascular malformations, trauma, disc herniations, neoplasms, and coagulopathies or infection causing thrombosis can compromise the spinal cord blood supply and drainage. The spinal cord arterial supply is derived from the anterior spinal artery, posterolateral spinal artery, and the arteria radicularis magna or artery of Adamkiewicz (AKA). The anterior spinal artery supplies the anterior two-thirds of the cord and arises from the vertebral arteries. It receives contributions from the ascending cervical artery, the inferior thyroid artery, the intercostal arteries, the lumbar artery, the iliolumbar artery, lateral sacral arteries, and the artery of Adamkiewicz. The AKA arises on the left side of the aorta between the T8 and L1 segments, to anastomose with the anterior spinal artery and supply the lower two-thirds of the spinal. Two posterolateral spinal arteries arise from the posteroinferior cerebellar arteries and supply the posterior third (posterior columns, posterior roots, and dorsal horns) of the spinal cord. The spinal venous system is divided into intrinsic and extrinsic veins differentiated by their location within the spinal canal or extrinsic to the canal, respectively. They drain into the radiculomedullary veins, subsequently to paravertebral and intervertebral plexuses then to the segmental veins that eventually drain into the ascending lumbar veins, azygos system, and pelvic venous plexuses.
REFERENCES


CPT Codes: 72191

INTRODUCTION:

Computed tomographic angiography (CTA) is used in the evaluation of many conditions affecting the veins and arteries of the pelvis or lower extremities. It is not appropriate as a screening tool for asymptomatic patients without a previous diagnosis.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR PELVIS CTA:

**For evaluation of known or suspected vascular disease:**
- For pelvic extent of known large vessel diseases (abdominal aorta, inferior vena cava, superior/inferior mesenteric, celiac, splenic, renal or iliac arteries/veins), e.g., aneurysm, dissection, arteriovenous malformations (AVMs), and fistulas, intramural hematoma, and vasculitis.
- Evidence of vascular abnormality seen on prior imaging studies.
- For suspected pelvic extent of aortic dissection.
- Evaluation of known or suspected aneurysms limited to the pelvis or in evaluating pelvic extent of aortic aneurysm (Khosa, 2011; Uberoi, 2011)**.
  - Known or suspected iliac artery aneurysm >2.5 cm AND equivocal or indeterminate ultrasound results OR
  - Prior imaging (e.g. ultrasound) demonstrating iliac artery aneurysm >2.5 cm in diameter OR
  - Suspected complications of known aneurysm as evidenced by clinical findings such as new onset of pelvic pain.
  - Follow up of iliac artery aneurysm: Six months if between 3.0-3.5 cm and if stable, follow yearly. If >3.5 cm, <six month follow up (and consider intervention)
- Suspected retroperitoneal hematoma or hemorrhage (To determine vascular source of hemorrhage in setting of trauma, tumor invasion, fistula or vasculitis; otherwise CT (rather than CTA) is sufficient and the modality of choice for diagnosing hemorrhage).
- For evaluation of suspected pelvic vascular disease when findings on ultrasound are indeterminate (MR or CT venography may be used as the initial study for pelvic thrombosis or thrombophlebitis) (ACR, 2013).
- Venous thrombosis if previous studies have not resulted in a clear diagnosis (ACR, 2013).
- Vascular invasion or displacement by tumor (Conventional CT or MRI also appropriate) (Certik, 2015; Kaufman, 2005).
- Pelvic vein thrombosis or thrombophlebitis (ACR, 2013).
- For evaluation of suspected pelvic vascular disease when findings on ultrasound are indeterminate (MR or CT venography may be used as the initial study for evaluating pelvic thrombosis or thrombophlebitis) (ACR, 2013).
- Mesenteric ischemia/ ischemic colitis (CTA is usually the preferred study (ACR, 2012)).
- Lower gastrointestinal hemorrhage: Active bleeding in a hemodynamically stable patient or non localized intermittent bleeding as an alternative to Tc-99m RBC scan when colonoscopy did not localize the bleeding, is contraindicated or unavailable (ACR, 2014; Clerc, 2017).
Preoperative evaluation (ACR, 2017):
- Evaluation of interventional vascular procedures prior to endovascular aneurysm repair (EVAR), or for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.

Postoperative or post-procedural evaluation:
- Evaluation of endovascular/interventional vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.
- Evaluation of post-operative complications e.g., pseudoaneurysms, related to surgical bypass grafts, vascular stents and stent-grafts in the peritoneal cavity.
- Follow-up for post-endovascular repair (EVAR) or open repair of abdominal aortic aneurysm (AAA) and iliac artery aneurysms. Routine, baseline study (post-op/intervention) is warranted within 1-3 months (Chaikof, 2018; Uberoi, 2011).
  - Asymptomatic at six (6) month intervals, for one (1) year, then annually.
  - Symptomatic/complications related to stent graft – more frequent imaging may be needed.
- Follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

Chest CTA/Pelvis CTA combo:
- For evaluation of extensive vascular disease involving the chest and abdominal cavities such as aortic dissection, vasculitic diseases such as Takayasu’s arteritis, significant post-traumatic or post-procedural vascular complications, etc.
- For preoperative or preprocedural evaluation such as transcatheter aortic valve replacement (TAVR).

ADDITIONAL INFORMATION RELATED TO PELVIS CTA:

Abd/Pelvis CTA & Lower Extremity CTA Runoff Requests: Only one authorization request is required, using CPT Code 75635 Abdominal Arteries CTA. This study provides for imaging of the abdomen, pelvis and both legs. The CPT code description is CTA aorto-iliofemoral runoff: abdominal aorta and bilateral ilio-femoral lower extremity runoff.

Bruit - blowing vascular sounds heard over partially occluded blood vessels. Abdominal bruits may indicate partial obstruction of the aorta or other major arteries such as the renal, iliac, or femoral arteries. Associated risks include but are not limited to: renal artery stenosis, aortic aneurysm, atherosclerosis, AVM, or coarctation of aorta.

Peripheral Artery Disease (PAD) – Before the availability of computed tomography angiography (CTA), peripheral arterial disease was evaluated using CT and only a portion of the peripheral arterial tree could be imaged. Multi-detector row CT (MDCT) overcomes this limitation and provides an accurate alternative to CT and is a cost-effective diagnostic strategy in evaluating PAD.

*MRI/CT and acute hemorrhage: MRI is not indicated and MRA/MRV (MR Angiography/Venography) is rarely indicated for evaluation of intraperitoneal or retroperitoneal hemorrhage, particularly in the acute setting. CT is the study of choice due to its availability, speed of the study and less susceptibility to artifact from patient motion. Advances in technology have allowed conventional CT to not just detect hematomas but also the source of acute vascular extravasation. In special cases finer vascular detail to
assess the specific source vessel responsible for hemorrhage may require the use of CTA. CTA in diagnosis of lower gastrointestinal bleeding is such an example (Clerc, 2017).

MRA/MRV is often utilized in non acute situations to assess vascular structure involved in atherosclerotic disease and its complications, vasculitis, venous thrombosis, vascular congestion or tumor invasion. Although some of these conditions may be associated with hemorrhage, it is usually not the primary reason why MRI/MRA/MRV is selected for the evaluation. A special condition where MRI may be superior to CT for evaluating hemorrhage is to detect an underlying neoplasm as the cause of bleeding (Abe, 2010).

**Follow-up of asymptomatic incidentally-detected iliac artery aneurysms (Uberoi, 2011):**
- <3.0 cm: rarely rupture, grow slowly, follow-up not generally needed
- 3.0-3.5 cm: followed up initially at 6 months
  - if stable, then annual imaging
- >3.5 cm: greater likelihood of rupture
  - <6 month follow up
  - consider intervention
REFERENCES


INTRODUCTION:

CT provides direct visualization of anatomic structures in the abdomen and pelvis and is a fast imaging tool used to detect and characterize disease involving the abdomen and pelvis. Pelvic imaging begins at the iliac crests through pubic symphysis. It has an ability to demonstrate abnormal calcifications or fluid/gas patterns in the viscera or peritoneal space.

In general, ionizing radiation from CT should be avoided during pregnancy. Ultrasound is clearly a safer imaging option and is the first imaging test of choice, although CT after equivocal ultrasound has been validated for diagnosis. Clinicians should exercise increased caution with CT imaging in children, pregnant women, and young adults due to the risks of exposure to ionizing radiation. Screening for pregnancy as part of a work-up is suggested to minimize the number of unexpected radiation exposures for women of childbearing age.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR PELVIS CT:

Initial staging of prostate cancer (NCCN, 2017):
PSA levels >20 ng/mL, biopsy, Gleason Score ≥8, or clinically advanced disease (T3, T4 or T1-T2 and nomogram (e.g. Partin, cancer of prostate risk assessment CAPRA) indicating probability of lymph node involvement >10%).

Known prostate cancer for workup of recurrence and response to treatment (NCCN, 2017):
- Initial treatment by radical prostatectomy:
  - Failure of PSA to fall to undetectable levels or PSA detectable and rising on at least 2 subsequent determinations.
- Initial treatment radiation therapy:
  - Post-RT rising PSA or positive digital exam and is candidate for local therapy.

Evaluation of suspicious known mass/tumors (unconfirmed diagnosis of cancer) for further evaluation of indeterminate or questionable findings:
- Initial evaluation of suspicious pelvic masses/tumors found only in the pelvis by physical exam and ultrasound has been performed or for further evaluation of abnormality seen on ultrasound (US) or when US would be inconclusive (ACR, 2013, 2014).
- Surveillance: One follow-up exam to ensure no suspicious change has occurred in a tumor in the pelvis. No further surveillance CT unless tumor(s) are specified as highly suspicious or change was found on exam or last follow-up imaging.

Evaluation of known cancer for further evaluation of indeterminate or questionable findings, identified by physical examination or imaging exams such as ultrasound (US):
- Initial staging of known cancer
  - All cancers, excluding the following:
- Basal Cell Carcinoma of the skin (NCCN, 2018).
- Melanoma without symptoms or signs of metastasis (NCCN, 2018; Trotter, 2013).
- Prostate cancer: unless PSA > 20 ng/ml, Gleason score on biopsy >/= 8 or clinically advanced disease (T3, T4 or T1-T2 and nomogram (e.g. Partin, cancer of prostate risk assessment CAPRA) indicating probability of lymph node involvement >10%) (NCCN, 2017).

Follow-up of Known Cancer (NCCN, 2018; Bourgioti, 2016):
  - Follow-up of known cancer of patient undergoing active treatment within the past year.
  - Known cancer with suspected pelvis metastasis based on a sign, symptom or an abnormal lab value.
  - Active monitoring for recurrence as clinically indicated.

For evaluation of enlargement of organ or abnormality seen on previous imaging:
  - Evaluation of an organ enlargement such as uterus or ovaries as evidenced by physical examination or an abnormality on prior ultrasound.
  - Further evaluation of organ enlargement or abnormality seen on previous imaging.

For evaluation of suspected infection or inflammatory disease (ACR, 2013; Cartwright 2015; McKay 2007):
  - Suspected acute appendicitis (or severe acute diverticulitis) in and adult if pelvic pain and tenderness to palpation is present, with at LEAST one of the following:
    - WBC elevated
    - Fever
    - Anorexia or
    - Nausea and vomiting.
  - Suspected appendicitis in a child after ultrasound has been obtained (Choose Wisely, ACR/AAP/ACS).
  - Suspected complications of diverticulitis (known to be limited to the pelvis by prior imaging) with pelvic pain or severe tenderness, not responding to antibiotic treatment.
  - Suspected infection (based on elevated WBC, fever, anorexia or nausea and vomiting) in the pelvis.
  - Suspected inflammatory bowel disease (Crohn’s or ulcerative colitis) with abdominal pain, and persistent diarrhea, or bloody diarrhea.

For evaluation of known infection or inflammatory disease follow up (ACR, 2013, 2014):
  - Complications of diverticulitis with severe pelvic pain or severe tenderness or mass, not responding to antibiotic treatment, (prior imaging study is not required for diverticulitis diagnosis).
  - Known inflammatory bowel disease, (Crohn’s or ulcerative colitis) with recurrence or worsening signs/symptoms requiring re-evaluation.
  - Any known infection that is clinically suspected to have created an abscess in the pelvis.
  - Any history of fistula limited to the pelvis that requires re-evaluation, or is suspected to have recurred.
  - Abnormal fluid collection seen on prior imaging that needs follow-up evaluation.
  - Known infection in the pelvis.

For evaluation of known or suspected vascular disease (e.g., aneurysms, hematomas) (Khosa, 2011; Uberoi, 2011) **:
  - Evidence of vascular abnormality identified on imaging studies.
  - Evaluation of suspected or known aneurysms limited to the pelvis or in evaluating pelvic extent of aortic aneurysm
• Suspected or known iliac artery aneurysm >2.5 cm AND equivocal or indeterminate ultrasound results OR
• Prior imaging (e.g. ultrasound) demonstrating iliac artery aneurysm >2.5 cm in diameter OR
• Suspected complications of known aneurysm as evidenced by clinical findings such as new onset of pelvic pain.
• Follow up of iliac artery aneurysm: Six month if between 3.0-3.5 cm and if stable follow yearly. If >3.5cm, <six month follow up (and consider intervention)

• Scheduled follow-up evaluation of aorto/iliac endograft or stent.
  • Asymptomatic at six (6) month intervals, for two (2) years
  • Symptomatic/complications related to stent graft – more frequent imaging may be needed.
• Suspected retroperitoneal hematoma or hemorrhage.

For evaluation of trauma (ACR, 2012):
• For evaluation of trauma with lab or physical findings of pelvic bleeding.
• For evaluation of physical or radiological evidence of pelvis fracture.

Pre-operative evaluation:
• For pelvic surgery or procedure.

For post-operative/procedural evaluation:
• Follow-up of known or suspected post-operative complication involving the hips or the pelvis (Davis, 2016; Yanny, 2012).
• A follow-up study to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:
• < 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.

Other indications for Pelvic CT:
• Persistent pelvic pain not explained by previous imaging/procedure.
• Unexplained pelvic pain in patients seventy-five (75) years or older.
• Hernia with suspected complications (e.g. bowel obstruction or strangulation) or prior to surgical repair or when physical exam or prior imaging (e.g. ultrasound) is non-diagnostic or equivocal (Lassandro, 2011; Miller, 2014; Robinson, 2013).
• Ischemic bowel (Dhatt, 2015).
• Known or suspected aseptic/avascular necrosis of hip(s) and MRI is contraindicated after completion of initial x-ray (ACR, 2015).
• Sacroiliitis (infectious or inflammatory) after completion of initial x-ray and MRI is contraindicated (ACR, 2016; Jans, 2014).
• Sacroiliac joint dysfunction and MRI contraindicated when there is:
  • Persistent back and/or sacral pain unresponsive to four (4) weeks of conservative treatment, received within the past six (6) months, including physical therapy or physician supervised home exercise plan (HEP).

Combination of studies with Pelvis CT:
• Abdomen CT/Pelvis CT/Chest CT/Neck MRI/Neck CT – known tumor/cancer for initial staging or evaluation before starting chemotherapy or radiation treatment.
If an Abdomen/Pelvis CT combo is indicated and the Abdomen CT has already been approved, then the Pelvis CT may be approved.

**ADDITIONAL INFORMATION RELATED TO PELVIS CT:**

**Ultrasound should be considered prior to a request for Pelvis CT for the following evaluations:**
- Evaluation or follow up of ovarian mass
- Repeat CT for aneurysm ordered by non-surgeon.

**CT for organ enlargement** - An Abd/pelvis combo is most appropriate because it will demonstrate the kidneys and the ureters. Other organs may require an Abdomen CT or Pelvis CT only.

**CT for suspected renal stones** - An initial CT study is done to identify the size of the stone and rule out obstruction. *(7 mm is the key size; less than that size the expectation is that it will pass)* After the initial CT study for kidney stone is done, the stone can be followed by x-ray or US (not CT). If a second exacerbation occurs/a new stone is suspected another CT would be indicated to access the size of stone and rule out obstruction.

**CT Imaging for Renal Colic and Hematuria** – Multidetector computed tomography (CT) is the modality of choice for the evaluation of the urinary tract. It is fast and it has good spatial resolution. It is superior to plain-film for imaging the renal parenchyma. CT protocols include: “stone protocol” for detecting urinary tract calculi, “renal mass protocol” for characterizing known renal masses and CT urography for evaluating hematuria. Non-contrast CT can be used for detecting most ureteral and renal stones but sometimes an intravenous contrast agent is needed to determine the relationship of the calculus to the opacified ureter. CT is an effective imaging examination for diagnosing hematuria caused by urinary tract calculi, renal tumors, and urothelial tumors.

**CT Imaging for Abdominal and Pelvic Aneurysms** – Abdominal and pelvic aneurysms are usually asymptomatic and most are discovered during imaging studies ordered for other indications or, particularly in the abdomen, on physical examination as a pulsatile mass. If a pulsatile abdominal mass is found, abdominal ultrasonography is an inexpensive and noninvasive technique for examination. For further examination, CT may be performed to better define the shape and extent of the aneurysm and the local anatomic relationships of the visceral and renal vessels. CT has high level of accuracy in sizing aneurysms.

**Follow-up of asymptomatic incidentally-detected iliac artery aneurysms (Uberoi, 2011):**
- <3.0 cm: rarely rupture, grow slowly, follow-up not generally needed
- 3.0-3.5 cm: followed up initially at 6 months
  - if stable, then annual imaging
- >3.5 cm: greater likelihood of rupture
  - <6 month follow up
  - consider intervention

**Combination request of Abdomen CT/Chest CT** - A Chest CT will produce images to the level of L3. Documentation for combo is required.
Hematuria and CT Imaging of Urinary Tract – Multidetector CT urography is a first line of investigation in patients with hematuria due to its ability to display the entire urinary tract, including renal parenchyma, pelvicaliceal systems, ureters and bladder with a single imaging test. To evaluate hematuria, the urinary tract is assessed for both calculi and neoplasms of the kidney and or urothelium.

Helical CT of Prostate Cancer – Conventional CT is not useful in detecting prostate cancer as it does not allow direct visualization. Contrast-enhanced MRI is more useful in detecting prostate cancer. MRI is recommended in patients with suspected cancer but prior negative biopsy because MRI alone can miss up to 26% of clinically significant cancers that would be detected on systemic biopsy (Borofsky, 2018). Helical CT of the prostate may be a useful alternative to MRI in patients with an increasing PSA level and negative findings on biopsy but is not the imaging study of choice.

Prostate Cancer – For symptomatic patients and/or those with a life expectancy of greater than 5 years, a bone scan is appropriate for patients with T1 to T2 disease who also have a PSA greater than 20ng/ml or a Gleason score of 8 or higher. Patients with a T3 to T4 disease or symptomatic disease should also receive a bone scan. Pelvic computed tomography (CT) or magnetic resonance imaging (MRI) scanning is recommended if there is T3 (tumor extent outside prostate with (T3b) or without (T3a) seminal vesicle invasion) or T4 (outside prostate but more extensive than seminal vesicle involvement) disease, or T1 (limited prostate volume involvement, typically <5%) or T2 (more extensive involvement confined to prostate) disease and a nomogram (combination of information, e.g. Gleason score, clinical stage and PSA) indicates that there is greater than 10% chance of lymph node involvement, although staging studies may not be cost effective until the chance of lymph node positively reaches 45%. Biopsy should be considered for further evaluation of suspicious nodal findings. For all other patients, no additional imaging is required for staging.

Pelvic Trauma and CT Imaging – Helical CT is useful in the evaluation of low or high flow vascular injuries in patient with blunt pelvic trauma. It provides detailing of fractures and position of fracture fragments along with the extent of diastasis of the sacroiliac joints and pubic symphysis. CT helps determine whether pelvic bleeding is present and can identify the source of bleeding. With CT, high flow hemorrhage can be distinguished from low flow hemorrhage aiding the proper treatment.

Bladder Cancer and CT Imaging – The diagnosis of upper tract transitional cell carcinoma is dependent on imaging. CT urography is increasingly being used in the imaging of the upper urinary tract in patients with bladder cancer. Multidetector CT scans are more accurate than the older ones and are used in the diagnosis, staging and surveillance of transitional cell carcinoma of the upper urinary tract.

Urinary Calculi and Reduced Radiation Dose – Studies have been performed to retrospectively determine the effect of 50% and 75% radiation dose reductions on sensitivity and specificity of CT for the detection of urinary calculi. Ciaschini, et al found no significant differences between the examinations at 100% radiation dose and those at the reduced dosage for the detection of calculi greater than 3 mm.

Imaging of hernias: Most hernias are diagnosed clinically with imaging recommended for the diagnosis of occult hernias or in the evaluation of hernia complications such as bowel obstruction or strangulation. To detect occult hernias, ultrasound is a first line study with a sensitivity of 86% and specificity of 77% compared to 80% sensitivity and 65% specificity for CT (Robinson, 2013). According to Miller et al “Magnetic resonance imaging is generally not considered a first- or even second-line evaluation modality for hernias...” (Miller, 2014). Based on this analysis MRI is recommended only when ultrasound and CT have been performed and fail to make a diagnosis.
REFERENCES


INTRODUCTION:

Magnetic resonance imaging of the pelvis is a noninvasive technique for the evaluation, assessment of severity, and follow-up of diseases of the male and female pelvic organs. MRI provides excellent contrast of soft tissues and provides multiplanar and 3D depiction of pathology and anatomy. Patients undergoing MRI do not have exposure to ionizing radiation or iodinated contrast materials. MRI techniques utilize body coils to image the entire pelvis or endoluminal coils for evaluation of the rectum, prostate and genitourinary system.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR PELVIC MRI:

Initial pelvic imaging for staging of prostate cancer (NCCN, 2017):
- PSA levels >20 ng/mL, biopsy GS ≥8, or clinically advanced disease (T3, T4 or T1-T2 and nomogram (e.g., Partin, Cancer of Prostate Risk Assessment CAPRA) indicating probability of lymph node involvement >10%).

Known prostate cancer for workup of recurrence and response to treatment (NCCN, 2017):
- Initial treatment by radical prostatectomy:
  - Failure of PSA to fall to undetectable levels or PSA detectable and rising on at least 2 subsequent determinations.
- Initial treatment radiation therapy:
  - Post-RT rising PSA or positive digital exam and is candidate for local therapy.

Indication for (suspected prostate) diagnostic transrectal prostate MRI (ACR, 2016; AUA-SAR, 2016; Bjurlin; Borofsky, 2018)):
- In patients without confirmed diagnosis of prostate cancer (with persistently elevated (≥ 4.0 ng/ml) or rising PSA and prior negative biopsy).

Evaluation of suspicious known mass/tumors (unconfirmed diagnosis of cancer) for further evaluation of indeterminate or questionable findings.
- Initial evaluation of suspicious pelvic masses/tumors found only in the pelvis by physical exam and ultrasound has been performed or for further evaluation of abnormality seen on ultrasound (US) or when US is inconclusive (ACR, 2013, 2014).
- Surveillance: One follow-up exam to ensure no suspicious change has occurred in a tumor in the pelvic. No further surveillance unless tumor(s) are specified as highly suspicious or change was found on exam or last follow-up imaging.

Evaluation of known cancer for further evaluation of indeterminate or questionable findings, identified by physical examination or imaging exams such as ultrasound (US) and CT:
- Initial staging of known cancer:
  - All cancers, excluding the following:
- Basal Cell Carcinoma of the skin (NCCN, 2018).
- Melanoma without symptoms or signs of metastasis (NCCN, 2018; Trotter, 2013).
- Prostate cancer: unless PSA > 20 ng/ml, Gleason score on biopsy >/= 8 or clinically advanced disease (T3, T4 or T1-T2 and nomogram (e.g., Partin, cancer of prostate risk assessment CAPRA) indicating probability of lymph node involvement >10%) (NCCN, 2017).

- Follow-up of Known Cancer (NCCN, 2018; Bourgioti, 2016):
  - Follow-up of known cancer of patient undergoing active treatment within the past year.
  - Known cancer with suspected pelvic metastasis based on a sign, symptom or an abnormal lab value.
  - Active monitoring for recurrence as clinically indicated.

**For evaluation of enlargement of organ or abnormality seen on previous imaging:**
- Evaluation of an organ enlargement such as uterus or ovaries as evidenced by physical examination or an abnormality on prior imaging (e.g. ultrasound or CT).
- Further evaluation of organ enlargement or abnormality seen on previous imaging.

**For evaluation of suspected infection or inflammatory disease and preliminary imaging has been performed or is contraindicated (ACR, 2013; Cartwright, 2015; McKay, 2007):**
- Suspected acute appendicitis (or severe acute diverticulitis) in an adult if pelvic pain and tenderness to palpation is present, with at LEAST one of the following:
  - WBC elevated
  - Fever
  - Anorexia or
  - Nausea and vomiting.
- Suspected appendicitis in a child after ultrasound has been obtained (Choosing Wisely®, ACR/AAP/ACS).
- Suspected complications of diverticulitis (known to be limited to the pelvis by prior imaging) with pelvic pain or severe tenderness, not responding to antibiotic treatment.
- Suspected infection (based on elevated WBC, fever, anorexia or nausea and vomiting) in the pelvis.
- Suspected inflammatory bowel disease (Crohn’s or ulcerative colitis) with abdominal pain, and persistent diarrhea, or bloody diarrhea (MRI may not be well tolerated in the acute setting of inflammatory bowel disease (ACR, 2014)).

**For evaluation of known infection or inflammatory disease follow up (ACR, 2013, 2014):**
- Complications of diverticulitis with severe abdominal pain or severe tenderness or mass, not responding to antibiotic treatment, (prior imaging study is not required for diverticulitis diagnosis).
- Known inflammatory bowel disease (Crohn’s or ulcerative colitis) with recurrence or worsening signs/symptoms requiring re-evaluation.
- Any known infection that is clinically suspected to have created an abscess in the pelvis and preliminary imaging has been performed or is contraindicated.
- Any history of fistula limited to the pelvis that requires re-evaluation, or is suspected to have recurred.
- Abnormal fluid collection seen on prior imaging that needs follow-up evaluation and preliminary imaging has been performed or is contraindicated.
- Known infection in the pelvis and preliminary imaging has been performed or is contraindicated.

**Pre-operative evaluation:**
For pelvic surgery or procedure.
For post-operative/procedural evaluation:
- Follow-up of known or suspected post-operative complication involving the hips or the pelvis (Davis, 2016; Yanny, 2012).
- A follow-up study to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed.

Indications for Musculoskeletal Pelvic MRI:
- Initial evaluation of suspicious mass/tumor of the bones, muscles or soft tissues of the pelvis found on an imaging study, and needing clarification, or found by physical exam and remains non-diagnostic after x-ray or ultrasound.
- Evaluation of suspected fracture and/or injury when initial imaging is inconclusive or needs further evaluation.
- For evaluation of known or suspected aseptic/avascular necrosis of hip(s) after completion of initial x-ray (ACR, 2015).
- Sacroiliitis (infectious or inflammatory) after completion of initial x-ray (ACR, 2016; Jans, 2014).
- Sacroiliac Joint Dysfunction when there is (Jans, 2014):
  - Persistent back and/or sacral pain unresponsive to four (4) weeks of conservative treatment, received within the past six (6) months, including physical therapy or physician supervised home exercise plan (HEP).
- Persistent Pain:
  - For evaluation of persistent pain unresponsive to four (4) weeks of conservative treatment received within the past six (6) months.
- Pelvic floor failure OR post operative complications after pelvic floor surgery (ACR, 2014):
  - For evaluation of incontinence and anatomical derangements including, but not limited to uterine prolapse, rectocele, cystocele.
- For further evaluation of congenital anomalies of the sacrum and pelvis and initial imaging has been performed.
- Athletic pubalgia (Koulouris, 2008; Omar, 2008):
  - For evaluation of persistent groin or symphysis pubis pain related to a suspected diagnosis of athletic pubalgia (sports hernia), when not responding to 4 weeks of conservative treatment*.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:
- ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine

Other Indications for a Pelvic MRI:
- For location or evaluation of undescended testes in adults and in children, including determination of location of testes, where ultrasound has been done previously (Tasian, 2011).
- To provide an alternative to follow-up of an indeterminate pelvic CT when previous CT/Ultrasound was equivocal and needed to clarify a finding a CT could not.
- For evaluation and characterization of uterine and adnexal masses, (e.g., fibroids, ovaries, tubes and uterine ligaments), or congenital abnormality where ultrasound has been done previously (ACR, 2018).
- For evaluation of uterus prior to and after embolization (Deshmukh, 2012).
- For evaluation of endometriosis when preliminary imaging has been completed or to follow up known endometriosis (ACR, 2012; Siegelman, 2012)
- Prior to uterine surgery if there is abnormality suspected on prior ultrasound.
- For evaluation of known or suspected abnormality of the fetus noted on prior imaging and no prior pelvis MRI (ACR-SPR, 2015; Perrone, 2008).
• Occult hernia when physical exam or prior imaging (ultrasound AND CT) is non-diagnostic or equivocal (Lassandro, 2011; Miller, 2014; Robinson, 2013).

ADDITIONAL INFORMATION RELATED TO PELVIC MRI:

*Conservative Therapy - Sacroiliac Joint Dysfunction should include a multimodality approach consisting of a combination of active and inactive components. Inactive components, such as rest, ice, heat, modified activities, medical devices, acupuncture and/or stimulators, medications, injections (epidural, facet, bursal, and/or joint, not including trigger point, and diathermy can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program - (HEP) – the following two elements are required to meet guidelines for completion of conservative therapy:
• Information provided on exercise prescription/plan AND
• Follow up with member with documentation provided regarding completion of HEP (after suitable 4 week period) or inability to complete HEP due to physical reason- i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

MRI and Undescended Testes – The most common genital malformation in boys is undescended testis. In one series 70% of undescended testes are palpable and despite the advances in ultrasound technology, ultrasound cannot reliably identify intra-abdominal testes, which comprise 20% of all undescended testes (Tasian, 2011). The timely management of undescended testis is important to potentially minimize the risk of infertility and lessen the risk of malignancy. MRI is used as a diagnostic tool in the detection of undescended testes and can reveal information for both anatomic and tissue characterization. It is noninvasive, non-ionizing, and can obtain multiplanar images.

MRI and Adnexal Masses – MRI is used in the evaluation of adnexal masses. It can identify and characterize different neoplastic and nonneoplastic abnormalities, e.g., exophytic leiomyoma, endometrioma, dermoid cyst, and ovarian edema. It is a useful adjunct when sonography is inconclusive in the evaluation of adnexal masses.

MRI and Endometriosis – MRI manifestations of endometriosis vary including endometrioma, peritoneal endometrial implant, adhesion and other rare features. The data obtained from imaging must be combined with clinical data to perform preoperative assessment of endometriosis.

MRI and Prostate Cancer – Although prostate cancer is the second leading cause of cancer in men, the majority of cases do not lead to a prostate cancer related death. Aggressive treatment of prostate cancer can have side effects such as incontinence, rectal injury, and impotence. It is very important to do an evaluation which will assist in making decisions about therapy or treatment. MRI can non-invasively assess prostate tissue, functionally and morphologically. MRI evaluation may use a large array of techniques, e.g., T1-weighted images, T2-weighted images, and dynamic contrast enhanced T1-weighted images.

Prostate Cancer – In selected patients diagnosed with prostate cancer, MRI of the pelvis can be used for initial staging, evaluation of recurrence and response to radiation therapy. A separate technique, transrectal prostate MRI, is used in patients with persistent PSA elevation despite prior negative biopsies. MRI is recommended in patients with suspected cancer but prior negative biopsy because MRI alone can miss up to 26% of clinically significant cancers that would be detected on systemic biopsy
(Borofsky, 2018). Patients with suspected prostate cancer should first undergo a systematic biopsy and if that fails to demonstrate tumor, an MRI can then be obtained to guide future biopsy attempts (Bjurlin).

For symptomatic patients and/or those with a life expectancy of greater than 5 years, a bone scan is appropriate for patients with T1 to T2 disease who also have a PSA greater than 20ng/mL or a Gleason score of 8 or higher. Patients with a T3 to T4 disease or symptomatic disease should also receive a bone scan. Pelvic computed tomography (CT) or magnetic resonance imaging (MRI) scanning is recommended if there is T3 or T4 disease, or T1 or T2 disease and a nomogram indicates that there is greater than 20% chance of lymph node involvement, although staging studies may not be optimal until the chance of lymph node positively reaches 45%. Biopsy should be considered for further evaluation of suspicious nodal findings. For all other patients, no additional imaging is required for staging.

Men who suffer a biochemical recurrence following prostatectomy fall into two groups: (1) those whose PSA level fails to fall to undetectable levels after surgery, or (2) those who achieve an undetectable PSA after surgery with a subsequent detectable PSA level that increases on two or more laboratory determinations. Since PSA elevation alone does not necessarily lead to clinical failure, the workup for both of these groups focuses on the assessment of distant metastasis. The specific tests depend on the clinical history, but potentially include a bone scan, biopsy, PSA doubling time assessment, CT/MRI or radioimmunologic scintigraphy (i.e., ProstaScint scan). Bone scans are appropriate when patients develop symptoms or when the PSA level is increasing rapidly. In one study, the probability of a positive bone scan for a patient not on ADT (androgen deprivation therapy) after radical prostatectomy was less than 5% unless the PSA increased to 40 to 45 ng/mL.

Further work up is indicated in patients who are considered candidates for local therapy. These patients include those with original clinical stage T1-2, a life expectancy of greater than 10 years, and a current PSA of less than 10ng/mL. Work up includes a prostate biopsy, bone scan and additional tests as clinically indicated such as abdominal/pelvic CT, MRI or radioimmunologic scintigraphy (i.e., ProstaScint scan).

A negative biopsy following post-radiation biochemical recurrence poses clinical uncertainties. Observation, ADT, or enrolling in clinical trials are viable options. Alternatively, the patients may undergo more aggressive workup, such as repeat biopsy, MR spectroscopy, and or endorectal MRI.

Fusion imaging of multi-parametric magnetic resonance imaging (MRI) and transrectal ultrasound (TRUS) to guide prostate biopsy is not covered.

MRI and Rectal Cancer – MRI is used in the evaluation of rectal cancer to visualize not only the intestinal wall but also the surrounding pelvic anatomy. MRI is an excellent imaging technique due to its high soft-tissue contrast, powerful gradient system, and high resolution. It provides accurate evaluation of the topographic relationship between lateral tumor extent and the mesorectal fascia.

Imaging of hernias: Most hernias are diagnosed clinically with imaging recommended for the diagnosis of occult hernias or in the evaluation of hernia complications such as bowel obstruction or strangulation. To detect occult hernias, ultrasound is a first line study with a sensitivity of 86% and specificity of 77%, compared to 80% sensitivity and 65% specificity for CT (Robinson, 2013). According to Miller et al “Magnetic resonance imaging is generally not considered a first- or even second-line evaluation modality for hernias...” (Miller, 2014). Based on this analysis, MRI is recommended only when ultrasound and CT have been performed and fail to make a diagnosis.
REFERENCES


CPT Codes: 72198

IMPORTANT NOTE:
Abdomen/Pelvis MRA & Lower Extremity MRA Runoff Requests: Two authorization requests are required, one Abd MRA, CPT code 74185 and one for Lower Extremity MRA, CPT code 73725. This will provide imaging of the abdomen, pelvis and both legs.

INTRODUCTION:
Magnetic resonance angiography (MRA) generates images of the arteries that can be evaluated for evidence of stenosis, occlusion, or aneurysms. It is used to evaluate the arteries of the abdominal aorta and the renal arteries. Contrast enhanced MRA requires the injection of a contrast agent which results in very high quality images. It does not use ionizing radiation, allowing MRA to be used for follow-up evaluations.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR PELVIS MRA:

For evaluation of known or suspected pelvic vascular disease:
- For pelvic extent of known large vessel diseases (abdominal aorta, inferior vena cava, superior/inferior mesenteric, celiac, splenic, renal or iliac arteries/veins), e.g., aneurysm, dissection, arteriovenous malformations (AVMs), and fistulas, intramural hematoma, and vasculitis.
- Evidence of vascular abnormality seen on prior imaging studies.
- For suspected pelvic extent of aortic dissection.
- Evaluation of known or suspected aneurysms limited to the pelvis or in evaluating pelvic extent of aortic aneurysm (Khosa, 2011; Uberoi, 2011) **
  - Known or suspected iliac artery aneurysm >2.5 cm AND equivocal or indeterminate ultrasound results OR
  - Prior imaging (e.g. ultrasound) demonstrating iliac artery aneurysm >2.5 cm in diameter OR
  - Suspected complications of known aneurysm as evidenced by clinical findings such as new onset of pelvic pain.
  - Follow up of iliac artery aneurysm: Six month if between 3.0-3.5 cm and if stable follow yearly. If >3.5 cm, <six month follow up (and consider intervention).
- Retroperitoneal hematoma or hemorrhage when an underlying neoplasm is suspected and prior imaging is inconclusive (Abe, 2010).*
- For evaluation of suspected pelvic vascular disease when findings on ultrasound are indeterminate (MR or CT venography may be used as the initial study for evaluating pelvic thrombosis or thrombophlebitis) (ACR, 2013).
- Venous thrombosis if previous studies have not resulted in a clear diagnosis (ACR, 2013).
- Vascular invasion or displacement by tumor (Conventional CT or MRI also appropriate) (Certik, 2015; Kaufman, 2005).
- Pelvic vein thrombosis or thrombophlebitis (ACR, 2013).
- Mesenteric ischemia (ACR, 2012).
Pre-operative evaluation (ACR, 2017):
- Evaluation of interventional vascular procedures prior to endovascular aneurysm repair (EVAR), or for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.

Post-operative or post-procedural evaluation:
- Evaluation of endovascular/ interventional vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.
- Evaluation of post-operative complications, e.g. pseudoaneurysms, related to surgical bypass grafts, vascular stents and stent-grafts in the peritoneal cavity.
- Follow-up for post-endovascular repair (EVAR) or open repair of abdominal aortic aneurysm (AAA) and iliac artery aneurysms. Routine, baseline study (post-op/intervention) is warranted within 1-3 months (Chaiikof, 2018; Uberoi, 2011).
  - Asymptomatic at six (6) month intervals, for one (1) year, then annually.
  - Symptomatic/complications related to stent graft – more frequent imaging may be needed.
- Follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

ADDITIONAL INFORMATION RELATED TO PELVIS MRA:

Abdomen/Pelvis MRA & Lower Extremity MRA Runoff Requests: Two authorization requests are required, one Abd MRA, CPT code 74185 and one for Lower Extremity MRA, CPT code 73725. This will provide imaging of the abdomen, pelvis and both legs.

Bruit: Blowing vascular sounds heard over partially occluded blood vessels. Abdominal bruits may indicate partial obstruction of the aorta or other major arteries such as the renal, iliac, or femoral arteries. Associated risks include but are not limited to: renal artery stenosis, aortic aneurysm, atherosclerosis, AVM, or coarctation of aorta.

MRA and Chronic Mesenteric Ischemia – Contrast-enhanced MRA is used for the evaluation of chronic mesenteric ischemia, including treatment follow-up. Chronic mesenteric ischemia is usually caused by severe atherosclerotic disease of the mesenteric arteries, e.g., celiac axis, superior mesenteric artery, inferior mesenteric artery. At least two of the arteries are usually affected before the occurrence of symptoms such as abdominal pain after meals and weight loss. MRA is the technique of choice for the evaluation of chronic mesenteric ischemia in patients with impaired renal function.

MRA and Abdominal Aortic Aneurysm Repair – MRA may be performed before endovascular repair of an abdominal aortic aneurysm. Endovascular repair of abdominal aortic aneurysm is a minimally invasive alternative to open surgical repair and its success depends on precise measurement of the dimensions of the aneurysm and vessels. This helps to determine selection of an appropriate stent-graft diameter and length to minimize complications such as endoleakage. MRA provides images of the aorta and branches in multiple 3D projections and may help to determine the dimensions needed for placement of an endovascular aortic stent graft. MRA is noninvasive and rapid and may be used in patients with renal impairment.

*MRI/CT and acute hemorrhage: MRI is not indicated and MRA/MRV (MR Angiography/Venography) is rarely indicated for evaluation of intraperitoneal or retroperitoneal hemorrhage, particularly in the acute setting. CT is the study of choice due to its availability, speed of the study, and less susceptibility to artifact from patient motion. Advances in technology have allowed conventional CT to not just detect
hematomas but also the source of acute vascular extravasation. In special cases, finer vascular detail to assess the specific source vessel responsible for hemorrhage may require the use of CTA. CTA in the diagnosis of lower gastrointestinal bleeding is such an example (Clerc, 2017).

MRA/MRV is often utilized in non acute situations to assess vascular structure involved in atherosclerotic disease and its complications, vasculitis, venous thrombosis, vascular congestion or tumor invasion. Although some of these conditions may be associated with hemorrhage, it is usually not the primary reason why MRI/MRA/MRV is selected for the evaluation. A special condition where MRI may be superior to CT for evaluating hemorrhage is to detect an underlying neoplasm as the cause of bleeding (Abe, 2010).

**Follow-up of asymptomatic incidentally-detected iliac artery aneurysms (Uboerio, 2011):**
- <3.0 cm: rarely rupture, grow slowly, follow-up not generally needed
- 3.0-3.5 cm: followed up initially at 6 months
  - if stable, then annual imaging
- >3.5 cm: greater likelihood of rupture
  - <6 month follow up
  - consider intervention
REFERENCES


INTRODUCTION:

Computed tomography (CT) may be used for the diagnosis, evaluation, and management of conditions of the hand, wrist, elbow and shoulder. CT is not usually the initial imaging test, but is performed after standard radiographs. CT is used for preoperative evaluation or to evaluate specific abnormalities of the bones, joints, and soft tissues of the upper extremities.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR UPPER EXTREMITY CT (HAND, WRIST, ARM, ELBOW, OR SHOULDER) (plain radiographs must precede CT evaluation):

Evaluation of suspicious mass/tumor (unconfirmed cancer diagnosis) (Zoga, 2017):
- Initial evaluation of suspicious mass/tumor which remains non-diagnostic after x-ray or ultrasound is completed.
- Surveillance: One follow-up exam if initial evaluation is indeterminate and lesion remains suspicious for cancer. No further surveillance unless tumor is specified as highly suspicious or change was found on last imaging.

Evaluation of known cancer (Fitzgerald, 2015; Morrison, 2013):
- Initial staging of known cancer in the upper extremity.
- Follow-up of known cancer of patient undergoing active treatment within the past year.
- Suspected tumor size increase or recurrence based on a sign, symptom, imaging study, or abnormal lab value.
- Known cancer with suspected upper extremity metastasis based on a sign, symptom, imaging study, or abnormal lab value.
- Active monitoring for recurrence as clinically indicated.

For evaluation of known or suspected infection or inflammatory disease: (e.g. osteomyelitis, septic arthritis, soft tissue infection) and MRI is contraindicated or cannot be performed (Fayad, 2007; Beaman, 2017):
- Further evaluation of abnormal or non-diagnostic findings on prior imaging.
- With abnormal physical or laboratory findings.
- Known or suspected (based upon initial workup including x-ray) septic arthritis or osteomyelitis.

For evaluation of suspected (AVN) avascular necrosis (e.g., aseptic necrosis) and MRI is contraindicated or cannot be performed:
- Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
- High suspicion for AVN (e.g. corticosteroid use, transplant recipients) with negative plain films.
For evaluation of known or suspected autoimmune disease, (e.g. rheumatoid arthritis) and MRI is contraindicated or cannot be performed (Colebatch, 2013):
- Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
- Imaging of a single joint for diagnosis or response to therapy after plain films and appropriate lab tests (e.g., RF, ANA, CRP, ESR, CCP).

For evaluation of known or suspected fracture and/or injury:
- Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
- Suspected fracture when imaging is negative or equivocal.
- Determine position of known fracture fragments/dislocation.
- Evaluate for delayed union or non-union of fracture or joint fusion.

For evaluation of persistent pain and initial imaging has been performed and MRI is contraindicated or cannot be performed:
- Chronic (lasting 3 months or greater) pain and/or persistent tendinitis unresponsive to conservative treatment*, within the last 6 months which includes active medical therapy (physical therapy, chiropractic treatments, and/or physician supervised exercise**) of at least four (4) weeks, OR
- With progression or worsening of symptoms during the course of conservative treatment.

Pre-operative/procedural evaluation:
- Pre-operative evaluation for a planned surgery or procedure.

Post-operative/procedural evaluation:
- When imaging, physical, or laboratory findings indicate joint infection, delayed or non-healing, or other surgical/procedural complications.

Additional indications for an Upper Extremity (Hand, Wrist, Arm, Elbow, or Shoulder) CT:
- Bone scan, ultrasound, or x-ray is non-diagnostic or requires further evaluation.
- CT arthrogram and MRI is contraindicated or cannot be performed (Amini, 2017).
- To assess status of osteochondral abnormalities including osteochondral fractures, osteochondritis dissecans, or treated osteochondral defects where physical or imaging findings suggest its presence and MRI is contraindicated or cannot be performed.
- Known or suspected partial or complete tendon rupture and MRI is contraindicated or cannot be performed.
- Suspected foreign body with negative or non-diagnostic x-ray AND ultrasound (Halaas, 2007; Horton, 2001; Beaman, 2017).

Additional indications for Shoulder CT (Burbank, 2008):
- For any evaluation of patient with shoulder prosthesis or other implanted metallic hardware where prosthetic loosening or dysfunction is suspected on physical examination or imaging (Buck, 2008).
- Evaluation of recurrent dislocation and MRI is contraindicated or cannot be performed (Ng, 2009).
- For evaluation of brachial plexus dysfunction (brachial plexopathy/thoracic outlet syndrome) and MRI is contraindicated or cannot be performed.
- For evaluation of known or suspected labral tear with instability on exam, abnormality on x-ray or history of prior known dislocation. (SLAP lesion, Bankart lesion) and MRI is contraindicated or cannot be performed.
- Impingement or rotator cuff tear indicated by positive Neer’s sign, Hawkins sign or drop sign and MRI is contraindicated or cannot be performed (Ardic, 2006; Nazarian, 2013).
• Status post prior rotator cuff repair with suspected re-tear and findings on prior imaging are indeterminate and MRI is contraindicated or cannot be performed (Buck, 2008).

Additional indications for Wrist CT when MRI is contraindicated or cannot be performed (Kaewlai, 2008):
• For evaluation of suspected ligament injury with evidence of wrist instability on examination or evidence of joint space widening on x-ray
• To differentiate between occult ganglion and synovitis in chronic dorsal wrist pain.
• For evaluation of suspected scaphoid fracture when 2 week follow up x-rays are negative or non-diagnostic (Phillips, 2004; Yin, 2010).

ADDITIONAL INFORMATION RELATED TO UPPER EXTREMITY CT:

*Conservative Therapy*: (musculoskeletal) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components such as rest, ice, heat, modified activities, medical devices, (such as crutches, immobilizer, metal braces, orthotics, rigid stabilizer or splints, etc and not to include neoprene sleeves), medications, injections (bursal, and/or joint, not including trigger point), and diathermy, can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program, and/or chiropractic care.

**Home Exercise Program - (HEP)** – the following two elements are required to meet guidelines for completion of conservative therapy:
• Information provided on exercise prescription/plan AND
• Follow up with member with information provided regarding completion of HEP (after suitable 4 week period), or inability to complete HEP due to physical reason- i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

CT to Evaluate Shoulder Pain – The initial work-up for chronic shoulder pain includes plain radiographs. When the diagnosis remains unclear, further testing including may include computed tomography. CT is the preferred imaging technique for evaluating bony disorders of the shoulders, e.g., arthritis, tumors, occult fractures, etc. CT may be useful in patients with suspected rotator cuff tears who cannot undergo magnetic resonance imaging (MRI).

Shoulder Dislocation – Glenoid bone loss occurs in anterior shoulder dislocation. Severe degrees of glenoid bone loss are shown on axial radiography, but it can be quantified more definitively using CT. This information is important as it helps to predict the likelihood of further dislocation and the need for bone augmentation surgery. The number of dislocations cannot reliably predict the degree of glenoid bone loss; it is important to quantify glenoid bone loss, initially by arthroscopy and later by CT. In the CT examination, both glenoids can be examined simultaneously resulting in a comparison of the width of the glenoid in the dislocating shoulder and in the non-dislocating shoulder.

Shoulder fractures – CT may be used to characterize shoulder fractures when more information is need preoperatively. CT can show the complexity of the fracture, and the displacement and angulation.

CT and Wrist Fractures – CT is indicated for wrist fractures where there is fracture comminution, displacement, or complex intraarticular extension. CT can provide a detailed evaluation of radiocarpal articular step-off and gap displacement which can predict the development of radiocarpal osteoarthritis. CT can be performed in several planes, providing soft-tissue and bone detail. CT is also useful in
determining the position of known fracture fragments and in assessing the union or status of fracture healing.

**CT for Preoperative Evaluation** – Where more information is needed preoperatively, CT is used to demonstrate fracture complexity, displacement and angulation.

**CT and Scaphoid Fractures** – CT is accurate in depicting occult cortical scaphoid fractures. It may be used as a second choice diagnostic method when patients are clinically suspected of having a scaphoid fracture but radiographs are negative or equivocal. Usually the diagnosis of a scaphoid fracture of the wrist is based upon clinical presentation and conventional radiographs. However, a large percentage of patients with a high clinical probability of a scaphoid fracture have unremarkable radiographs. Computed tomography (CT) is another diagnostic tool for patients who have symptoms of a scaphoid fracture but have negative findings on conventional radiographs. Multidetector CT allows coverage of the whole wrist with excellent spatial resolution. It has been proven to be superior to MRI in the detection of cortical involvement of occult scaphoid fractures.

**CT and Avascular Necrosis Complicating Chronic Scaphoid Nonunion** – Preoperative CT of a scaphoid nonunion may be helpful in identifying avascular necrosis and predicting subsequent fracture union. If the results of CT suggest avascular necrosis, treatment options may include vascularized bone grafts or limited wrist arthrodesis.

**CT and Posttraumatic Elbow Effusions** – Multidetector computed tomography (MDCT) may help to detect occult fractures of the elbow when posttraumatic elbow effusions are shown on radiographs without any findings of fracture. Effusions may be visualized on radiographs as fat pads, which can be elevated by the presence of fluid in the joint caused by an acute fracture. MDCT may be useful when effusions are shown on radiographs without a visualized fracture, but there is a clinical suspicion of a lateral condylar or radial head fracture.

**CT and Avascular Necrosis** – Sports such as racquetball and gymnastics may cause repeated microtrauma due to the compressive forces between the radial head and capitellum. Focal avascular necrosis and osteochondritis dissecans of the capitellum may result. CT may show the extent of subchondral necrosis and chondral abnormalities. The images may also help detect intraarticular loose bodies.

**CT and Acute Osseous Trauma** – Many elbow injuries result from repetitive microtrauma rather than acute trauma and the injuries are sometimes hard to diagnose. Non-displaced fractures are not always evident on plain radiographs. When fracture is suspected, CT may improve diagnostic specificity and accuracy.

**CT and Wrist Tumor** – Osteoma does not often occur in the wrist. Symptoms may resemble atypical tenosynovitis. Pain may seem to be related to an injury. CT may be used to evaluate a suspected tumor and may visualize a round lucency surrounded by a rim of sclerosis. CT can give details about the location of the tumor, relative to joints.

**Upper Extremity Osteomyelitis and Septic Arthritis** – CT helps to distinguish among the types of musculoskeletal infections. Its specific imaging features help identify the forms of infection in the bones and soft tissue. Osteomyelitis, a bone infection most commonly associated with an open fracture or direct trauma, is often not detected in the initial conventional radiographic evaluation because bone changes are not evident for 14-21 days after the onset of infection. CT is also used to help diagnose septic arthritis; CT features include joint effusion and bone erosions around the joint.
**American Academy of Pediatrics “Choosing Wisely” Guidelines** advise against ordering advanced imaging studies (MRI or CT) for most musculoskeletal conditions in a child until all appropriate clinical, laboratory and plain radiographic examinations have been completed. “History, physical examination, and appropriate radiographs remain the primary diagnostic modalities in pediatric orthopaedics, as they are both diagnostic and prognostic for the great majority of pediatric musculoskeletal conditions. Examples of such conditions would include, but not be limited to, the workup of injury or pain (spine, knees and ankles), possible infection, and deformity. MRI examinations and other advanced imaging studies frequently require sedation in the young child (5 years old or less) and may not result in appropriate interpretation if clinical correlations cannot be made. Many conditions require specific MRI sequences or protocols best ordered by the specialist who will be treating the patient… if you believe findings warrant additional advanced imaging, discuss with the consulting orthopaedic surgeon to make sure the optimal studies are ordered.
REFERENCES


CPT Codes: 73206

INTRODUCTION:

Computed tomography angiography (CTA) can visualize blood flow in arterial and venous structures throughout the upper extremity using a computerized analysis of x-ray images. It is enhanced by contrast material that is injected into a peripheral vein to promote visualization. CTA is much less invasive than catheter angiography which involves injecting contrast material into an artery. CTA is less expensive and carries lower risks than catheter angiography.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR UPPER EXTREMITY CTA:

For assessment/evaluation of known or suspected vascular disease/condition:
- For evaluation of suspected vascular disease: aneurysm, arteriovenous malformation, fistula, vasculitis, or intramural hematoma (Bozlar, 2013).
- For evaluation of Raynaud's syndrome.
- For evaluation of vascular invasion or displacement by tumor (Kransdorf, 2017).
- For evaluation of suspected upper extremity embolism or thrombosis (Dill, 2014; Bozlar, 2013).
- For evaluation of traumatic injuries to the upper extremity with clinical findings suggestive of arterial injury (Peng, 2008).

Pre-operative/procedural evaluation:
- Pre-operative evaluation for a planned surgery or procedure (Ahmed, 2017; Hsu, 2008).

Post-operative/procedural evaluations:
- For evaluation of complications of interventional vascular procedures, e.g., pseudoaneurysms related to surgical bypass grafts, vascular stents, or stent-grafts.
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

Other indications for Upper Extremity CTA:
- For evaluation of a dialysis graft (Neyman, 2006).

ADDITIONAL INFORMATION RELATED TO UPPER EXTREMITY CTA:

CTA and Raynaud's Syndrome – Raynaud’s syndrome is evidenced by episodic waxy pallor or cyanosis of the fingers caused by vasoconstriction of small arteries or arterioles in the fingers. It usually occurs due to a response to cold or to emotional stimuli. CTA may be used in the evaluation of Raynaud’s syndrome.
**CTA and Dialysis Graft** – The management of the hemodialysis access is important for patients undergoing dialysis. With evaluation and interventions, the patency of hemodialysis fistulas may be prolonged. In selected cases, CTA is useful in the evaluation of hemodialysis graft dysfunction due to its speed and high resolution. Rapid data acquisition during the arterial phase, improved visualization of small vessels and lengthened anatomic coverage increase the usefulness of CTA.

**CTA and Stenosis or Occlusion** – CTA of the central veins of the chest is used for the detection of central venous stenoses and occlusions. High-spatial resolution CTA characterizes the general morphology and degree of stenosis. Enlarged and well-developed collateral veins in combination with the non-visualization of a central vein may be indicative of chronic occlusion, whereas less-developed or absent collateral veins are suggestive of acute occlusions. A hemodynamically significant stenosis may be indicated by the presence of luminal narrowing with local collaterals.
REFERENCES


CPT Codes: 73218, 73219, 73220, 73221, 73222, 73223

INTRODUCTION:

Magnetic resonance imaging shows the soft tissues and bones. With its multiplanar capabilities, high contrast, and high spatial resolution, it is an accurate diagnostic tool for conditions affecting the joint and adjacent structures. MRI has the ability to positively influence clinicians’ diagnoses and management plans for patients with conditions such as primary bone cancer, fractures, abnormalities in ligaments/tendons/cartilage, septic arthritis, and infection/inflammation.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR UPPER EXTREMITY MRI (HAND, WRIST, ARM, ELBOW or SHOULDER) (plain radiographs must precede MRI evaluation):

Evaluation of suspicious mass/tumor (unconfirmed cancer diagnosis) (Zoga, 2017):
- Initial evaluation of suspicious mass/tumor which remains non-diagnostic after x-ray or ultrasound is completed.
- Surveillance: One follow-up exam if initial evaluation is indeterminate and lesion remains suspicious for cancer. No further surveillance unless tumor is specified as highly suspicious or change was found on last imaging.

Evaluation of known cancer (Fitzgerald, 2015; Morrison, 2013):
- Initial staging of known cancer in the upper extremity.
- Follow-up of known cancer of patient undergoing active treatment within the past year.
- Suspected tumor size increase or recurrence based on a sign, symptom, imaging study, or abnormal lab value.
- Known cancer with suspected upper extremity metastasis based on a sign, symptom, imaging study or abnormal lab value.
- Active monitoring for recurrence as clinically indicated

For evaluation of known or suspected infection or inflammatory disease (e.g. osteomyelitis, septic arthritis, soft tissue infection) (Beaman, 2017):
- Further evaluation of abnormal or non-diagnostic findings on prior imaging.
- With abnormal physical or laboratory findings.
- Known or suspected (based upon initial workup including x-ray) septic arthritis or osteomyelitis.

For evaluation of suspected (AVN) avascular necrosis (i.e. aseptic necrosis) (Kekatpure, 2014):
- Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
- High suspicion for AVN (e.g. corticosteroid use, transplant recipients) with negative plain films.

For evaluation of known or suspected autoimmune disease (e.g., rheumatoid arthritis) (Boutry, 2007; Colebatch, 2013):
- Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
• Imaging of a single joint for diagnosis or response to therapy after plain films and appropriate lab
tests (e.g., RF, ANA, CRP, ESR).

For evaluation of known or suspected fracture and/or injury:
• Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
• Suspected fracture when imaging is negative or equivocal.
• Determine position of known fracture fragments/dislocation.

For evaluation of persistent pain and initial imaging (e.g. x-ray) has been performed:
• Chronic (lasting 3 months or greater) pain and/or persistent tendonitis unresponsive to conservative
treatment*, within the last 6 months which includes active medical therapy (physical therapy,
chiropractic treatments, and/or physician supervised exercise**) of at least four (4) weeks, OR
• With progression or worsening of symptoms during the course of conservative treatment.

Pre-operative/procedural evaluation.
• Pre-operative evaluation for a planned surgery or procedure.

Post-operative/procedural evaluation:
• When imaging, physical or laboratory findings indicate joint infection, delayed or non-healing or other
surgical/procedural complications.

Additional indications for Upper Extremity (Hand, Wrist, Arm, Elbow, or Shoulder) MRI:
• Bone scan, ultrasound, or x-ray is non-diagnostic or requires further evaluation.
• MR arthrogram (Amini, 2017).
• To assess status of osteochondral abnormalities including osteochondral fractures, osteochondritis
dissecans, or treated osteochondral defects where physical or imaging findings suggest its presence.
• Known or suspected partial or complete tendon rupture.
• Suspected foreign body with negative or non-diagnostic x-ray AND ultrasound (Horton, 2001;
Beaman, 2017).

Additional indications for Shoulder MRI (Burbank, 2008):
• For evaluation of known or suspected labral tear with instability on exam, abnormality on x-ray or
history of prior known dislocation. (SLAP lesion, Bankart lesion)
• Impingement or rotator cuff tear indicated by positive Neer’s sign, Hawkin’s sign or drop sign
(Nazarian, 2013; Ardic, 2006).
• Status post prior rotator cuff repair with suspected re-tear and findings on prior imaging are
indeterminate (Buck, 2008).
• For evaluation of brachial plexus dysfunction (brachial plexopathy/thoracic outlet syndrome).
• For evaluation of recurrent dislocation (Ng, 2009).

Additional indications for Wrist MRI:
• For evaluation of suspected ligament injury with evidence of wrist instability on examination or
evidence of joint space widening on x-ray
• For suspected TFCC (triangular fibrocartilage complex) injury (Ng, 2017).
• To differentiate between occult ganglion and synovitis in chronic dorsal wrist pain (Anderson, 2006).
• For evaluation of suspected scaphoid fracture when 2 week follow up x-rays are negative or non-
diagnostic (Phillips, 2004; Yin, 2010).
ADDITIONAL INFORMATION RELATED TO UPPER EXTREMITY MRI:

*Conservative Therapy* (musculoskeletal) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components such as rest, ice, heat, modified activities, medical devices, (such as crutches, immobilizer, metal braces, orthotics, rigid stabilizer or splints, etc and not to include neoprene sleeves), medications, injections (bursal, and/or joint, not including trigger point), and diathermy, can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care

**Home Exercise Program - (HEP)** – the following two elements are required to meet guidelines for completion of conservative therapy:
- Information provided on exercise prescription/plan AND
- Follow up with member with information provided regarding completion of HEP (after suitable 4 week period), or inability to complete HEP due to physical reason i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

**Rotator Cuff Tears** – 3.0 Tesla MRI has been found valuable for the detection of partial thickness rotator cuff tendon tears and small rotator cuff tendon tears. It is especially useful in detecting the partial tears due to increased spatial resolution. Increased spatial resolution results in precise measurements of rotator cuff tendon tears in all 3 planes and it also reduces acquisition time which reduces motion artifacts. 3.0 Tesla makes it possible to adequately evaluate tendon edges and avoid underestimation of tears. MRI is less invasive than MR arthrography and it is faster and less expensive. MRI may be useful in the selection of patients that may benefit from arthroscopy.

**MRI and Occult Fractures** – Magnetic resonance imaging may help to detect occult fractures of the elbow when posttraumatic elbow effusions are shown on radiographs without any findings of fracture. Effusions may be visualized on radiographs as fat pads, which can be elevated by the presence of fluid in the joint caused by an acute fracture. MRI may be useful when effusions are shown on radiographs without a visualized fracture, but there is a clinical suspicion of a lateral condylar or radial head fracture.

**MRI and Avascular Necrosis** – Sports such as racquetball and gymnastics may cause repeated microtrauma due to the compressive forces between the radial head and capitellum. Focal avascular necrosis and osteochondritis dissecans of the capitellum may result. MRI can be used to evaluate the extent of subchondral necrosis and chondral abnormalities. The images may also help detect intraarticular loose bodies.

**MRI and Acute Osseous Trauma** – Many elbow injuries result from repetitive microtrauma rather than acute trauma and the injuries are sometimes hard to diagnose. Non-displaced fractures are not always evident on plain radiographs. When fracture is suspected, MRI may improve diagnostic specificity and accuracy. T1-weighted images can delineate morphologic features of the fracture.

**MRI and Brachial Plexus** - MRI is the only diagnostic tool that accurately provides high resolution imaging of the brachial plexus. The brachial plexus is formed by the cervical ventral rami of the lower cervical and upper thoracic nerves which arise from the cervical spinal cord, exit the bony confines of the cervical spine, and traverse along the soft tissues of the neck, upper chest, and course into the arms.
The American Academy of Pediatrics “Choosing Wisely” Guidelines advise against ordering advanced imaging studies (MRI or CT) for most musculoskeletal conditions in a child until all appropriate clinical, laboratory and plain radiographic examinations have been completed. “History, physical examination, and appropriate radiographs remain the primary diagnostic modalities in pediatric orthopaedics, as they are both diagnostic and prognostic for the great majority of pediatric musculoskeletal conditions. Examples of such conditions would include, but not be limited to, the work up of injury or pain (spine, knees and ankles), possible infection, and deformity. MRI examinations and other advanced imaging studies frequently require sedation in the young child (5 years old or less) and may not result in appropriate interpretation if clinical correlations cannot be made. Many conditions require specific MRI sequences or protocols best ordered by the specialist who will be treating the patient. If you believe findings warrant additional advanced imaging, discuss with the consulting orthopaedic surgeon to make sure the optimal studies are ordered.
REFERENCES


CPT Codes: 73225

INTRODUCTION:

Magnetic resonance angiography (MRA) is a noninvasive alternative to catheter angiography for evaluation of vascular structures in the upper extremity. Magnetic resonance venography (MRV) is used to image veins instead of arteries. MRA and MRV are less invasive than conventional x-ray digital subtraction angiography.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR UPPER EXTREMITY MRA/MRV:

For assessment/evaluation of known or suspected vascular disease/condition:
- For evaluation of suspected vascular disease: aneurysm, arteriovenous malformation, fistula, vasculitis, or intramural hematoma (Connell, 2002).
- For evaluation of Raynaud's syndrome (Connell, 2002).
- For evaluation of vascular invasion or displacement by tumor (Kransdorf, 2017).
- For evaluation of suspected upper extremity embolism or thrombosis (Dill, 2014).
- For evaluation of traumatic injuries to the upper extremity with clinical findings suggestive of arterial injury (Connell, 2002).
- Suspected fibromuscular dysplasia of the brachial artery (Sharma, 2014).

Pre-operative/procedural evaluation:
- Pre-operative evaluation for a planned surgery or procedure (Ahmed, 2017).

Post-operative/procedural evaluations:
- Post-operative or interventional vascular procedure for luminal patency versus re-stenosis (due to atherosclerosis, thromboembolism, intimal hyperplasia and other causes), as well as complications such as pseudoaneurysms related to surgical bypass grafts and vascular stents and stent-grafts.
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

ADDITIONAL INFORMATION RELATED TO UPPER EXTREMITY MRA/MRV:

MRA/MRV and Raynaud's Syndrome – Raynaud's syndrome is evidenced by episodic waxy pallor or cyanosis of the fingers caused by vasoconstriction of small arteries or arterioles in the fingers. It usually occurs due to a response to cold or to emotional stimuli. MRA may be used in the evaluation of Raynaud’s syndrome.

MRA/MRV and Stenosis or Occlusion – MRA of the central veins of the chest is used for the detection of central venous stenoses and occlusions. High-spatial resolution MRA characterizes the general
morphology and degree of stenosis. Enlarged and well-developed collateral veins in combination with the non-visualization of a central vein may be indicative of chronic occlusion, whereas less-developed or absent collateral veins are suggestive of acute occlusions. A hemodynamically significant stenosis may be indicated by the presence of luminal narrowing with local collaterals (Kim, 2008).
REFERENCES


CPT Codes: 73700, 73701, 73702

INTRODUCTION:

Plain radiographs are typically used as the first-line modality for assessment of lower extremity conditions. Computed tomography (CT) is used for evaluation of tumors, metastatic lesions, infection, fractures and other problems. Magnetic resonance imaging (MRI) is the first-line choice for imaging of many conditions, but CT may be used in these cases if MRI is contraindicated or unable to be performed.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR LOWER EXTREMITY CT (FOOT, ANKLE, KNEE, LEG or HIP):
(plain radiographs must precede CT evaluation):

Evaluation of suspicious mass/tumor (unconfirmed cancer diagnosis):
• Initial evaluation of suspicious mass/tumor which remains non-diagnostic after x-ray or ultrasound is completed.
• Surveillance: One follow-up exam if initial evaluation is indeterminate and lesion remains suspicious for cancer. No further surveillance unless tumor is specified as highly suspicious, or change was found on last imaging (Zoga, 2017).

Evaluation of known cancer:
• Initial staging of known cancer in the lower extremity.
• Follow-up of known cancer of patient undergoing active treatment within the past year.
• Suspected tumor size increase or recurrence based on a sign, symptom, imaging study or abnormal lab value.
• Known cancer with suspected lower extremity metastasis based on a sign, symptom, imaging study or abnormal lab value.
• Active monitoring for recurrence as clinically indicated (Fitzgerald, 2015; Morrison, 2013).

For evaluation of known or suspected infection or inflammatory disease (e.g. osteomyelitis, septic arthritis, soft tissue infection) and MRI is contraindicated or cannot be performed:
• Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
• With abnormal physical, laboratory, and/or imaging findings.
• Known or suspected (based upon initial workup including imaging) septic arthritis or osteomyelitis (Beaman, 2017).

For evaluation of suspected (AVN) avascular necrosis (e.g., aseptic necrosis, Legg-Calve-Perthes disease in children) and MRI is contraindicated or cannot be performed:
• Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
• High suspicion for AVN (e.g. corticosteroid use, transplant recipients) with negative plain films (Murphey, 2016).

For evaluation of known or suspected autoimmune disease, (e.g. rheumatoid arthritis) and MRI is contraindicated or cannot be performed:
• Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
• Imaging of a single joint for diagnosis or response to therapy after plain films and appropriate lab tests (e.g. RF, ANA, CRP, ESR) (Colebatch, 2013).

**For evaluation of known or suspected fracture and/or injury:**
• Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
• Suspected fracture when imaging is negative or equivocal.
• Determine position of known fracture fragments/dislocation.

**For evaluation of persistent pain, initial imaging has been performed and MRI is contraindicated or cannot be performed:**
• Chronic (lasting 3 months or greater) pain and/or persistent tendonitis unresponsive to conservative treatment*, within the last 6 months which includes active medical therapy (physical therapy, chiropractic treatments, and/or physician supervised exercise**) of at least four (4) weeks, OR
• With progression or worsening of symptoms during the course of conservative treatment.

**Pre-operative/procedural evaluation.**
• Pre-operative evaluation for a planned surgery or procedure.

**Post-operative/procedural evaluation:**
• When imaging, physical, or laboratory findings indicate joint infection, delayed or non-healing, or other surgical/procedural complications.

**Additional indications for Lower Extremity (Foot, Ankle, Knee, Leg, or Hip) CT:**
• Bone scan, ultrasound, or x-ray is non-diagnostic or requires further evaluation.
• For evaluation of leg length discrepancy when physical deformities of the lower extremities would prevent standard modalities such as x-rays or a Scanogram from being performed. (Scanogram (CPT code 77073); bone length study is available as an alternative to lower extremity CT evaluation for leg length discrepancy) (Sabharwal, 2008).
• CT arthrogram **and MRI is contraindicated or cannot be performed.**
• To assess status of osteochondral abnormalities including osteochondral fractures, osteochondritis dissecans, or treated osteochondral defects where physical or imaging findings suggest its presence **and MRI is contraindicated or cannot be performed.**
• Suspected foreign body with negative or non-diagnostic x-ray AND ultrasound (Halaas, 2007; Horton, 2001; Beaman, 2017).

**Additional indications specifically for FOOT or ANKLE CT:**
• Chronic (lasting 3 months or greater) pain in a child or an adolescent with painful rigid flat foot where imaging is unremarkable or equivocal or to evaluate for known or suspected tarsal coalition (Harris, 2004).
• Physical findings of ligament damage such as an abnormal drawer test of the ankle or significant laxity on valgus or varus stress testing and/or joint space widening on x-ray, **and MRI is contraindicated or cannot be performed.**

**Additional indications specifically for KNEE CT and MRI is contraindicated or cannot be performed:**
• Blood in the joint (hemarthrosis) demonstrated by aspiration.
• For evaluation of suspected Baker’s cyst or posterior knee swelling with equivocal or non-diagnostic findings on ultrasound (Ward, 2001).
- Physical findings of a meniscal injury determined by physical examination tests (e.g. McMurray's, Apley's, Thessaly's).
- Physical findings of anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) ligamentous injury determined by the drawer test, pivot shift test, or the Lachman test.
- Physical findings of medial cruciate ligament (MCL) or lateral cruciate ligament (LCL) ligamentous injury determined by significant laxity on varus or valgus stress tests. (Bennett, 2012; Mohankumar, 2014; Tuite, 2014).

**Additional indications specifically for HIP CT:**
- For evaluation of patient with hip prosthesis or other implanted metallic hardware where prosthetic loosening or dysfunction is suspected on physical examination or imaging (Fritz, 2014).
- For evaluation of suspected slipped capital femoral epiphysis with non-diagnostic or equivocal imaging and MRI is contraindicated or cannot be performed (Hesper, 2017).
- Suspected labral tear of the hip and MRI is contraindicated or cannot be performed.

**ADDITIONAL INFORMATION RELATED TO LOWER EXTREMITY CT:**

*Conservative Therapy:* (musculoskeletal) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components such as rest, ice, heat, modified activities, medical devices, (such as crutches, immobilizer, metal braces, orthotics, rigid stabilizer or splints, etc and not to include neoprene sleeves), medications, injections (bursal, and/or joint, not including trigger point), and diathermy, can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program - (HEP)** – the following two elements are required to meet guidelines for completion of conservative therapy:
- Information provided on exercise prescription/plan AND
- Follow up with member with information provided regarding completion of HEP (after suitable 4 week period), or inability to complete HEP due to physical reason- i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

**CT and Ankle Fractures** – One of the most frequently injured areas of the skeleton is the ankle. These injuries may include ligament sprains, as well as fractures. A suspected fracture is first imaged with conventional radiographs in anteroposterior, internal oblique and lateral projections. CT is used in patients with complex ankle and foot fractures after radiography.

**CT and Hip Trauma** – Computed tomography is primarily used to evaluate acute trauma, e.g., acetabular fracture or hip dislocation. It can detect intraarticular fragments and associated articular surface fractures and it is useful in surgical planning.

**CT and Knee Fractures** – CT is used after plain films to evaluate fractures to the tibial plateau. These fractures occur just below the knee joint, involving the cartilage surface of the knee. Soft tissue injuries are usually associated with the fractures. The meniscus is a stabilizer of the knee and it is very important to detect meniscal injury in patients with tibial plateau fractures. CT of the knee with two-dimensional reconstruction in the sagittal and coronal planes may be performed for evaluation of injuries with multiple fragments and comminuted fractures. Spiral CT has an advantage of rapid acquisition and
reconstruction times and may improve the quality of images of bone. Soft tissue injuries are better demonstrated with MRI.

**CT and Knee Infections** – CT is used to depict early infection which may be evidenced by increased intraosseous density or the appearance of fragments of necrotic bone separated from living bone by soft tissue or fluid density. Contrast-enhanced CT may help in the visualization of abscesses and necrotic tissue.

**CT and Knee Tumors** – CT complements arthrography in diagnosing necrotic malignant soft-tissue tumors and other cysts and masses in the knee. Meniscal and ganglion cysts are palpable masses around the knee. CT is useful in evaluations of the vascular nature of lesions.

**CT and Legg-Calve-Perthes Disease (LPD)** – This childhood condition is associated with an insufficient blood supply to the femoral head which is then at risk for osteonecrosis. Clinical signs of LPD include a limp with groin, thigh or knee pain. Flexion and adduction contractures may develop as the disease progresses and eventually movement may only occur in the flexion-extension plane. This condition is staged based on plain radiographic findings. CT scans are used in the evaluation of LPD and can demonstrate changes in the bone trabecular pattern. They also allow diagnosis of bone collapse and sclerosis early in the disease where plain radiography is not as sensitive.

**CT and Osteolysis** – Since computed tomography scans show both the extent and the location of lytic lesions, they are useful to guide treatment decisions, as well as to assist in planning for surgical intervention when needed, in patients with suspected osteolysis after Total Hip Arthroplasty (THA).

**CT and Tarsal Coalition** – This is a congenital condition in which two or more bones in the mid-foot or hind-foot are joined. It usually presents during late childhood or late adolescence and is associated with repetitive ankle sprains. Mild pain, deep in the subtalar joint and limited range of motion are clinical symptoms. Tarsal coalition is detectable on oblique radiographs, but these are not routinely obtained at many institutions. Clinical diagnosis is not simple; it requires the expertise of skilled examiners. CT is valuable in diagnosing tarsal coalition because it allows differentiation of osseous from non-osseous coalitions and also depicts the extent of joint involvement as well as degenerative changes. It may also detect the overgrowth of the medial aspect of the talus that may be associated with talocalcaneal coalitions.

**American Academy of Pediatrics “Choosing Wisely” Guidelines** advise against ordering advanced imaging studies (MRI or CT) for most musculoskeletal conditions in a child until all appropriate clinical, laboratory and plain radiographic examinations have been completed. “History, physical examination, and appropriate radiographs remain the primary diagnostic modalities in pediatric orthopaedics, as they are both diagnostic and prognostic for the great majority of pediatric musculoskeletal conditions. Examples of such conditions would include, but not be limited to, the work up of injury or pain (spine, knees and ankles), possible infection, and deformity. MRI examinations and other advanced imaging studies frequently require sedation in the young child (5 years old or less), and may not result in appropriate interpretation if clinical correlations cannot be made. Many conditions require specific MRI sequences or protocols best ordered by the specialist who will be treating the patient… if you believe findings warrant additional advanced imaging, discuss with the consulting orthopaedic surgeon to make sure the optimal studies are ordered.
REFERENCES


CPT Codes: 73706

INTRODUCTION:

Lower extremity computed tomography angiography (CTA) is an effective, noninvasive and robust imaging modality that is used in the assessment of symptomatic lower extremity vascular disease. It has excellent spatial resolution and shows accurate details of peripheral vasculature. CTA is an effective alternative to catheter-based angiography and allows accurate planning of open surgical and endovascular interventions.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR LOWER EXTREMITY CTA:

For assessment/evaluation of suspected or known vascular disease/condition:
- Significant ischemia in the presence of ulcers/gangrene (Weiss, 2018)
- Large vessel diseases, e.g. aneurysm, dissection, arteriovenous malformations (AVMs), fistulas, intramural hematoma, and vasculitis.
- Arterial entrapment syndrome (Hai, 2008).
- Venous thrombosis after non-diagnostic ultrasound (Hanley, 2013)
- Vascular invasion or displacement by tumor (Kransdorf, 2017).
- Pelvic vein thrombosis or thrombophlebitis (Hanley, 2013; Karande, 2016).
- Abnormal preliminary testing (ankle/brachial index, ultrasound/doppler arterial evaluation) associated with significant symptoms of claudication with exercise (Ahmed, 2017; Met, 2009)
- For evaluation of traumatic injuries to the lower extremity with clinical findings suggestive of arterial injury (Tuite, 2018; Inaba, 2006; LeBus, 2008)

Pre-operative/procedural evaluation:
- Pre-operative evaluation for a planned surgery or procedure (Ahmed, 2017; Godshall, 2005).

Post-operative/procedural evaluation:
- Post-operative or interventional vascular procedure for luminal patency versus re-stenosis (due to atherosclerosis, thromboembolism, intimal hyperplasia and other causes) as well as complications such as pseudoaneurysms related to surgical bypass grafts and vascular stents and stent-grafts (Lopera, 2008; Toomay, 2006).
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

ADDITIONAL INFORMATION RELATED TO LOWER EXTREMITY CTA:

Abdominal Arteries CTA: For imaging of the abdomen, pelvis AND both legs (CTA aorto-iliofemoral runoff: abdominal aorta and bilateral iliofemoral lower extremity runoff) use CPT code 75635.
**Peripheral Arterial Disease** – Multi-detector CTA (MDCTA) is used in the evaluation of patients with peripheral arterial disease. It can be used to evaluate the patency after revascularization procedures. It is the modality of choice in patients with intermittent claudication. A drawback is its hampered vessel assessment caused by the depiction of arterial wall calcifications, resulting in a decreased accuracy in severely calcified arteries.

**Chronic Limb Threatening Ischemia** · Assessment and promotion of blood flow through the calf arteries is very important in patients with chronic limb threatening ischemia. MDCTA allows for visualization of pedal vessels.

**Surgical or Percutaneous Revascularization** – CTA is accurate in the detection of graft-related complications, including stenosis and aneurysmal changes. It can reveal both vascular and extravascular complications.

**CTA and screening for peripheral vascular disease:** The USPSTF (U.S. Preventative Services Task Force) does not recommend routine screening for peripheral vascular disease in asymptomatic patients. High risk patients (eg. diabetics) may be screened with ABI (ankle brachial index) and duplex ultrasound.
REFERENCES


CPT Codes: 73718, 73719, 73720, 73721, 73722, 73723

INTRODUCTION:

Magnetic resonance imaging shows the soft tissues and bones. With its multiplanar capabilities, high contrast, and high spatial resolution, it is an accurate diagnostic tool for conditions affecting the joint and adjacent structures. MRI has the ability to positively influence clinicians’ diagnoses and management plans for patients with conditions such as primary bone cancer, fractures, abnormalities in ligaments/tendons/cartilage, septic arthritis, and infection/inflammation.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR LOWER EXTREMITY MRI (FOOT, ANKLE, KNEE, LEG or HIP) (plain radiographs must precede MRI evaluation):

Evaluation of suspicious mass/tumor (unconfirmed cancer diagnosis) (Zoga, 2017):
- Initial evaluation of suspicious mass/tumor which remains non-diagnostic after x-ray or ultrasound is completed.
- Surveillance: One follow-up exam if initial evaluation is indeterminate and lesion remains suspicious for cancer. No further surveillance unless tumor is specified as highly suspicious, or change was found on last imaging.

Evaluation of known cancer (Fitzgerald, 2015; Morrison, 2013):
- Initial staging of known cancer in the lower extremity.
- Follow-up of known cancer of patient undergoing active treatment within the past year.
- Suspected tumor size increase or recurrence based on a sign, symptom, imaging study or abnormal lab value.
- Known cancer with suspected lower extremity metastasis based on a sign, symptom, imaging study or abnormal lab value.
- Active monitoring for recurrence as clinically indicated.

For evaluation of known or suspected infection or inflammatory disease (e.g. osteomyelitis, septic arthritis, soft tissue infection):
- Further evaluation of abnormal or non-diagnostic findings on prior imaging.
- With abnormal physical or laboratory findings.
- Known or suspected (based upon initial workup including x-ray) septic arthritis or osteomyelitis (Bancroft, 2007; Beaman, 2017).

For evaluation of suspected (AVN) avascular necrosis (i.e. aseptic necrosis, Legg-Calve-Perthes disease in children):
- Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
- High suspicion for AVN (e.g. corticosteroid use, transplant recipients) with negative plain films (Murphey, 2016).

For evaluation of known or suspected autoimmune disease (e.g. rheumatoid arthritis):
• Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
• Imaging of a single joint for diagnosis or response to therapy after plain films and appropriate lab tests (e.g. RF, ANA, CRP, ESR) (Boutry, 2007; Colebatch, 2013).

**For evaluation of known or suspected fracture and/or injury:**
• Further evaluation of an abnormality or non-diagnostic findings on prior imaging.
• Suspected fracture when imaging is negative or equivocal.
• Determine position of known fracture fragments/dislocation.

**For evaluation of persistent pain and initial imaging has been performed:**
• Chronic (lasting 3 months or greater) pain and/or persistent tendonitis unresponsive to conservative treatment*, within the last 6 months which includes active medical therapy (physical therapy, chiropractic treatments, and/or physician supervised exercise**) of at least four (4) weeks, OR
• With progression or worsening of symptoms during the course of conservative treatment.

**Pre-operative/procedural evaluation:**
• Pre-operative evaluation for a planned surgery or procedure.

**Post-operative/procedural evaluation:**
• When imaging, physical or laboratory findings indicate joint infection, delayed or non-healing or other surgical/procedural complications.

**Additional indications for a Lower Extremity (Foot, Ankle, Knee, Leg or Hip) MRI:**
• Bone scan, ultrasound, or x-ray is non-diagnostic or requires further evaluation.
• MR arthrogram.
• To assess status of osteochondral abnormalities including osteochondral fractures, osteochondritis dissecans, or treated osteochondral defects where physical or imaging findings suggest its presence.
• Known or suspected partial or complete tendon rupture.
• Suspected foreign body with negative or non-diagnostic x-ray AND ultrasound (Halaas, 2007; Horton, 2001; Beaman, 2017).

**Additional indications specifically for FOOT or ANKLE MRI**
• Chronic (lasting 3 months or greater) pain in a child or adolescent with painful rigid flat foot where imaging is unremarkable or equivocal or to evaluate for known or suspected tarsal coalition (Harris, 2004).
• Physical findings of ligament damage such as an abnormal drawer test of the ankle or significant laxity on valgus or varus stress testing and/or joint space widening on x-rays.
• Evaluation of tarsal tunnel syndrome after abnormal plain films or abnormal nerve conduction studies or a failure of 4 weeks of conservative treatment.

**Additional indications specifically for KNEE MRI:**
• Blood in the joint (hemarthrosis) demonstrated by aspiration.
• For evaluation of suspected Baker’s cyst or posterior knee swelling with equivocal or non-diagnostic findings on ultrasound (Ward, 2001).
• Physical findings of a meniscal injury determined by physical examination tests (e.g. McMurray’s, Apley’s, Thessaly’s).
• Physical findings of anterior cruciate ligament (ACL) or posterior cruciate ligament (PCL) ligamentous injury determined by the drawer test, pivot shift test, or the Lachman test.
• Physical findings of medial collateral ligament (MCL) or lateral collateral ligament (LCL) ligamentous injury determined by significant laxity on varus or valgus stress tests (Bennett, 2012; Mohankumar, 2014; Tuite, 2014).

**Additional indications specifically for HIP MRI:**
- For evaluation of suspected slipped capital femoral epiphysis with non-diagnostic imaging (Hesper, 2017).
- For evaluation of patient with hip prosthesis or other implanted metallic hardware where prosthetic loosening or dysfunction is suspected on physical examination or imaging (Fritz, 2014).
- Suspected labral tear of the hip (Naraghi, 2015; Ward, 2013).

**ADDITIONAL INFORMATION RELATED TO A LOWER EXTREMITY MRI:**

*Conservative Therapy:* (musculoskeletal) should include a multimodality approach consisting of a combination of active and inactive components. Inactive components such as rest, ice, heat, modified activities, medical devices, (such as crutches, immobilizer, metal braces, orthotics, rigid stabilizer or splints, etc and not to include neoprene sleeves), medications, injections (bursal, and/or joint, not including trigger point), and diathermy, can be utilized. Active modalities may consist of physical therapy, a physician supervised home exercise program**, and/or chiropractic care.

**Home Exercise Program - (HEP)** – the following two elements are required to meet guidelines for completion of conservative therapy:
- Information provided on exercise prescription/plan AND
- Follow up with member with information provided regarding completion of HEP (after suitable 4 week period), or inability to complete HEP due to physical reason i.e. increased pain, inability to physically perform exercises. (Patient inconvenience or noncompliance without explanation does not constitute “inability to complete” HEP).

**MRI and Knee Trauma** - MRI is an effective means of evaluating internal derangements of the knee with a very high accuracy for detection of meniscal injury. On MRI of the knee, meniscal injury may appear “free-floating”, corresponding to a meniscal avulsion or detachment from the tibial plateau. The floating meniscus seen on MRI is a result of significant trauma. It may also be associated with significant ligamentous injury. The results of the MRI are valuable to the surgeon as he plans to reattach the meniscus to the tibial plateau.

**MRI and Osteonecrosis** – Osteonecrosis is a complication of knee surgery which may be accompanied by new or persistent pain after meniscal surgery. It can be detected by MRI with subcortical low signal intensity of T1-weighted images with or without central high signal intensity on T2-weighted images. Osteonecrosis can result in collapse of the articular surface.

**MRI and Legg-Calve-Perthes Disease (LPD)** – This childhood condition is associated with an insufficient blood supply to the femoral head which is then at risk for osteonecrosis. Clinical signs of LPD include a limp with groin, thigh or knee pain. Flexion and adduction contractures may develop as the disease progresses and eventually movement may only occur in the flexion-extension plane. This condition is staged based on plain radiographic findings. MRI is used in identifying the early stage of LPD when plain films are normal. It is also used in preoperative planning to diagnose “hinge abduction” (lateral side of the femoral head contacts the acetabular margin and femoral head does not slide as it should). However, MRI is not used as a standard diagnostic tool.
**MRI and Septic Arthritis** – Young children and older adults are the most likely to develop septic arthritis in the hip joint. Early symptoms include pain in the hip, groin, or thigh along with a limping gait and fever. It is sometimes hard to differentiate this condition from transient synovitis, a less serious condition with no known long-term sequelae. MRI may help in the differential diagnosis of these two conditions. Coronal T1-weighted MRI, performed immediately after contrast administration, can evaluate blood perfusion at the femoral epiphysis.

**MRI and Slipped Capital Femoral Epiphysis** – This condition, where the femoral head is displaced in relation to the femoral neck, is the most common hip disorder in adolescents and it is more common in obese children. Its symptoms include a limping gait, groin pain, thigh pain and knee pain. Most cases are stable and the prognosis is good with early diagnosis and treatment. Unstable slipped capital femoral epiphysis may lead to avascular necrosis. MRI is used for diagnosis of slipped capital femoral epiphysis. Its image can be oriented to a plane orthogonal to the plane of the physis to detect edema in the area of the physis.

**MRI and Tarsal Coalition** – This is a congenital condition in which two or more bones in the midfoot or hindfoot are joined. It usually presents during late childhood or late adolescence and is associated with repetitive ankle sprains. Mild pain, deep in the subtalar joint and limited range of motion are clinical symptoms. Tarsal coalition is detectable on oblique radiographs, but these are not routinely obtained at many institutions. Clinical diagnosis is not simple; it requires the expertise of skilled examiners. MRI is valuable in diagnosing tarsal coalition because it allows differentiation of osseous from non-osseous coalitions and also depicts the extent of joint involvement as well as degenerative changes. It may also detect overgrowth of the medial aspect of the talus that may be associated with talocalcaneal coalitions.

**MRI and Tarsal Tunnel** – Tarsal Tunnel Syndrome is due to compression of the posterior tibial nerve as it passes through the tarsal tunnel into the foot. Compression can cause a sensation of burning or numbness to the bottom of the foot. Common causes include flat foot, over-protonation, and arthritis. Nerve conduction studies can reveal damage to the posterior tibial nerve. MRI may be valuable in demonstrating other structures causing extrinsic compression on the nerve.

**The American Medical Society for Sports Medicine “Choosing Wisely” Guidelines** advise against ordering a knee MRI for a patient with anterior knee pain without mechanical symptoms or effusion unless the patient has not improved following completion of an appropriate functional rehabilitation program. “The most common cause of anterior knee pain is patellofemoral pain syndrome. Magnetic resonance imaging (MRI) is rarely helpful in managing this syndrome. Treatment should focus on a guided exercise program to correct lumbopelvic and lower limb strength and flexibility imbalances. If pain persists, if there is recurrent swelling or if mechanical symptoms such as locking and painful clicking are present, and radiographs are non-diagnostic, an MRI may be useful.”

**The American Academy of Pediatrics “Choosing Wisely” Guidelines** advise against ordering advanced imaging studies (MRI or CT) for most musculoskeletal conditions in a child until all appropriate clinical, laboratory and plain radiographic examinations have been completed. “History, physical examination, and appropriate radiographs remain the primary diagnostic modalities in pediatric orthopaedics, as they are both diagnostic and prognostic for the great majority of pediatric musculoskeletal conditions. Examples of such conditions would include, but not be limited to, the work up of injury or pain (spine, knees and ankles), possible infection, and deformity. MRI examinations and other advanced imaging studies frequently require sedation in the young child (5 years old or less), and may not result in appropriate interpretation if clinical correlations cannot be made. Many conditions require specific MRI sequences or protocols best ordered by the specialist who will be treating the patient... if you...”
believe findings warrant additional advanced imaging, discuss with the consulting orthopaedic surgeon to make sure the optimal studies are ordered.
REFERENCES


INTRODUCTION:

Magnetic resonance angiography (MRA) is a noninvasive alternative to catheter angiography for evaluation of vascular structures in the lower extremity. Magnetic resonance venography (MRV) is used to image veins instead of arteries. MRA and MRV are less invasive than conventional x-ray digital subtraction angiography.

A request for MR Angiography includes standard MRI imaging. An authorization for MRI in addition to MRA is not required.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR LOWER EXTREMITY MRA/MRV:

For assessment/evaluation of suspected or known vascular disease/condition:
- Significant ischemia in the presence of ulcers/gangrene (Weiss, 2018).
- Large vessel diseases, e.g., aneurysm, dissection, arteriovenous malformations (AVMs), fistulas, intramural hematoma, and vasculitis.
- Arterial entrapment syndrome (Hai, 2008).
- Venous thrombosis after non-diagnostic ultrasound (Hanley, 2013).
- Vascular invasion or displacement by tumor (Kransdorf, 2017).
- Pelvic vein thrombosis or thrombophlebitis (Hanley, 2013; Karande, 2016).
- Abnormal preliminary testing (ankle/brachial index, ultrasound/doppler arterial evaluation) associated with significant symptoms of claudication with exercise (Ahmed, 2017).
- For evaluation of traumatic injuries to the lower extremity with clinical findings suggestive of arterial injury (Tuite, 2018).

Pre-operative/procedural evaluation:
- Pre-operative evaluation for a planned surgery or procedure (Ahmed, 2017).

Post-operative/procedural evaluation:
- Post-operative or interventional vascular procedure for luminal patency versus re-stenosis (due to atherosclerosis, thromboembolism, intimal hyperplasia and other causes), as well as complications such as pseudoaneurysms related to surgical bypass grafts and vascular stents and stent-grafts (Lopera, 2008).
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

ADDITIONAL INFORMATION RELATED TO LOWER EXTREMITY MRA/MRV:
**MRA of Foot** – Fast contrast-enhanced time-resolved 3D MR angiography is used in evaluating the arterial supply of the foot. It does not require the use of ionizing radiation and iodinated contrast medium and it is minimally invasive, safe, fast, and accurate. Dorsalis pedis bypass surgery is an option for preserving a foot in a patient with arterial occlusive disease and MRA may be used in the preoperative evaluation. It can discriminate arteries from veins and can provide other key information, e.g., patency of the pedal arch, presence of collateral pathways, and depiction of target vessel suitable for surgical bypass. Time-resolved gadolinium enhanced MRA can identify injured fat pads in the foot before they have become ulcerated.

**MRA and arterial obstructive disease** – Catheter angiography is the standard of reference for assessing arterial disease but MRA with contrast enhanced media has gained acceptance and can image the entire vascular system. Contrast agents such as high dose gadolinium have been associated with the development of nephrogenic systemic fibrosis in patients with chronic renal insufficiency. Gadolinium dosage may be decreased without compromising image quality in high-spatial-resolution contrast-enhanced MRA of the lower extremity.
REFERENCES


INTRODUCTION:

CT provides direct visualization of anatomic structures in the abdomen and pelvis and is a fast imaging tool used to detect and characterize diseases involving the abdomen and pelvis. Abdominal imaging begins at the diaphragm and extends to the umbilicus or iliac crests. CT uses x-rays and multiple detectors to create cross sectional images of the normal anatomy, as well as demonstrate abnormal soft tissue densities, calcifications or fluid/gas patterns in the viscera or peritoneal space.

In general, ionizing radiation from CT should be avoided during pregnancy. Ultrasound is clearly a safer imaging option and is the first imaging test of choice, although CT after equivocal ultrasound has been validated for diagnosis. Clinicians should exercise increased caution with CT imaging in children, pregnant women, and young adults due to the risks of exposure to ionizing radiation. Screening for pregnancy as part of a work-up is suggested to minimize the number of unexpected radiation exposures for women of childbearing age.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR ABDOMEN CT:

Evaluation of suspicious known mass/tumors (unconfirmed diagnosis of cancer) for further evaluation of indeterminate or questionable findings:
- Initial evaluation of suspicious masses/tumors found only in the abdomen by physical exam or imaging study, such as ultrasound (US) (ACR, 2014).
- Surveillance: One follow-up exam to ensure no suspicious change has occurred in a tumor in the abdomen. No further surveillance CT unless tumor(s) are specified as highly suspicious, or change was found on last follow-up CT, new/changing sign/symptoms or abnormal lab values.

Evaluation of known cancer for further evaluation of indeterminate or questionable findings, identified by physical examination or imaging exams such as ultrasound (US):
- Initial staging of known cancer
  - All cancers, excluding the following:
    - Basal cell carcinoma of the skin (NCCN, 2018).
    - Melanoma without symptoms or signs of metastasis (NCCN, 2018; Trotter, 2013).
- Follow-up of known cancer (NCCN, 2018):
  - Follow-up of known cancer of patient undergoing active treatment within the past year.
  - Known cancer with suspected abdominal metastasis based on a sign, symptom or an abnormal lab value.
  - Active monitoring for recurrence as clinically indicated.

For evaluation of an organ or abnormality seen on previous imaging:
- For the evaluation of an organ enlargement such as splenomegaly or hepatomegaly as evidenced by physical examination or confirmed on any previous imaging study.
For evaluation of suspected infection or inflammatory disease (ACR, 2013; Cartwright, 2015; McKay, 2007):
- Suspected acute appendicitis (or severe acute diverticulitis) in an adult if abdominal pain and tenderness to palpation is present, and at LEAST one of the following:
  - WBC elevated
  - Fever
  - Anorexia or
  - Nausea and vomiting.
- Suspected appendicitis in a child after ultrasound has been obtained (Choosing Wisely, ACR/AAP/ACS).
- Suspected peritonitis (from any cause) if abdominal pain and tenderness to palpation is present, and at LEAST one of the following:
  - Rebound, rigid abdomen, or
  - Severe tenderness to palpation present over entire abdomen.
- Suspected pancreatitis: can have pancreatitis without abnormally elevated amylase and lipase (Mathur, 2015).
- Suspected inflammatory bowel disease (Crohn’s or ulcerative colitis) with abdominal pain, and persistent diarrhea, or bloody diarrhea.
- Suspected cholecystitis or retained gallstones with recent equivocal ultrasound.
- Suspected infection in the abdomen (based on elevated WBC, fever, anorexia, or nausea and vomiting).

For evaluation of known infection or inflammatory disease follow up (ACR, 2013; Cartwright, 2015; McKay, 2007):
- Complications of diverticulitis with severe abdominal pain or severe tenderness or mass, not responding to antibiotic treatment, (prior imaging study is not required for diverticulitis diagnosis).
- Pancreatitis by history, (including pancreatic pseudocyst) with abdominal pain suspicious for worsening, or re-exacerbation.
- Known inflammatory bowel disease (Crohn’s or ulcerative colitis) with recurrence or worsening signs/symptoms requiring re-evaluation.
- Any known infection that is clinically suspected to have created an abscess in the abdomen.
- Any history of fistula limited to the abdomen that requires re-evaluation, or is suspected to have recurred.
- Abnormal fluid collection seen on prior imaging that needs follow-up evaluation.
- Follow up for peritonitis (from any cause) if abdominal/pelvic pain and tenderness to palpation is present, and at LEAST one of the following:
  - Rebound, rigid abdomen, or
  - Severe tenderness to palpation present over entire abdomen.
- Hepatitis/hepatoma screening after ultrasound is abnormal, equivocal, or non-diagnostic (Bruix, 2011; Marquardt, 2016). (No literature supports the use of AFP alone in the screening of HCC).
- Known infection in the abdomen.

For evaluation of known or suspected vascular disease (e.g., aneurysms or hematomas) (Khosa, 2011; Ubero, 2011)**:
- Evidence of vascular abnormality seen on imaging studies.
- Evaluation of suspected or known aneurysm limited to abdomen or in evaluating abdominal extent of aortic aneurysm**
  - Suspected or known aneurysm > 2.5 cm AND equivocal or indeterminate ultrasound results OR
- Prior imaging (e.g. ultrasound) demonstrating aneurysm >2.5 cm in diameter OR
- Suspected complications of known aneurysm as evidenced by clinical findings such as new onset of abdominal pain.

- Scheduled follow-up evaluation of aorto/iliac endograft or stent (Aabd/Pelvis CTA is preferred)
  - Asymptomatic at six (6) month intervals, for two (2) years
  - Symptomatic/complications related to stent graft – more frequent imaging may be needed
- Suspected retroperitoneal hematoma or hemorrhage.

For evaluation of trauma (ACR, 2012):
- For evaluation of trauma with lab or physical findings of intra-abdominal bleeding limited to the abdomen.
- Suspected retroperitoneal hematoma or hemorrhage.

Pre-operative evaluation:
- For abdominal surgery or procedure.

Post-operative/procedural evaluation:
- Follow-up of known or suspected post-operative complication involving only the abdomen.
- A follow-up study to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:
- ≤5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.

Other Indications for an Abdomen CT:
- Suspected adrenal mass based on diagnostic testing/imaging results, and/or a suspicious clinical presentation. (Biopsy or FDG PET is recommended when pheochromocytoma is not suspected, the mass is > 4 cm, AND there is a history of primary malignancy (ACR, 2012)).
- Persistent abdominal pain not explained by previous imaging/procedure
- Unexplained weight loss of 10% of body weight in two months (patient history is acceptable); with a second MD visit documenting some further decline in weight.
- Unexplained weight loss of 5% of body weight in six months confirmed by documentation to include the following (Bosch, 2017; Wong, 2014).
  - Related history and abdominal exam.
  - Chest x-ray
  - Abdominal Ultrasound
  - Lab tests, must include TSH
  - Colonoscopy if patient fifty plus (50+) years old
- Unexplained abdominal pain in patients seventy-five (75) years or older (USPSTF does not recommend screening colonoscopy in patients over 75).
- Suspected spigelian hernia (ventral hernia) or incisional hernia (evidenced by a surgical abdominal scar) when ordered as a pre-operative study OR when physical exam or prior imaging (e.g. ultrasound) is non-diagnostic or equivocal (Lassandro, 2011) OR ultrasound is contraindicated due to obesity.
- Hernia with suspected complications (e.g. bowel obstruction or strangulation) or prior to surgical repair OR when physical exam or prior imaging (e.g. ultrasound) is non-diagnostic or equivocal (Lassandro, 2011) OR ultrasound is contraindicated due to obesity.
- Ischemic bowel.
- Suspected complete or high-grade partial small bowel obstruction limited to the abdomen.

**Combination of studies with Abdomen CT:**
- **Abdomen CT/Pelvis CT/Chest CT/Neck MRI/Neck CT with MUGA** – known tumor/cancer for initial staging or evaluation before starting chemotherapy or radiation treatment.

**If an Abdomen/Pelvis CT combo is indicated and the Abdomen CT has already been approved, then the Pelvis CT may be approved.**

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**ADDITIONAL INFORMATION RELATED TO ABDOMEN CT:**

**Combination studies for suspected appendicitis, peritonitis, diverticulitis, or inflammatory bowel disease (IBD):**
- Combined Abdomen CT and Pelvis CT is usually ordered
- There are situations that a combo Abd/Pelvis CT was not ordered such as Pelvis CT previously approved and separate subsequent request for Abdomen CT, etc.

**Ultrasound should be considered prior to a request for Abdomen CT for the following evaluations:**
- Possible gallstones or abnormal liver function tests with gall bladder present.
- Evaluation of cholecystitis.
- Repeat CT studies of renal mass.
- Repeat CT Hepatic mass follow-up.
- Repeat CT for aortic aneurysm.

**Screening for Hepatocellular carcinoma (HCC):** AASLD (American Association for the Study of Liver Diseases) recommends screening for HCC with ultrasound every 6 months for patients with hepatitis C and B (Bruix, 2011). The literature differs on the role of AFP (alpha fetoprotein) in the screening of HCC. Some authors argue against its use altogether due to its lack of sensitivity and specificity in detecting HCC (Bruix, 2011; Marquardt, 2016) and instead recommend ultrasound alone for screening. According to Marquardt the AASLD and EASLD (European Association for the Study of the Liver) “do not endorse its [AFP] use in clinical routine, neither alone nor in combination with ultrasound”. This approach is supported by reports of patients with chronic viral hepatitis and elevated AFP but normal livers on imaging. AFP elevation in these cases is due to hepatic inflammation and viral replication (Patil, 2013), not neoplasm. Others advocate for combined ultrasound and AFP for screening (Tzartzeva, 2018; Tan, 2011) citing increased sensitivity compared to ultrasound alone in detecting early stage HCC particularly in cirrhotic patients. In a meta-analysis by Tzartzeva, et al of thirty-two studies (13,367 patients with cirrhosis), ultrasound with AFP had a 63% sensitivity of detecting early stage HCC, compared to 45% for ultrasound alone. In the final analysis, no literature supports the use of AFP alone in the screening of HCC.

**CT for organ enlargement** - An abd/pelvis combo is most appropriate because it will demonstrate the kidneys and the ureters. Other organs may require an Abdomen CT or Pelvis CT only.

**CT for suspected renal stones** - An initial CT study is done to identify the size of the stone and rule out obstruction. *(7 mm is the key size: less than that size the expectation is that it will pass)*. After the initial CT study for kidney stone is done, the stone can be followed by x-ray or US (not CT). If a second exacerbation occurs/a new stone is suspected another CT would be indicated to access the size of stone and rule out obstruction.
CT Imaging for renal colic and hematuria: CT protocols include: “stone protocol” for detecting urinary tract calculi, “renal mass protocol” for characterizing known renal masses, and CT urography for evaluating hematuria. Non-contrast CT can be used for detecting most ureteral and renal stones, but sometimes an intravenous contrast agent is needed to determine the relationship of the calculus to the opacified ureter. CT is an effective imaging examination for diagnosing hematuria caused by urinary tract calculi, renal tumors, and urothelial tumors.

CT Imaging for abdominal aortic aneurysms (AAA): If a pulsatile abdominal mass is found in an asymptomatic patient, abdominal ultrasonography is an inexpensive and noninvasive technique for initial evaluation. For further examination, CT may be performed to better define the shape and extent of the aneurysm and the local anatomic relationships of the visceral and renal vessels. CT has high level of accuracy in sizing aneurysms. CT angiography is not routinely required to assess abdominal aortic aneurysms and the decision to utilize conventional CT or CT angiography is based on factors unique to the individual case.

Risk of rupture in 6 years for an AAA < 4 cm is 1%. For a 4-5 cm AAA the risk of rupture increases to 1-3% per year and becomes 6-11% per year for AAA 5-7 cm in cross sectional diameter. >7 cm the risk of rupture goes to 7% per year.

**Abdominal aneurysms and general guidelines for follow-up:**
The normal diameter of the suprarenal abdominal aorta is 3.0 cm and that of the infrarenal is 2.0 cm. Aneurysmal dilatation of the infrarenal aorta is defined as diameter >/= 3.0 cm or dilatation of the aorta >/= 1.5x the normal diameter. Initial evaluation of AAA is accurately made by ultrasound. Ultrasound can detect and size AAA, with the advantage of being relatively inexpensive, noninvasive, and not require iodinate contrast. The limitations are that overlying bowel gas can obscure findings and the technique is operator dependent.

Recommended intervals for initial follow-up imaging (any modality) of ectatic aortas and abdominal aortas (follow up intervals may vary depending on comorbidities and the growth rate of the aneurysm):
- 2.5-2.9 cm: ..........5yr
- 3.0-3.4 cm: .......... 3yr
- 3.5-3.9 cm: ..........2yr
- 4.0-4.4 cm: ..........1yr
- 4.5-4.9 cm: ............6 mo
- 5.0-5.5 cm: ............3-6 mo

The Society of Vascular Surgery has different follow up intervals for AAA (SVS, 2018):
- >2.5 cm - <3 cm........10 yr
- 3.0 - 3.9 cm............3 yr
- 4.0 - 4.9 cm.............12 mo
- 5.0 - 5.4 cm............6 mo.

The Society of Vascular Surgery recommends elective repair of AAA >/= 5.5 cm in patients at low or acceptable surgical risk (Chaikof, 2018).

CTA is not always the study of choice to following an aneurysm. Clinicians interested in documenting size in asymptomatic patient without the concern for complications or branch vessel patency may chose a non-contrast CT.
Combination request of Abdomen CT/Chest CT - A Chest CT will produce images to the level of L3. Documentation for combo is required.

REDUCING RADIATION EXPOSURE:

CT urography - Utilization of appropriate imaging techniques can reduce radiation exposure in performance of CT urography. Some protocols may result in 15-35 mSv of exposure. In the article by Chow, et al. a technique involving administration of IV contrast in two boluses separated by a suitable time delay, allows nephrographic and excretory phases to be acquired in a single imaging pass. This allows for full non-contrast and contrast imaging to be obtained with two imaging passes.

Evaluation for appendicitis following clinical and laboratory evaluation - Sonography of the right upper quadrant and pelvis followed by graded compression and color Doppler sonography of the right lower quadrant was used by Gaitini and colleagues as the initial imaging study in 420 consecutive patients referred for emergency evaluation of acute appendicitis. This method correctly diagnosed acute appendicitis in 66 of 75 patients (88%) and excluded it correctly in 312 of 326 patients (96%). It was inconclusive in 19 patient (<5%). Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 74.2%, 97%, 88%, 93%, and 92%, respectively and comparable to CT. Appropriate and timely diagnosis of acute appendicitis is needed. Negative laparotomy rates can range from 16% to 47% when based on clinical and laboratory data alone, while perforation rate can reach 35% when surgery is delayed. Appropriate initial imaging can lower the negative laparotomy rate to 6-10%. Ultrasound has a higher non-diagnostic rate, 4% vs. 0.8% for MDCT. In a prospective study operator experience and patient BMI did not affect diagnostic accuracy.

Consider the role of barium contrast studies - Effective doses for fluoroscopic SBFT (small bowel follow through) imaging ranged between 1.37-3.83 mSv for the right lower quadrant, central abdomen and pelvis, respectively. The findings by Jaffe, et al suggest a modified examination for Crohn’s disease indications would have lower effective doses than these. For MDCT the effective dose was 16.1 mSv. This indicates a 5 fold increase in the use of MDCT over SBFT. For patients with Crohn’s disease, efforts should be made to minimize the number of CT examinations, decrease the CT dose or consider MR Enterography. Limitations of SBFT include partial evaluation of extramucosal and extraluminal disease, impaired evaluation of small-bowel loops, especially those inaccessible in the deep pelvis.

Consider the role of capsule endoscopy - Retrospective comparison of capsule endoscopy (CE) to CT in patients with no evidence of a small-bowel stricture at barium examination was the focus of the article by Hara, et al. Studies were done for bleeding of unknown origin after colonoscopy and/or Gastroenterologist, inflammatory bowel disease or chronic abdominal pain. CE was found to be more sensitive than CT examination in the 19 patients that underwent both. CE provides a complimentary and sensitive approach to the evaluation of the small bowel without radiation exposure. A negative examination does not completely rule out pathology.

Work up for distant metastasis in the initial evaluation of melanoma - Multiple studies, including the two authored by Miranda and Yancovitz, indicate that imaging studies including Chest x-ray, Chest CT, Abdomen/Pelvis CT, Brain CT or Brain MRI in the absence of symptoms or findings of metastatic disease have extremely low yields (< 1%) in the survey evaluation of newly diagnosed melanoma, even in the presence of a positive sentinel node biopsy. The further work-up of the more common benign incidental finding (5-7%) on these studies lead to many more diagnostic tests, including surgery, which are seldom warranted.
Initial evaluation of abdominal aortic aneurysm (AAA) - Initial evaluation of AAA is accurately made by ultrasound. Risk of rupture in 6 years for an AAA < 4 cm is 1%. For a 4-5 cm AAA the risk of rupture increases to 1-3% per year and becomes 6-11% per year for AAA 5-7 cm in cross sectional diameter. >7 cm the risk of rupture goes to 7% per year. Chronic contained ruptures should meet the following criteria- known abdominal aortic aneurysm, previous pain symptoms that may have resolved; stable hemodynamic status with a normal HCT, CT scans showing retroperitoneal hemorrhage, and pathologic confirmation of organized hematoma.

Initial evaluation of adnexal masses - MRI is a sensitive and specific modality for evaluation of adnexal masses in comparison to CT. While improved diagnostic accuracy of MRI was not shown to be statistically significant in the study there was a trend to more accurate results with MRI over multi-detector (16-row) CT.

Evaluation for recurrence of ovarian cancer metastases - MRI was noted to be superior to PET/CT (with non-contrast CT) in the detection of recurrence of ovarian cancer in a small study (36 patients).

Pre-operative evaluation of primary rectal cancer - Abdomen CT may detect hepatic and extra-hepatic disease relevant to decision making and prognosis in rectal cancer but complete imaging through the pelvis does not add useful information. The area of the pelvis in pre-operative evaluation of rectal cancer is better defined by Pelvis MRI.

Imaging of hernias: Most hernias are diagnosed clinically with imaging recommended for the diagnosis of occult hernias or in the evaluation of hernia complications such as bowel obstruction or strangulation. To detect occult hernias, ultrasound is a first line study with a sensitivity of 86% and specificity of 77% compared to 80% sensitivity and 65% specificity for CT (Robinson, 2013). According to Miller, et al “Magnetic resonance imaging is generally not considered a first- or even second-line evaluation modality for hernias...” (Miller, 2014). Based on this analysis MRI is recommended only when ultrasound and CT have been performed and fail to make a diagnosis.
REFERENCES


CPT Codes: 74174

INTRODUCTION:

Computed tomographic angiography (CTA) is used in the evaluation of many conditions affecting the veins and arteries of the abdomen and pelvis or lower extremities. This study (Abdomen/Pelvis CTA) is useful for evaluation of the arteries/veins in the peritoneal cavity (abdominal aorta, iliac arteries) while the Abdominal Arteries CTA is more useful for the evaluation of the abdominal aorta and the vascular supply to the legs. It is not appropriate as a screening tool for asymptomatic patients without a previous diagnosis.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR ABDOMEN/PELVIS CTA:

For evaluation of known or suspected abdominal vascular disease:
- For known large vessel diseases (abdominal aorta, inferior vena cava, superior/inferior mesenteric, celiac, splenic, renal or iliac arteries/veins), e.g., aneurysm, dissection, arteriovenous malformations (AVMs), and fistulas, intramural hematoma, and vasculitis.
- Evidence of vascular abnormality seen on prior imaging studies.
- For suspected aortic dissection.
- Evaluation of known or suspected aortic aneurysm (Khosa, 2013; Chaikof, 2018)**:
  - Known or suspected aneurysm > 2.5 cm AND equivocal or indeterminate ultrasound results OR
  - Prior imaging (e.g. ultrasound) demonstrating aneurysm >2.5 cm in diameter OR
  - Suspected complications of known aneurysm as evidenced by signs/symptoms such as new onset of abdominal or pelvic pain.
- Suspected retroperitoneal hematoma or hemorrhage (To determine vascular source of hemorrhage in setting of trauma, tumor invasion, fistula or vasculitis; otherwise CT (rather than CTA) is sufficient and the modality of choice for diagnosing hemorrhage).
- Lower gastrointestinal hemorrhage: Active bleeding in a hemodynamically stable patient or non localized intermittent bleeding as an alternative to Tc-99m RBC scan when colonoscopy did not localize the bleeding, is contraindicated or unavailable (ACR, 2014; Clerc, 2017).
- Venous thrombosis if previous studies have not resulted in a clear diagnosis.
- For evaluation of suspected mesenteric ischemia (ACR, 2012).
- Vascular invasion or displacement by tumor (Conventional CT or MRI also appropriate) (Certik, 2015; Kaufman, 2005).
- For evaluation of known or suspected renal artery stenosis or resistant hypertension in the setting of normal renal function or impaired renal function unrelated to recent medication (ACR, 2017) demonstrated by any of the following (Hartman, 2009; Tullus, 2010):
  - Unsuccessful control after treatment with 3 or more (>2) anti-hypertensive medication at optimal dosing.
  - Acute elevation of creatinine after initiation of an angiotensin converting enzyme inhibitor, (ACE inhibitor) or angiotensin receptor blocker, (ARB).
  - Asymmetric kidney size noted on ultrasound.
- Onset of hypertension in a person younger than age 30 without any other risk factors or family history of hypertension.
- Significant hypertension (diastolic blood pressure > 110 mm Hg) in a young adult (i.e., younger than 35 years) suggestive of fibromuscular dysplasia.
- Diagnosis of a syndrome with a higher risk of vascular disease, such as neurofibromatosis, tuberous sclerosis and Williams’ syndrome.
- New onset of hypertension after age 50.
- Acute rise in blood pressure in a person with previously stable blood pressures.
- Flash pulmonary edema without identifiable causes.
- Malignant hypertension.
- Bruit heard over renal artery and hypertension.

**Pre-operative evaluation:**
- Evaluation of interventional vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.

**Post-operative or post-procedural evaluation:**
- Evaluation of endovascular/interventional abdominal vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism and intimal hyperplasia.
- Evaluation of post-operative complications, e.g. pseudoaneurysms, related to surgical bypass grafts, vascular stents and stent-grafts in the peritoneal cavity.
- Follow-up for post-endovascular repair (EVAR) or open repair of abdominal aortic aneurysm (AAA) or abdominal extent of iliac artery aneurysms. Routine, baseline study (post-op/intervention) is warranted within 1-3 months (Chaikof, 2018; Uberoi, 2011).
  - Asymptomatic at six (6) month intervals, for one (1) year, then annually.
  - Symptomatic/complications related to stent graft – more frequent imaging may be needed.
- Follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

**Chest CTA/Abdomen/Pelvis CTA combo:**
- For evaluation of extensive vascular disease involving the chest and abdominal cavities such as aortic dissection, vasculitic diseases such as Takayasu’s arteritis, significant post-traumatic or post-procedural vascular complications, etc.
- For preoperative or preprocedural evaluation such as transcatheter aortic valve replacement (TAVR).

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**ADDITIONAL INFORMATION RELATED TO ABDOMEN/PELVIS CTA:**

**Abd/Pelvis CTA & Lower Extremity CTA Runoff Requests:** Only one authorization request is required, using CPT Code 75635 Abdominal Arteries CTA. This study provides for imaging of the abdomen, pelvis, and both legs. The CPT code description is CTA aorto-iliofemoral runoff: abdominal aorta and bilateral ilio-femoral lower extremity runoff.

**Bruit** - blowing vascular sounds heard over partially occluded blood vessels. Abdominal bruits may indicate partial obstruction of the aorta or other major arteries such as the renal, iliac, or femoral arteries. Associated risks include but are not limited to: renal artery stenosis, aortic aneurysm, atherosclerosis, AVM, or coarctation of aorta.
Peripheral Artery Disease (PAD) – Before the availability of computed tomography angiography (CTA), peripheral arterial disease was evaluated using CT and only a portion of the peripheral arterial tree could be imaged. Multi-detector row CT (MDCT) overcomes this limitation and provides an accurate alternative to CT and is a cost-effective diagnostic strategy in evaluating PAD. **Abdominal Arteries CTA (including runoff to the lower extremities) is the preferred study when evaluation of arterial sufficiency to the legs is part of the evaluation.**

CTA and Abdominal Aortic Aneurysm – Endovascular repair is an alternative to open surgical repair of an abdominal aortic aneurysm. It has lower morbidity and mortality rates and is minimally invasive. In order to be successful, it depends on precise measurement of the aneurysm and involved vessels. CTA with 3D reconstruction is useful in obtaining exact morphologic information on abdominal aortic aneurysms. CTA is also used for the detection of postoperative complications of endovascular repair.

CTA and Abdominal Aortic Aneurysm ** – The normal diameter of the suprarenal abdominal aorta is 3.0 cm and that of the infrarenal is 2.0 cm. Aneurysmal dilatation of the infrarenal aorta is defined as diameter >/= 3.0 cm or dilatation of the aorta >/= 1.5x the normal diameter.

**Recommended intervals for initial follow-up imaging of ectatic aortas and abdominal aortas (follow up intervals may vary depending on comorbidities and the growth rate of the aneurysm) from the white paper of the ACR Incidental Findings Committee II on vascular findings (Khosa, 2013):**

2.5-2.9 cm: ............5yr
3.0-3.4 cm':............3yr
3.5-3.9 cm':............2yr
4.0-4.4 cm':............1yr
4.5-4.9 cm:............6 mo
5.0-5.5 cm':............3-6 mo

The Society of Vascular Surgery has different follow up intervals for AAA (SVS 2018):
>2.5 cm · <3 cm........10 yr
3.0 - 3.9 cm............3 yr
4.0 - 4.9 cm............12 mo
5.0 - 5.4 cm............6 mo.

The Society of Vascular Surgery recommends elective repair of AAA >/= 5.5 cm in patients at low or acceptable surgical risk (Chaikof, 2018).

**CTA and Renal Artery Stenosis** – Renal artery stenosis is the major cause of secondary hypertension. It may also cause renal insufficiency and end-stage renal disease. **Abdomen CTA (limiting evaluation to the aorta above the bifurcation and including the abdominal arteries) is the preferred study.** Atherosclerosis is one of the common causes of this condition, especially in older patients with multiple cardiovascular risk factors and worsening hypertension or deterioration of renal function. CTA is used to evaluate the renal arteries and detect renal artery stenosis.

**CTA and Thoracic Aorta Endovascular Stent-Grafts** – CTA is an effective alternative to conventional angiography for postoperative follow-up of aortic stent grafts. It is used to review complications after thoracic endovascular aortic repair. CTA can detect luminal and extraluminal changes to the thoracic aortic after stent-grafting and can be performed efficiently with fast scanning speed and high spatial and temporal resolution.
**MRI/CT and acute hemorrhage**: MRI is not indicated and MRA/MRV (MR Angiography/Venography) is rarely indicated for evaluation of intraperitoneal or retroperitoneal hemorrhage, particularly in the acute setting. CT is the study of choice due to its availability, speed of the study and less susceptibility to artifact from patient motion. Advances in technology have allowed conventional CT to not just detect hematomas but also the source of acute vascular extravasation. In special cases finer vascular detail to assess the specific source vessel responsible for hemorrhage may require the use of CTA. CTA in diagnosis of lower gastrointestinal bleeding is such an example (Clerc, 2017).

MRA/MRV is often utilized in non acute situations to assess vascular structure involved in atherosclerotic disease and its complications, vasculitis, venous thrombosis, vascular congestion or tumor invasion. Although some of these conditions may be associated with hemorrhage, it is usually not the primary reason why MRI/MRA/MRV is selected for the evaluation. A special condition where MRI may be superior to CT for evaluating hemorrhage is to detect an underlying neoplasm as the cause of bleeding (Abe, 2010).
REFERENCES


INTRODUCTION:

Computed tomography angiography (CTA) generates images of the arteries that can be evaluated for evidence of stenosis, occlusion, or aneurysms. It is used to evaluate the arteries of the abdominal aorta and the renal arteries. CTA uses ionizing radiation and requires the administration of iodinated contrast agent which is a potential hazard in patients with impaired renal function. Abdominal CTA is not used as a screening tool, e.g. evaluation of asymptomatic patients without a previous diagnosis.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR ABDOMEN CTA:

For evaluation of known or suspected abdominal vascular disease:

- For known large vessel diseases (abdominal aorta, inferior vena cava, superior/inferior mesenteric, celiac, splenic, renal, or iliac arteries/veins), e.g., aneurysm, dissection, arteriovenous malformations (AVMs), and fistulas, intramural hematoma, and vasculitis.
- Evidence of vascular abnormality seen on prior imaging studies.
- For suspected aortic dissection.
- Evaluation of known or suspected aortic aneurysm (Khosa, 2013; Chaikof, 2018)**:
  - Known or suspected aneurysm > 2.5 cm AND equivocal or indeterminate ultrasound results OR
  - Prior imaging (e.g. ultrasound) demonstrating aneurysm >2.5 cm in diameter OR
  - Suspected complications of known aneurysm as evidenced by signs/symptoms such as new onset of abdominal or pelvic pain.
- Suspected retroperitoneal hematoma or hemorrhage (To determine vascular source of hemorrhage in setting of trauma, tumor invasion, fistula or vasculitis; otherwise CT (rather than CTA) is sufficient and the modality of choice for diagnosing hemorrhage).
- Suspected renal vein thrombosis in patient with known renal mass.
- For evaluation of suspected mesenteric ischemia (ACR, 2012).
- Venous thrombosis if previous studies have not resulted in a clear diagnosis.
- Vascular invasion or displacement by tumor.
- For evaluation of portal venous system (hepatic portal system) after doppler ultrasound has been performed.
- For evaluation of known or suspected renal artery stenosis or resistant hypertension in the setting of normal renal function or impaired renal function unrelated to recent medication (ACR, 2017) demonstrated by any of the following (Hartman, 2009; Tullus, 2010):
  - Unsuccessful control after treatment with 3 or more (>2) anti-hypertensive medication at optimal dosing.
  - Acute elevation of creatinine after initiation of an angiotension converting enzyme inhibitor (ACE inhibitor) or angiotension receptor blocker (ARB).
  - Asymmetric kidney size noted on ultrasound.
- Onset of hypertension in a person younger than age 30 without any other risk factors or family history of hypertension.
- Significant hypertension (diastolic blood pressure > 110 mm Hg) in a young adult (i.e., younger than 35 years) suggestive of fibromuscular dysplasia
- Diagnosis of a syndrome with a higher risk of vascular disease, such as neurofibromatosis, tuberous sclerosis and Williams’ syndrome
- New onset of hypertension after age 50.
- Acute rise in blood pressure in a person with previously stable blood pressures.
- Flash pulmonary edema without identifiable causes.
- Malignant hypertension.
- Bruit heard over renal artery and hypertension.

Pre-operative evaluation:
- Evaluation prior to interventional vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.

Post-operative or post-procedural evaluation:
- Evaluation of endovascular/interventional abdominal vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.
- Evaluation of post-operative complications, e.g. pseudoaneurysms related to surgical bypass grafts, vascular stents, and stent-grafts in the peritoneal cavity.
- Follow-up for post-endovascular repair (EVAR) or open repair of abdominal aortic aneurysm (AAA) or abdominal extent of iliac artery aneurysms. Routine, baseline study (post-op/intervention) is warranted within 1-3 months (Chaikof, 2018; Uberoi, 2011).
  - Asymptomatic at six (6) month intervals for one (1) year, then annually.
  - Symptomatic/complications related to stent graft – more frequent imaging may be needed.
- Follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

Chest CTA/Abdomen CTA combo:
- For evaluation of extensive vascular disease involving the chest and abdominal cavities such as aortic dissection, vasculitic diseases such as Takayasu’s arteritis, significant post-traumatic or post-procedural vascular complications, etc.
- For preoperative or preprocedural evaluation such as transcatheter aortic valve replacement (TAVR).

ADDITIONAL INFORMATION RELATED TO ABDOMEN CTA:

**Abd/Pelvis CTA & Lower Extremity CTA Runoff Requests:** Only one authorization request is required, using CPT Code 75635 Abdominal Arteries CTA. This study provides for imaging of the abdomen, pelvis, and both legs. The CPT code description is CTA aorto-iliofemoral runoff: abdominal aorta and bilateral ilio-femoral lower extremity runoff.

**CTA and Abdominal Aortic Aneurysm (AAA):**
Endovascular repair is an alternative to open surgical repair of an abdominal aortic aneurysm. It has lower morbidity and mortality rates and is minimally invasive. In order to be successful, it depends on precise measurement of the aneurysm and involved vessels. CTA with 3D reconstruction is useful in obtaining exact morphologic information on abdominal aortic aneurysms. CTA is also used for the detection of postoperative complications of endovascular repair.
**Abdominal Aneurysms and general Guidelines for follow-up:**
The normal diameter of the suprarenal abdominal aorta is 3.0 cm and that of the infrarenal is 2.0 cm. Aneurysmal dilatation of the infrarenal aorta is defined as diameter $\geq 3.0$ cm or dilatation of the aorta $\geq 1.5 \times$ the normal diameter. Initial evaluation of AAA is accurately made by ultrasound. Ultrasound can detect and size AAA, with the advantage of being relatively inexpensive, noninvasive and not require iodinate contrast. The limitations are that overlying bowel gas can obscure findings and the technique is operator dependent.

**Recommended intervals for initial follow-up imaging of ectatic aortas and abdominal aortas** (follow up intervals may vary depending on comorbidities and the growth rate of the aneurysm) from the white paper of the ACR Incidental Findings Committee II on vascular findings (Khosa, 2013):

- 2.5–2.9 cm: ……….5yr
- 3.0–3.4 cm:……….. 3yr
- 3.5–3.9 cm:………..2yr
- 4.0–4.4 cm:..........1yr
- 4.5–4.9 cm:..........6 mo
- 5.0–5.5 cm:..........3–6 mo

The Society of Vascular Surgery has different follow up intervals for AAA (SVS, 2018):

- >2.5 cm - <3 cm:……….10 yr
- 3.0 - 3.9 cm:……………3 yr
- 4.0 - 4.9 cm:…………12 mo
- 5.0 - 5.4 cm:…………..6 mo.

The Society of Vascular Surgery recommends elective repair of AAA $\geq 5.5$ cm in patients at low or acceptable surgical risk (Chaikof, 2018).

**CTA and Renal Artery Stenosis** – Renal artery stenosis is the major cause of secondary hypertension. It may also cause renal insufficiency and end-stage renal disease. Atherosclerosis is one of the common causes of this condition, especially in older patients with multiple cardiovascular risk factors and worsening hypertension or deterioration of renal function. CTA is used to evaluate the renal arteries and detect renal artery stenosis.
REFERENCES


CPT Codes: 74176, 74177, 74178

**INTRODUCTION:**

CT provides direct visualization of anatomic structures in the abdomen and pelvis and is a fast imaging tool used to detect and characterize disease involving the abdomen and pelvis. Abdomen/pelvis imaging begins at the diaphragmatic dome through pubic symphysis. CT uses x-rays and multiple detectors to create cross sectional images of the normal anatomy as well as demonstrate abnormal soft tissue densities, calcifications or fluid/gas patterns in the viscera or peritoneal space.

In general, ionizing radiation from CT should be avoided during pregnancy. Ultrasound is clearly a safer imaging option and is the first imaging test of choice, although CT after equivocal ultrasound has been validated for diagnosis. Clinicians should exercise increased caution with CT imaging in children, pregnant women, and young adults due to the risks of exposure to ionizing radiation. Screening for pregnancy as part of a work-up is suggested to minimize the number of unexpected radiation exposures for women of childbearing age.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

**INDICATIONS FOR ABDOMEN/PELVIS CT:**

**For evaluation of hematuria (Davis, 2012; Sharp, 2013):**
- Hematuria (All hematuria should be documented by greater than 3 RBC per high-power field on urinalysis):
- Hematuria (non-infectious)
- Hematuria (infectious) persisting six weeks after the completion of antibiotic therapy.

**For evaluation of known or suspected kidney or ureteral stones (ACEP, 2014):**
- Delineation of suspected renal calculi or ureteral calculi.
- Known calculi in patients >50 years of age.
- Known renal calculi in patients <50 years of age after ultrasound has been obtained and is non-diagnostic, inconclusive, or shows an abnormality needing further evaluation.

**Evaluation of suspicious known mass/tumors (unconfirmed diagnosis of cancer) for further evaluation of indeterminate or questionable findings:**
- Initial evaluation of suspicious masses/tumors found by physical exam or imaging study, such as ultrasound (US) and both the abdomen and pelvis are likely affected (ACR, 2013, 2014).
- Surveillance: One follow-up exam to ensure no suspicious change has occurred in a tumor in the abdomen and pelvis. No further surveillance CT unless tumor(s) are specified as highly suspicious or change was found on last follow-up CT, new/changing sign/symptoms or abnormal lab values.

**Evaluation of known cancer for further evaluation of indeterminate or questionable findings, identified by physical examination or imaging exams such as ultrasound (US):**
- Initial staging of known cancer
- All cancers, excluding the following:
  - Basal Cell Carcinoma of the skin (NCCN, 2018).
  - Melanoma without symptoms or signs of metastasis (NCCN, 2018; Trotter, 2013).
  - Prostate cancer unless Gleason score seven plus (7+) or PSA over twenty (20) (NCCN, 2017).
- Follow-up of known cancer (NCCN, 2018; Bourgioti, 2016):
  - Follow-up of known cancer of patient undergoing active treatment within the past year.
  - Known cancer with suspected abdominal/pelvic metastasis based on a sign, symptom or an abnormal lab value.
  - Active monitoring for recurrence as clinically indicated.

For evaluation of an organ enlargement:
- For the evaluation of an organ enlargement such as splenomegaly, hepatomegaly, uterus or ovaries as evidenced by physical examination or confirmed on any previous imaging study.

For evaluation of suspected infection or inflammatory disease (ACR, 2013; Cartwright, 2015; McKay, 2007):
- Suspected acute appendicitis (or severe acute diverticulitis) in an adult if abdominal pain and tenderness to palpation is present, and at LEAST one of the following:
  - WBC elevated
  - Fever
  - Anorexia or
  - Nausea and vomiting.
- Suspected appendicitis in a child after ultrasound has been obtained (Choosing Wisely, ACR/AAP/ACS).
- Suspected peritonitis (from any cause) if abdominal pain and tenderness to palpation is present, and at LEAST one of the following:
  - Rebound, rigid abdomen, or
  - Severe tenderness to palpation present over entire abdomen.
- Suspected pancreatitis; can have pancreatitis without abnormally elevated amylase and lipase (Mathur, 2015).
- Suspected complications of diverticulitis (known to be limited to the abdomen/pelvis by prior imaging) with abdominal/pelvic pain or severe tenderness, not responding to antibiotics treatment.
- Suspected inflammatory bowel disease (Crohn’s or ulcerative colitis) with abdominal pain, and persistent diarrhea, or bloody diarrhea.
- Suspected cholecystitis or retained gallstones with recent equivocal ultrasound.
- Suspected infection in abdomen/pelvis (based on elevated WBC, fever, anorexia, or nausea and vomiting).

For evaluation of known infection or inflammatory disease follow up (ACR, 2013; Cartwright, 2015; McKay, 2007):
- Complications of diverticulitis with severe abdominal/pelvic pain or severe tenderness or mass not responding to antibiotic treatment (prior imaging study is not required for diverticulitis diagnosis).
- Pancreatitis by history (including pancreatic pseudocyst) with abdominal pain suspicious for worsening, or re-exacerbation.
- Known inflammatory bowel disease, (Crohn’s or Ulcerative colitis) with recurrence or worsening signs/symptoms requiring re-evaluation.
- Any known infection that is clinically suspected to have created an abscess in the abdomen or pelvis.
- Any history of fistula that requires re-evaluation, or is suspected to have recurred in the abdomen or pelvis.
- Abnormal fluid collection seen on prior imaging that needs follow-up evaluation.
Follow up for peritonitis (from any cause) if abdominal/pelvic pain and tenderness to palpation is present, and at LEAST one of the following:
   o Rebound, rigid abdomen, or
   o Severe tenderness to palpation present over entire abdomen.

Hepatitis/hepatoma screening after ultrasound has been obtained and is abnormal, equivocal or non-diagnostic (Bruix, 2011; Marquardt, 2016). (No literature supports the use of AFP alone in the screening of HCC).

Known infection in the abdomen/pelvis region.

For evaluation of known or suspected vascular disease (e.g., aneurysms or hematomas) (Khosa, 2011; Uberoi, 2011)**:
   - Evidence of vascular abnormality seen on imaging studies.
     - Evaluation of suspected or known aortic aneurysm limited to the abdomen/pelvis or in evaluating abdominal/pelvic extent of aortic aneurysm**:
       - Suspected or known aneurysm > 2.5 cm AND equivocal or indeterminate ultrasound results OR
       - Prior imaging (e.g. ultrasound) demonstrating aneurysm > 2.5 cm in diameter OR
       - Suspected complications of known aneurysm as evidenced by clinical findings such as new onset of abdominal or pelvic pain
   - Scheduled follow-up evaluation of aorto/iliac endograft or stent. (Abd/Pelvis CTA is preferred)
     - Asymptomatic at six (6) month intervals, for two (2) years
     - Symptomatic/complications related to stent graft – more frequent imaging may be needed.
   - Suspected retroperitoneal hematoma or hemorrhage

For evaluation of trauma (ACR, 2012):
   - For evaluation of trauma with lab or physical findings of intra-abdominal/pelvic bleeding.
   - Suspected retroperitoneal hematoma or hemorrhage.

Pre-operative evaluation:
   - For abdominal/pelvic surgery or procedure.

Post-operative/procedural evaluation:
   - Follow-up of known or suspected post-operative complication.
   - A follow-up study to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed.

Indication for combination studies for the initial pre-therapy staging of cancer, OR active monitoring for recurrence as clinically indicated OR evaluation of suspected metastases:
   - ≤5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine, or Lumbar Spine.

Other indications for Abdomen/Pelvic CT Combo:
   - Suspected adrenal mass or pheochromocytoma based on diagnostic testing/imaging results, and/or a suspicious clinical presentation. (Biopsy or FDG PET is recommended when pheochromocytoma is not suspected, the mass is > 4 cm, AND there is a history of primary malignancy (ACR, 2012)).
   - Persistent abdomen/pelvic pain not explained by previous imaging/procedure.
   - Unexplained weight loss of 10% of body weight in two months (patient history is acceptable); with a second MD visit documenting some further decline in weight.
• Unexplained weight loss of 5% of body weight in six months confirmed by documentation to include the following (Bosch, 2017; Wong, 2014).
  o Related history and abdominal exam.
  o Chest x-ray
  o Abdominal ultrasound
  o Lab tests, must include TSH
  o Colonoscopy if patient fifty plus (50+) years old
• Unexplained abdominal pain in patients seventy-five (75) years or older (USPSTF does not recommend screening colonoscopy in patients over 75).
• Suspected spigelian hernia (ventral hernia) or incisional hernia (evidenced by a surgical abdominal scar) when ordered as a pre-operative study OR when physical exam or prior imaging (e.g. ultrasound) is non-diagnostic or equivocal (Lassandro, 2011) OR ultrasound is contraindicated due to obesity.
• Hernia with suspected complications. (e.g. bowel obstruction or strangulation) or prior to surgical repair OR when physical exam or prior imaging (e.g. ultrasound) is non-diagnostic or equivocal (Lassandro, 2011; Miller, 2014; Robinson, 2013).
• Ischemic bowel.
• Suspected complete or high-grade partial small bowel obstruction.

ADDITIONAL INFORMATION RELATED TO ABDOMEN/PELVIS CT:

Ultrasound should be considered prior to a request for Abdomen or Pelvis CT for the following evaluations:
  o Possible gallstones or abnormal liver function tests with gall bladder present.
  o Evaluation of cholecystitis.
  o Repeat CT studies of renal mass.
  o Repeat CT Hepatic mass follow-up.
  o Repeat CT for aortic aneurysm ordered by non-surgeon.

CT for suspected renal stones: An initial CT study is done to identify the size of the stone and rule out obstruction. (7 mm is the key size; less than that size the expectation is that it will pass) After the initial CT study for kidney stone is done, the stone can be followed by x-ray or US (not CT). If a second exacerbation occurs/a new stone is suspected another CT would be indicated to access the size of stone and rule out obstruction.

CT Imaging for renal colic and hematuria: CT protocols include: “stone protocol” for detecting urinary tract calculi, “renal mass protocol” for characterizing known renal masses, and CT urography for evaluating hematuria. Non-contrast CT can be used for detecting most ureteral and renal stones but sometimes an intravenous contrast agent is needed to determine the relationship of the calculus to the opacified ureter. CT is an effective imaging examination for diagnosing hematuria caused by urinary tract calculi, renal tumors and urothelial tumors.

Screening for Hepatocellular carcinoma (HCC): AASLD (American Association for the Study of Liver Diseases) recommends screening for HCC with ultrasound every 6 months for patients with hepatitis C and B (Bruix, 2011). The literature differs on the role of AFP (alpha fetoprotein) in the screening of HCC. Some authors argue against its use altogether due to its lack of sensitivity and specificity in detecting HCC (Bruix, 2011; Marquardt, 2016) and instead recommend ultrasound alone for screening. According to Marquardt the AASLD and EASLD (European Association for the Study of the Liver) “do not endorse its [AFP] use in clinical routine, neither alone nor in combination with ultrasound”. This approach is
supported by reports of patients with chronic viral hepatitis and elevated AFP but normal livers on imaging. AFP elevation in these cases is due to hepatic inflammation and viral replication (Patil, 2013), not neoplasm. Others advocate for combined ultrasound and AFP for screening (Tzartzeva, 2018; Tan, 2011) citing increased sensitivity compared to ultrasound alone in detecting early stage HCC particularly in cirrhotic patients. In a meta-analysis by Tzartzeva, et al of thirty-two studies (13,367 patients with cirrhosis), ultrasound with AFP had a 63% sensitivity of detecting early stage HCC compared to 45% for ultrasound alone. In the final analysis, no literature supports the use of AFP alone in the screening of HCC.

**CT Imaging for abdominal aortic aneurysms:** If a pulsatile abdominal mass is found in an asymptomatic patient, abdominal ultrasonography is an inexpensive and noninvasive technique for initial evaluation. For further examination, CT may be performed to better define the shape and extent of the aneurysm and the local anatomic relationships of the visceral and renal vessels. CT has high level of accuracy in sizing aneurysms. CT angiography is not routinely required to assess abdominal aortic aneurysms and the decision to utilize conventional CT or CT angiography is based on factors unique to the individual case.

Risk of rupture in 6 years for an AAA < 4 cm is 1%. For a 4-5 cm AAA the risk of rupture increases to 1-3% per year and becomes 6-11% per year for AAA 5-7 cm in cross sectional diameter. >7 cm the risk of rupture goes to 7% per year.

**Abdominal aneurysms and general guidelines for follow-up:**
The normal diameter of the suprarenal abdominal aorta is 3.0 cm and that of the infrarenal is 2.0 cm. Aneurysmal dilatation of the infrarenal aorta is defined as diameter >/= 3.0 cm or dilatation of the aorta >/= 1.5x the normal diameter. Initial evaluation of AAA is accurately made by ultrasound. Ultrasound can detect and size AAA, with the advantage of being relatively inexpensive, noninvasive and not require iodinate contrast. The limitations are that overlying bowel gas can obscure findings and the technique is operator dependent.

**Recommended intervals for initial follow-up imaging (any modality) of ectatic aortas and abdominal aortas (follow up intervals may vary depending on comorbidities and the growth rate of the aneurysm):**
- 2.5-2.9 cm: ............5yr
- 3.0-3.4 cm: .......... 3yr
- 3.5-3.9 cm: ..........2yr
- 4.0-4.4 cm: ............1yr
- 4.5-4.9 cm: ............6 mo
- 5.0-5.5 cm: ............3-6 mo

The Society of Vascular Surgery has different follow up intervals for AAA (SVS, 2018):
- >2.5 cm · <3 cm........10 yr
- 3.0 - 3.9 cm..............3 yr
- 4.0 - 4.9 cm...............12 mo
- 5.0 - 5.4 cm...............6 mo.

The Society of Vascular Surgery recommends elective repair of AAA >/= 5.5 cm in patients at low or acceptable surgical risk (Chaikof, 2018).

**Combination request of Abdomen CT/Chest CT** - A Chest CT will produce images to the level of L3. Documentation for combo is required.

**REDUCING RADIATION EXPOSURE:**
**Evaluation for appendicitis following clinical and laboratory evaluation** - 
Sonography of the right upper quadrant and pelvis followed by graded compression and color Doppler sonography of the right lower quadrant was used by Gaitini and colleagues as the initial imaging study in 420 consecutive patients referred for emergency evaluation of acute appendicitis. This method correctly diagnosed acute appendicitis in 66 of 75 patients (88%) and excluded it correctly in 312 of 326 patients (96%). It was inconclusive in 19 patient (<5%). Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 74.2%, 97%, 88%, 93%, and 92%, respectively and comparable to CT. Appropriate and timely diagnosis of acute appendicitis is needed. Negative laparotomy rates can range from 16% to 47% when based on clinical and laboratory data alone, while perforation rate can reach 35% when surgery is delayed. Appropriate initial imaging can lower the negative laparotomy rate to 6-10%. Ultrasound has a higher non-diagnostic rate (4%) vs. 0.8% for MDCT. In a prospective study operator experience and patient BMI did not affect diagnostic accuracy.

**Consider alternatives to CT imaging in patients with Crohn disease**: In facilities where the technical and clinical expertise exists, MR enterography is emerging as the study of choice (replacing CT) for patients requiring frequent follow up examinations to determine disease extent or progression. The technique also has advantage over small bowel follow through (SBFT) in that it avoids ionizing radiation completely, yet allows evaluation of extramucosal and extraluminal disease.

**Consider the role of capsule endoscopy** - Retrospective comparison of capsule endoscopy (CE) to CT in patients with no evidence of a small-bowel stricture at barium examination was the focus of the article by Hara, et al. Studies were done for bleeding of unknown origin after colonoscopy and/or Gastroenterologist, inflammatory bowel disease or chronic abdominal pain. CE was found to be more sensitive than CT examination in the 19 patients that underwent both. CE provides a complimentary and sensitive approach to the evaluation of the small bowel without radiation exposure. A negative examination does not completely rule out pathology.

**Initial evaluation of abdominal aortic aneurysm (AAA)** - Initial evaluation of AAA is accurately made by ultrasound.

**Imaging of hernias**: Most hernias are diagnosed clinically with imaging recommended for the diagnosis of occult hernias or in the evaluation of hernia complications, such as bowel obstruction or strangulation. To detect occult hernias, ultrasound is a first line study with a sensitivity of 86% and specificity of 77%, compared to 80% sensitivity and 65% specificity for CT (Robinson, 2013). According to Miller, et al “Magnetic resonance imaging is generally not considered a first- or even second-line evaluation modality for hernias...” (Miller, 2014). Based on this analysis, MRI is recommended only when ultrasound and CT have been performed and fail to make a diagnosis.
REFERENCES


INTRODUCTION:

Abdominal magnetic resonance imaging (MRI) is a proven and useful tool for the diagnosis, evaluation, assessment of severity and follow-up of diseases of the abdomen. It is more expensive than computed tomography (CT) but it avoids exposing the patient to ionizing radiation. MRI may be the best imaging procedure for patients with allergy to radiographic contrast material or renal failure. It may also be the procedure of choice for suspected lesions that require a technique to detect subtle soft-tissue contrast and provide a three-dimensional depiction of a lesion. Abdominal MRI studies are usually targeted for further evaluation of indeterminate or questionable findings, identified on more standard imaging exams such as Ultrasound (US) and CT.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR ABDOMEN MRI:

Evaluation of suspicious known mass/tumors (unconfirmed diagnosis of cancer) for further evaluation of indeterminate or questionable findings:
- Initial evaluation of suspicious abdomen masses/tumors found only in the abdomen by physical exam or imaging study, such as ultrasound (US).
- Surveillance: One follow-up exam to ensure no suspicious change has occurred in a tumor in the abdomen. No further surveillance unless tumor(s) are specified as highly suspicious, or change was found on last follow-up.

Evaluation of known cancer for further evaluation of indeterminate or questionable findings, identified by physical examination or imaging exams such as ultrasound (US) and CT:
- Initial staging of known cancer
  - All cancers, excluding the following:
    - Basal Cell Carcinoma of the skin,
    - Melanoma without symptoms or signs of metastasis.
- Three (3) month follow-up of known abdominal cancer undergoing active treatment within the past year.
- Six (6) month follow-up of known abdominal cancer undergoing active treatment within the past year.
- Follow-up of known cancer of patient undergoing active treatment within the past year.
- Known cancer with suspected abdominal metastasis based on a sign, symptom or an abnormal lab value.
- Cancer surveillance: Active monitoring for recurrence as clinically indicated.

For evaluation of suspected infection or inflammatory disease:
- Suspected acute appendicitis (or severe acute diverticulitis) if abdominal pain and tenderness to palpation is present, and at LEAST one of the following:
  - WBC elevated
  - Fever
  - Anorexia or
Nausea and vomiting.

- Suspected peritonitis (from any cause) if abdominal pain and tenderness to palpation is present, and at LEAST one of the following:
  - Rebound, rigid abdomen, or
  - Severe tenderness to palpation present over entire abdomen.
- Suspected pancreatitis; can have pancreatitis without abnormally elevated amylase and lipase.
- Suspected inflammatory bowel disease (Crohn’s or ulcerative colitis) with abdominal pain, and persistent diarrhea, or bloody diarrhea.
- Suspected cholecystitis or retained gallstones with recent equivocal ultrasound.
- Suspected infection in the abdomen.

For evaluation of known infection or inflammatory disease follow up:

- Complications of diverticulitis with severe abdominal pain or severe tenderness or mass, not responding to antibiotic treatment, (prior imaging study is not required for diverticulitis diagnosis).
- Pancreatitis by history, (including pancreatic pseudocyst) with abdominal pain suspicious for worsening, or re-exacerbation.
- Known inflammatory bowel disease, (Crohn’s or ulcerative colitis) with recurrence or worsening signs/symptoms requiring re-evaluation.
- Any known infection that is clinically suspected to have created an abscess in the abdomen.
- Any history of fistula limited to the abdomen that requires re-evaluation, or is suspected to have recurred.
- Abnormal fluid collection seen on prior imaging that needs follow-up evaluation.
- Follow up of known peritonitis (from any cause) if abdominal pain and tenderness to palpation is present, and at LEAST one of the following:
  - Rebound, rigid abdomen, or
  - Severe tenderness to palpation present over entire abdomen.
- Hepatitis/hepatoma screening after ultrasound and/or alpha-fetoprotein (AFP) have been obtained and where either alpha-fetoprotein (AFP) is elevated or ultrasound is abnormal, equivocal or non-diagnostic.
- Known infection in the abdomen.

Pre-operative evaluation:
- For abdominal surgery or procedure.

Post-operative/procedural evaluation:
- Follow-up of known or suspected post-operative complication involving only the abdomen.
- A follow-up study to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed.

Indication for combination studies for the initial pre-therapy staging of cancer, OR ongoing tumor/cancer surveillance OR evaluation of suspected metastases:
- ≤ 5 concurrent studies to include CT or MRI of any of the following areas as appropriate depending on the cancer: Neck, Abdomen, Pelvis, Chest, Brain, Cervical Spine, Thoracic Spine or Lumbar Spine.
  - Cancer surveillance – Active monitoring for recurrence as clinically indicated.

Other Indications for an Abdominal MRI:
- To provide an alternative to abdominal CT when CT would be limited due to allergy to radiographic contrast material.
- To provide an alternative to follow-up of an indeterminate abdomen CT when previous CT/Ultrasound was equivocal.
• Suspected adrenal mass or pheochromocytoma based on diagnostic testing/imaging results, and/or a suspicious clinical presentation.

**ADDITIONAL INFORMATION RELATED TO ABDOMINAL MRI:**

**MRI of the liver** – The liver is a common site of metastatic spread. Patients with a history of known or suspected malignancy, especially tumors from the colon, lung, pancreas and stomach, are at risk for developing hepatocellular carcinoma. Patients with chronic liver disease are also at risk for developing liver cancer and undergo periodic liver screening for focal liver lesion detection, usually with ultrasonography (US). Extra-cellular gadolinium chelate contrast-enhanced MRI is used for evaluating patients with an abnormal US. Patients with hepatic metastases being considered for metastasectomy undergo contrast-enhanced MRI using tissue-specific contrast agents.

**MRI of the adrenal glands** – The adrenal glands are susceptible for metastases from various tumors, especially of lung or breast. Adrenal lesions may also represent primary tumors of the adrenal cortex of medulla, both benign and malignant. MRI may be done to distinguish between benign and malignant lesions. Metastases are predominantly hypointense on T1-weighted images and hyperintense on T2-weighted images. Benign lesions, which have high lipid content, exhibit a drop in signal intensity on apposed phase chemical shift imaging.

**MRI of the pancreas** – The most common pancreatic endocrine tumors, accounting for up to 50% of all cases, are insulinomas, which are usually benign. The next most common is gastrinomas. Patients with gastrinomas generally present with recurrent, multiple or ‘ectopic’ peptic ulceration, the Zollinger-Ellison syndrome. After a diagnosis of gastrinomas has been confirmed, imaging should be done to localize and stage the disease. Other pancreatic endocrine tumors are rare and often associated with genetic disorders such as the multiple endocrine neoplasia type 1 (MEN 1). MRI is the preferred imaging for follow-up in patients with MEN 1 where repeated imaging may be required to assess the response to therapy.

**MRI of the kidney** – MRI in renal imaging has been used to differentiate benign lesions versus malignant lesions in patients unable to undergo CT scanning with contrast media or in cases where the CT findings were questionable. Initial evaluation of renal lesions is often undertaken with ultrasound. MRI can have additional diagnostic value in the evaluation of lesions with minimal amounts of fat or with intracellular fat. MRI may have a higher accuracy than CT in the evaluation of early lymph node spread. Although MRI of the kidney has not yet found broad clinical application, it may have an increasing role in the management of patients with renal disease.

**MRI of the spleen** – Among some radiologists, the spleen is considered a ‘forgotten organ’ although it is included and demonstrated on every abdominal CT and MRI. Malignant tumors of the spleen are rare; malignant lymphomas are the most common and are usually a manifestation of generalized lymphoma. Splenic metastases are predominantly hypointense on T1-weighted images and hyperintense on T2-weighted images and MRI is used for the detection of necrotic or hemorrhagic metastases.

**MRI to diagnose abdominal aortic aneurysm** – MRI can be useful in the diagnosis of aortic aneurysms in patients with chronic aortic disease. The advantages include: safety, noninvasive nature (except for intravenous contrast), wide field of view, multi-planar imaging and 3D relationship viewing. MRI, unlike CT, does not require large volumes of iodinated contrast. ECG-gated spin-echo MRI is the basis for many MRI imaging algorithms for diagnosing abdominal aortic disease. A rapid breath holds MRI, allows more comprehensive examination of the aorta and defines many types of aortic pathology.
MRI for the evaluation of vascular abnormalities such as renal artery stenosis and celiac/superior mesenteric artery stenosis (in chronic mesenteric ischemia) - Doppler Ultrasound, MRA or CTA should be considered as the preferred imaging modalities.
REFERENCES


INTRODUCTION:

**Magnetic resonance cholangiopancreatography (MRCP)** is a non-invasive radiologic technique for imaging the biliary and pancreatic ducts, and it is used to evaluate patients with cholestatic liver function tests, right upper quadrant pain, and recurrent pancreatitis. The MRCP uses magnetic resonance imaging (MRI) to produce detailed pictures of the pancreas, liver and bile ducts. MRCP is reliable for the diagnosis of ductal abnormalities, e.g., pancreas divisum. It is also used to diagnose bile duct stones and assess the level of obstruction. MRCP is especially useful when a noninvasive exam is desired. Due to the variable accuracy of ultrasound in detecting choledocholithiasis, preoperative MRCP prior to cholecystectomy has been advocated particularly in the setting of acute cholecystitis, near normal common bile duct diameter (where ultrasound is less accurate) and elevated liver functions, especially alanine aminotransaminase (ALT).

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

**INDICATIONS FOR MRCP:**

- Evaluation of suspected congenital anomaly of the pancreaticobiliary tract, e.g., aberrant ducts, choledochal cysts, pancreas divisum or related complications.
- Evaluation of chronic pancreatitis or the complications related to such (pseudocysts and bile duct strictures).
- Pre-operative evaluation: Prior to surgery or other invasive procedure.
- Post-operative evaluation: For evaluation of suspected biliary abnormalities after surgery or invasive procedure.
- Further evaluation of inconclusive abnormalities identified on other imaging (ultrasound, CT, or MRI).
- Evaluation of abnormality related to the biliary tree based on symptoms or laboratory findings and initial imaging has been performed.

**ADDITIONAL INFORMATION RELATED TO MRCP:**

**Ultrasound** - Ultrasound is the initial imaging technique used for screening suspected biliary or pancreatic disease, but it has limited ability to characterize abnormalities in the biliary and pancreatic ducts.

**Endoscopic retrograde cholangiopancreatography (ERCP)** – ERCP can combine diagnosis with therapeutic intervention, e.g., removal of stones, but it is an invasive procedure that carries significant risk of complications, e.g., pancreatitis. ERCP is also technically challenging in patients with post-surgical biliary and/or surgical anastomoses.

**Magnetic resonance Cholangiopancreatography (MRCP)** – MRCP is a noninvasive method for depicting biliary and pancreatic ducts and assessing the level of obstruction. It is also used to evaluate congenital anomalies of these structures. In clinical practice MRCP is often combined with conventional MRI imaging of the liver and pancreas. MRCP does not require the use of any contrast materials. Unlike ERCP, it does not combine diagnosis with therapeutic intervention. MRCP is not cost effective if the patient will need ERCP mediated intervention after the MRCP. MRCP is preferred over ERCP when a noninvasive examination is needed or when there is a very small likelihood that the patient will need
therapeutic intervention afforded by ERCP. Secretin-enhanced MR Cholangiopancreatography has been recently developed to improve the diagnostic quality of MRCP images.

**Cystic Pancreatic neoplasms**: In the evaluation of cystic neoplasms, MRCP is more sensitive than ERCP in differentiating mural nodules from mucin globules and in studying the duct anatomy, as ERCP quality is negatively affected when intraductal mucin plugs obscure the filling of the pancreatic duct (Cao et al). It also consistently demonstrates the internal architecture of the main duct and the extent of IPMN (Intraductal Papillary Mucinous Neoplasms) better than ERCP. (ACG-GL)

**Biliary strictures**: Approximately 15% of biliary strictures in the western world are benign. 80% are related to previous surgery, usually an injury during gallbladder surgery. After liver transplantation anastomatic strictures usually develop 3-6 months after surgery. Rare causes of stricture formation include infectious agents such as TB, parasites and viruses. Other etiologies include recurrent pyogenic cholangitis, Mirizzi syndrome with external compression of the bile duct by an inflamed gallbladder, blunt trauma and an even smaller number of strictures of unknown etiology also occur.

**PSC (primary sclerosing cholangitis)**: Magnetic resonance cholangiography is increasingly available but does not yet visualize the intrahepatic bile ducts sufficiently to replace direct cholangiography. Neither liver histology nor cholangiography alone will reliably reflect the severity of the disease. They must be used together with symptoms, physical findings, blood tests, and imaging or upper endoscopy tests that indicate the presence and severity of portal hypertension. (Griffin et al)
REFERENCES


CPT Codes: 74185

INTRODUCTION:

Magnetic resonance angiography (MRA) generates images of the arteries that can be evaluated for evidence of stenosis, occlusion or aneurysms. It is used to evaluate the arteries of the abdominal aorta and the renal arteries. Contrast enhanced MRA requires the injection of a contrast agent which results in very high quality images. MRA does not use ionizing radiation, allowing MRA to be used for follow-up evaluations. Abdominal MRA is not used as a screening tool, e.g. evaluation of asymptomatic patients without a previous diagnosis.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR ABDOMEN MRA:

For evaluation of known or suspected abdominal vascular disease:

- For known large vessel diseases (abdominal aorta, inferior vena cava, superior/inferior mesenteric, celiac, splenic, renal or iliac arteries/veins), e.g., aneurysm, dissection, arteriovenous malformations (AVMs), and fistulas, intramural hematoma, and vasculitis.
- Evidence of vascular abnormality seen on prior imaging studies.
  - Evaluation of known or suspected aortic aneurysm (Khosa, 2013; Chaikof, 2018★★):
    - Known or suspected aneurysm > 2.5 cm AND equivocal or indeterminate ultrasound results OR
    - Prior imaging (e.g. ultrasound) demonstrating aneurysm >2.5 cm in diameter OR
    - Suspected complications of known aneurysm as evidenced by signs/symptoms such as new onset of abdominal or pelvic pain.
- To determine the vascular source of retroperitoneal hematoma or hemorrhage when CTA is contraindicated
- Suspected renal vein thrombosis in patient with known renal mass.
- For evaluation of suspected mesenteric ischemia/ischemic colitis when CTA is contraindicated (ACR, 2012).
- Venous thrombosis if previous studies have not resulted in a clear diagnosis.
- Vascular invasion or displacement by tumor.
- For evaluation of hepatic blood vessel abnormalities (aneurysm, hepatic vein thrombosis, stenosis post transplant) after doppler ultrasound has been performed: to clarify or further evaluate ultrasound findings.
- For evaluation of splenic artery aneurysm.
- Kidney failure or renal insufficiency if initial evaluation performed with Ultrasound is inconclusive.
- For evaluation of known or suspected renal artery stenosis or resistant hypertension in the setting of normal renal function or impaired renal function unrelated to recent medication (ACR, 2017) demonstrated by any of the following (Hartman, 2009; Tullus, 2010):
  - Unsuccessful control after treatment with 3 or more (>2) anti-hypertensive medication at optimal dosing.
  - Acute elevation of creatinine after initiation of an angiotension converting enzyme inhibitor (ACE inhibitor) or angiotension receptor blocker (ARB).
Asymmetric kidney size noted on ultrasound.

- Onset of hypertension in a person younger than age 30 without any other risk factors or family history of hypertension.
- Significant hypertension (diastolic blood pressure > 110 mm Hg) in a young adult (i.e., younger than 35 years) suggestive of fibromuscular dysplasia
- Diagnosis of a syndrome with a higher risk of vascular disease, such as neurofibromatosis, tuberous sclerosis and Williams’ syndrome
- New onset of hypertension after age 50.
- Acute rise in blood pressure in a person with previously stable blood pressures.
- Flash pulmonary edema without identifiable causes.
- Malignant hypertension.
- Bruit heard over renal artery and hypertension.

Pre-operative evaluation:
- Evaluation prior to interventional vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.
- For pretransplant evaluation of either liver or kidney.

Post-operative or post-procedural evaluation:
- Evaluation of endovascular/interventional abdominal vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.
- Evaluation of post-operative complications, e.g. pseudoaneurysms, related to surgical bypass grafts, vascular stents, and stent-grafts in the peritoneal cavity.
- Follow-up for post-endovascular repair (EVAR) or open repair of abdominal aortic aneurysm (AAA) or abdominal extent of iliac artery aneurysms. Routine, baseline study (post-op/intervention) is warranted within 1-3 months (Chaikof, 2018; Uberoi, 2011).
  - Asymptomatic at six (6) month intervals for one (1) year, then annually.
  - Symptomatic/complications related to stent graft – more frequent imaging may be needed.
- Follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

ADDITIONAL INFORMATION RELATED TO ABDOMEN MRA:

MRI Follow-up for post-endovascular repair (EVAR) – Although studies have shown that MRA is as sensitive as CT in detecting endoleaks, CT is generally the study of choice in this evaluation due to convenience, improved spatial resolution and less artifact from components of the stent graft. MRA is most helpful in the postoperative evaluation of patients with impaired renal function, but not severe enough to have contraindication to gadolinium administration

Abd/Pelvis MRA & Lower Extremity MRA Runoff Requests: Two (2) authorization requests are required, one Abd MRA, CPT code 74185 and one for Lower Extremity MRA, CPT code 73725. This will provide imaging of the abdomen, pelvis, and both legs.
MRA and Abdominal Aortic Aneurysm – Endovascular repair is an alternative to open surgical repair of an abdominal aortic aneurysm. It has lower morbidity and mortality rates and is minimally invasive. In order to be successful, it depends on precise measurement of the aneurysm and involved vessels. MRA with gadolinium allows visualization of the aorta and major branches and is effective and reliable for use in planning the placement of the endovascular aortic stent graft. MRA is also used for the detection of postoperative complications of endovascular repair.

**Abdominal Aneurysms and general Guidelines for follow-up:**
The normal diameter of the suprarenal abdominal aorta is 3.0 cm and that of the infrarenal is 2.0 cm. Aneurysmal dilatation of the infrarenal aorta is defined as diameter >/= 3.0 cm or dilatation of the aorta >/= 1.5x the normal diameter (Khosa, et al). Initial evaluation of AAA is accurately made by ultrasound. Ultrasound can detect and size AAA, with the advantage of being relatively inexpensive, noninvasive and not require iodinate contrast. The limitations are that overlying bowel gas can obscure findings and the technique is operator dependent.

Recommended intervals for initial follow-up imaging of ectatic aortas and abdominal aortas (follow up intervals may vary depending on comorbidities and the growth rate of the aneurysm) from the white paper of the ACR Incidental Findings Committee II on vascular findings (Khosa, 2013):

- 2.5-2.9 cm:………….5yr
- 3.0-3.4 cm:………….....3yr
- 3.5-3.9 cm:…………….2yr
- 4.0-4.4 cm:…………..1yr
- 4.5-4.9 cm:………………6 mo
- 5.0-5.5 cm:………………3-6 mo

The Society of Vascular Surgery has different follow up intervals for AAA (SVS, 2018):

- >2.5 cm - <3 cm……..10 yr
- 3.0 - 3.9 cm…………….3 yr
- 4.0 - 4.9 cm………………12 mo
- 5.0 - 5.4 cm………………6 mo.

The Society of Vascular Surgery recommends elective repair of AAA >/= 5.5 cm in patients at low or acceptable surgical risk (Chaikof, 2018).

MRA and Renal Artery Stenosis – Renal artery stenosis is the major cause of secondary hypertension. It may also cause renal insufficiency and end-stage renal disease. Atherosclerosis is one of the common causes of this condition, especially in older patients with multiple cardiovascular risk factors and worsening hypertension or deterioration of renal function. Navigator-gated MR angiography is used to evaluate the renal arteries and detect renal artery stenosis.

MRA and Renal Vein Thrombosis – Renal vein thrombosis is a common complication of nephritic syndrome and often occurs with membranous glomerulonephritis. Gadolinium-enhanced MRA can demonstrate both the venous anatomy and the arterial anatomy and find filling defects within renal veins. The test can be used for follow-up purposes as it does not use ionizing radiation

*MRI/CT and acute hemorrhage:* MRI is not indicated and MRA/MRV (MR Angiography/Venography) is rarely indicated for evaluation of intraperitoneal or retroperitoneal hemorrhage, particularly in the acute setting. CT is the study of choice due to its availability, speed of the study, and less susceptibility to artifact from patient motion. Advances in technology have allowed conventional CT to not just detect
hematomas but also the source of acute vascular extravasation. In special cases finer vascular detail to assess the specific source vessel responsible for hemorrhage may require the use of CTA. CTA in diagnosis of lower gastrointestinal bleeding is such an example (Clerc, 2017).

MRA/MRV is often utilized in non acute situations to assess vascular structure involved in atherosclerotic disease and its complications, vasculitis, venous thrombosis, vascular congestion or tumor invasion. Although some of these conditions may be associated with hemorrhage, it is usually not the primary reason why MRI/MRA/MRV is selected for the evaluation. A special condition where MRI may be superior to CT for evaluating hemorrhage is to detect an underlying neoplasm as the cause of bleeding (Abe, 2010).
REFERENCES


CPT Codes: 74261, 74262

INTRODUCTION:

Computed tomographic (CT) colonography, also referred to virtual colonoscopy, is used to examine the colon and rectum to detect abnormalities such as polyps and cancer. Polyps may be adenomatous (which have the potential to become malignant) or completely benign.

Colorectal cancer (CRC) is the third most common cancer and the second most common cause of cancer death in the United States. Symptoms include blood in the stool, change in bowel habit, abdominal pain, and unexplained weight loss.

In addition to its use as a diagnostic test in symptomatic patients, CT colonography may be used in asymptomatic patients with a high risk of developing colorectal cancer. Conventional colonoscopy and double-contrast barium enema are the main methods currently used for examining the colon.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCR) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR CT COLONOSCOPY (VIRTUAL COLONOSCOPY):

For diagnostic (symptomatic patient) evaluation when conventional colonoscopy is contraindicated or could not be completed (AGA, 2015):

- Patient had failed colonoscopy due to conditions such as hypotension secondary to the sedation; adhesions from prior surgery; excessive colonic tortuosity.
- Patient has obstructive colorectal cancer.
- Patient is unable to undergo sedation or has medical conditions, e.g., recent myocardial infarction, recent colonic surgery, bleeding disorders, severe lung and/or heart disease.

ADDITIONAL INFORMATION RELATED TO CT COLONOSCOPY (VIRTUAL COLONOSCOPY):

Request for a follow-up study - A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.
REFERENCES

American Gastroenterological Association (AGA). *CT Colonography Standards.*


INTRODUCTION:

The goal of CT (computer tomographic) colonography (CTC), sometimes referred to as CT colonoscopy or virtual colonoscopy screening is to reduce colorectal cancer mortality through cancer prevention and early detection. Virtual colonoscopy is an American Cancer Society-recommended screening exam that has been shown in studies in the United States and abroad to increase screening rates where offered. Virtual colonoscopy has been proven comparably accurate to colonoscopy in most people of screening age. Mandatory insurance coverage of CT colonography and the other USPSTF-recognized exams is a major step forward in the battle against colorectal cancer (USPSTF, 2016).

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR CT COLONOSCOPY (VIRTUAL COLONOSCOPY) SCREENING:

CTC is considered medically appropriate as an alternative to colonoscopy for screening an “average risk” and “moderate risk” member, every 5 (five) years, who is (ACR, 2013; USPSTF, 2016):

Average, Moderate, or High risk (ACR, 2013):
After incomplete colonoscopy
Unable to undergo sedation or has medical conditions, e.g., recent myocardial infarction, recent colonic surgery, bleeding disorders, severe lung and/or heart disease.

Average Risk Individuals:
- 50 – 75 years of age (See list of other weak evidence rec below).
- asymptomatic
- and without any of the following:
  - a family history of known genetic disorders that predispose them to a high lifetime risk of colorectal cancer (such as Lynch syndrome (Hereditary Nonpolyposis Colorectal Cancer))
  - a personal history of inflammatory bowel disease

Moderate Risk Individuals:
- Patient with history of carcinoma or adenoma (ACR, 2013)
- First degree family member with history of cancer or adenoma (ACR, 2013): in these instances the MSTF recommends screening be initiated earlier (Rex, 2017)**

Additional Information:

“While Virtual Colonoscopy is an alternative, ACG notes its limitations: CT Colonography every 5 years (Also known as “virtual” colonoscopy) is endorsed in the updated MSTF guideline as a “tier 2” alternative
to colonoscopy every 10 years for patients who decline colonoscopy. The College includes CRC as an alternative in light of recent studies which reveal that CTC has a sensitivity of 82 to 92% for adenomas ≥1 cm. Although the benefits of CTC include low risk of perforation compared to colonoscopy, the College does not consider CTC as an equivalent to colonoscopy as a screening strategy for several reasons:

- its inability to detect polyps 5 millimeters and smaller, which constitute 80 percent of colorectal neoplasms;
- false positives are common with CTC; and concerns about the radiation risk associated with one or repeated CT colonography studies, although the exact risk associated with radiation is unclear.”

Screening Recommendations, the USPSTF, ACG, ACR, and ACS:

The United States Preventative Services Task Force (USPSTF) and The U.S. Multi-Society Task Force on Colorectal Cancer (MSTF) and American College of Radiology (ACR) recommend colorectal screening of asymptomatic adults starting at the age of 50 for the general population. The MSTF, but not the USPSTF or ACR, indicates “limited evidence” supports screening for African Americans starting at age 45 (Rex, 2017). Screening is recommended until the age of 75. The USPSTF gives screening a grade of “A”. This means “the USPSTF recommends the service and there is high certainty that the net benefit is substantial”. For adults older than 76 years, and younger than 85, the USPSTF recommendation grade is a “C” indicating “there is at least moderate certainty that the net benefit is small and the service should be offered “….for selected patients depending on individual circumstances”. All three organizations’ guidelines exclude from these general screening criteria some groups with an increased risk of developing cancer compared to the general population based on “genetic disorders that predispose them to a high lifetime risk of colorectal cancer (such as Lynch syndrome or familial adenomatous polyposis), or a personal history of inflammatory bowel disease…. (ACR, 2013). These patients are screened more frequently with colonoscopy and are not candidates for CTC except in the ACR appropriateness criteria where CTC is given a grade of “9” for patients with “a personal history of adenoma or carcinoma or first-degree family history of cancer or adenoma”.

According to the MSTF “The advantages of colonoscopy include high sensitivity for cancer and all classes of precancerous lesions, single-session diagnosis and treatment, and long intervals between examinations (10 years) in subjects with normal examinations”. The ACR appropriateness criteria gives CTC a grade of 9 out of 10, or “usually appropriate”, as the preferred imaging study for screening. Double contrast barium enema has been replaced by CTC as the preferred imaging study by both the MSTF and ACR (receiving a 6 out of 10 grade in the ACR appropriateness criteria “may be appropriate”). The ACR appropriateness criteria does not measure the relative merits of no radiologic tests for colorectal screening such as colonoscopy, flexible sigmoidoscopy, fecal occult blood test, fecal immunochemical test, or serum testing (Septin9 assay is the first FDA approved test) but comments in the appropriates criteria text: “....of the structural tests available, colonoscopy is currently considered to be the most sensitive and specific for detecting colorectal polyps and cancers”. The ACR indicates in its recommendation charts for high risk individuals with hereditary non-polyposis colorectal cancer, or inflammatory bowel disease, that colonoscopy is the preferred procedure giving CTC a grade of “3’ (usually not appropriate).

The American Cancer Society follows the screening intervals described by the organizations above but does not provide recommendations on the preferred exam. They recommend screening every 10 years for CT colonoscopy and every 5 years for CTC, flexible sigmoidoscopy, and double contrast barium enema.

U.S. Multi-Society Task Force on Colorectal Cancer (USMSTF) and the ACR has divided colorectal cancer risk levels into three categories (ACR, 2013).
1) Average (individuals ≥50 years of age),
2) Moderate (individuals with a personal history of a large adenoma or carcinoma or a first-degree relative with a history of adenoma or carcinoma), and
3) High (individuals with hereditary syndromes, such as hereditary nonpolyposis colorectal cancer and familial polyposis, or a personal history of ulcerative colitis or Crohn colitis).

*The U.S. Multi-Society Task Force on Colorectal Cancer: The American College of Gastroenterology, the American Gastroenterological Association, and the American Society for Gastrointestinal Endoscopy


**Recommendations
1. We suggest that persons with 1 first-degree relative with CRC or a documented advanced adenoma diagnosed at age <60 years or with 2 first-degree relatives with CRC and/or documented advanced adenomas undergo colonoscopy every 5 years beginning 10 years younger than the age at which the youngest first-degree relative was diagnosed or age 40, whichever is earlier (weak recommendation, low-quality evidence).
2. We suggest that persons with 1 first-degree relative diagnosed with CRC or a documented advanced adenoma at age ≥60 years begin screening at age 40. The options for screening and the recommended intervals are the same as those for average-risk persons (weak recommendation, very-low-quality evidence).
3. We suggest that persons with 1 or more first-degree relatives with a documented advanced serrated lesion (SSP or traditional serrated adenoma ≥10 mm in size or an SSP with cytologic dysplasia) should be screened according to above recommendations for persons with a family history of a documented advanced adenoma (weak recommendation, very-low-quality evidence).
4. We recommend that persons with 1 or more first-degree relatives with CRC or documented advanced adenomas, for whom we recommend colonoscopy, should be offered annual FIT if they decline colonoscopy (strong recommendation, moderate-quality evidence).
REFERENCES


CPT Codes: 75557, 75559, 75561, 75563 +75565

INTRODUCTION
(Pennell 2010)

- Cardiac magnetic resonance imaging (MRI or CMR) provides high quality cardiovascular imaging without exposure to radiation. Quality imaging process requires patient ability to perform breath holding or regular free breathing, a regular rhythm, and absence of local implants that interfere with image or any implants that interfere with safety (Gerber 2018).

- Cardiac magnetic imaging (CMR) is often required when transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) elicit inadequate imaging data.

- Stress CMR for assessment of coronary artery disease (CAD) is performed pharmacologically either as:
  - Vasodilator perfusion imaging with gadolinium contrast
  - Dobutamine inotropic wall motion (ventriculography)

- CMR is frequently competitive with Cardiac CT (Cardiac Computed Tomography) with respect to structural imaging (Warnes 2008; Baumgartner 2010; Pennell 2010).

<table>
<thead>
<tr>
<th>Modality</th>
<th>Cardiac CT</th>
<th>Cardiac MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrast</td>
<td>Often required</td>
<td>Required for some tissue characterization studies, often unnecessary</td>
</tr>
<tr>
<td>Radiation*</td>
<td>Yes</td>
<td>None, advantage for young patients and those requiring frequent exams</td>
</tr>
<tr>
<td>Resolution</td>
<td>Higher spatial</td>
<td>Higher temporal</td>
</tr>
<tr>
<td>Flow</td>
<td>Not standard</td>
<td>Standard</td>
</tr>
<tr>
<td>Patient comfort</td>
<td>Easy</td>
<td>Claustrophobia issues</td>
</tr>
<tr>
<td>Ferromagnetic implants</td>
<td>No issue</td>
<td>Relative contraindication</td>
</tr>
<tr>
<td>Cost</td>
<td>Moderate to High</td>
<td>High</td>
</tr>
</tbody>
</table>

* (Hirshfeld 2018)
Some scenarios might provide more detail with low dose CT than with CMR, thereby overriding the radiation risk (Ohana 2015).

- With respect to CAD evaluation, since CMR is only pharmacologic (non-exercise stress), and stress echocardiography (SE) or myocardial perfusion imaging (MPI) provide similar information about CAD, with SE performed at lower cost:
Requests for stress CMR require **diversion** to exercise SE first, to exercise MPI second.

**Exemptions** for the diversion to SE or exercise MPI:
- If body habitus or marked obesity (e.g. BMI > 40) would interfere significantly with imaging with SE and MPI (Shah 2014)
- Evaluation of young (< 55 years old) patients with documented complex CAD, who are likely to need frequent non-invasive coronary ischemia evaluation and/or frequent radiation exposure from other testing (Hirshfeld 2018).

CMR can be used as an **alternative to required pharmacologic** MPI (Fihn 2012).

Pharmacologic perfusion imaging is indicated over exercise perfusion imaging in the following (Askew 2018):
- Inability to exercise safely (e.g. prohibitive comorbidity, severe valvular disease, provocation of serious arrhythmia with exercise, uncontrolled hypertension, with systolic BP > 180 or diastolic BP > 120)
- Complete left bundle branch block (LBBB) or a V-paced rhythm (due to perfusion artifacts)

CMR can also be performed as a dobutamine stress test **when vasodilator MPI would be contraindicated**: (Chareonthaitawee 2018; Henzlova 2016)
- Pulmonary or allergic intolerance to adenosine and analogues, documented or anticipated
- Dipyridamole within < 48 hours
- Relative unsuitability due to:
  - Hypotension or bradyarrhythmia
  - Interfering medications: Theophylline/aminophylline, caffeine, or theobromine within the past 12-24 hours
  - Seizure disorder with potential for adenosine provocation

CAD stenosis ≥ 50% is considered clinically significant or obstructive CAD. CAD and ischemic heart disease (IHD) mean the same thing. Hemodynamically or functionally significant CAD means the degree of stenosis is severe enough to cause ischemia. This is discussed in more detail in the Additional Information section (Fihn 2012; Wolk 2013; Montalescot 2013; Gerber 2018; Tobis 2007).

**Indications for CMR**
(Hendel 2006; Hundley 2010)

**CMR in CAD**
(Fihn 2012; Wolk 2013; Montalescot 2013)

- **Stable patients without known CAD** fall into 2 categories (Fihn 2012; Wolk 2013; Montalescot 2013):
  - **Asymptomatic**, for whom global risk of CAD events can be determined from coronary risk factors, using calculators available online (see part III in the Additional Information section).
Symptomatic, for whom we estimate the pretest probability that their chest-related symptoms are due to clinically significant (≥ 50%) CAD (below):

The 3 Types of Chest Pain or Discomfort

- **Typical Angina (Definite)** is defined as including all 3 characteristics:
  1) Substernal chest pain or discomfort with characteristic quality and duration
  2) Provoked by exertion or emotional stress
  3) Relieved by rest and/or nitroglycerine

- **Atypical Angina (Probable)** has only 2 of the above characteristics

- **Nonanginal Chest Pain/Discomfort** has only 0-1 of the above characteristics

Once the type of chest pain has been established from the medical record, the Pretest Probability of CAD (meaning obstructive CAD defined as coronary arterial narrowing ≥ 50%) is estimated from the **Diamond Forrester Table** below, recognizing that in some cases multiple additional coronary risk factors could increase pretest probability (Wolk 2013):

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Nonanginal Chest Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=39</td>
<td>Men</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40–49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
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<td>Women</td>
<td>Intermediate</td>
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<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
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</tbody>
</table>

- **Very low**: < 5% pretest probability of CAD, usually not requiring stress evaluation (Fihn 2012)
- **Low**: 5-10% pretest probability of CAD
- **Intermediate**: 10% - 90% pretest probability of CAD
- **High**: > 90% pretest probability of CAD

**Indications for Cardiac Magnetic Resonance (CMR)**
(Hendel 2006; Fuisz 2018)

**Use of CMR in CAD**
(Fihn 2012; Wolk 2013; Montalescot 2013; Askew 2018; Hendel 2006)

**Suspected CAD**
(Without known history of CAD)
**CMR available as an alternative to appropriate vasodilator MPI**

1. Symptomatic patients without known CAD
2. Asymptomatic patients without known CAD:

- Low pretest probability who are unable to exercise
- Intermediate pre-test probability
- High pre-test probability
- Repeat testing in patient with recurrent symptomatic presentation and negative result over 2 years ago
- Repeat testing in patient with new or worse symptoms and negative result at least one year ago

3. Incomplete or inconclusive CAD evaluation, within the past 2 years without known CAD

- Exercise stress ECG with low risk Duke treadmill score, but patient’s current symptoms indicate an intermediate or high pretest probability, which should include stress imaging
- Exercise stress ECG with intermediate Duke treadmill score
- Inconclusive/borderline CCTA (e.g. 40-70% lesions)
- An indeterminate (equivocal, borderline, or discordant) evaluation by prior stress imaging (SE or MPI) within the past 2 years, for whom a noninvasive approach is preferable to proceeding to invasive coronary arteriography (e.g. unclear symptoms, ECG and imaging discordant, etc., but patient has severe contrast allergy, CKD, etc.)

<table>
<thead>
<tr>
<th>Known Major Vessel CAD</th>
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<tr>
<td>CMR available as an alternative to appropriate vasodilator MPI</td>
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<td>(Patel 2017)</td>
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</table>

- Validated concern for a previous acute coronary syndrome without subsequent invasive or non-invasive coronary evaluation
- Follow up MPI at 2-year intervals is approvable, if it will affect consideration of coronary revascularization (initial or additional), in patients with one of the following:
  - History of silent ischemia with severe unrevascularized CAD, and revascularization could be feasible (Deedwania 2018)
  - History of severe unrevascularized major multivessel CAD, and revascularization could be feasible
  - Ejection fraction <= 40% with severe unrevascularized CAD, and revascularization could be feasible
- Ischemia assessment following inconclusive findings of invasive coronary arteriography or CCTA, for the purpose of assessing extent of ischemia and need for additional medical, interventional, or surgical therapy
- For myocardial viability assessment with reduced LVEF <= 50% to assist with decisions regarding coronary revascularization, even when MPI or SE have been inconclusive in that regard (Patel 2013; Yancy 2013)
- New or worsening symptoms of ischemia in the absence of an acute coronary syndrome, unless the most current stress imaging study would warrant invasive coronary arteriography instead (e.g. History of high risk stress test without subsequent invasive coronary arteriography might warrant invasive coronary angiography) (Patel 2013; Yancy 2012)
- De novo HF, who have known CAD, even without angina, unless the patient is not eligible for revascularization of any kind, or unless invasive coronary arteriography is immediately planned (Yancy 2013)
• Newly diagnosed systolic or diastolic heart failure, especially with symptoms or signs of ischemia AND without invasive coronary angiography immediately planned (Yancy 2013; Patel 2013; Fihn 2012)

• Newly found wall motion abnormality (Colucci 2018a)

• Ventricular arrhythmias
  o Sustained VT >100 bpm, VF, or exercise induced VT, when invasive coronary arteriography is the initially required test (Al-Khatib 2018 in press)
  o Nonsustained VT, multiple episodes, each ≥3 beats at ≥100 bpm, without known cause or associated cardiac pathology, when an exercise ECG has shown an intermediate risk Duke Score (Zimetbaum 2018)
  o Frequent PVCs ≥ 30/hour, or any PVC on a 12 lead ECG, without known cause or associated cardiac pathology, when an exercise ECG has shown an intermediate risk Duke Score OR an exercise ECG is not feasible due to inability to exercise or due to an uninterpretable ECG (Cha 2012; Manolis 2018)

• Prior to Class IC antiarrhythmic drug initiation in intermediate and high global risk patients (see risk calculators in Additional Information Section) (Kumar 2018)

• Assessment of hemodynamic significance of one of the following previously documented conditions (also see Congenital Heart section below) (Anagnostopoulos 2004):
  o Anomalous coronary arteries (Grani 2017; Kilner 2010)
  o Muscle bridging of coronary artery (perform with exercise stress) (Sorajja 2018)
  o Coronary aneurysms in Kawasaki’s disease (Newburger 2018)

---

**Congenital Heart Disease**

*(Warnes 2008; Baumgartner 2010; Kilner 2010; Orwat 2014; Wiant 2009)*
For evaluation of anomalous thoracic arteriovenous vessels, such as TGA (Cohen 2016).
Further assessment of complex adult congenital heart disease after confirmation by initial echocardiography (TTE and/or TEE), to answer remaining clinically relevant questions with the exception that:
- Echocardiography is preferable to CMR for the identification of patent foramen ovale, structural abnormalities of valve leaflets, and their suspensory apparatus, and CMR should generally not be required (Douglas 2011)
- When TTE and/or TEE has been or would be insufficient for clinical management, for the choice between CMR and CT, several aspects must be considered including radiation exposure, resolution required, summation of information required, its impact upon management, the presence of a pacemaker/ICD, or other implants and patient claustrophobia. Sample indications include:
  - Quantification of right ventricular (RV) volumes and ejection fraction (tetralogy of Fallot, systemic RV, and tricuspid regurgitation) CMR is preferred over CT (Haddad 2008; Dupont 2006; Benza 2008).
  - Evaluation of the RV outflow tract and RV-PA conduits (CMR or CT).
  - Quantification of pulmonic regurgitation (PR) (CMR, not CT).
  - Quantification of shunts by measurements of flow in the ascending aorta and pulmonary trunk (CMR, not CT).
  - Evaluation of the entire aorta (aneurysm, dissection, intramural hematoma, Loeys-Dietz, Ehlers-Danlos, or confirmed genetic mutation known to predispose to aortic aneurysm and dissection).(CMR or CT initially, with annual CMR (MRI) for Loeys-Dietz, Ehlers Danlos; multiple options for Marfan’s, Turner’s; see Aortic Pathology section below) (Hiratzka 2010).
  - Evaluation of pulmonary arteries (stenosis and aneurysms) and the aorta (coarctation) (CMR or CT).
  - Evaluation of systemic and pulmonary veins (anomalous connection, obstruction, etc.) (CMR or CT).
  - Aorto-pulmonary collaterals and arteriovenous malformations (either, but CT is superior to CMR for spatial resolution).
  - Identification of coronary anomalies and CAD (CCTA better than CMR, if no other CMR data required) (also see coronary section above - Special Diagnostic Conditions)
  - Evaluation of intra- and extra-cardiac masses (CMR or CT).
  - Quantification of myocardial (muscle) mass (CMR or CT).
  - Detection and quantification of myocardial fibrosis/scar (gadolinium late enhancement) [CMR, not CT].
- Tissue characterization (fibrosis, fat, iron etc.) (CMR, not CT).
- Assessment of right ventricular morphology in arrhythmogenic right ventricular dysplasia/cardiomyopathy, based upon reason for suspicion, of which examples are:
  - Nonsustained VT
  - Syncope
  - ECG abnormality: Prolonged S wave upstroke, epsilon waves, or right precordial T wave inversions (> 14 yr old) in the absence of complete right bundle branch block
  - First degree relative with phenotype or genotype of ARVD/C (either, but CMR is superior to CT) (Marcus 2010; McKenna 2018; te Riele 2015).

**Valvular (Doherty 2017; Baumgartner 2017; Nishimura 2014; Ordovas 2008)**

- Both TTE and TTE images are inadequate or not feasible for evaluation of possible valvular heart disease due to patient characteristics.
- Severe tricuspid regurgitation and suboptimal TTE images, for assessment of RV systolic function and systolic and diastolic volumes

- In patients with MR, when TTE and TEE (if able) show:
  - Moderate or severe MR, but images are suboptimal for assessment of MR severity, left ventricular function, and/or systolic and diastolic volumes

  OR

  - Severity of the MR that is discordant with the clinical assessment
In patients with AR, when TTE shows:

- Moderate or severe AR, but images are suboptimal for assessment of AR severity, left ventricular function, and/or systolic and diastolic volumes

- OR

- Severity of the AR that is discordant with the clinical assessment

- Pre TAVR assessment of aortic annular size and shape and/or the aortic dimensions, when the patient cannot undergo cardiac CT (Otto 2017)

- Prior to transcatheter mitral valve interventions, when TTE and TEE result in uncertain assessment of the severity of mitral regurgitation (Wunderlich 2018)

- Patients with bicuspid aortic valve and aortic dilation > 4.0 cm require annual imaging with CT, MRI, or echo.

  (Echo is required when it can evaluate the full extent of pathology under surveillance.)

  This would increase to biannual (twice-yearly) imaging in the event of any one of the additional conditions: diameter > 4.5 cm, rapid rate of change 0.5 cm/yr, or a family history of a first degree relative with aortic dissection. Initial imaging with first 6 month re-evaluation for rate of expansion is appropriate.

  Characterization of bioprosthetic valve if suspected clinically significant valvular dysfunction and inadequate images from TTE and TEE.

<table>
<thead>
<tr>
<th>Myocardial &amp; Heart Failure</th>
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<td>(Patel 2013, Yancy 2013)</td>
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- Evaluation of LV function following myocardial infarction OR in heart failure patients, when TTE (even with contrast agents) or MUGA, have been inadequate or discordant with prior information. (Montalescot 2013)

  For management of patients requiring cardiotoxic chemotherapy, with any ONE of the following: (Plana 2014)

  Cardio-Oncology section under Additional Information.)

  - TTE has been inadequate, unreliable, or discordant with prior information.

  - Candidacy for cardiotoxic chemotherapy is questionable due to borderline left ventricular dysfunction or other imaging

  - Discontinuation of cardiotoxic chemotherapy on the basis of a decline in left ventricular dysfunction is considered

  Left ventricular function assessment at baseline prior to initiation of radiation to the anterior or left chest, at years post initiation, and every 5 years thereafter, when TTE has been inadequate. (Lancellotti 2013)

  Diagnosis and monitoring of specific infiltrative cardiomyopathies, amyloidosis, sarcoidosis, hemochromatosis, endomyocardial fibrosis (Pereira 2018, Ordovas 2008)

  - Assisting with assessment of sudden cardiac arrest/death in patients with non ischemic cardiomyopathy, which will affect decision making with respect to management of the risk for sudden cardiac arrest/death (e.g. ICD implantation) (Al-Khatib 2017, Kuruvilla 2014, Halliday 2017)

  - In a patient suspected of cardiac sarcoid, evaluation of possible diffuse inflammation noted on 18-FDG PET, in order to guide therapy (Vita 2018)

  - Diagnosis of acute myocarditis, with suspicion based upon new, unexplained findings such as any one of:

    - Rise in troponin not clearly due to acute myocardial infarction

    - Change in ECG suggesting acute myocardial injury or pericarditis, without evident myocardial infarction, often with arrhythmia

    - Abnormal systolic function

  when the results could alter management (Friedrich 2013, Kinderman 2012, Cooper 2018, Ordovas 2008)

  - In cardiomyopathy (Ordovas 2008)

    - For detailed assessment of hypertrophic cardiomyopathy, when TTE is inadequate for diagnosis. Management or operative planning, or when tissue characterization (fibrosis quantitation) will impact indications for ICD (Maron 2012, Maron 2014, Al-Khatib 2017)
For confirming a diagnosis of ischemic cardiomyopathy when it will make a difference in clinical management (Fuisz 2016, bColucci 2018)

- Evaluation of first degree relatives with strong family history of cardiomyopathy, when TTE (even with contrast) was inadequate.

**Evaluation of Intra- and Extra-Cardiac Structures**

Suspected cardiac mass, paravalvular abscess, suspected tumor or non-valvular thrombus (CT for valvular thrombus), or potential cardiac source of emboli, when TTE and TEE images are inadequate (Doherty 2017, Pennell 2010, Baumgartner 2017, Nishimura 2014, Kassop 2014, Ordovas 2008, Sexton 2018)

- In suspected infective endocarditis with moderate to high pretest probability (i.e. staph bacteremia, fungemia, prosthetic heart valve, or intracardiac device), when TTE is inadequate and TEE cannot be performed (Doherty 2017)

- Detailed evaluation of a known cardiac mass (tumor), non-valvular thrombus (CT for valvular thrombus), paravalvular abscess (most often previously noted on echocardiography) (Doherty 2017, Pennell 2010, Baumgartner 2017, Nishimura 2014, Kassop 2014, Ordovas 2008)

- When TTE and/or TEE are inadequate, evaluation of pericardial conditions (pericardial mass, constrictive pericarditis, constriction versus restrictive cardiomyopathy) (CT superior for calcium assessment) (Klein 2013, Pennell 2010, Ordovas 2008)

Evaluation of left atrium and pulmonary veins prior to radiofrequency ablation for atrial fibrillation, including dimensions of veins for mapping purposes. (Ohana 2015, Figtree 2011)

- Assessment of left ventricular pseudoaneurysm, when TTE was inadequate and/or left ventriculography was not performed with cardiac catheterization or was inadequate. (Shapira 2018)

**Aortic Pathology**


Echo is required when is can evaluate the full extent of pathology under surveillance.

- CT, MR, or echo can be used for screening and follow up, with CT and MR preferred for imaging beyond the proximal ascending thoracic aorta (see table below for top normal sizes).
  
  o Screening first degree relatives of individuals with a history of thoracic aortic aneurysm (defined as ≥50% above top normal) or dissection or an associated high risk mutation for thoracic aneurysm in the family as common.
  
  o Screening second degree relative of a patient with thoracic aortic aneurysm (defined as ≥50% above normal), when the first degree relative has aortic dilation, aneurysm, or dissection
  
  o Six month follow up after initial finding of a dilated thoracic aorta, for assessment of rate of change
  
  o Annual follow up of enlarged thoracic aorta that is above top normal for age, gender, and size up to 4.4 cm
  
  o Biannual (twice/yr) follow up of enlarged aortic root ≥4.5 (>4.5 cm with bicuspid aortic valve) cm showing growth rate ≥0.5 cm/year
An aneurysm is defined as > 50% greater than top normal. (Cikach 2018; Hiratzka 2010)

- Marfan’s patients require annual imaging with CT, MRI (avoids radiation, especially when frequent evaluation required), or echo when it can evaluate the full extent of pathology, with increase to biannual (twice-yearly) imaging when diameter reaches 4.5 cm or when expansions is > 0.5 cm/yr. (Complete aortic annual CMR is recommended for annual evaluation Loeys-Dietz, Ehlers-Danlos, and certain other noted genetic mutations, wherein surgical intervention is recommended at 4.2 cm.)

- Turner’s syndrome patients should undergo imaging (CT, MRI - avoids radiation, especially when frequent evaluation required, or echo (when it can evaluate the full extent of pathology), of the heart and aorta for evidence of dilatation of the ascending thoracic aorta, and with normal imaging and no risk factors for aortic dissection, repeat imaging should be performed every 5-10 years or if otherwise indicated. If the aorta is enlarged, appropriate follow up imaging should be done according to size, as noted above. With a bicuspid aortic valve, the recommendation below applies.

- Patients with bicuspid aortic valve and aortic dilation > 4.0 cm require annual imaging with CT, MRI, or echo. (Echo is required when is can evaluate the full extent of pathology under surveillance.) This would increase to biannual (twice-yearly) imaging in the event of any one of the additional conditions: diameter > 4.5 cm, rate of change 0.5 cm/yr, or a family history of a first degree relative with aortic dissection. Initial imaging with first 6 month re-evaluation for rate of expansion is appropriate.
• CMR can be used for the diagnosis and surveillance of aortitis (Bhave 2018).
• Any interval increase > 3 mm on echo should be validated by CT or CMR. (Baumgartner 2014).
• When higher resolution measurement is required for determining an indication or surgery, CT appear slightly better (Baumgartner 2014).
• Computed tomographic imaging or magnetic resonance imaging of the thoracic aorta is reasonable after an A or B aortic dissection or after prophylactic repair of the aortic root/ascending aorta.
• Computed tomographic imaging or magnetic resonance imaging of the aorta is reasonable at 1, 3, 6, and 12 months post un-operated dissection or intramural hematoma, penetrating atherosclerotic aortic ulcer, and if unstable, annually thereafter so that any threatening enlargement can be detected in a timely fashion.
• Postoperative surveillance recommendations are taken from the 2010 ACC Thoracic Aortic Disease Guideline. See Table below (Hiratzka 2010).
CT and MR preferred for imaging beyond the proximal ascending thoracic aorta.

(Table above from Hiratzka 2010)
ADDITIONAL INFORMATION
I. General

Scenarios for which approval CMR is generally not approvable:
- For any combination imaging study
- For same imaging tests less than six weeks part unless specific guideline criteria states otherwise, e.g. evaluation of cardiac sarcoid with MR subsequent to PET (Vita 2018)
- For different imaging tests, such as CTA and CMR, of same anatomical structure less than six weeks apart without high level review to evaluate for medical necessity.
- For re-imaging of repeat or poor quality study

Request for a follow-up study - A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

Cardiac Tumors (Kassop 2014; Ordovas 2008)
MRI is the modality of choice to evaluate cardiac tumors due to its high contrast resolution and multiplanar capability which allows for optimal evaluation of myocardial infiltration, pericardial involvement and extra-cardiac vascular structures within and beyond the thorax. It is also useful in the differentiation of benign and malignant cardiac tumors and in differentiating thrombi from cardiac tumors.

CMR Safety (Chernoff 2018; Russo 2017; Nazarian 2017; Indik 2017; Brignole 2013)
Since many cardiac patients have cardiac implanted electrical devices (CIEDSs), the risk of CMR to the patient and the device must be weighed against the benefit to the patient, in terms of clinical value in optimal management.

Many newer CIEDs are ‘MR conditional’ for thoracic scanning, some only for non-thoracic scanning, and some for both. With adherence to manufacturer’s recommendations and precautions with respect to programming and patient/device monitoring, MR conditional CIEDs do permit safe MR scanning, with a limited amount of data available specific to cardiac MR.

The older ‘non MR conditional’ devices are often amendable to MR scanning at field strength ≤ 1.5 Tesla. However, the presence of a CIED is still generally considered a strong relative contraindication to routine MR examination, and therefore, MR imaging in patients with non-MRI-conditional permanent pacemakers or ICD should be undertaken only if no alternative diagnostic test is available and the potential benefit to the patient clearly outweighs the potential risks. Such an approach warrants informed patient consent, and the scanning protocol requires on site imaging and device management expertise.

Additional non-conditional device materials include combinations of components (even if individually conditional) from various manufacturers that have not been specifically tested together for conditional labeling. Other examples of non-conditional components include epicardial leads, abandoned leads, fractured leads, or an active non cardiac device.
II. ECG Stress Test Alone versus Stress Testing with Imaging

Prominent scenarios suitable for an ECG stress test WITHOUT imaging (i.e. exercise treadmill ECG test) are inferred from the guidelines presented above, often (but not always) requiring that the patient can exercise for at least 3 minutes of Bruce protocol with achievement of near maximal heart rate AND has an interpretable ECG for ischemia during exercise (Wolk 2013):

The (symptomatic) low pretest probability patient who is able to exercise and has an interpretable ECG

The (asymptomatic) high global risk patient who is able to exercise and has an interpretable ECG

- The patient who is under evaluation for exercise induced arrhythmia (or long QT interval evaluation when the resting QTc is normal), and coronary artery disease is not suspected (Al-Khatib 2017)

- The patient who requires an entrance stress test ECG for a cardiac rehab program or for an exercise prescription.

Duke Exercise ECG Treadmill Score calculates risk from ECG treadmill alone:

- The equation for calculating the Duke treadmill score (DTS) is: \(\text{DTS} = \text{exercise time in minutes} - (5 \times \text{ST deviation in mm or 0.1 mV increments}) - (4 \times \text{exercise angina score}),\) with angina score being 0 = none, 1 = non-limiting, and 2 = exercise-limiting.

- The score typically ranges from -25 to +15. These values correspond to low-risk (with a score of ≥ +5), intermediate risk (with scores ranging from -10 to +4), and high-risk (with a score of ≤ -11) categories.

An uninterpretable baseline ECG includes (Fihn 2012):

- Abnormalities of ST segment depression of 0.1 mV (1 mm with conventional calibration) or more
- Ischemic looking T wave inversions of at least 0.25 mV (2.5 mm with conventional calibration)
- ECG findings of probable or definite LVH, WPW, a ventricular paced rhythm, or left bundle branch block
- Digitalis use or hypokalemia
- Resting HR under 50 bpm on a beta blocker and an anticipated suboptimal workload (e.g. rate-pressure product less than 20-25K) could render inconclusive result
- Prior false positive stress ECG

III. Global Risk of Cardiovascular Disease

Global risk of CAD is defined as the probability of manifesting cardiovascular disease over the next 10 years and refers to asymptomatic patients without known cardiovascular disease. It should be determined using one of the risk calculators below. A high risk is considered greater than a 20% risk of a cardiovascular event over the ensuing 10 years. High global risk by itself generally lacks scientific support as an indication for stress imaging (Douglas 2018). There are rare exemptions, such as patients requiring a I-C antiarrhythmic drug, who might require coronary risk stratification prior to initiation of the drug, when global risk is moderate or high.
- **CAD Risk—Low**
  10-year absolute coronary or cardiovascular risk less than 10%.
- **CAD Risk—Moderate**
  10-year absolute coronary or cardiovascular risk between 10% and 20%.
- **CAD Risk—High**
  10-year absolute coronary or cardiovascular risk of greater than 20%.

**Links to Global Cardiovascular Risk Calculators***

*Patients who have already manifested cardiovascular disease are already at high global risk and are not applicable to the calculators.

(D’Agostino 2008; Ridker 2007; McClelland 2015; Goff 2014)

<table>
<thead>
<tr>
<th>Risk Calculator</th>
<th>Link to Online Calculator</th>
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<tbody>
<tr>
<td>Reynolds Risk Score</td>
<td><a href="http://www.reynoldsriskscore.org/">http://www.reynoldsriskscore.org/</a></td>
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<tr>
<td>Pooled Cohort Equation</td>
<td><a href="http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example">http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example</a></td>
</tr>
<tr>
<td>MESA Risk Calculator</td>
<td><a href="https://www.mesa-">https://www.mesa-</a> nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx</td>
</tr>
</tbody>
</table>

**IV. Definitions of Coronary Artery Disease**

(Fihn 2012; Montalescot 2013; Patel 2017; Mintz 2016; Tobis 2007)

1. Percentage stenosis refers to the reduction in diameter stenosis when angiography is the method and refers to cross sectional narrowing when IVUS (intravascular ultrasound) is the method of determination.
2. Coronary artery calcification is a marker of risk, as measured by Agatston score on coronary artery calcium imaging. It is not a diagnostic tool so much as it is a risk stratification tool. Its incorporation into global risk can be achieved by using the MESA risk calculator.
3. Stenoses ≥ 50% are considered obstructive coronary artery disease (also referred to as clinically significant), while stenoses ≤ 50% are considered nonobstructive coronary artery disease (Gerber 2018).
4. Ischemia-producing disease (also called hemodynamically or functionally significant disease, for which revascularization might be appropriate) generally implies at least one of the following:
   i. Suggested by percentage diameter stenosis ≥ 70% by angiography; borderline lesions are 40-70% (Fihn 2012; Tobis 2007)
ii. For a left main artery, suggested by a percentage stenosis ≥ 50% or minimum lumen cross sectional area on IVUS ≤ 6 square mm (Fihn 2012; Mintz 2016)

iii. FFR (fractional flow reserve) ≤ 0.80 for a major vessel (Mintz 2016)

iv. Demonstrable ischemic findings on stress testing (ECG or stress imaging), that are at least mild in degree

5. A major vessel would be a coronary vessel that would typically be substantial enough for revascularization, if it were indicated. Lesser forms of coronary artery disease would be labeled as “limited” and not major (i.e. A 50% lesion in a tiny septal or modest size mid PDA would be limited obstructive coronary artery disease.)

6. Microvascular ischemic coronary artery disease, as might be described by a normal FFR (fractional flow reserve) above 0.80 with a reduced CFR (coronary flow reserve less than 2.5), has not otherwise been addressed in this manuscript, because it is very rarely an issue in compliance determinations. However, it would constitute a form of ischemic heart disease.

7. FFR (fractional flow reserve) is the distal to proximal pressure ratio across a coronary lesion during maximal hyperemia induced by either intravenous or intracoronary adenosine. Less than or equal to 0.80 is considered a significant reduction in coronary flow. Newer iterations such as iFR (instantaneous wave free ratio) might supersede basic FFR technology in the near future.

8. New technology is evolving that estimates FFR from CCTA images. This is covered under the separate NIA Guideline for FFR-CT.

V. Anginal Equivalent

Development of an anginal equivalent (e.g. shortness of breath, fatigue, or weakness) either with or without prior coronary revascularization should be based upon the documentation of reasons to suspect that symptoms other than chest discomfort are not due to other organ systems (e.g. dyspnea due to lung disease, fatigue due to anemia), by presentation of clinical data such as respiratory rate, oximetry, lung exam, (as well as d-dimer, chest CT(A), and/or PFTs, when appropriate), and then incorporated into the evaluation of coronary artery disease as would chest discomfort. Syncope per se is not an anginal equivalent (Moya 2009; Shen 2017; Fihn 2012).

VI. Peripheral Arterial Disease/Cerebrovascular Disease

Arterial vascular disease below the renal arteries is generally referred to as peripheral arterial disease, when the ankle brachial index is <0.9 or there is at least 50% vessel diameter narrowing on ultrasound or angiography (Hussain 2018).

Cerebrovascular disease generally refers to a history of TIA (transient ischemic attack) or stroke, or cerebrovascular lesions that put the patient at considerable risk for stroke (Caplan 2018).

There is no evidence to demonstrate that screening all patients with peripheral arterial disease for asymptomatic atherosclerosis in other arterial beds improves clinical outcome. Intensive treatment of risk factors through guideline directed medical therapy is the principal method for preventing adverse cardiovascular ischemic events secondary to atherosclerotic disease in other arterial beds (Gerhard-Herman 2016).

VII. Imaging Surveillance for Cardiotoxic Chemotherapy

(Plana 2014; Zamorano 2016; Maleszewski 2018; Herrmann 2014)
**TTE is the method of choice** for the evaluation of patients before, during, and after cancer therapy. Ideally accuracy prefers that 3D and global longitudinal strain (GLS) are part of the exam, and serum troponin (Tn) should also be measured. However, GLS and Tn might not have been performed, in which case determinations might need to be made with LVEF only. *Serum troponin (Tn) and GLS abnormities constitute an abnormal assessment of LV function, because their abnormalities frequently herald an imminent fall in LVEF* (Plana 2014; Zamorano 2016).

**CMR** is recommended when TTE has been unreliable and/or candidacy for cardiotoxic chemotherapy based upon LVEF is questionable. MUGA can also be considered when TTE is inadequate and CMR is not available (Plana 2014).

**MUGA** is accurate and reproducible, but lacks information about pericardium and valves, incurs repeated radiation exposure, and is inaccurate during an irregular cardiac rhythm (Plana 2014).

**Surveillance guidelines** are somewhat complex, possibly beyond the scope of this guideline, especially in patients with additional risk factors for LV dysfunction (Herrmann 2014). As with all guidelines, adequate information for complex decisions might be impractical to acquire. However, if the reader requires more rigorous recommendations, they are summarized concisely in the table below. Necessity determinations might not require strict adherence to this table at this time, but it is here to serve as a helpful reference for the reader, if desired.

### TTE Surveillance Strategy for Cardiotoxic Chemotherapy (Optional Information)
(Plana 2014; Herrmann 2014; Zamorano 2016; Maleszewski 2018)

| Suspected/Detected LV Status at Baseline, During, or After Completion of Therapy (LVEF is minimum information, GLS and Tn can reveal early LV dysfunction prior to LVEF) | Normal: EF is > 55%, troponin is negative, and global longitudinal strain (GLS) > lower limit of normal* | Abnormal: any one of:
|---|---|---|
| Type I Anthracyclines: Doxorubicin, Epirubicin, Idarubicin Mitoxantrone (Asnani 2018) | Normal assessment:
Assess after a cumulative dose > 200mg/M² (or its anthracycline equivalent) and prior to each additional 50 mg/M², and at completion of therapy, and 6 months later, and for cumulative dose > 300 mg/M² include assessment at 1 year and at 5 years post completion of therapy. (Zamorano 2016) | Abnormal assessment:
Assess after every cycle, and re-assess for verification 2-3 weeks later if a drop in LV function has been detected/suspected; assess 6 months post completion of therapy, followed by re-assessment every 6 months until stable, and for cumulative dose > 300 mg/M² include assessment at |
| Type II Trastuzumab, Labatinib, Pertuzumab, Sorafenib, Sunitinib, Bevacizumab, Bortezomib ** | Normal assessment:
Assess every 3 months during therapy and at 6 months post completion of therapy | Abnormal assessment:
Assess after every cycle, and re-assess for verification 2-3 weeks later if a drop in LV function has been detected/suspected; assess 6 months post completion of therapy, and if still not stable reassess every 6 months until stable. |

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Proprietary

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| Symptomatic/≥10 points for an asymptomatic patient. (Maleszewski 2018) | 1 year *and* 5 years post completion of therapy. (Zamorano 2016) |

* GLS of (negative) 20 is generally normal, but individual labs vary (Collier 2017).
** Imatinib, rarely cardiotoxic, does not require surveillance of LV function (Floyd 2018).
### Abbreviations

<table>
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ARVD/C</td>
<td>Arrhythmogenic right ventricular dysplasia/cardiomyopathy</td>
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<tr>
<td>CABG</td>
<td>Coronary artery bypass grafting surgery</td>
</tr>
<tr>
<td>CAD</td>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>CCT</td>
<td>Cardiac CT</td>
</tr>
<tr>
<td>CCTA</td>
<td>Coronary CT angiography</td>
</tr>
<tr>
<td>CHF</td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>CMR</td>
<td>Cardiac magnetic resonance (imaging)</td>
</tr>
<tr>
<td>CT</td>
<td>Computed tomography</td>
</tr>
<tr>
<td>CTA</td>
<td>Computed tomographic angiography</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>GLS</td>
<td>Global longitudinal strain (measure of left ventricular function)</td>
</tr>
<tr>
<td>HF</td>
<td>Heart failure</td>
</tr>
<tr>
<td>LBBB</td>
<td>Left bundle-branch block</td>
</tr>
<tr>
<td>LV</td>
<td>Left ventricular</td>
</tr>
<tr>
<td>MI</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>MPI</td>
<td>Myocardial perfusion imaging</td>
</tr>
<tr>
<td>MR(I)</td>
<td>Magnetic resonance (imaging)</td>
</tr>
<tr>
<td>PCI</td>
<td>Percutaneous coronary intervention</td>
</tr>
<tr>
<td>PET</td>
<td>Positron emission tomography</td>
</tr>
<tr>
<td>RNA</td>
<td>Radionuclide angiography</td>
</tr>
<tr>
<td>RV</td>
<td>Right ventricle</td>
</tr>
<tr>
<td>SE</td>
<td>Stress echocardiography</td>
</tr>
<tr>
<td>Tn</td>
<td>Troponin</td>
</tr>
<tr>
<td>TR</td>
<td>Tricuspid regurgitation</td>
</tr>
</tbody>
</table>
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INTRODUCTION
(Gerber 2018; Hecht 2017; Blankstein 2017; Greenland 2018)

- Coronary artery calcium (CAC) testing is a cardiovascular risk assessment tool, applicable only to the patient without known cardiovascular disease, for the purpose of primary prevention. It is not for the patient with suspected or known cardiovascular disease, coronary or otherwise, who already require aggressive risk factor modification.

- CAC testing, by either EBCT or non-contrast CCT, provides a quantitative assessment of coronary artery calcium content in Agatston units, which is an adjunct to the estimation of global risk for coronary or cardiovascular events over the next 10 years (McClelland 2015). A CAC Score > 0 is a highly specific feature of coronary atherosclerosis.

- Despite controversies that exist (Nasir 2012; Blaha 2017), a growing concern about overutilization of statin therapy in large numbers of patients at lower than conventionally determined risk has led to promotion of CAC testing as a way to address this problem. It infrequently (5% of those who would ordinarily not warrant a statin) shows an increase over conventionally determined risk (see explanatory table in Additional Information section) (Nasir 2015; Greenland 2018; Michos 2017; Pender 2016; Mahabadi 2017).

- CAC score > 100 can also provide support for aspirin therapy (Hecht 2017).

Indications for CAC Testing
(Greenland 2018; Hecht 2017; Blankstein 2017; Pender 2016; Goff 2014; Nasir 2015; McClelland 2015; Piepoli 2016; Mahabadi 2017; Gerber 2018)

- In the context of shared decision making among patients aged 40 to 75 years who are free of clinical atherosclerotic cardiovascular disease and deemed to be at intermediate-to-low or intermediate risk (5 - 20%), and adjusting that risk up or down based upon the CAC score has been documented in the record as necessary to adjust cardiovascular risk management, such as decisions with respect to statin therapy (Stone 2013; Michos 2017; Hecht 2017; Wilkins 2018).

- Patients who are over 75 or younger than 40 are far less likely to have meaningful alteration in risk, but CAC testing can be considered in these patients when there is strong, well-documented evidence that the result of CAC testing could alter management, in the context of documented patient-physician shared decision making (Tota-Maharaj 2012).

- Patients with estimated 10-year risk of less than 5%, but are suspected to be at elevated atherosclerotic cardiovascular disease (ASCVD) risk because of a major risk factor not accounted for in the global risk equations, such as erectile dysfunction, rheumatologic diseases (lupus, psoriasis, ankylosing spondylitis, or rheumatoid arthritis), or family history of premature CAD (Greenland 2018; Michos 2017; Hecht 2017).
• Patients in whom statin therapy is indicated but who have intolerable adverse effects from statins or reluctance to take statin medication, to guide the need for alternative lipid-lowering strategies (Nasir 2015; Michos 2017; Blankstein 2017).

• Repeat CAC testing may be repeated for risk re-assessment after a minimum of 5 years, if documentation indicates it will alter management (e.g. prior CAC = 0), which should be rare in patients who already have a prior CAC score > 0 (Michos 2017; Greenland 2018; Hecht 2017). It should not be repeated if the patient has already had two CAC Scores of zero 5 years apart (Greenland 2018).

The Determination of Global Cardiovascular Risk*
*Patients who have already manifested cardiovascular disease are already at high global risk and are not applicable to the calculators.

Links to Global Cardiovascular Risk Calculators
(D’Agostino 2008; Ridker 2007; McClelland 2015; Goff 2014)

<table>
<thead>
<tr>
<th>Risk Calculator</th>
<th>Link to Online Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reynolds Risk Score</td>
<td><a href="http://www.reynoldsriskscore.org/">http://www.reynoldsriskscore.org/</a></td>
</tr>
<tr>
<td>Pooled Cohort Equation</td>
<td><a href="http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example">http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example</a></td>
</tr>
<tr>
<td>MESA Risk Calculator With addition of Coronary Artery Calcium Score, for CAD-only risk</td>
<td><a href="https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx">https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx</a></td>
</tr>
</tbody>
</table>

Risk tiers:
• Low < 10%.
• Moderate 10% - 20%.
• High risk - > 20%.

Management Approach Using CAC Scoring
(Greenland 2018)
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCVD</td>
<td>Atherosclerotic cardiovascular disease</td>
</tr>
<tr>
<td>CAC</td>
<td>Coronary artery calcium</td>
</tr>
<tr>
<td>CAD</td>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>CCT</td>
<td>Cardiac computed tomography</td>
</tr>
<tr>
<td>EBCT</td>
<td>Electron beam computed tomography</td>
</tr>
</tbody>
</table>

The figure shows a modified approach to the guideline-based decision making by incorporating a consideration of coronary artery calcium (CAC) testing to reclassify a patient's risk up or down where it would make a clinically important change in the clinical decision. Adapted with permission from Nest et al. (90).
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CPT Codes: 75572, 75573

INTRODUCTION

- Cardiac computed tomography (Heart CT) serves to image the cardiac chambers, great vessels, valves, myocardium and pericardium to assess cardiac structure and function, particularly when echocardiography (transthoracic echocardiography and transesophageal echocardiography) cannot provide adequate information.

- CT imaging can be used for assessment of the
  - Structures of the heart (chambers, valves, great vessels, masses, etc.), as in this guideline
  - The coronary circulation, as in the separate coronary computed tomography angiography (CCTA) guideline
  - Quantitative level of calcium in the walls of the coronary arteries, in the separate coronary artery calcium (CAC) scoring guideline

- CT imaging is frequently competitive with CMR (Cardiac Magnetic Resonance Imaging), or MRI (Warnes 2008, Baumgartner 2010, Pennell 2010)

<table>
<thead>
<tr>
<th>Modality</th>
<th>Cardiac CT</th>
<th>Cardiac MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrast</td>
<td>Often required</td>
<td>Required for some tissue characterization studies, often unnecessary</td>
</tr>
<tr>
<td>Radiation*</td>
<td>Yes</td>
<td>None, advantage for young patients and those requiring frequent exams</td>
</tr>
<tr>
<td>Resolution</td>
<td>Higher spatial</td>
<td>Higher temporal</td>
</tr>
<tr>
<td>Flow</td>
<td>Not standard</td>
<td>Standard</td>
</tr>
<tr>
<td>Patient comfort</td>
<td>Easy</td>
<td>Claustrophobia issues</td>
</tr>
<tr>
<td>Ferromagnetic implants</td>
<td>No issue</td>
<td>Relative contraindication</td>
</tr>
<tr>
<td>Cost</td>
<td>Moderate to High</td>
<td>High</td>
</tr>
</tbody>
</table>

*(Hirshfeld 2018)
Some scenarios might provide more detail with low dose CT than with CMR, thereby overriding the radiation risk (Ohana 2015, Schoenhagen 2005).

INDICATIONS FOR HEART CT
(Taylor 2011; Douglas 2011)

<table>
<thead>
<tr>
<th>Evaluation of Cardiac Structure and Function</th>
<th>(Warnes 2008; Wiant 2009; Baumgartner 2010; Orwat 2014; Kilner 2010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Congenital Heart Disease</td>
<td></td>
</tr>
<tr>
<td>• For evaluation of anomalous thoracic arteriovenous vessels, such as TGA, when MRI cannot be performed (Cohen 2016; Warnes 2008).</td>
<td></td>
</tr>
</tbody>
</table>
• Further assessment of complex adult congenital heart disease after confirmation by transthoracic echocardiography (TTE), but TTE was inadequate for clinical management (consider advantages of CMR below).

• When TTE and/or transesophageal echocardiography (TEE) has been or would be insufficient for clinical management, for the choice between CMR and CT, several aspects must be considered including radiation exposure, resolution required, sum of information required, its impact upon management, the presence of a pacemaker/implantable cardioverter defibrillator (ICD) or other implants, and patient claustrophobia. Sample indications include:
  o Quantification of RV volumes and ejection fraction (tetralogy of Fallot, systemic RV, and tricuspid regurgitation) [CMR better than CT, if available] (Haddad 2008, Dupont 2009, Benza 2008).
  o Evaluation of the RV outflow tract and RV-PA conduits (CMR or CT).
  o Evaluation of the entire aorta (aneurysm, dissection, intramural hematoma, Loey-Dietz, Ehlers-Danlos, or confirmed genetic mutation known to predispose to aortic aneurysm and dissection. CMR or CT initially, with annual CMR (MRI) for Loey-Dietz, Ehlers Danlos; multiple options for Marfan’s, Turner’s (see Aortic Pathology section below) (Hiratzka 2010).
  o Evaluation of pulmonary arteries (stenosis and aneurysms) and the aorta (coarctation) (CMR or CT).
  o Evaluation of systemic and pulmonary veins (anomalous connection, obstruction, etc) (CMR or CT).
  o Aorto-pulmonary collaterals and arteriovenous malformations (either, but CT is superior to CMR for spatial resolution, if needed).
  o Coronary anomalies and CAD (indication for CCTA, better than CMR).
  o Quantification of myocardial (muscle) mass (CMR or CT).
• Assessment of right ventricular morphology in arrhythmogenic right ventricular dysplasia/cardiomyopathy, based upon reason for suspicion, of which examples are:
  o Nonsustained VT
  o Syncope
  o ECG abnormality: Prolonged S wave upstroke, epsilon waves, or right precordial T wave inversions (> 14 yr old) in the absence of complete RBBB
  o First degree relative with phenotype or genotype of ARVD/C (either, but CMR is superior to CT) (Marcus 2010; McKenna 2018; te Riele 2015).

Left Ventricular Function Assessment
• Evaluation of left ventricular function following acute MI or in HF patients, when echocardiography (even with contrast) and radionuclide angiography/ventriculography are inadequate (Fihn 2012; Patel 2013).

Valvular Assessment
• Characterization of native or prosthetic valves with clinical signs or symptoms suggesting valve dysfunction, when TTE, TEE, and fluoroscopy have been inadequate (e.g. bioprosthetic valve thrombus post transcatheter or surgical valve replacement) (Doherty 2017).
• Evaluation of the calcium score of the aortic valve in symptomatic patients with severe calcific aortic stenosis by calculated valve area (≤ 1.0 square cm), low flow (stroke volume ≤ 35 mL/square M) with low gradient (mean < 40 mm Hg or Doppler < 4 M/sec), and ejection fraction < 50%, when low dose dobutamine shows no flow (contractile reserve (failure to increase stroke volume > 20%), to assist with the determination of the severity of the aortic stenosis. Severe (in Aggatston units): >1,200 women, >2,000 men (Baumgartner 2017; Steiner 2017; Clavel 2017).

• Evaluation of the calcium score of the aortic valve in symptomatic patients with severe calcific aortic stenosis by calculated valve area (≤ 1.0 square cm), low flow (stroke volume ≤ 35 mL/square M) with low gradient (mean < 40 mm Hg or Doppler < 4 M/sec), and preserved ejection fraction ≥ 50%, to assist with the determination of the severity of the aortic stenosis. Severe (in Aggatston units): >1,200 women, >2,000 men (Baumgartner 2017; Clavel 2017).

• Evaluation of the calcium score of the aortic valve in symptomatic patients with severe calcific aortic stenosis by calculated valve area (≤ 1.0 square cm and index ≤ 0.6 square cm/square M), normal flow (stroke volume ≥ 35 mL/square M) with low gradient (mean < 40 mm Hg or Doppler < 4 M/sec), and preserved ejection fraction ≥ 50%, to assist with the determination of the severity of the aortic stenosis. Severe (in Aggatston units): >1,200 women, >2,000 men (Clavel 2017).

• Evaluation of RV systolic function, including systolic and diastolic volumes, in severe tricuspid TR, when TTE images are inadequate and CMR is not readily available.

• Evaluation of suspected infective endocarditis with moderate to high pretest probability (i.e. staph bacteremia, fungemia, prosthetic heart valve, or intracardiac device), when TTE and TEE have been inadequate.

• Evaluate morphology/anatomy in the setting of suspected paravalvar infections when the anatomy cannot be clearly delineated by TTE and TEE (Nishimura 2014).

• Patients with bicuspid aortic valve and aortic dilation > 4.0 cm require annual imaging with CT, MRI, or echo. Echo is required when it can evaluate the full extent of pathology under surveillance. This would increase to biannual (twice-yearly) imaging in the event of any one of the additional conditions: diameter > 4.5 cm, rapid rate of change 0.5 cm/yr, or a family history of a first degree relative with aortic dissection. Initial imaging with first 6 month re-evaluation for rate of expansion is appropriate.

Evaluation of Intra- and Extracardiac Structures

• Evaluation of cardiac mass (suspected tumor or thrombus, including valvular mass or vegetation), when imaging with TTE and TEE have been inadequate (consider advantage of CMR for superior tissue characterization). (Doherty 2017; Kassop 2014; Baumgartner 2017; Nishimura 2014; Sexton 2018)

Evaluation of pericardial anatomy, when TTE and/or TEE are inadequate or for better tissue characterization of a mass and detection of metastasis, if malignancy is suspected (CMR superior for physiologic assessment (constrictive versus restrictive) and tissue characterization, CT superior for calcium assessment) (Klein 2013; Pennell 2010).

Electrophysiologic Procedure Planning

• Evaluation of pulmonary venous anatomy prior to radiofrequency ablation of atrial fibrillation and for follow up when needed for evaluation of pulmonary vein stenosis (Wai-ee, 2012; Ohana, 2015; Niinuma 2008; Schoenhagen 2010; Raijah 2013).
• Non-invasive coronary vein mapping prior to placement of biventricular pacing leads (Raijah 2013; Van de Veire 2006; Heydari 2012)

### Transcatheter Structural Intervention Planning

• When TTE and TTE cannot provide adequate imaging, CT imaging can be used for planning: robotic mitral valve repair, atrial septal defect closure, left atrial appendage closure, ventricular septal defect closure, endovascular grafts, and percutaneous pulmonic valve implantation (Raijah 2013; Schoenhagen 2010; Flachskampf 2014; Pison 2015).
• Evaluation for suitability of TMVR, transcatheter mitral annuloplasty, and transcatheter mitral PVML closure, alone or in addition to TEE (Wunderlich 2018).

### Aortic Pathology:
(Hiratzka 2010; Erbel 2014; Schiller 2017; Wright a&b 2018; Woo a&b 2018; Svensson 2013; Doherty 2017; Nishimura 2014; Baumgartner 2014; Hendel 2006; Bhave 2018)

Echo is required when it can evaluate the full extent of pathology under surveillance.

• CT, MR, or echo can be used for screening and follow up, with CT and MR preferred for imaging beyond the proximal ascending thoracic aorta (see table below for top normal sizes).
  o Screening first degree relatives of individuals with a history of thoracic aortic aneurysm (defined as ≥ 50% above top normal) or dissection or an associated high risk mutation for thoracic aneurysm in common.
  o Screening second degree relative of a patient with thoracic aortic aneurysm (defined as ≥ 50% above top normal), when the first degree relative has aortic dilation, aneurysm, or dissection.
  o Six month follow up after initial finding of a dilated thoracic aorta, for assessment of rate of change.
  o Annual follow up of enlarged thoracic aorta that is above top normal for age, gender, and size up to 4.4 cm.
  o Biannual (twice/yr) follow up of enlarged aortic root ≥ 4.5 cm (> 4.5 cm for bicuspid aortic valve) or showing growth rate ≥ 0.5 cm/year.
An aneurysm is defined as $> 50\%$ greater than top normal (Cikach 2018, Hiratzka 2010).

- Marfan’s patients require annual imaging with CT, MRI (avoids radiation, especially, when frequent evaluation required), or echo when it can evaluate the full extent of pathology, with increase to biannual (twice-yearly) when diameter $\geq 4.5$ cm or when expansions is $> 0.5$ cm /yr (complete aortic annual CMR is recommended for Loeys-Dietz, Ehlers-Danlos, and certain other noted genetic mutations, wherein surgical intervention is recommended as at low as 4.2 cm).

- Turner’s syndrome patients should undergo imaging (CT, MRI - avoids radiation, especially when frequent evaluation required, or echo (when it can evaluate the full extent of pathology), of the heart and aorta for evidence of dilatation of the ascending thoracic aorta, and with normal imaging and no risk factors for aortic dissection, repeat imaging should be performed every 5-10 years, or if otherwise indicated. If the aorta is enlarged, appropriate follow up imaging should be done according to size, as above. With a bicuspid aortic valve, the recommendation below applies.

### Table above from Wolak 2008, as adapted by Cikach 2018

An aneurysm is defined as $\geq 50\%$ greater than top normal (Cikach 2018, Hiratzka 2010).

- Marfan’s patients require annual imaging with CT, MRI (avoids radiation, especially, when frequent evaluation required), or echo when it can evaluate the full extent of pathology, with increase to biannual (twice-yearly) when diameter $\geq 4.5$ cm or when expansions is $> 0.5$ cm /yr (complete aortic annual CMR is recommended for Loeys-Dietz, Ehlers-Danlos, and certain other noted genetic mutations, wherein surgical intervention is recommended as at low as 4.2 cm).

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### Aortic diameters: Upper limits of normal

<table>
<thead>
<tr>
<th>Age (years) BSA (m$^2$)</th>
<th>Ascending aorta (mm)</th>
<th>Descending aorta (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women (n = 1,147)</td>
<td>Men (n = 1,805)</td>
</tr>
<tr>
<td>&lt; 45</td>
<td>33.8</td>
<td>33.0</td>
</tr>
<tr>
<td>1.70–1.89</td>
<td>34.4</td>
<td>36.3</td>
</tr>
<tr>
<td>1.90–2.09</td>
<td>35.0</td>
<td>36.3</td>
</tr>
<tr>
<td>&gt; 2.1</td>
<td>NA</td>
<td>38.3</td>
</tr>
<tr>
<td>45–54</td>
<td>35.2</td>
<td>38.6</td>
</tr>
<tr>
<td>1.70–1.89</td>
<td>37.2</td>
<td>38.1</td>
</tr>
<tr>
<td>1.90–2.09</td>
<td>38.9</td>
<td>39.7</td>
</tr>
<tr>
<td>&gt; 2.1</td>
<td>40.6</td>
<td>40.6</td>
</tr>
<tr>
<td>55–64</td>
<td>36.9</td>
<td>36.3</td>
</tr>
<tr>
<td>1.70–1.89</td>
<td>37.0</td>
<td>39.7</td>
</tr>
<tr>
<td>1.90–2.09</td>
<td>39.0</td>
<td>41.2</td>
</tr>
<tr>
<td>&gt; 2.1</td>
<td>42.0</td>
<td>43.1</td>
</tr>
<tr>
<td>$\geq$ 65</td>
<td>37.5</td>
<td>38.5</td>
</tr>
<tr>
<td>1.70–1.89</td>
<td>39.2</td>
<td>41.0</td>
</tr>
<tr>
<td>1.90–2.09</td>
<td>42.7</td>
<td>42.2</td>
</tr>
<tr>
<td>&gt; 2.1</td>
<td>NA</td>
<td>42.4</td>
</tr>
</tbody>
</table>

$^a$Upper limits of normal are 2 standard deviations above the mean. Not calculated if there were fewer than 6 patients in a group. BSA = body surface area. NA = not available.
- Patients with bicuspid aortic valve and aortic dilation > 4.0 cm require annual imaging with CT, MRI, or echo. (Echo is required when is can evaluate the full extent of pathology under surveillance.) This would increase to biannual (twice-yearly) imaging in the event of any one of the additional conditions: diameter > 4.5 cm, rapid rate of change 0.5 cm/yr, or a family history of a first degree relative with aortic dissection. Initial imaging with first 6 month re-evaluation for rate of expansion is appropriate.
- Any interval increase > 3 mm on echo should be validated by CT or CMR (Baumgartner 2014).
- When higher resolution measurement is required for determining an indication for surgery, CT appears slightly better (Baumgartner 2014).
- Computed tomographic imaging or magnetic resonance imaging of the thoracic aorta is reasonable after a Type A or B aortic dissection or after prophylactic repair of the aortic root/ascending aorta.
- Computed tomographic imaging or magnetic resonance imaging of the aorta is reasonable at 1, 3, 6, and 12 months post un-operated dissection, penetrating atherosclerotic aortic ulcer, and, if stable, annually thereafter, so that any threatening enlargement can be detected in a timely fashion.
- Postoperative surveillance recommendations are taken from the 2010 ACC Thoracic Aortic Disease Guideline (see table below) (Hiratzka 2010).
Table 17. Suggested Follow-Up of Aortic Pathologies After Repair or Treatment

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Interval</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute dissection</td>
<td>Before discharge, 1 mo, 6 mo, yearly</td>
<td>CT or MR, chest plus abdomen TTE</td>
</tr>
<tr>
<td>Chronic dissection</td>
<td>Before discharge, 1 y, 2 to 3 y</td>
<td>CT or MR, chest plus abdomen TTE</td>
</tr>
<tr>
<td>Aortic root repair</td>
<td>Before discharge, yearly</td>
<td>TTE</td>
</tr>
<tr>
<td>AVR plus ascending</td>
<td>Before discharge, yearly</td>
<td>TTE</td>
</tr>
<tr>
<td>Aortic arch</td>
<td>Before discharge, 1 y, 2 to 3 y</td>
<td>CT or MR, chest plus abdomen</td>
</tr>
<tr>
<td>Thoracic aortic stent</td>
<td>Before discharge, 1 mo, 2 mo, 6 mo, yearly or 30 days*</td>
<td>CXR, CT, chest plus abdomen</td>
</tr>
<tr>
<td>Acute IMH/PAU</td>
<td>Before discharge, 1 mo, 3 mo, 6 mo, yearly</td>
<td>CT or MR, chest plus abdomen</td>
</tr>
</tbody>
</table>

*US Food and Drug Administration stent graft studies usually required before discharge or at 30-day CT scan to detect endovascular leaks. If there is concern about a leak, a predischarge study is recommended; however, the risk of renal injury should be borne in mind. All patients should be receiving beta blockers after surgery or medically managed aortic dissection, if tolerated. Adapted from Erbel et al (539).

AVR indicates aortic valve replacement; CT, computed tomographic imaging; CXR, chest x-ray; IMH, intramural hematoma; MR, magnetic resonance imaging; PAU, penetrating atherosclerotic ulcer; and TTE, transthoracic echocardiography.

CT and MR preferred for imaging beyond the proximal ascending thoracic aorta.

(Hiratzka 2010)
ADDITIONAL INFORMATION
(Taylor 2010; Schoenhagen 2005; Raijah 2013)

Scenarios for which approval of Heart CT is generally not approvable

- For same imaging tests less than six weeks apart unless specific guideline criteria states otherwise.
- For different imaging tests, such as CT and MRI, of same anatomical structure less than six weeks apart without high level review to evaluate for medical necessity.
- For re-imaging of repeat or poor quality studies.

Echocardiography
This study remains the best test for initially examining children in the assessment of congenital heart disease. However, if findings are unclear or need confirmation, CMR or CT can be useful.

CT and CMR in Congenital Heart Disease (CHD)
Many more children with congenital heart disease (CHD) are surviving to adulthood, increasing the need for specialized care and sophisticated imaging. Currently more adults than children have CHD. CT and CMR provide 3D anatomic relationship of the blood vessels and chest wall, and depict cardiovascular anatomic structures. (Warnes 2008; Wiant 2009).

CT and Cardiac Masses
CT and CMR are used to evaluate cardiac masses, describing their size, density, tissue characteristics, and spatial relationship to adjacent structures. Nearly all cardiac tumors are metastases. Primary tumors of the heart are rare, and most are benign. Cardiac myxoma is the most common type of primary heart tumor in adults and usually develops in the left atrium. Echocardiography is typically the first method for evaluation of cardiac myxoma. CT and CMR can provide adjunctive information on myxomas when necessary (Kassop 2014).

CT and Pericardial Disease
While echocardiography is most often used in the initial examination of pericardial disease, CT and CMR can evaluate pericardial thickening and masses which are often detected initially with echocardiography. CT and CMR can accurately define the site and extent of masses, e.g., cysts, hematomas and neoplasms (Klein 2013).

CT and Radiofrequency Ablation for Atrial Fibrillation
Atrial fibrillation, an arrhythmia triggered by abnormal electrical activity in the pulmonary veins, is the most common supraventricular arrhythmia in the United States. In patients with atrial fibrillation, radiofrequency ablation is used to electrically disconnect the pulmonary veins from the left atrium. Prior to this procedure, CT or CMR is useful to define the pulmonary venous anatomy encountered during the procedure. Determination of how many pulmonary veins are present and their ostial locations is important to make sure that all the ostia are ablated. Post ablation pulmonary vein stenosis can also be diagnosed with CT and CMR. The higher resolution detail of CT might make it preferable over CMR in some cases (Ohana 2015).
**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARVD/C</td>
<td>Arrhythmogenic right ventricular dysplasia/cardiomypathy</td>
</tr>
<tr>
<td>CABG</td>
<td>Coronary artery bypass grafting surgery</td>
</tr>
<tr>
<td>CAD</td>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>CCS</td>
<td>Coronary calcium score</td>
</tr>
<tr>
<td>CCT</td>
<td>Cardiac (heart) CT</td>
</tr>
<tr>
<td>CHD</td>
<td>Coronary heart disease</td>
</tr>
<tr>
<td>CMR</td>
<td>Cardiac magnetic resonance (imaging)</td>
</tr>
<tr>
<td>CT</td>
<td>Computed tomography</td>
</tr>
<tr>
<td>CTA</td>
<td>Computed tomography angiography</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>EF</td>
<td>Ejection fraction</td>
</tr>
<tr>
<td>HF</td>
<td>Heart failure</td>
</tr>
<tr>
<td>MI</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>MPI</td>
<td>Myocardial perfusion Imaging or cardiac nuclear imaging</td>
</tr>
<tr>
<td>MR(I)</td>
<td>Magnetic resonance (imaging)</td>
</tr>
<tr>
<td>PCI</td>
<td>Percutaneous coronary intervention</td>
</tr>
<tr>
<td>PVML</td>
<td>Paravalvular mitral leak</td>
</tr>
<tr>
<td>RV</td>
<td>Right ventricle</td>
</tr>
<tr>
<td>SE</td>
<td>Stress Echocardiogram</td>
</tr>
<tr>
<td>TAVR</td>
<td>Transcatheter Aortic Valve Replacement</td>
</tr>
<tr>
<td>TMVR</td>
<td>Transcatheter mitral valve replacement</td>
</tr>
<tr>
<td>TR</td>
<td>Tricuspid regurgitation</td>
</tr>
<tr>
<td>TTE</td>
<td>Transthoracic echocardiography</td>
</tr>
</tbody>
</table>
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Proprietary

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INTRODUCTION

- Coronary computed tomographic angiography (CCTA) is a noninvasive imaging study that uses intravenously administered contrast material and high-resolution, rapid imaging computed tomography (CT) equipment to obtain detailed volumetric images of the coronary blood vessels (while cardiac CT perfusion imaging is sometimes added to CCTA, the current utility of CT perfusion imaging is low and appears to require further study) (Gerber & Manning 2018).

- CCTA remains controversial for the assessment of asymptomatic high risk individuals, and while endorsed by some literature (Taylor 2010), it is not clearly recommended by most others (Mark 2010; Gerber & Manning 2018; Douglas 2018; Wolk 2013; Greenland 2010).

- Image quality depends on keeping HR < 70, a regular rhythm, limited calcification and stents, ≥ 5 second breath hold, and vessels requiring imaging ≥ 1.5 mm diameter (Gerber & Manning 2018).

- Coronary artery disease (CAD) stenosis ≥ 50% is considered clinically significant or obstructive CAD. CAD and ischemic heart disease (IHD) mean the same thing. Hemodynamically or functionally significant CAD means the degree of stenosis is severe enough to cause ischemia. This is discussed in more detail in the Additional Information section (Fihn 2012; Wolk 2013; Montalescot 2013; Gerber & Manning 2018; Tobis 2007).

- Stable patients without known CAD fall into 2 categories (Fihn 2012; Wolk 2013; Montalescot 2013):
  - **Asymptomatic**, for whom global risk of CAD events can be determined from coronary risk factors, using calculators available online (see Part III in the Additional Information section).
  - **Symptomatic**, for whom we estimate the pretest probability that their chest-related symptoms are due to clinically significant (≥ 50%) CAD

**The Three Types of Chest Pain or Discomfort**

- **Typical Angina (Definite)** is defined as including all 3 characteristics:
  1) Substernal chest pain or discomfort with characteristic quality and duration
  2) Provoked by exertion or emotional stress
  3) Relieved by rest and/or nitroglycerin

- **Atypical Angina (Probable)** has only 2 of the above characteristics

- **Nonanginal Chest Pain/Discomfort** has only 0 - 1 of the above characteristics
Once the type of chest pain has been established from the medical record, the Pretest Probability of significant CAD is estimated from the Diamond Forrester Table below, recognizing that additional coronary risk factors could increase pretest probability (Wolk 2013):

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Nonanginal Chest Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 39</td>
<td>Men</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40–49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>≥ 60</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

- **Very low**: < 5% pretest probability of CAD, usually not requiring stress evaluation (Fihn 2012)
- **Low**: 5-10% pretest probability of CAD
- **Intermediate**: 10% - 90% pretest probability of CAD
- **High**: > 90% pretest probability of CAD (Fihn 2012)

**Indications for CCTA**
(Gerber & Manning 2018; Fihn 2012; Montalescot 2013; Wolk 2010; Taylor 2010)

- **Evaluation in suspected CAD** (Douglas 2015; Newby 2015; Nicol 2008; Fordyce 2016; Moss 2017):
  - Intermediate pretest probability patients who are not suitable for stress echo (see Additional Information section)
  - Low pretest probability patients who are not suitable for either exercise stress ECG (uninterpretable) or stress echo (see Additional Information section)
  - Appropriate exercise electrocardiogram (ECG) stress test with low Duke Score (≥ 5) and continued symptoms that are concerning for CAD, usually typical or atypical angina
  - Appropriate exercise ECG stress test with intermediate (negative 10 to +4) Duke Score.
  - Equivocal, borderline, discordant, or inconclusive prior stress imaging evaluation, including discordant exercise ECG and stress imaging
  - Repeat non-invasive coronary testing in patient with new or worse symptoms since prior normal stress imaging (Wolk 2013; Taylor 2010)
  - Newly diagnosed clinical systolic heart failure without known CAD or current CAD evaluation, in the presence of angina or an anginal equivalent (Patel 2012; Patel 2013; Wolk 2013; Taylor 2010)
  - Reduced left ventricular ejection fraction (<40% EF), when invasive coronary arteriography is not the preferred method of evaluation
  - An alternative to coronary angiography before valve surgery or transcatheter intervention in patients with severe valvular heart disease (VHD) and low or
intermediate pretest probability of CAD or in whom conventional coronary angiography is technically not feasible or associated with a high risk (Baumgartner 2017; Nishimura 2014)
  o Unable to undergo otherwise appropriate non-invasive coronary evaluation with any of the following: exercise ECG, myocardial perfusion imaging (MPI), and stress echocardiography (SE) (Douglas 2015; Newby 2015; Nicol 2008; Fordyce 2016)
  o To establish the etiology of chronic secondary mitral regurgitation (Nishimura 2014)
  o Evaluation of coronary anomaly or aneurysm (e.g. post Kawasaki’s disease) when CMR is not available (Datta 2005; Newburger 2016; Newburger 2018; Grani 2017)
  o For evaluation of coronary artery bypass grafts, to assess (Eisenberg 2017):
    ▪ Patency and location, when invasive coronary arteriography was unable to acquire adequate images
    ▪ Patency, if it might avoid invasive coronary arteriography
    ▪ Coronary bypass graft location when reoperative cardiac or other chest surgery requires

ADDITIONAL INFORMATION

Unsuitability for Stress Echo
(Askew 2018; Henzlova 2016)

I. Poor Quality Echo Image
   • Obesity with BMI over 40 or poor acoustic imaging window

II. Inability to Exercise
   • Physical infirmities precluding a reasonable ability to exercise for at least 3 full minutes of Bruce protocol
   • The patient has limited functional capacity (< 4 METS) such as one of the following:
     i. Cannot take care of their activities of daily living (ADLs) or ambulate
     ii. Cannot walk 2 blocks on level ground
     iii. Cannot climb 1 flight of stairs
     iv. Cannot vacuum, dust, do dishes, sweep, or carry a small grocery bag
   • Patients who cannot walk up a single flight of stairs at even a slow pace or even perform ADLs based upon documented limitations

III. Comorbidity Related
   • Prior cardiac surgery (coronary artery bypass graft or valvular), CHF with left ventricular ejection fraction ≤ 40%
   • Severe chronic obstructive pulmonary disease (COPD) with pulmonary function test (PFT) documentation, severe shortness of breath on minimal exertion, or requirement of home oxygen during the day
   • Poorly controlled hypertension, with systolic blood pressure (BP) > 180 or Diastolic BP > 120
- Medical instability or serious acute illness, where maximal exercise is not recommended or appropriate (e.g. acute myocarditis or pericarditis, active infective endocarditis, acute aortic dissection)
- Resting wall motion abnormalities that would make exercise stress echocardiography (SE) interpretation difficult, which includes left bundle branch block (LBBB)
- More than moderate valvular heart disease, when coronary data, not valvular hemodynamics, are required

IV. ECG Related Uninterpretable Wall Motion
- Pacemaker or implantable cardioverter defibrillator (ICD)
- Poorly controlled atrial fibrillation/ectopy
- Frequent premature ventricular contractions (PVCs)
- Ventricular pre-excitation (e.g. Wolff Parkinson White)
- Complete LBBB (SE doable, but more difficult to interpret)

V. Risk Related
- High pretest probability in suspected CAD
- Intermediate or high global risk in patients requiring type IC antiarhythmic drugs
- Patients with prior coronary revascularization
- Arrhythmia risk with exercise and provocation of arrhythmia not required for test
- Left ventricular ejection fraction ≤ 40%

Unsuitability for MPI
(Henzlova 2016; Chareonthaitawee 2018)

- Patient cannot be adequately positioned or imaged with MPI due to comorbidity, body habitus
- Intolerance to required coronary vasodilators, pulmonary or allergic, either documented or anticipated.
- Uncontrolled hypertension, systolic > 200 or diastolic > 110
- Dipyridamole within < 48 hours
- Relative unsuitability due to:
  - Hypotension or marked bradyarrhythmia
  - Interfering medications: Theophylline/aminophylline, caffeine, or theobromine within the past 12-24 hours
  - Severe aortic stenosis
  - Seizure disorder with potential for adenosine provocation

Coronary Artery Calcium Scoring
(Gerber & Kramer 2018)

Non-contrast coronary computed tomography (non-contrast coronary CT) and its older technological version, electron beam computed tomography (EBCT), provide quantitative coronary artery calcium scoring, which is appropriate for further evaluation of coronary risk in asymptomatic patients without known cardiovascular disease, who are at low to intermediate or intermediate global risk for coronary or
overall cardiovascular disease. Non-contrast coronary CT (computed tomography) and EBCT are supported by a separate CPT code and guideline document with references titled EBCT or Non-Contrast Coronary CT.

**Definitions of Coronary Artery Disease**
(Fihn 2012; Montalescort 2013; Patel 2017; Mintz 2016; Tobis 2007)

9. Percentage stenosis refers to the reduction in diameter stenosis when angiography is the method and refers to cross sectional narrowing when intravascular ultrasound (IVUS) is the method of determination.

10. Coronary artery calcification is a marker of risk, as measured by Agatston score on coronary artery calcium imaging. It is not a diagnostic tool so much as it is a risk stratification tool. Its incorporation into global risk can be achieved by using the MESA risk calculator.

11. Stenoses ≥ 50% are considered obstructive coronary artery disease (also referred to as clinically significant), while stenoses ≤ 50% are considered nonobstructive coronary artery disease (Gerber & Manning 2018).

12. Ischemia-producing disease (also called hemodynamically or functionally significant disease, for which revascularization might be appropriate) generally implies at least one of the following:
   i. Suggested by percentage diameter stenosis ≥ 70% by angiography; borderline lesions are 40-70% (Fihn 2012; Tobis 2007)
   ii. For a left main artery, suggested by a percentage stenosis ≥ 50% or minimum lumen cross sectional area on IVUS < 6 square mm (Fihn 2012; Mintz 2016)
   iii. FFR (fractional flow reserve) < 0.80 for a major vessel (Mintz 2016)
   iv. Demonstrable ischemic findings on stress testing (ECG or stress imaging), that are at least mild in degree

13. A major vessel would be a coronary vessel that would typically be substantial enough for revascularization, if it were indicated. Lesser forms of coronary artery disease would be labeled as “limited” and not major (i.e. a 50% lesion in a tiny septal or modest size mid PDA would be limited obstructive coronary artery disease).

14. Microvascular ischemic coronary artery disease, as might be described by a normal FFR (fractional flow reserve) above 0.80 with a reduced CFR (coronary flow reserve less than 2.5), has not otherwise been addressed in this manuscript, because it is very rarely an issue in compliance determinations. However, it would constitute a form of ischemic heart disease.

15. FFR is the distal to proximal pressure ratio across a coronary lesion during maximal hyperemia induced by either intravenous or intracoronary adenosine. Less than or equal to 0.80 is considered a significant reduction in coronary flow. Newer iterations such as iFR (instantaneous wave free ratio) might supersede basic FFR technology in the near future.

16. New technology is evolving that estimates FFR from CCTA images. This is covered under the separate NIA Guideline for FFR-CT.

**Anginal Equivalent**
(Moya 2009; Shen 2017; Fihn 2012)

Development of an anginal equivalent (e.g. shortness of breath, fatigue, or weakness) either with or without prior coronary revascularization should be based upon the documentation of reasons to suspect that symptoms other than chest discomfort are not due to other organ systems (e.g. dyspnea due to lung disease, fatigue due to anemia), by presentation of clinical data such as respiratory rate, oximetry, lung exam, etc. (as well as d-dimer, chest CT(A), and/or PFTs, when appropriate), and then incorporated into
the evaluation of coronary artery disease as would chest discomfort. Syncope per se is not an anginal equivalent.

**Abbreviations**

- ACS: Acute coronary syndrome
- CABG: Coronary artery bypass grafting surgery
- CAD: Coronary artery disease
- CCS: Coronary calcium score
- CCTA: Coronary computed tomography angiography
- ECG: Electrocardiogram
- MI: Myocardial infarction
- MPI: Myocardial Perfusion Imaging
- PCI: Percutaneous coronary intervention
- SE: Stress echocardiography
- TTE: Transthoracic echocardiography
- TAVR: Transcatheter aortic valve replacement
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CPT Codes: 75635

IMPORTANT NOTE:
Abd/Pelvis CTA & Lower Extremity CTA Runoff Requests: Only one authorization request is required, using CPT Code 75635 Abdominal Arteries CTA. This study provides for imaging of the abdomen, pelvis and both legs and is the noninvasive equivalent to an “aortogram and run-off”. The CPT code description is CTA aorto-iliofemoral runoff: abdominal aorta and bilateral ilio-femoral lower extremity runoff.

INTRODUCTION
Computed tomography angiography (CTA) provides a cost-effective and accurate imaging assessment in patients with suspected thoracic aortic aneurysms, aortic dissections, or peripheral arterial disease. Early detection and treatment of a thoracic aortic aneurysm is important as it may rupture or dissect resulting in life-threatening bleeding. High resolution CTA may be used in the diagnosis and follow-up of patients with aortic dissection and lower extremity peripheral arterial disease (PAD).

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR ABDOMINAL ARTERIES CTA:

For evaluation of known or suspected abdominal vascular disease (Conte, 2015):
- For known or suspected peripheral arterial disease based on prior imaging or noninvasive ultrasound.
- Significant ischemia that could be related to the presence of an ulcer, gangrene or significant claudication.

Pre-operative evaluation:
- Evaluation of interventional vascular procedures for luminal patency versus restenosis due to conditions such as atherosclerosis, thromboembolism, and intimal hyperplasia.

Post-operative or post-procedural evaluation:
- Evaluation of post-operative complications, e.g. pseudoaneurysms, related to surgical bypass grafts, vascular stents and stent-grafts.
- Follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

ADDITIONAL INFORMATION RELATED TO ABDOMINAL ARTERIES CTA:

Abd/Pelvis CTA & Lower Extremity CTA Runoff Requests: Only one authorization request is required, using CPT Code 75635 Abdominal Arteries CTA. This study provides for imaging of the abdomen, pelvis and both legs. The CPT code description is CTA aorto-iliofemoral runoff: abdominal aorta and bilateral ilio-femoral lower extremity runoff.
**Thoracic Aortic Aneurysm** – CTA is useful in diagnosing thoracic aortic aneurysms, determining their extent, and predicting best treatment. The Dual Source 64 slice CTA allows for removal of many artifacts on the images, thus improving image quality. Prior to initiating thoracic endovascular aneurysm repair for a ruptured aneurysm, CTA may assess the access route for device delivery.

**Thoracic Aortic Dissection** – Thoracic aortic dissection is difficult to diagnose as many other conditions share similar symptoms with dissection. It is the most common aortic life-threatening emergency and must be diagnosed and treated quickly. With a small amount of contrast medium, the 64-slice CT scanner can accurately locate aortic dissection and other vascular problems within a short period of time.

**Suspected Peripheral Arterial Disease** – CTA is an excellent tool to diagnose lower extremity peripheral arterial disease (PAD). Benefits include the fast scanning time and accurate detection of occlusions and stenoses. According to the Society for Vascular Surgery guidelines (Conte, 2015) “Measurement of the ankle-brachial index (ABI) is the primary method for establishing the diagnosis of PAD. An ABI of ≤0.90 has been demonstrated to have high sensitivity and specificity for the identification of PAD compared with the gold standard of invasive arteriography. In symptomatic patients in whom revascularization treatment is being considered, we recommend anatomic imaging studies, such as arterial duplex ultrasound, CTA, MRA, and contrast arteriography”. This later statement is accompanied by a “B” (moderate) rating for the accompanying evidence (“A’ = high, “C’ = low).
REFERENCES


CPT Codes: 76390

INTRODUCTION:

Magnetic resonance spectroscopy (MRS) is a noninvasive imaging technique that determines the concentration of brain metabolites such as N-acetylaspartate, choline, creatine, and lactate within the body tissue examined. Radiofrequency waves are translated into biochemical composition of the scanned tissue; the resulting metabolic profile is useful in identifying brain tumors, e.g., differentiating radiation necrosis from recurring brain tumor.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR BRAIN MRS (ACR, 2017; Barajas, 2009; Debnam, 2007; Lee, 2004; Lin, 2005; Smith, 2009; Sundgren, 2009; Vezina, 2008):

- For the evaluation of a recurrent or residual brain tumor from post-treatment changes e.g., radiation necrosis.
- To assess progress after surgery. A documented medical reason must clearly explain the medical necessity for the post-operative follow up

ADDITIONAL INFORMATION RELATED TO BRAIN MRS:

Tumor Recurrence vs. Radiation Necrosis – Differentiation between recurrent brain tumors and treatment related injury, e.g., radiation necrosis, is difficult using conventional MRI. The typical appearance of radiation necrosis is similar to that of recurrent brain tumors. MRS allows a new, quantitative approach, measuring various brain metabolic markers, to help in the differentiation of recurrent tumors and radiation necrosis. This differentiation is important as additional radiation can benefit recurrent disease but can be detrimental to radiation necrosis. It may help in determining treatment options and in preventing unnecessary surgery. In addition, a tumor recurrence diagnosed by MRS allows the surgeon to begin treatment early instead of having to wait for symptoms of recurrence or biopsy confirmation.

Cystic lesions vs. cystic metastasis or cystic primary neoplasm – MRS may determine the concentration of certain brain metabolites whose ratios help in distinguishing abscesses from cystic necrotic tumors. For example, an increased choline signal or the ratio of certain brain metabolites may indicate the presence of cancerous cells. MRS may be used to diagnose the disease and to determine appropriate treatment.

MRS in other diseases (Oz, 2014) - A role for MRS has been suggested in the management of neurodegenerative disease, epilepsy, and stroke. However, to better define this role, it will be necessary to standardize the MRS methodology, as well as the collection, analysis, and interpretation of data so it can be consistently translated to the applicable clinical settings. Currently, these potential applications remain experimental.
REFERENCES


INTRODUCTION:
Magnetic resonance imaging (MRI) of the breast is a useful tool for the detection and characterization of breast disease, assessment of local extent of disease, evaluation of treatment response, and guidance for biopsy and localization. Breast MRI should be bilateral except for those with a history of mastectomy or when the MRI is being performed expressly to further evaluate or follow findings in one breast. MRI findings should be correlated with clinical history, physical examination results, and the results of mammography and any other prior breast imaging.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR BREAST MRI:

Silicone Implants:
- Confirmation of silicone gel-filled breast implant ruptures, when this diagnosis cannot be confirmed by mammography or breast ultrasound.
- For postoperative evaluation of silicone breast implant complications.

No History of Known Breast Cancer

For screening examination to detect breast cancer in any of the following situations:
- Inconclusive screening mammogram due to breast characteristics limiting the sensitivity of mammography (e.g., extremely or heterogeneously dense breasts, implants).
- A Breast Cancer Risk Assessment (by the Gail risk or other validated breast cancer risk assessment models) that identifies the patient as having a lifetime risk of 20% or greater of developing breast cancer (Approve annually).
- Two or more first degree relatives (parents, siblings, and children) have history of breast cancer.
- Patients with histories of extensive chest irradiation (usually as treatment for Hodgkin’s or other lymphoma.) Approve annually starting at age 30.
- Patients with known BRCA mutation. Approve annually starting at age 30.
- Patients not yet tested for BRCA gene, but with known BRCA mutation in first degree relative. Approve annually starting at age 30.

For evaluation of identified lesion, mass or abnormality in breast in any of the following situations:
- Two or more first degree relatives (parents, siblings, and children) have history of breast cancer.
- Evaluation of suspected breast cancer when other imaging examinations, such as ultrasound and mammography, and physical examination are inconclusive for the presence of breast cancer, and biopsy could not be performed (e.g. seen only in single view mammogram without ultrasound correlation).
• Previous positive breast biopsy within the previous four (4) months and no intervening previous breast MRI.
• Inconclusive screening mammogram due to breast characteristics limiting the sensitivity of mammography (e.g., extremely or heterogeneously dense breasts, implants).
• Evaluation of palpable lesion on physical examination and not visualized on ultrasound or mammogram and MRI guided biopsy considered.
• For evaluation of axillary node metastasis or adenocarcinoma with normal physical examination and normal breast mammogram.
• Patients diagnosed with biopsy-proven lobular neoplasia or ADH (atypical ductal hyperplasia).
• Personal history of or first-degree relative with Li-Fraumeni syndrome (TP53 mutation), Cowden syndrome (PTEN) or Bannayan-Riley-Ruvalcaba syndrome (BRRS).

**History of Known Breast Cancer**

**For screening examination to detect breast cancer in any of the following situations:**

- Patients with a known history of Breast Cancer: Approve initial staging, with treatment [within three (3) months], and yearly surveillance for detection of recurrence or a new cancer.

**For evaluation of identified lesion, mass or abnormality in breast in any of the following situations:**

- For evaluation of breast lesion, identifying whether single or multi-focal, in patient with diagnosed breast cancer.
- For evaluation of suspicious mass, lesion, distortion or abnormality of breast in patient with history of breast cancer.

**Pre-operative:**

- For preoperative evaluation for known breast cancer when surgery planned within thirty (30) days.
- Evaluation of more than two (2) lesions to optimize surgical planning when requested by surgeon or primary care provider on behalf of surgeon who has seen the patient.

**ADDITIONAL INFORMATION RELATED TO BREAST MRI:**

**CAD Breast MRI:** There are no proven indications for use of CAD with/without an approved Breast MRI.

**Request for a follow-up study** - A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

**MRI imaging** – Metal devices or foreign body fragments within the body, such as indwelling pacemakers and intracranial aneurysm surgical clips that are not compatible with the use of MRI, may be contraindicated. Other implanted metal devices in the patient as well as external devices such as portable O₂ tanks may also be contraindicated.

**MRI as First-Line Screening Modality** – Only recently has the use of MRI for screening been encouraged. It is now used for screening in patients with increased risk for breast cancer due to certain factors, e.g., history of mediastinal irradiation for Hodgkin disease, mutation in a breast cancer susceptibility gene, and familial clustering of breast cancer. Certain mutations, including BRCA1 and BRCA2 genes confer significantly elevated risk of breast cancer. Even when a patient tests negative for BRCA mutations, this patient may still be at risk for breast cancer if the patient has first degree relatives with a history of breast cancer or positive BRCA mutations.
MRI in Patient with Normal Physical Examination and Normal Mammogram but with Clinical Signs of Breast Cancer – Metastatic spread in the axillary lymph nodes suggest the breast as the site of the primary cancer even when the results of a mammogram are normal. MRI is useful in detecting primary breast malignancies in these cases. A negative MRI may also be used to prevent an unnecessary mastectomy.

MRI during or after Neoadjuvant Chemotherapy – Dynamic contrast material-enhanced MRI may be used to monitor response of a tumor to neoadjuvant chemotherapy used to shrink the tumor before surgery. This is very important in clinical decision making as alternative therapies may be selected based upon the results obtained from the MRI. It may also be used to depict residual disease after neoadjuvant chemotherapy.

MRI and Breast Implants – MRI may be used in patients with breast implants to evaluate breast implant integrity. It may also detect cancers arising behind an implant that may not be diagnosed with mammography.

MRI and Invasive Lobular Carcinoma – Invasive lobular carcinoma (ILC) is not the most common type of breast carcinoma but it is second to invasive ductal carcinoma. MRI is used in the evaluation of ILC and can measure the extent of the disease with high reliability.

REFERENCES


Saslow et al American Cancer Society Guidelines for Breast Screening with MRI as an Adjunct to Mammography CA Cancer J Clin 2007;57:75–89


INTRODUCTION:

Magnetic Resonance Imaging (MRI) is currently used for the detection of metastatic disease in the bone marrow. Whole body MRI, using moving tables and special coils to survey the whole body, is used for screening to search for primary tumors and metastases. The unique soft-tissue contrast of MRI enables precise assessment of bone marrow infiltration and adjacent soft tissues allowing detection of alterations within the bone marrow earlier than with other imaging modalities. MRI results in a high detection rate for both focal and diffuse disease, mainly due to its high sensitivity in directly assessing the bone marrow components: fat and water bound protons.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR BONE MARROW MRI:

- For vertebral fractures with suspected bone metastasis.
- For the diagnosis, staging and follow-up of patients with multiple myeloma and related disorders (Dutoit, 2016).
- Suspected progression of smoldering multiple myeloma (SMM) to multiple myeloma (MM) or high risk SMM patients (IMWG, 2015; Caers, 2016).
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention, or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) requested.

ADDITIONAL INFORMATION RELATED TO BONE MARROW MRI:

General Information - MRI allows bone marrow components to be visualized and is the most sensitive technique for the detection of bone marrow pathologies. The soft-tissue contrast of MRI enables detection of alterations within the bone marrow before osseous destruction becomes apparent in CT. Whole-body MRI has been applied for bone marrow screening of metastasis, as well as for systemic primary bone malignancies such as multiple myeloma (MM). Sensitive detection is mandatory in order to estimate prognosis and to determine adequate therapy.

MRI findings are included as one of the International Myeloma Working Group (IMWG) diagnostic criteria of active myeloma (Dutoit, 2016). Although MRI is not the only imaging tool for diagnosis, when “more than one focal lesion on MRI that is at least 5mm or greater in size” in addition to >10% clonal bone marrow plasma cells the diagnosis of active myeloma can be made. For smoldering multiple myeloma (SMM), defined as asymptomatic patients with increased levels of M protein and increased bone marrow plasma cells, “The IMWG now recommends that one of PET-CT, [Low dose whole body CT] (LDWBCt), or MRI of the whole body or spine be done in all patients with suspected smoldering myeloma, with the exact imaging modality determined by availability and resources” (IMWG, 2015). The importance of imaging in the diagnosis of active myeloma is highlighted as “The IMWG consensus statement now recommends that SMM patients with more than one unequivocal focal lesion
(diameter > 5 mm) should be considered to have symptomatic myeloma that requires treatment” (Dutoit, 2016). Recent advances have allowed the identification of a subset of SMM patients with a greater than 80% risk of progression to MM in 2 years based on biomarkers (Caers, 2016).
REFERENCES


CPT Code: 78451, 78452, 78453, 78454, 78466, 78468, 78469, 78481, 78483, 78499

INTRODUCTION

- Myocardial perfusion imaging (MPI) with either exercise stress or pharmacologic coronary vasodilation is the subject of this guideline.

- Since MPI and stress echocardiography (SE) provide similar information, with SE performed at lower cost and without radiation, this guideline requires diversion from MPI to SE when feasible (Askew 2018; Douglas 2011; Metz 2007; Einstein 2012; Fazel 2011; Fleischmann 1998; Garber 1999; Heijenbrok-Kal 2007; Hirshfeld 2018; Marwick 2003; Pellikka 2007; Schinkel 2003; Scott-Moncrieff 2011; Sicari 2008; Sicari 2017; Yao 2003; Zhang 2014).

- However, this diversion is limited due to practical issues and physician preferences that endorse MPI without diversion in any of the following cases (see details in Scenarios that support MPI over SE in the Additional Information section) (Henzlova 2016; Askew 2018; Wolk 2013):
  - Poor quality echo images
  - Inability to exercise
  - Specific comorbidities
  - Electrocardiography (ECG)-related wall motion abnormalities
  - Elevated coronary risk

- Coronary artery disease (CAD) stenosis ≥ 50% is considered clinically significant or obstructive CAD. CAD and ischemic heart disease (IHD) mean the same thing. Hemodynamically or functionally significant CAD means the degree of stenosis is severe enough to cause ischemia. This is discussed in more detail in the Additional Information section (Fihn 2012; Wolk 2013; Montalescot 2013; Gerber 2018; Tobis 2007).

- **Stable patients without known CAD** fall into 2 categories (Fihn 2012; Wolk 2013; Montalescot 2013):
  - **Asymptomatic**, for whom global risk of CAD events can be determined from coronary risk factors, using calculators available online (see Part III in the Additional Information section).
  - **Symptomatic**, for whom we estimate the pretest probability that their chest-related symptoms are due to clinically significant (≥ 50%) CAD (below):

  The 3 Types of Chest Pain or Discomfort

  - **Typical Angina (Definite)** is defined as including all 3 characteristics:
    1) Substernal chest pain or discomfort with characteristic quality and duration
    2) Provoked by exertion or emotional stress
    3) Relieved by rest and/or nitroglycerine
• **Atypical Angina (Probable)** has only 2 of the above characteristics

• **Nonanginal Chest Pain/Discomfort** has only 0-1 of the above characteristics

• Once the type of chest pain has been established from the medical record, the Pretest Probability of obstructive CAD is estimated from the **Diamond Forrester Table** below, recognizing that in some cases multiple additional coronary risk factors could increase pretest probability (Wolk 2013; Fihn 2012):

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Nonanginal Chest Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=39</td>
<td>Men</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40–49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
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<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Intermediate</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>&gt;=60</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

- **Very low:** < 5% pretest probability of CAD, usually not requiring stress evaluation
- **Low:** 5-10% pretest probability of CAD
- **Intermediate:** 10% - 90% pretest probability of CAD
- **High:** > 90% pretest probability of CAD
  
  (Fihn 2012)

**INDICATIONS for MPI**
  
  (Fihn 2012; Wolk 2013; Montalescot 2013; Hendel 2009)

**Suspected CAD**
  
  (Without known history of CAD)

1. **Symptomatic patients without known CAD**

   - Low pretest probability who are unable to exercise
   - Intermediate pretest probability
   - High pretest probability (SE diversion not required) (Hachamovitch 2004)
   - Repeat testing in patient with recurrent symptomatic presentation and negative result over 2 years ago
   - Repeat testing in patient with new or worse symptoms and negative result at least one year ago

2. **Asymptomatic patients without known CAD:**
• Previously unevaluated ECG evidence of possible myocardial ischemia such as substantial ischemic ST segment or T wave abnormalities (SE diversion not required if wall motion abnormality present)
• Previously unevaluated pathologic Q waves or wall motion abnormality (evidence of prior myocardial infarction) (SE diversion not required)
• Unevaluated complete left bundle branch block (SE diversion not required)
• Following radiation therapy to the anterior or left chest, at 5 years post inception of radiation and every 5 years thereafter (Lancellotti 2013)

3. Incomplete or inconclusive CAD evaluation, within the past 2 years without known CAD
• Exercise stress ECG with low risk Duke treadmill score, but patient’s current symptoms indicate an intermediate or high pretest probability, which should include stress imaging (diversion not required for high pretest probability)
• Exercise stress ECG with intermediate Duke treadmill score
• Inconclusive/borderline coronary computed tomography angiography (CCTA) (e.g. 40-70% lesions)
• An indeterminate (equivocal, borderline, or discordant) evaluation by prior stress imaging (SE or CMR) within the past 2 years, for whom a noninvasive approach is preferable to proceeding to invasive coronary arteriography (e.g. unclear symptoms, ECG and imaging discordant, etc., but patient has severe contrast allergy, CKD, etc.)

Known Major Vessel CAD
(SE diversion not required due to increased risk in this category)
(Patel 2017)

• Validated concern for a previous acute coronary syndrome without subsequent invasive or non-invasive coronary evaluation

• Follow up MPI at 2 year intervals is approvable, if it will affect consideration of coronary revascularization (initial or additional), in patients with one of the following:
  ○ History of silent ischemia with severe unrevascularized CAD, and revascularization could be feasible (Deedwania 2018)
  ○ History of severe unrevascularized major multivessel CAD, and revascularization could be feasible
  ○ Ejection fraction <= 40% with severe unrevascularized CAD, and revascularization could be feasible

• Ischemia assessment following inconclusive findings of invasive coronary arteriography or CCTA, for the purpose of assessing extent of ischemia and need for additional medical, interventional, or surgical therapy

• Resting MPI, is appropriate for patients with reduced LVEF ≤50% requiring myocardial viability assessment to assist with decisions regarding coronary revascularization (Patel 2013; Yancy 2013)

• New or worsening symptoms of ischemia in the absence of an acute coronary syndrome, unless the most current stress imaging study would warrant invasive coronary angiography instead (e.g. history of high risk stress test without subsequent invasive
coronary arteriography might warrant invasive coronary angiography) (Patel 2012)

- De novo HF, who have known CAD, even without angina, unless the patient is not eligible for revascularization of any kind, or unless invasive coronary arteriography is immediately planned (Yancy 2013)

**Special Diagnostic Conditions Requiring Coronary Evaluation**

- Newly diagnosed systolic or diastolic heart failure, especially with symptoms or signs of ischemia AND without invasive coronary angiography immediately planned (SE diversion not required) (Yancy 2013; Patel 2013; Fihn 2012)
- Newly found wall motion abnormality (SE diversion not required) (Colucci 2018)
- Ventricular arrhythmias (SE diversion not required.)
  - Sustained ventricular tachycardia (VT) >100 bpm, ventricular fibrillation (VF), or exercise induced VT, when invasive coronary arteriography is not the initially required test (Al-Khatib 2018, in press)
  - Nonsustained VT, multiple episodes, each ≥ 3 beats at ≥100 bpm, without known cause or associated cardiac pathology, when an exercise ECG has shown an intermediate risk Duke Score or an exercise ECG could not be performed (Zimetbaum 2018)
  - Frequent PVCs ≥ 30/hour, or any PVC on a 12 lead ECG, without known cause or associated cardiac pathology, when an exercise ECG has shown an intermediate risk Duke Score OR an exercise ECG is not feasible due to inability to exercise or due to an uninterpretable ECG (Cha 2012; Manolis 2018; Al-Khatib 2017)
- Prior to Class IC antiarrhythmic drug initiation in intermediate and high global risk patients (SE diversion not required) (see global risk calculators in Additional Information section) (Kumar 2018)
- Assessment of hemodynamic significance of one of the following documented conditions (SE diversion not required) (Anagnostopoulos 2004):
  - Anomalous coronary arteries (Grani 2017)
  - Muscle bridging of coronary artery (perform with exercise stress) (Sorajja 2018)
  - Coronary aneurysms in Kawasaki’s disease (Newburger 2018)

**Prior to Elective Noncardiac Surgery**
(Fleischer 2014; Patel 2015)

- Patients who have no other indication for a non-invasive coronary evaluation, but are referred for preoperative cardiac evaluation, are eligible for MPI, based upon cardiac risk ≥ 1%, if all 4 criteria are met:
  - Surgery is supra-inguinal vascular, intrathoracic, or intra-abdominal.
  - The patient has at least one of the additional cardiac complication risk factors:
    - Ischemic Heart Disease
    - History of stroke or TIA
    - History of congestive heart failure or ejection fraction <=35%
    - Insulin-requiring diabetes mellitus
• Creatinine ≥ 2.0 mg/dl

**AND**

- The patient has limited functional capacity (< 4 METS), such as one of the following:
  - Cannot take care of their activities of daily living (ADLs) or ambulate
  - Cannot walk 2 blocks on level ground
  - Cannot climb 1 flight of stairs
  - Cannot vacuum, dust, do dishes, sweep, or carry small grocery bag

**AND**

- There has been no non-invasive coronary testing within one year, and the result of such a test would be likely to substantially alter therapy and/or preclude proceeding with the intended surgery.

• Planning for solid organ (mainly kidney or liver) transplantation is an indication for preoperative MPI, if there has not been a conclusive stress evaluation within the past year and one of the following: (SE diversion not required) (Lentine 2012).

  - The patient has limited functional capacity (< 4 METS), such as one of the following:
    - Cannot take care of their ADLs or ambulate
    - Cannot walk 2 blocks on level ground
    - Cannot climb 1 flight of stairs
    - Cannot vacuum, dust, do dishes, sweep, or carry small grocery bag
    (Wolk 2013)

**OR**

- In a patient with ≥ 3 of the following:
  - Age > 60
  - Smoking
  - Hypertension
  - Dyslipidemia
  - Left ventricular hypertrophy
  - > 1 year on dialysis (for renal transplant patients)
  - Diabetes mellitus
  - Prior cardiovascular disease
  (Lentine 2012)

  - When the above risk calculators prove inadequate, and cardiac risk could be ≥1%, the American College of Surgeons NSQIP cardiac risk calculator can be used as a less validated alternative, available at [http://www.surgicalriskcalculator.com/miorcardiacarrest](http://www.surgicalriskcalculator.com/miorcardiacarrest), with an application download required.

**Post Cardiac Transplantation**

(Gustafsson 2016)
• During the first five years post cardiac transplantation, patients with glomerular filtration rates less than 40 mL/min/1.73 BSA, or who otherwise should not undergo annual invasive coronary arteriography.

• After the first five years post cardiac transplantation:
  o Patients considered at low risk for transplant vasculopathy (i.e. with normal invasive coronary arteriography)
  o Patients with transplant coronary vasculopathy, if the risk of annual invasive coronary arteriography is not acceptable (e.g. high risk of contrast nephropathy).

ADDITIONAL INFORMATION
(Fihn 2012; Wolk 2013; Montalescot 2013)

Scenarios that support MPI over SE
(Henzlova 2016; Askew 2018)

VI. Poor Quality Echo Image
  • Obesity with body mass index (BMI) over 40 or poor acoustic imaging window

VII. Inability to Exercise
  • Physical infirmities precluding a reasonable ability to exercise for at least 3 full minutes of Bruce protocol
  • The patient has limited functional capacity (< 4 METS) such as one of the following:
    i. Cannot take care of their ADLs or ambulate
    ii. Cannot walk 2 blocks on level ground
    iii. Cannot climb 1 flight of stairs
    iv. Cannot vacuum, dust, do dishes, sweep, or carry small grocery bag
  • Patients who cannot walk up a single flight of stairs at even a slow pace or even perform ADLs based upon documented limitations

VIII. Comorbidity Related
  • Prior cardiac surgery (coronary artery bypass graft or valvular), CHF with left ventricular ejection fraction ≤ 40%
  • Severe chronic obstructive pulmonary disease (COPD) with pulmonary function test (PFT) documentation, severe shortness of breath on minimal exertion, or requirement of home oxygen during the day
  • Poorly controlled hypertension, with systolic BP > 180 or diastolic BP > 120
  • Medical instability or serious acute illness, where maximal exercise is not recommended or appropriate (e.g. acute myocarditis or pericarditis, active infective endocarditis, acute aortic dissection)
  • Resting wall motion abnormalities that would make exercise SE interpretation difficult, which includes left bundle branch block
  • More than moderate valvular heart disease, when coronary data, not valvular hemodynamics, are required

IX. ECG Related Uninterpretable Wall Motion
- Pacemaker or ICD
- Poorly controlled atrial fibrillation/ectopy
- Frequent PVCs
- Ventricular pre-excitation (e.g. Wolff Parkinson White)
- Complete LBBB (SE doable, but more difficult to interpret)

X. Risk Related
- High pretest probability in suspected CAD
- Intermediate or high global risk in patients requiring type IC antiarrhythmic drugs
- Patients with prior coronary revascularization
- Arrhythmia risk with exercise and provocation of arrhythmia not required for test
- LVEF ≤ 40%

Unsuitability for MPI
(Henzlova 2016; Chareonthaitawee 2018)

- Patient cannot be adequately positioned or imaged with MPI due to comorbidity, body habitus
- Intolerance to required coronary vasodilators, pulmonary or allergic, either documented or anticipated.
- Uncontrolled hypertension, systolic > 200 or diastolic > 110
- Dipyridamole within < 48 hours
- Relative unsuitability due to:
  - Hypotension or marked bradyarrhythmia
  - Interfering medications: Theophylline/aminophylline, caffeine, or theobromine within the past 12-24 hours
  - Severe aortic stenosis
  - Seizure disorder with potential for adenosine provocation

ECG Stress Test Alone versus Stress Testing with Imaging

Prominent scenarios suitable for an ECG stress test WITHOUT imaging (i.e. exercise treadmill ECG test) are inferred from the guidelines presented above, often (but not always) requiring that the patient can exercise for at least 3 minutes of Bruce protocol with achievement of near maximal heart rate AND has an interpretable ECG for ischemia during exercise (Wolk 2013):

- The (symptomatic) low pretest probability patient who is able to exercise and has an interpretable ECG
- The (asymptomatic) high global risk patient who is able to exercise and has an interpretable ECG
  - The patient who is under evaluation for exercise induced arrhythmia (or long QT interval evaluation when the resting QTc is normal), and coronary artery disease is not suspected (Al-Khatib 2017)

The patient who requires an entrance stress test ECG for a cardiac rehab program or for an exercise prescription.

Duke Exercise ECG Treadmill Score calculates risk from ECG treadmill alone:
- The equation for calculating the Duke treadmill score (DTS) is: DTS = exercise time in minutes \( \times (5 \times ST \text{ deviation in mm or } 0.1 \text{ mV increments}) \times (4 \times exercise \text{ angina score}) \), with angina score being 0 = none, 1 = non-limiting, and 2 = exercise-limiting.
• The score typically ranges from -25 to +15. These values correspond to low-risk (with a score of \( \geq +5 \)), intermediate risk (with scores ranging from -10 to +4), and high-risk (with a score of \( \leq -11 \)) categories.

An uninterpretable baseline ECG includes (Fihn 2012):
- Abnormalities of ST segment depression of 0.1 mV (1 mm with conventional calibration) or more
- Ischemic looking T wave inversions of at least 0.25 mV (2.5 mm with conventional calibration)
- ECG findings of probable or definite LVH, WPW, a ventricular paced rhythm, or left bundle branch block
- Digitalis use or hypokalemia
- Resting HR under 50 bpm on a beta blocker and an anticipated suboptimal workload (e.g. rate-pressure product less than 20-25K) could render inconclusive result
- Prior false positive stress ECG

**Global Risk of Cardiovascular Disease**

**Global risk** of CAD is defined as the probability of manifesting cardiovascular disease over the next 10 years and refers to asymptomatic patients without known cardiovascular disease. It should be determined using one of the risk calculators below. A high risk is considered greater than a 20% risk of a cardiovascular event over the ensuing 10 years. High global risk by itself generally lacks scientific support as an indication for stress imaging (Douglas 2018). There are rare exemptions, such as patients requiring an I-C antiarrhythmic drug, who might require coronary risk stratification prior to initiation of the drug, when global risk is moderate or high.

- **CAD Risk—Low**
  10-year absolute coronary or cardiovascular risk less than 10%.
- **CAD Risk—Moderate**
  10-year absolute coronary or cardiovascular risk between 10% and 20%.
- **CAD Risk—High**
  10-year absolute coronary or cardiovascular risk of greater than 20%.

**Links to Global Cardiovascular Risk Calculators**

*Patients who have already manifested cardiovascular disease are already at high global risk and are not applicable to the calculators.

(D’Agostino 2008; Ridker 2007; McClelland 2015; Goff 2014)

<table>
<thead>
<tr>
<th>Risk Calculator</th>
<th>Link to Online Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique for use of family history</td>
<td></td>
</tr>
</tbody>
</table>
MESA Risk Calculator
With addition of Coronary Artery Calcium Score, for CAD-only risk

https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx

Definitions of Coronary Artery Disease
(Fihn 2012; Montalescot 2013; Patel 2017; Mintz 2016; Tobis 2007)

17. Percentage stenosis refers to the reduction in diameter stenosis when angiography is the method and refers to cross sectional narrowing when intravascular ultrasound (IVUS) is the method of determination.
18. Coronary artery calcification is a marker of risk, as measured by Agatston score on coronary artery calcium imaging. It is not a diagnostic tool so much as it is a risk stratification tool. Its incorporation into Global Risk can be achieved by using the MESA risk calculator.
19. Stenoses > 50% are considered obstructive coronary artery disease (also referred to as clinically significant), while stenoses ≤ 50% are considered nonobstructive coronary artery disease. (Gerber 2018)
20. Ischemia-producing disease (also called hemodynamically or functionally significant disease, for which revascularization might be appropriate) generally implies at least one of the following:
   i. Suggested by percentage diameter stenosis ≥ 70% by angiography; borderline lesions are 40-70% (Fihn 2012; Tobis 2007)
   ii. For a left main artery, suggested by a percentage stenosis > 50% or minimum lumen cross sectional area on IVUS < 6 square mm (Fihn 2012; Mintz 2016)
   iii. FFR (fractional flow reserve) < 0.80 for a major vessel (Mintz 2016)
   iv. Demonstrable ischemic findings on stress testing (ECG or stress imaging), that are at least mild in degree
21. A major vessel would be a coronary vessel that would typically be substantial enough for revascularization, if it were indicated. Lesser forms of coronary artery disease would be labeled as “limited” and not major (i.e. a 50% lesion in a tiny septal or modest size mid PDA would be limited obstructive coronary artery disease).
22. Microvascular ischemic coronary artery disease, as might be described by a normal FFR (fractional flow reserve) above 0.80 with a reduced CFR (coronary flow reserve less than 2.5), has not otherwise been addressed in this manuscript, because it is very rarely an issue in compliance determinations. However, it would constitute a form of ischemic heart disease.
23. FFR (fractional flow reserve) is the distal to proximal pressure ratio across a coronary lesion during maximal hyperemia induced by either intravenous or intracoronary adenosine. Less than or equal to 0.80 is considered a significant reduction in coronary flow. Newer iterations such as iFR (instantaneous wave free ratio) might supersede basic FFR technology in the near future.
24. New technology is evolving that estimates FFR from CCTA images. This is covered under the separate NIA Guideline for FFR-CT.

Anginal Equivalent

Development of an anginal equivalent (e.g. shortness of breath, fatigue, or weakness) either with or without prior coronary revascularization should be based upon the documentation of reasons to suspect that symptoms other than chest discomfort are not due to other organ systems (e.g. dyspnea due to lung disease, fatigue due to anemia), by presentation of clinical data such as respiratory rate, oximetry, lung
exam, etc. (as well as d-dimer, chest CT(A), and/or PFTs, when appropriate), and then incorporated into the evaluation of coronary artery disease as would chest discomfort. Syncope per se is not an anginal equivalent (Moya 2009; Shen 2017; Fihn 2012).

**Peripheral Arterial Disease/Cerebrovascular Disease**

Arterial vascular disease below the renal arteries is generally referred to as peripheral arterial disease, when the ankle brachial index is <0.9 or there is at least 50% vessel diameter narrowing on ultrasound or angiography (Hussain 2018).

Cerebrovascular disease generally refers to a history of transient ischemic attack (TIA) or stroke, or cerebrovascular lesions that put the patient at considerable risk for stroke (Caplan 2018).

There is no evidence to demonstrate that screening all patients with peripheral arterial disease for asymptomatic atherosclerosis in other arterial beds improves clinical outcome. Intensive treatment of risk factors through guideline directed medical therapy is the principal method for preventing adverse cardiovascular ischemic events secondary to atherosclerotic disease in other arterial beds (Gerhard-Herman 2016).

**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>AAD</td>
<td>Antiarrhythmic drug</td>
</tr>
<tr>
<td>ADLs</td>
<td>Activities of daily living</td>
</tr>
<tr>
<td>BSA</td>
<td>Body surface area in square meters</td>
</tr>
<tr>
<td>CAD</td>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>FFR</td>
<td>Fractional flow reserve</td>
</tr>
<tr>
<td>LBBB</td>
<td>Left bundle-branch block</td>
</tr>
<tr>
<td>LVEF</td>
<td>Left ventricular ejection fraction</td>
</tr>
<tr>
<td>LVH</td>
<td>Left ventricular hypertrophy</td>
</tr>
<tr>
<td>MI</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>MET</td>
<td>Estimated metabolic equivalent of exercise</td>
</tr>
<tr>
<td>MPI</td>
<td>Myocardial perfusion imaging</td>
</tr>
<tr>
<td>PFT</td>
<td>Pulmonary function test</td>
</tr>
<tr>
<td>PVCs</td>
<td>Premature ventricular contractions</td>
</tr>
<tr>
<td>SE</td>
<td>Stress echocardiography</td>
</tr>
<tr>
<td>VT</td>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td>VF</td>
<td>Ventricular fibrillation</td>
</tr>
<tr>
<td>WPW</td>
<td>Wolf Parkinson White</td>
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</tbody>
</table>
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INTRODUCTION
(Askew 2018; Bateman 2016; Chareonthaitawee 2018; Soman 2018; Fazel 2011)

- Cardiac positron emission tomography (PET) can characterize myocardial blood flow by perfusion scanning with either rubidium-82 (Rb-82) or nitrogen-13 (N-13) ammonia.

- PET can identify regions of myocardial viability with hibernating myocardium (viable, with poor flow and contractility) by imaging with fluorine18 (F-18) fluorodeoxyglucose (FDG or 18-FDG) for this purpose.

- PET stress testing provides prognostic data with respect to CAD, comparable to SE and myocardial perfusion imaging (MPI) (Parker 2012; Nandular 2008; Bengel 2009).

- PET poses a reduced radiation burden (2-3 mSv) compared to stress myocardial perfusion imaging (MPI) with technetium based tracers (7-24 mSv), the short half-life of PET tracers does not work well for exercise stress testing.

- PET can be useful in the evaluation of inflammation: e.g. evaluation and therapy monitoring in patients with sarcoidosis, after documentation of cardiac involvement by echo or electrocardiography (ECG), when cardiac magnetic resonance (CMR) cannot be performed as a prior test, or subsequent to CMR if needed to help with an uncertain diagnosis (Vita 2018).

- With respect to coronary artery disease (CAD) evaluation:
  - Coronary evaluation by cardiac PET should generally be used only when vasodilator MPI is otherwise indicated (e.g. inability to exercise, MPI with complete left bundle branch block) but not suitable due to an exemption below:
  - Exemptions from the above diversion from coronary evaluation by PET to SE or MPI are for any one of the following:
    - Alternative perfusion imaging is not suitable due to body habitus or marked obesity (e.g. body mass index ≥ 40) interfering significantly with imaging
    - For assessment of suspected significant hibernating myocardium in the presence of known severe major vessel CAD, when EF is below 40%, in order to determine a patient’s potential benefit from coronary revascularization (Patel 2013; Tsai 2014; Yancy 2013; Askew 2018; Chareonthaitawee 2018; Soman 2018)
    - Evaluation of young (< 55 years old) patients with documented complex CAD, who are likely to need frequent non-invasive coronary ischemia evaluation and/or frequent radiation exposure from other testing (Bateman 2016; Hirshfeld 2018)
When strong suspicion of balanced ischemia is noted, and further non-invasive coronary evaluation required, PET can be used, without diversion from PET (Bengel 2009)

Prior alternative perfusion (MPI or CMR) imaging resulted in an indeterminate evaluation for CAD

- PET is frequently performed in modern dual scanners that include low dose CT (computerized tomography) imaging, and the synergistic hybrid technology of PET/CT produces high quality images without additional radiation compared to PET alone (Dorbala 2012; Bateman 2016). This guideline implicitly allows for PET/CT when PET is appropriate.

- CAD stenosis ≥ 50% is considered clinically significant or obstructive CAD. CAD and ischemic heart disease (IHD) mean the same thing. Hemodynamically or functionally significant CAD means the degree of stenosis is severe enough to cause ischemia. This is discussed in more detail in the Additional Information section. (Fihn 2012; Wolk 2013; Montalescot 2013; Gerber 2018; Tobis 2007)

- Coronary application of PET includes evaluation of stable patients without known CAD, who fall into two categories (Fihn 2012; Wolk 2013; Montalescot 2013):
  - Asymptomatic, for whom global risk of CAD events can be determined from coronary risk factors, using calculators available online (see Part III in the Additional Information section)
  - Symptomatic, for whom we estimate the pretest probability that their chest-related symptoms are due to clinically significant (≥ 50%) CAD (below):

The 3 Types of Chest Pain or Discomfort

- Typical Angina (Definite) is defined as including all 3 characteristics:
  1) Substernal chest pain or discomfort with characteristic quality and duration
  2) Provoked by exertion or emotional stress
  3) Relieved by rest and/or nitroglycerine

- Atypical Angina (Probable) has only 2 of the above characteristics

- Nonanginal Chest Pain/Discomfort has only 0-1 of the above characteristics

Once the type of chest pain has been established from the medical record, the Pretest Probability of CAD (meaning obstructive CAD defined as coronary arterial narrowing ≥ 50%) is estimated from the Diamond Forrester Table below, recognizing that in some cases multiple additional coronary risk factors could increase pretest probability (Wolk 2013; Fihn 2012):

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Nonanginal Chest Pain</th>
</tr>
</thead>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Intermediate</th>
<th>Intermediate</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=39</td>
<td>Women</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Very low</td>
</tr>
<tr>
<td>40–49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>&gt;=60</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

- **Very low**: < 5% pretest probability of CAD, usually not requiring stress evaluation
- **Low**: 5-10% pretest probability of CAD
- **Intermediate**: 10% - 90% pretest probability of CAD
- **High**: > 90% pretest probability of CAD

*(Fihn 2012)*

**Indications for Cardiac PET**

*(Diversion required as described in Introduction)*

*(Fihn 2012; Montalescot 2013; Bateman 2016; Wolk 2013; Hendel 2009; Bengel 2009; Soman 2018)*

**Suspected CAD**

*(Without known history of CAD)*

**When neither SE nor MPI were or would be satisfactory**

1. **Symptomatic patients without known CAD**
   - Intermediate pre-test probability
   - High pre-test probability
   - Repeat testing in patient with recurrent symptomatic presentation and negative result over 2 years ago
   - Repeat testing in patient with new or worse symptoms and negative result at least one year ago

2. **Asymptomatic patients without known CAD**
   - Previously unevaluated ECG evidence of possible myocardial ischemia such as potentially ischemic ST segment or T wave abnormalities
   - Previously unevaluated pathologic Q waves or wall motion abnormality (evidence of prior myocardial infarction)
   - Un evaluated complete left bundle branch block
   - Following radiation therapy to the anterior or left chest, at 5 years post inception of radiation and every 5 years thereafter *(Lancellotti 2013)*

3. **Incomplete or inconclusive CAD evaluation, within the past 2 years without known CAD**
   - Exercise stress ECG with low risk Duke treadmill score, but patient's current symptoms indicate an intermediate or high pretest probability, which should include stress imaging
   - Exercise stress ECG with intermediate Duke treadmill score
   - Inconclusive/borderline coronary computed tomography angiography (CCTA) (e.g. 40-70% lesions)
   - An indeterminate (equivocal, borderline, or discordant) evaluation by prior stress imaging (SE, MPI or CMR) within the past 2 years, for whom a noninvasive approach is preferable to proceeding to
invasive coronary arteriography (e.g. unclear symptoms, ECG and imaging discordant, in a patient who has severe contrast allergy or chronic kidney disease)

**Known Major Vessel CAD**
*When neither SE nor MPI were or would be satisfactory OR When LVEF ≤40% with known severe CAD, and revascularization is under consideration (diversion from PET not required)*
(Patel 2017)

- Validated concern for a previous acute coronary syndrome without subsequent invasive or non-invasive coronary evaluation
- Follow up stress imaging at 2-year intervals is approvable, if it will affect consideration of coronary revascularization (initial or additional), in patients with one of the following:
  - History of silent ischemia with severe unrevascularized CAD, and revascularization could be feasible (Deedwania 2018)
  - History of severe unrevascularized major multivessel CAD, and revascularization could be feasible
  - Ejection fraction ≤40% with severe unrevascularized CAD, and revascularization could be feasible
- Ischemia assessment following inconclusive findings of invasive coronary arteriography or CCTA, for the purpose of assessing extent of ischemia and need for additional medical, interventional, or surgical therapy. When strong suspicion of balanced ischemia noted, and further non-invasive coronary evaluation required, PET can be used (quantitative coronary flow), without diversion from PET (Bengel 2009).
- PET (can be FDG only) is appropriate for patients with LVEF ≤ 50% requiring myocardial viability assessment of significant dysfunctional myocardium (so-called hibernating myocardium) to assist with decisions regarding coronary revascularization in known severe major vessel CAD (Diversion from PET not required when LVEF < 40%) (Askew 2018; Chareonthaitawee 2018; Patel 2013; Soman 2018; Tsai 2014; Yancy 2013).
- New or worsening symptoms of ischemia in the absence of an acute coronary syndrome, unless the most current stress imaging study would warrant invasive coronary arteriography instead (e.g. History of high risk stress test without subsequent invasive coronary arteriography might warrant invasive coronary angiography) (Patel 2012).
- De novo heart failure (HF), who have known CAD, even without angina, unless the patient is not eligible for revascularization of any kind, or unless invasive coronary arteriography is immediately planned (Yancy 2013).

**Special Diagnostic Conditions Requiring Coronary Evaluation**
*When neither SE nor MPI were or would be satisfactory*

- Newly diagnosed systolic or diastolic heart failure, especially with symptoms or signs of ischemia AND without invasive coronary angiography immediately planned (Yancy 2013; Patel 2013; Fihn 2012)
- Newly found wall motion abnormality (Colucci 2018)
- Ventricular arrhythmias
  - Sustained ventricular tachycardia (VT) >100 bpm, ventricular fibrillation (VF), or exercise induced VT, when invasive coronary arteriography is not the initially required test (Al-Khatib 2018 in press)
  - Nonsustained VT, multiple episodes, each ≥ 3 beats at ≥100 bpm, without known cause or associated cardiac pathology, when an exercise ECG has shown an intermediate risk Duke Score or an exercise ECG could not be performed (Zimetbaum 2018)
- Frequent PVCs ≥ 30/hour, or any PVC on a 12 lead ECG, without known cause or associated cardiac pathology, when an exercise ECG has shown an intermediate risk Duke Score OR an exercise ECG is not feasible due to inability to exercise or due to an uninterpretable ECG (Cha 2012; Manolis 2018)
- Prior to Class IC antiarrhythmic drug initiation in intermediate and high global risk patients (see global risk calculators in Additional Information section) (Kumar 2018)
- Assessment of hemodynamic significance of one of the following documented conditions (Anagnostopoulos 2004):
  - Anomalous coronary arteries (Grani 2017)
  - Coronary aneurysms in Kawasaki's disease (Newburger 2018)

<table>
<thead>
<tr>
<th>Cardiac Sarcoidosis</th>
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<tr>
<td>(Blankstein 2018; Blankstein 2014; Bravo 2017; Vita 2018)</td>
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</table>
- Evaluation and therapy monitoring in patients with sarcoidosis, after documentation of suspected cardiac involvement by echo or ECG, when CMR cannot be the prior study
- Evaluation of suspected cardiac sarcoid, after CMR has shown equivocal or negative findings in the setting of a high clinical suspicion (Vita 2018)
- Evaluation of CMR findings showing highly probable cardiac sarcoidosis, when PET could serve to identify inflammation and the consequent potential role for immunosuppressive therapy (Vita 2018)
- Initial and follow up PET in monitoring therapy for cardiac sarcoid with immunosuppressive therapy, typically about 4 times over 2 years (Osborne 2014; Bokhari 2017)

<table>
<thead>
<tr>
<th>Infective Endocarditis</th>
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</thead>
</table>
| In suspected infective endocarditis with moderate to high probability (i.e. staph bacteremia, fungemia, prosthetic heart valve, or intracardiac device), when TTE and TEE have been inconclusive with respect to diagnosis of infective endocarditis or characterization of paravalvular invasive complications (Doherty 2017; Karchmer 2018a; Karchmer 2018b; Sexton 2018; Wang 2018; Habib 2016), but it is not appropriate for pure native valve endocarditis (Salaun 2018)

<table>
<thead>
<tr>
<th>Aortitis</th>
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<tbody>
<tr>
<td>For diagnosis and surveillance of Aortitis, PET/CT or PET/MRI hybrid imaging (Bhave 2018)</td>
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</table>

<table>
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<tr>
<th>Prior to Elective Non-Cardiac Surgery</th>
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</thead>
<tbody>
<tr>
<td>When SE or MPI was or would not be adequate</td>
</tr>
<tr>
<td>(Fleischer 2014; Patel 2015)</td>
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</table>
- Patients who have no other indication for a non-invasive coronary evaluation, but are referred for preoperative cardiac evaluation, are eligible for stress imaging based upon cardiac risk ≥1%, if all 4 criteria are met:
  - Surgery is suprainguinal vascular, intrathoracic, or intra-abdominal.
  - The patient has at least one of the additional cardiac complication risk factors:
    - Ischemic Heart Disease
    - History of stroke or transient ischemic attack (TIA)
    - History of congestive heart failure or ejection fraction ≤35%
    - Insulin-requiring diabetes mellitus
    - Creatinine ≥ 2.0 mg/dl
AND

- The patient has limited functional capacity (< 4 METS), such as one of the following:
  - Cannot take care of their activities of daily living (ADLs) or ambulate
  - Cannot walk 2 blocks on level ground
  - Cannot climb 1 flight of stairs
  - Cannot vacuum, dust, do dishes, sweep, or carry small grocery bag

AND

- There has been no non-invasive coronary testing within one year, and the result of such a test would be likely to substantially alter therapy and/or preclude proceeding with the intended surgery.

- Planning for solid organ (mainly kidney or liver) transplantation is an indication for preoperative stress imaging, if there has not been a conclusive stress evaluation within the past year and one of the following (Lentine 2012):
  - The patient has limited functional capacity (< 4 METS), such as one of the following:
    - Cannot take care of their activities of daily living (ADLs) or ambulate
    - Cannot walk 2 blocks on level ground
    - Cannot climb 1 flight of stairs
    - Cannot vacuum, dust, do dishes, sweep, or carry small grocery bag
  - (Wolk 2013)

OR

- In a patient with ≥ 3 of the following: (Lentine 2012)
  - Age > 60
  - Smoking
  - Hypertension
  - Dyslipidemia
  - Left ventricular hypertrophy
  - > 1 year on dialysis (for renal transplant patients)
  - Diabetes mellitus
  - Prior cardiovascular disease
  - (Lentino 2012)

- When the above risk calculators prove inadequate, and cardiac risk could be ≥1%, the American College of Surgeons NSQIP cardiac risk calculator can be used as a less validated alternative: and is available at http://www.surgicalriskcalculator.com/miorcardiacarrest, with an application download required.

Post Cardiac Transplantation
When SE or MPI was or would not be adequate
(Gustafsson 2016)

- During the first five years post cardiac transplantation, patients with glomerular filtration rates less than 40 mL/min/1.73 BSA, or who otherwise should not undergo annual invasive coronary arteriography
- After the first five years post cardiac transplantation, one of the following:
  - Patients considered at low risk for transplant vasculopathy (i.e., with normal invasive coronary arteriography)
  - Patients with transplant coronary vasculopathy, if the risk of annual invasive coronary arteriography is not acceptable (e.g. high risk of contrast nephropathy)

### ADDITIONAL INFORMATION

#### I. General Information about PET

**Quantitation of Myocardial Blood Flow and Flow Reserve by PET**

While this technology has been progressively promising, and can assist in the evaluation of coronary microvascular dysfunction, its use is still investigation, although easily added to the cardiac PET examination. At this time it is not justifiable as a stand-alone test. (Bateman 2016, Juneau 2017)

**Cardiac neoplasm and metastasis**

The use of PET has shown promise in the evaluation of cardiac neoplasm. Precise indications for the use of this technology are currently in evolution, but are promising (Rahbar 2012; Fathala 2017). CT and MR are presently better supported for this use (Gaasch 2018).

**Endocarditis** (Sexton 2018; Karchmer 2018a; Wang 2018; Habib 2016)

TTE and TEE remain the main imaging modalities for the diagnosis of infective endocarditis. Use of FDG PET/CT for paravalvular abscess and for confirmation of prosthetic valve endocarditis has been demonstrated, but issues of necessary expertise for interpretation and false positivity have limited its use. It has been much less helpful in the diagnosis of native valve infective endocarditis (Salaun 2018)**.

**Cardiac Device Infection** (Karchmer 2018b, Wang 2018, Habib 2016)

FDG PET/CT has an adjunctive role in the diagnosis of cardiac electrical device infectious complications when conventional TTE/TEE and blood culture methods have been unsuccessful.**

**While not endorsed by the AHA 2015 Infective Endocarditis Guidelines (Baddour 2015), since 2015 there appears to have been an increase in evidence supporting the utilization of PET/CT in this scenario ad the above references indicate.**

#### II. ECG Stress Test Alone versus Stress Testing with Imaging

Prominent scenarios suitable for an ECG stress test WITHOUT imaging (i.e. exercise treadmill ECG test) are inferred from the guidelines presented above, often (but not always) requiring that the patient can exercise for at least 3 minutes of Bruce protocol with achievement of near maximal heart rate AND has an interpretable ECG for ischemia during exercise (Wolk 2013):

- The (symptomatic) low pretest probability patient who is able to exercise and has an interpretable ECG
- The (asymptomatic) high global risk patient who is able to exercise and has an interpretable ECG
- The patient who is under evaluation for exercise induced arrhythmia (or long QT interval evaluation when the resting QTc is normal), and coronary artery disease is not suspected (Al-Khatib 2017)
The patient who requires an entrance stress test ECG for a cardiac rehab program or for an exercise prescription.

**Duke Exercise ECG Treadmill Score** calculates risk from ECG treadmill alone:
- The equation for calculating the Duke treadmill score (DTS) is: 
  \[ \text{DTS} = \text{exercise time in minutes} - \left(5 \times \text{ST deviation in mm or 0.1 mV increments}\right) - \left(4 \times \text{exercise angina score}\right), \] 
  with angina score being 0 = none, 1 = non-limiting, and 2 = exercise-limiting.
- The score typically ranges from -25 to +15. These values correspond to low-risk (with a score of ≥ +5), intermediate risk (with scores ranging from -10 to +4), and high-risk (with a score of ≤ -11) categories.

An uninterpretable baseline ECG includes (Fihn 2012):
- Abnormalities of ST segment depression of 0.1 mV (1 mm with conventional calibration) or more
- Ischemic looking T wave inversions of at least 0.25 mV (2.5 mm with conventional calibration)
- ECG findings of probable or definite LVH, WPW, a ventricular paced rhythm, or left bundle branch block
- Digitalis use or hypokalemia
- Resting HR under 50 bpm on a beta blocker and an anticipated suboptimal workload (e.g. rate-pressure product less than 20-25K) could render inconclusive result
- Prior false positive stress ECG

### III. Global Risk of Cardiovascular Disease

**Global risk** of CAD is defined as the probability of manifesting cardiovascular disease over the next 10 years and refers to asymptomatic patients without known cardiovascular disease. It should be determined using one of the risk calculators below. A high risk is considered greater than a 20% risk of a cardiovascular event over the ensuing 10 years. High global risk by itself generally lacks scientific support as an indication for stress imaging. (Douglas 2018) There are rare exemptions, such as patients requiring a I-C antiarrhythmic drug, who might require coronary risk stratification prior to initiation of the drug, when global risk is moderate or high.

- **CAD Risk—Low**
  10-year absolute coronary or cardiovascular risk less than 10%.
- **CAD Risk—Moderate**
  10-year absolute coronary or cardiovascular risk between 10% and 20%.
- **CAD Risk—High**
  10-year absolute coronary or cardiovascular risk of greater than 20%.

**Links to Global Cardiovascular Risk Calculators**

*Patients who have already manifested cardiovascular disease are already at high global risk and are not applicable to the calculators.

(D’Agostino 2008; Ridker 2007; McClelland 2015; Goff 2014)
<table>
<thead>
<tr>
<th>Risk Calculator</th>
<th>Link to Online Calculator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reynolds Risk Score</td>
<td><a href="http://www.reynoldsriskscore.org/">http://www.reynoldsriskscore.org/</a></td>
</tr>
<tr>
<td>Pooled Cohort Equation</td>
<td><a href="http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example">http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example</a></td>
</tr>
<tr>
<td>MESA Risk Calculator</td>
<td><a href="https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx">https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx</a></td>
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</table>

IV. Definitions of Coronary Artery Disease
(Fihn 2012; Montalescot 2013; Patel 2017; Mintz 2016; Tobis 2007)

1. Percentage stenosis refers to the reduction in diameter stenosis when angiography is the method and refers to cross sectional narrowing when intravascular ultrasound (IVUS) is the method of determination.

2. Coronary artery calcification is a marker of risk, as measured by Agatston score on coronary artery calcium imaging. It is not a diagnostic tool so much as it is a risk stratification tool. Its incorporation into global risk can be achieved by using the MESA risk calculator.

3. Stenoses \( \geq 50\% \) are considered obstructive coronary artery disease (also referred to as clinically significant), while stenoses \( < 50\% \) are considered nonobstructive coronary artery disease (Gerber 2018).

4. Ischemia-producing disease (also called hemodynamically or functionally significant disease, for which revascularization might be appropriate) generally implies at least one of the following:
   i. Suggested by percentage diameter stenosis \( \geq 70\% \) by angiography; borderline lesions are 40-70\% (Fihn 2012; Tobis 2007)
   ii. For a left main artery, suggested by a percentage stenosis \( \geq 50\% \) or minimum lumen cross sectional area on IVUS \( \leq 6 \) square mm (Fihn 2012; Mintz 2016)
   iii. Fractional flow reserve (FFR) \( \leq 0.80 \) for a major vessel (Mintz 2016)
   iv. Demonstrable ischemic findings on stress testing (ECG or stress imaging), that are at least mild in degree

5. A major vessel would be a coronary vessel that would typically be substantial enough for revascularization, if it were indicated. Lesser forms of coronary artery disease would be labeled as “limited” and not major (i.e. a 50\% lesion in a tiny septal or modest size mid PDA would be limited obstructive coronary artery disease.)

6. Microvascular ischemic coronary artery disease, as might be described by a normal FFR above 0.80 with a reduced coronary flow reserve (CFR) (CFR < 2.5), has not otherwise been addressed in this manuscript, because it is very rarely an issue in compliance determinations. However, it would constitute a form of ischemic heart disease.

7. FFR is the distal to proximal pressure ratio across a coronary lesion during maximal hyperemia induced by either intravenous or intracoronary adenosine. Less than or equal to 0.80 is
considered a significant reduction in coronary flow. Newer iterations such as instantaneous wave free ratio (iFR) might supersede basic FFR technology in the near future.

8. New technology is evolving that estimates FFR from CCTA images. This is covered under the separate NIA Guideline for FFR-CT.

V. Anginal Equivalent

Development of an anginal equivalent (e.g. shortness of breath, fatigue, or weakness) either with or without prior coronary revascularization should be based upon the documentation of reasons to suspect that symptoms other than chest discomfort are not due to other organ systems (e.g. dyspnea due to lung disease, fatigue due to anemia), by presentation of clinical data such as respiratory rate, oximetry, lung exam, etc. (as well as d-dimer, chest CT(A), and/or PFTs, when appropriate), and then incorporated into the evaluation of coronary artery disease as would chest discomfort. Syncope per se is not an anginal equivalent (Moya 2009; Shen 2017; Fihn 2012)

VI. Peripheral Arterial Disease/Cerebrovascular Disease

Arterial vascular disease below the renal arteries is generally referred to as peripheral arterial disease, when the ankle brachial index is <0.9 or there is at least 50% vessel diameter narrowing on ultrasound or angiography (Hussain 2018).

Cerebrovascular disease generally refers to a history of TIA (transient ischemic attack) or stroke, or cerebrovascular lesions that put the patient at considerable risk for stroke (Caplan 2018).

There is no evidence to demonstrate that screening all patients with peripheral arterial disease for asymptomatic atherosclerosis in other arterial beds improves clinical outcome. Intensive treatment of risk factors through guideline directed medical therapy is the principal method for preventing adverse cardiovascular ischemic events secondary to atherosclerotic disease in other arterial beds (Gerhard-Herman 2016.)

Abbreviations

AAD Antiarrhythmic drug
ADLs Activities of daily living
BSA Body surface area in square meters
CAD Coronary artery disease
ECG Electrocardiogram
FFR Fractional flow reserve
LBBB Left bundle-branch block
LVH Left ventricular hypertrophy
MI Myocardial infarction
MET Estimated metabolic equivalent of exercise
MPI Myocardial perfusion imaging
PFT Pulmonary function test
PVCs Premature ventricular contractions
SE Exercise stress echocardiography
VT Ventricular tachycardia
<table>
<thead>
<tr>
<th>VF</th>
<th>Ventricular fibrillation</th>
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<tbody>
<tr>
<td>WPW</td>
<td>Wolf Parkinson White</td>
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</table>
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CPT Codes: 78472, 78473, 78494, +78496

INTRODUCTION
(Srichai 2018; Mitra 2102; Patel 2013)

- Multiple-gated acquisition (MUGA) scanning uses radio-labelled red blood cells to scan right and left ventricular images in a cine loop format that is synchronized with the ECG, which requires a regular rhythm for accuracy.

- Right and left ventricular systolic wall motion, ejection fraction, ventricular volumes, stroke volume ratios, diastolic function, pulmonary blood volumes, regurgitant fractions, and exercise response can be derived from the data acquired by the gamma camera (Scheiner 2002; Ritchie 1995). However, in the current era, the test is primarily for a left ventricular ejection fraction (LVEF) determination, when transthoracic echocardiography (TTE) has been inadequate, and cardiac magnetic resonance imaging (CMR) precision is not demanded.

INDICATIONS FOR A MUGA SCAN
(Srichai 2018; Mitra 2102; Patel 2013; Corbett 2008; Friedman 2009)

- In the course of cardiotoxic chemotherapy and/or subsequent to radiation to the anterior or left chest, when TTE has not been helpful and CMR is not available, to evaluate left ventricular systolic function (Zamorano 2016; Plana 2014; Patel 2013; Yancy 2013):
  - Prior to cardiotoxic chemotherapy, and subsequently for monitoring and follow up (see cardio-oncology section under Additional Information)
  - For radiation to the anterior or left chest, left ventricular function assessment at baseline, 5 years post inception, and every 5 years thereafter (Lancellotti 2013)

- To evaluate biventricular or left ventricular function in a patient with CAD, valvular heart disease, myocardial disease, or congenital heart disease, in any of the following scenarios:
  - When ventricular function is required for management and/or post therapeutic/post interventional/post-operative follow up, and echocardiography or other required concomitant imaging has proven inadequate (e.g. COPD, obesity) for an adequate determination of ejection fraction (Yancy 2013; Patel 2013)
  - With new, worsening, intractable (Mitra 2012) or other major status change in congestive heart failure (CHF), when TTE or other required concomitant imaging has proven inadequate (e.g. COPD, obesity interfering with TTE) (Fihn 2012; Yancy 2013; Patel 2013)
  - In the presence of significant resting wall motion abnormalities or distorted geometry (Patel 2013)
  - For accurate verification of ejection fraction in meeting criteria for an implantable cardioverter defibrillator (ICD) and/or cardiac resynchronization therapy (CRT) implantation (Krahn 2008)
As an alternative form of stress imaging instead of myocardial perfusion imaging, based upon similar necessity criteria for the evaluation of coronary artery disease, recognizing some prohibitive limitations with respect to (Ritchie 1995; Corbett 2008; Friedman 2009):

- Localization of ischemia (superior with MPI)
- Quantitation of myocardium at risk (superior with MPI)
- Requirement for ability/safety with performance of exercise or with inotropic stimulation
- Lack of interpretability when
  - Resting MUGA images are poor
  - ECG-related issues are present (affecting wall motion or gating technique)
    - Complete left bundle branch block
    - Ventricular pacing or ICD
    - Ventricular pre-excitation (e.g. Wolff Parkinson White)
    - Atrial fibrillation
    - Frequent ectopy, irregular rhythm

**Additional Information**

**Imaging Surveillance for Cardiotoxic Chemotherapy**
(Plana 2014; Zamorano 2016; Maleszewski 2018; Herrmann 2014)

**TTE is the method of choice** for the evaluation of patients before, during, and after cancer therapy. Ideally accuracy prefers that 3D and global longitudinal strain (GLS) are part of the exam, and serum troponin (Tn) should also be measured. However, GLS and Tn might not have been performed, in which case determinations might need to be made with left ventricular ejection fraction (LVEF) only. *Serum troponin (Tn) and GLS abnormalities constitute an abnormal assessment of LV function, because their abnormalities frequently herald an imminent fall in LVEF* (Plana 2014; Zamorano 2016).

**CMR** is recommended when TTE has been unreliable and/or candidacy for cardiotoxic chemotherapy based upon LVEF is questionable (Plana 2014). MUGA can also be considered when TTE is inadequate and CMR is not available.

**MUGA** is accurate and reproducible, but lacks information about pericardium and valves, incurs repeated radiation exposure, and is inaccurate during an irregular cardiac rhythm (Plana 2014).

**Surveillance guidelines** are somewhat complex, possibly beyond the scope of this guideline, especially in patients with additional risk factors for LV dysfunction (Herrmann 2014). As with all guidelines, adequate information for complex decisions might be impractical to acquire. However, if the reader requires more rigorous recommendations, they are summarized concisely in the table below. **Necessity determinations might not require strict adherence to this table at this time, but it is here to serve as a helpful reference for the reader, if desired.**

**TTE Surveillance Strategy for Cardiotoxic Chemotherapy (Optional Information)**
(Plana 2014; Herrmann 2014; Zamorano 2016; Maleszewski 2018)

<table>
<thead>
<tr>
<th>Suspected/Detected LV Status at Baseline, During, or After Completion of Therapy (LVEF is minimum information,)</th>
<th>Type I Anthracyclines: Doxorubicin, Epirubicin, Idarubicin Mitoxantrone (Asnani 2018)</th>
<th>Type II Trastuzumab, Labatinib, Pertuzumab, Sorafenib, Sunitinib, Bevacizumab, Bortezomib **</th>
</tr>
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</table>
**GLS and Tn can reveal early LV dysfunction prior to LVEF**

<table>
<thead>
<tr>
<th>Normal: EF is ≥ 55%, troponin is negative, and global longitudinal strain (GLS) &gt; lower limit of normal*</th>
<th>Normal assessment: Assess after a cumulative dose &gt; 200mg/M² (or its anthracycline equivalent) and prior to each additional 50 mg/M², and at completion of therapy, and 6 months later, and for cumulative dose &gt; 300 mg/M² include assessment at 1 year and at 5 years post completion of therapy. (Zamorano 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal: any one of:</td>
<td>Abnormal assessment: Assess after every cycle, and reassess for verification 2-3 weeks later if a drop in LV function has been detected/suspected: assess 6 months post completion of therapy, followed by re-assessment every 6 months until stable, and for cumulative dose &gt; 300 mg/M² include assessment at 1 year and 5 years post completion of therapy. (Zamorano 2016)</td>
</tr>
<tr>
<td>o GLS reduced ≥ 10-15% below normal (about 20 is normal*, labs vary)</td>
<td></td>
</tr>
<tr>
<td>o Troponin positive</td>
<td></td>
</tr>
<tr>
<td>o LVEF started &lt; 55%</td>
<td></td>
</tr>
<tr>
<td>o During therapy LVEF drops below 55% and ≥ 5 points for a symptomatic ≥ 10 points for an asymptomatic patient. (Maleszewski 2018)</td>
<td></td>
</tr>
</tbody>
</table>

* GLS of (negative) 20 is generally normal, but individual labs vary (Collier 2017).

** Imatinib, rarely cardiotoxic, does not require surveillance of LV function (Floyd 2018).

---

**First Pass Radionuclide Angiography**  
(Friedman 2009)

First pass radionuclide ventriculography provides similar information by radiotracer blood pool scanning, but requires only a single pass of isotope through the heart, made possible by rapid, high count rate acquisition, achievable with certain multi-crystal gamma cameras. Its indications are essentially the same as for MUGA, also referred to as equilibrium radionuclide angiography, which requires time (i.e. multiple cardiac cycles) for isotope circulation.

**Combination of Other Studies with MUGA**

Abdomen CT/Pelvis CT/Chest CT/Neck MRI/Neck CT with MUGA – known tumor/cancer for initial staging or evaluation before starting chemotherapy or radiation treatment.
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>CMR</td>
<td>Cardiac Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>CT</td>
<td>Computed Tomography Imaging</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>GLS</td>
<td>Global longitudinal strain (measurement of left ventricular function)</td>
</tr>
<tr>
<td>mg</td>
<td>Milligrams</td>
</tr>
<tr>
<td>MUGA</td>
<td>Multiple Gated Acquisition (nuclear scan of ventricular function)</td>
</tr>
<tr>
<td>PAC</td>
<td>Premature atrial contraction</td>
</tr>
<tr>
<td>PVC</td>
<td>Premature ventricular contraction</td>
</tr>
<tr>
<td>sqM</td>
<td>Square meters of body surface area</td>
</tr>
<tr>
<td>Tn</td>
<td>Troponin</td>
</tr>
<tr>
<td>TTE</td>
<td>Transthoracic echocardiography</td>
</tr>
<tr>
<td>WPW</td>
<td>Wolf Parkinson White Syndrome (electrical pre-excitation)</td>
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</tbody>
</table>
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Retrieved May 23, 2018


CPT Codes: 78608, 78609

INTRODUCTION:

Positron Emission Tomography (PET) scanning using FDG (fluorodeoxyglucose) assesses brain metabolism and perfusion. Uses include identifying epileptic foci prior to surgery, differentiation of residual tumor versus scar, and causes of cognitive decline.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR BRAIN PET SCAN:

**Known brain tumor or cancer:**
- New signs or symptoms indicative of a recurrence (Heiss, 2011).
- Short-term follow-up to differentiate scarring/fibrosis from residual tumor, as an adjunct to Brain MRI (Heiss, 2011; Bashir, 2015).

**Pre-operative for refractory seizures (Jones, 2016).**

**Post-operative/procedural evaluation:**
- A follow-up study may be needed to help evaluate a patient’s progress after treatment, procedure, intervention or surgery. Documentation requires a medical reason that clearly indicates why additional imaging is needed for the type and area(s) of requested imaging.

**Mild Cognitive Impairment or Dementia:**
- Diagnosis: both have been met
  - Objective cognitive impairment on longitudinal assessment, i.e., historical or observed evidence of decline over time (Albert, 2011; Iaccarino, 2017).
    - Mini Mental Status Evaluation (MMSE) or Montreal Cognitive Assessment (MoCA) less than 26 (Davis, 2015)
    - Formal neuropsych testing showing mild cognitive impairment
  - Potential treatable causes assessed and addressed (Albert, 2011)
    - Metabolic such as thyroid or vitamin deficiency, anemia, or chemical encephalopathy
    - Medication side effects (Campbell, 2010).
    - Medical causes such as vascular or traumatic
REFERENCES


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INTRODUCTION:

Positron emission tomography (PET) is a rapidly developing technology that is able to detect biochemical reactions, e.g., metabolism, or abnormal distribution of cell receptors within body tissues. A radioactive tracer is used during the procedure. Unlike other nuclear medicine examinations, PET can measure metabolic activity of the cells of body tissues, providing information about the functionality and structure of the particular organ or tissue examined. PET may also detect biochemical changes that help to evaluate malignant tumors and other lesions.

The degree of radioactive tracer uptake may indicate increased metabolism in the cells of body tissues or an abnormal distribution of cell receptors. Cancer cells may show increased radioactive tracer relative to tissue not involved with tumor. Radioactive tracer uptake is often higher in fast-growing tumors; PET is often not as useful or beneficial for slow-growing tumors.

Radioactive tracer uptake may occur in various types of active inflammation and is not specific for cancer. Thus it is not used for the initial diagnosis of cancer, but is useful in staging and monitoring cancer cell viability and for the diagnosis and detection of recurrence of cancer. PET is also useful for monitoring the response to treatment of various cancers.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

IMPORTANT NOTE:

The appropriateness of an ordered PET/CT study is fully dependent on the answer to the question of which radiopharmaceutical will be used for the PET/CT. This guideline only covers the radiopharmaceuticals FDG and Dotatate.

- The following are noncovered for all other indications including (but not limited to):
  - **Breast Cancer** – Initial Treatment Strategy (formerly diagnosis and initial staging) of axillary lymph nodes.
  - **Melanoma** – Initial Treatment Strategy (formerly Evaluation) of regional lymph nodes.
  - **Prostate Cancer** – Initial Treatment Strategy (formerly Diagnosis and initial staging.)
  - **Infection and/or Inflammation** – PET for chronic osteomyelitis, infection of hip arthroplasty, and fever of unknown origin.

INDICATIONS FOR AN ONCOLOGICAL FDG PET SCAN:
**Initial Treatment Strategy**

All solid tumors, including myeloma, with biopsy proven cancer or strongly suspected based on other diagnostic testing:

Including

- CLL – chronic lymphocytic leukemia (PET/CT is generally not useful in CLL/SLL but may be necessary to direct nodal tissue sampling when high-grade histologic transformation is suspected) (NCCN, 2018).
- SPN – solitary (or clearly dominant) indeterminate pulmonary nodule ≥ to 8mm in size without existing tissue diagnosis (note: patient may have other non-suspicious nodules in the lung, such as granulomas and hamartomas) (Vansteenkiste, 2006).

Excluding

- ALL - acute lymphoblastic leukemia
  - Unless prior CT imaging suggest lymphomatous involvement
- AML – acute myelogenous leukemia
  - Unless clinical suspicion for extramedullary disease
- BCC – basal cell carcinoma (of the skin)
- Prostate cancer (NCCN, 2018)

- To determine the anatomic extent of tumor when the recommended anti-tumor treatment reasonably depends on the extent of the tumor, or
- To determine if patient is an appropriate candidate for an invasive diagnostic or therapeutic procedure, or
- To determine the optimal anatomic location for an invasive procedure.

**Subsequent Treatment Strategy**

Restaging or monitoring response to active treatment, and/or a single evaluation after completion/cessation of therapy not to be performed within 4 weeks of completion of therapy (ideally FDG PET is delayed 2-3 months after surgical therapy, 2-3 months after radiation therapy if locoregional assessment is the imaging goal), and/or evaluation for suspicion of recurrence due to new or changing signs/symptoms. (Asymptomatic surveillance is not approvable) (NCCN, 2018).

- Breast cancer (female and males)
- Cervical cancer
- Colorectal cancer (including colon, rectal, appendiceal or anal cancer)
- Esophageal cancer
- Head and neck cancer (not including Brain cancer/tumor; thyroid noted below)
- Lung cancer - Non-small cell
- Lymphoma
- Melanoma
- Myeloma
- Ovarian cancer
- Soft tissue sarcoma (Schuetze, 2005)
- Vulvar/vaginal (Robertson, 2016)
Subsequent PET Scans may be performed only if other imaging (ie. US, CT, MRI, NM) is inconclusive in determining a treatment plan or unable to be performed:

- Brain cancer: (with metastasis to non-head areas) Refer to Brain PET Scan Guidelines to image the brain
- Lung cancer - Small cell (Tucker, 1997)
- Neuroendocrine cancer (e.g. carcinoid, pheochromocytoma, etc)
- Pancreatic cancer (Rijkers, 2014)
- Prostate cancer (Bach-Gansmo, 2017)
- Testicular cancer (Hinz, 2005)
- Tumors of unknown origin (Møller, 2012)
- Other malignancies where the tumor has been shown to be FDG avid on prior PET/CT imaging if done, and other imaging (ie: US, CT, MRI, NM) is inconclusive in determining a treatment plan or unable to be performed

**Thyroid cancer:**
- Subsequent treatment strategy for recurrence or distant metastasis for thyroid cancer of Papillary, Follicular, or Hurthle cell origin AND patient has the following:
  - A thyroidectomy and radioiodine ablation initially, and
  - Stimulated serum thyroglobulin > 2 ng/ml, and
  - Current whole body I-131 scan is negative (Kloos, 2005).

Medullary thyroid cancer when calcitonin levels > 150 pg/ml post-operatively (Wells, 2015)

Anaplastic

  3-6 months after initial treatment
  3-6 month interval if persistent structural disease (Smallridge, 2012)

**Surveillance/Remission**

Surveillance/remission PET scan testing to assess for possible changes in status with no signs or symptoms of active cancer changes and not on any active treatment. Unless otherwise specified above, PET scan is not indicated for surveillance/remission.

**INDICATIONS FOR AN ONCOLOGICAL GALLIUM 68 DOTATATE PET/CT SCAN:**

**Initial Treatment Strategy or Subsequent Treatment Strategy (Deppen, 2016a,b)**

*For the following neuroendocrine tumors:*

- Gastrointestinal tract, pancreas, lung, thymus (carcinoid tumors)
- Pheochromocytoma, paraganglioma
- Large or small cell carcinoma other than lung
- Neuroendocrine tumors of unknown primary

*OR syndromes:*

- Multiple endocrine neoplasia 1 (MEN-1)
- Multiple endocrine neoplasia 2 (MEN-2)

Neuroendocrine tumors should be biopsy proven (required in unknown primary cases) or very strongly suspected based on other diagnostic testing WITH recent Chest/Abdominal (for example, if lung or thymus) or Abdominal/pelvic (for example, if GI tract, pancreatic, MEN-1, MEN-2) multiphasic CT or MRI having been performed and reasonably deemed insufficient for the following:
• To determine the anatomic extent of tumor when the recommended anti-tumor treatment reasonably depends on the extent of the tumor, or
• To determine if patient is an appropriate candidate for an invasive diagnostic or therapeutic procedure, or
• To determine the optimal anatomic location for an invasive procedure.
• Restaging or monitoring response to active treatment, and/or evaluation for suspicion of recurrence due to new or changing signs/symptoms. (Asymptomatic surveillance is not approvable).

**NOTE:** Gallium-68 DOTATATE PET/CT scans should be performed only if other imaging (CT, MRI) is inconclusive/insufficient AND the patient has not already been evaluated with Somatostatin Receptor SPECT scanning (another form of somatostatin receptor imaging performed on standard nuclear cameras), or that scanning was negative or equivocal.

**Surveillance/Remission**

Both somatostatin receptor imaging (Gallium-68 DOTATATE PET) and FDG PET/CT are NOT recommended for routine surveillance.
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CPT Codes: G0219

IMPORTANT NOTE:

PET scan for whole body, melanoma for non-covered indications is considered to be **not medically necessary** and is therefore a non-covered study.
CPT Codes: G0235

IMPORTANT NOTE:

PET imaging, any site, not otherwise specified, is a non-covered CPT code.
CPT Codes: G0252

IMPORTANT NOTE:

PET scan imaging, full and partial-ring pet scanners only, for initial diagnosis of breast cancer and/or surgical planning for breast cancer (e.g. initial staging of axillary lymph nodes) is considered to be not medically necessary and is therefore a non-covered study.
CPT Codes: G0297

INTRODUCTION:

Smoking-related lung cancer is the leading cause of cancer deaths in both men and women in the United States. Treatment for most lung cancer is focused on surgery which is usually curative only when the tumors are very small. Screening for early lung cancer with sputum cytology and chest x-rays has not been successful in reducing deaths from lung cancer. However, in 2011 a large, prospective, multicenter trial was published that showed CT Chest screening identified early cancers better than other approaches and reduced the death rate from lung cancer. In 2014, the United States Preventive Service Task Force (USPSTF) recommended annual low dose CT Chest screening (CPT code G0297) for people with current or recent past smoking histories.

Initial Clinical Reviewers (ICRs) and Physician Clinical Reviewers (PCRs) must be able to apply criteria based on individual needs and based on an assessment of the local delivery system.

INDICATIONS FOR LOW DOSE CT FOR LUNG CANCER SCREENING:

For annual lung cancer screening:

The use of low-dose, non-contrast spiral (helical) multi-detector CT imaging as a screening technique for lung cancer is considered medically necessary ONLY when used to screen for lung cancer for certain high-risk, asymptomatic individuals when ALL of the following criteria are met (USPSTF, 2013):

- Individual is between 55-80 years of age; AND
- There is at least a 30 pack-year history of cigarette smoking; AND
- If the individual is a former smoker, that individual had quit smoking within the previous 15 years.

ADDITIONAL INFORMATION:

Screening should be discontinued once a person has not smoked for 15 years or develops a health problem that substantially limits life expectancy or the ability or willingness to have curative lung surgery.

REFERENCES

CPT Codes: S8042

IMPORTANT NOTE:

Low Field MRI services are not considered to be medically necessary, are not approvable for payment, and cannot be approved.

ADDITIONAL INFORMATION:

MRI scanners with a field strength of greater than 1.0 Tesla (T) are considered high field. The typical high field MRI units in clinical practice range between 1.0 – 3.0 Tesla. In October 2017 the FDA cleared the first 7 T MRI units. The definition of mid and low field MRI is more variable with mid field units having a lower field strength range of 0.3 to 0.5 and an upper limit under 1.0 T. Low field units have field strengths below 0.3 to 0.2 T. The major disadvantage of low field strength MRI relative to higher field scanners is lower signal to noise ratios, less homogeneity in the magnetic field, lower detection of calcification, hemorrhage or gadolinium enhancement. Lee et al showed that low field (<0.5 T) units were effective in evaluating medial meniscal, anterior cruciate ligament, and rotator cuff tears but not effective for evaluating lateral meniscal tears, osteochondral defects, or shoulder superior labrum-anterior posterior (SLAP) ligament complex pathology (Lee 2013, 2014).
REFERENCES


INTRODUCTION

(Cardiac Resynchronization Therapy (CRT), which paces two ventricular sites in rapid sequence, also known as biventricular pacing, improves coordination of ventricular contraction in the presence of a wide QRS complex in the setting of systolic heart failure.

CRT improves cardiac function and quality of life, and it decreases cardiac events and mortality among appropriately chosen patients. The improved survival in patients with CRT is greater than that provided by ICD insertion alone.

Guiding principles in the consideration of CRT:

- NYHA class is an important qualifying factor, with candidacy ranging from New York Heart Association (NYHA) class I to ambulatory NYHA class IV (See Additional information for NYHA class descriptions)

- Bundle branch block/intraventricular conduction delay should be persistent, not rate-related (Russo 2013)

- Guideline directed medical therapy (GDMT) should have been in place continuously for at least 3 months (Epstein 2012; Yancy 2013; Ponikowski 2016), unless a non-elective permanent pacemaker and/or ICD is indicated prior to completion of the 3 months, and CRT would have been likely required even after 3 months of GDMT. Otherwise, recovery of left ventricular ejection fraction (LVEF) from myocardial infarction (40 days) and reversible causes (e.g. ischemia) should be allowed (Katsumoto 2014; Marine 2018) (See Additional Information section regarding GDMT definition).

- The patient should have expected survival with reasonably good functional status for more than a year (Epstein 2012; Ponikowski 2016; Hernandez-Madrid 2018; Khairy 2014).

- If CRT is indicated, use of an ICD with CRT should be considered (Epstein 2012), and biventricular pacing should occur nearly 100% the time (Yancy 2013, Ponikowski 2016).

- There are no accepted guidelines for CRT in the pediatric population (Motonaga 2014). Available guidelines are extensions of adult indications.

- Elective CRT generator replacement indicators support generator change (Russo 2013).
Indications for Cardiac Resynchronization Therapy (CRT)
(Epstein 2012; Brignole 2013; Yancy 2013; Ponikowski 2016; Russo 2013; Adelstein 2018)

- LVEF $\leq 35\%$, sinus rhythm, left bundle branch block (LBBB) with a QRS $\geq 130$ ms, and NYHA class II, III, or ambulatory IV symptoms on GDMT (guideline-directed medical therapy) (Ponikowski 2016; Adelstein 2018).
- LVEF $\leq 35\%$, sinus rhythm, a non-LBBB pattern with a QRS duration $\geq 130$ ms, and NYHA III or ambulatory class IV symptoms on GDMT (Epstein 2012; Yancy 2013; Ponikowski 2016).
- Atrial fibrillation and LVEF $\leq 35\%$ on GDMT if:
  1. the patient requires ventricular pacing or otherwise meets CRT criteria (as with sinus rhythm)
  2. AV nodal ablation or pharmacologic rate control allows nearly 100% ventricular pacing with CRT, or else the patient is expected to return to sinus rhythm (Yancy 2013).
- LVEF $< 50\%$ with heart failure (HF) on GDMT, regardless of NYHA class, when patient will require new ventricular pacing that would be $\geq 40\%$ (Brignole 2013; Yancy 2013; Ponikowski 2016; Adelstein 2018; Curtis 2013)
- LVEF $< 50\%$ with HF, with worsening HF, despite GDMT, subsequent to implantation of a conventional pacemaker or ICD that is pacing $\geq 40\%$ (Ponikowski 201; Adelstein 2018; Curtis 2013)
- LVEF $\leq 30\%$, ischemic etiology of HF, sinus rhythm, LBBB with a QRS duration $\geq 150$ ms, and NYHA class I symptoms on GDMT
- LVEF $< 35\%$, sinus rhythm, a non-LBBB pattern with a QRS duration $\geq 150$ ms, and NYHA class II on GDMT

NOT Indications for Cardiac Resynchronization Therapy (CRT)
- NYHA class I or II symptoms and non-LBBB pattern with QRS duration $< 150$ ms (Epstein 2012)
- Comorbidities and/or frailty expected to limit survival with good functional capacity to $< 1$ year.

Indications for CRT in Adult Congenital Heart Disease
(Hernandez-Madrid 2018; Khairy 2014)

- Systemic LVEF $\leq 35\%$, sinus rhythm, wide QRS complex $\geq 120$ ms with complete left bundle branch block QRS morphology (spontaneous or paced) and NYHA function Class II—ambulatory IV.
- Systemic ventricle, regardless of ejection fraction (EF), intrinsic narrow QRS complex, NYHA function Class I—ambulatory IV and undergoing new device placement or replacement with anticipated requirement for significant ($\geq 40\%$) ventricular pacing (single site pacing from the systemic ventricular apex or mid-lateral wall may be considered as alternative).
- Systemic right ventricle (RV) with an EF $\leq 35\%$, NYHA function Class II—ambulatory IV, and wide QRS complex $\geq 150$ ms with a complete right bundle branch block QRS morphology (spontaneous or paced).
- Single ventricle with an EF $\leq 35\%$, NYHA function Class II—ambulatory IV and wide QRS complex $\geq 150$ ms due to intraventricular conduction delay causing either a complete right or left bundle branch block QRS morphology (spontaneous or paced).
- Systemic RV with an EF $\geq 35\%$, **sinus rhythm**, wide QRS complex (120—149 ms) with complete right bundle branch block QRS morphology (spontaneous or paced) and NYHA function Class II—ambulatory IV (Hernandez-Madrid 2018).
• Single ventricle with an EF > 35%, **sinus rhythm**, wide QRS complex (120–149 ms) due to intraventricular conduction delay causing either a complete right or left bundle branch block QRS morphology (spontaneous or paced) and NYHA function Class II—ambulatory IV (Hernandez-Madrid 2018).

• Cardiac surgery (especially if thoracotomy access is needed for lead implantation) with an intrinsic or paced QRS duration ≥ 150 ms, complete bundle branch block morphology ipsilateral to the systemic ventricle (left or right), NYHA class I - ambulatory IV, and progressive systolic systemic ventricular dysfunction and/or dilatation or expectation of such development regardless of the ejection fraction value, especially if epicardial access is required to implement CRT.

• Systemic RV and significant tricuspid valve regurgitation without a specific EF limit, NYHA function Class I—ambulatory IV, wide QRS complex ≥ 150 ms with a complete right bundle branch block QRS morphology (spontaneous or paced) undergoing surgery for significant tricuspid valve regurgitation.

• Severe subpulmonary RV dysfunction and dilatation despite interventions to decrease RV volume overload (as in Tetralogy of Fallot), NYHA function Class II—ambulatory IV and wide QRS complex ≥ 150 ms due to a complete right bundle branch block.

• Selected adults with CHD, NYHA class IV, and severe systemic ventricular dysfunction in an attempt to delay or avert cardiac transplantation or mechanical support.

**NOT an Indication for CRT in Adult Congenital Heart Disease**

• CRT is not indicated in patients with a narrow QRS complex (<120 ms) without major electrical activation delay within the failing ventricle.

• CRT is not indicated for patients whose co-morbidities and/or frailty limit survival with good functional capacity to less than 1 year.

**Exemption for < 3 Months GDMT**

**Indications for CRT as the Appropriate Pacing Modality in Special Situations**

(Marine 2018; Katsumoto 2014; Russo 2013)

• Criteria are met for a non-elective implantable cardioverter defibrillator (ICD) or a non-elective pacemaker, either initial or replacement, and based upon the low likelihood of improvement in symptoms and adequate recovery of LVEF, despite less than 3 months GDMT for heart failure or < 40 days post myocardial infarction, criteria for CRT are otherwise met.*

*Based on ICD status, in a setting that would warrant CRT as the appropriate pacing modality. This enables avoidance of a second implantation procedure within less than 3 months.

**ADDITIONAL INFORMATION**

**NYHA Class Definitions**

(Russo 2013; Colucci 2018)

• Class I: No limitation of functional activity or only at levels of exertion that would limit normal individuals (patient can carry 24 pounds up 8 stairs, play basketball, and shovel soil).

• Class II: Slight limitation of activity. Fatigue, palpitation, or dyspnea with moderate exercise (patient able to dance, garden, walk 4 MPH on level ground, and have sexual intercourse).

• Class III: Marked limitation of activity. Fatigue, palpitation, or dyspnea with minimal activity (patient able to shower, make bed, bowl or golf, dress, and walk 2.5 MPH on level).
• Class IV: Severe limitation of activity. Symptoms even at rest, worse with activity (patient unable to comfortably perform any significant activity).

• Ambulatory Class IV: Class IV heart failure with:
  no active acute coronary syndrome,
  no inotropes, AND
  on GDMT.

**Heart Block Definitions**
( Epstein 2012)

• First Degree: All atrial beats are conducted to the ventriles, but with a delay of > 200 ms.

• Second Degree: Intermittent failure of conduction of single beats from atrium to ventriles.
  o Type I: Conducted beats have variable conduction times from atrium to ventriles.
  o Type II: Conducted beats have uniform conduction times from atrium to ventriles.
  o Advanced: Two or more consecutive non-conducted beats (premature atrial beats might not normally be conducted).

• Third Degree: No atrial beats are conducted from atrium to ventricle

**Guideline Directed (or Optimal) Medical Therapy in Heart Failure**
(Yancy 2013; Yancy 2017)

  o Angiotensin converting enzyme inhibitor (ACE-I), angiotensin receptor blocker (ARB), or combined angiotensin receptor inhibitor and nephrilysin inhibitor (ARNI)
  o Beta blocker (might be less critical in permanent atrial fibrillation, still recommended) (Kotecha 2017)
  o Addition of loop diuretic for all NYHA class II – IV patients
  o Addition of hydralazine and nitrate for persistently symptomatic African Americans
  o Addition of an aldosterone antagonist, provided eGFR is > 30 ml/min and K+ < 5.0
  o Not required for consideration of CRT: Ivabradine for NYHA class II – III, when a beta blocker has failed to reduce a sinus rate to < 70 bpm. Ivabradine listed as a class IIa recommendation, while others are class I recommendations. CRT trials antedated routine use of ivabradine.

**Pediatric respiratory rate and heart rate by age**

<table>
<thead>
<tr>
<th>Age group</th>
<th>Respiratory rate</th>
<th>Heart rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (1st-99th percentile)</td>
<td>Median (1st-99th percentile)</td>
</tr>
<tr>
<td>0 to 3 months</td>
<td>43 (25-66)</td>
<td>143 (107-181); term newborn at birth: 127 (90-164)</td>
</tr>
<tr>
<td>3 to 6 months</td>
<td>41 (24-64)</td>
<td>140 (104-175)</td>
</tr>
<tr>
<td>6 to 9 months</td>
<td>39 (23-61)</td>
<td>134 (98-168)</td>
</tr>
<tr>
<td>Age Group</td>
<td>Respiratory Rate</td>
<td>Heart Rate</td>
</tr>
<tr>
<td>-------------------</td>
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</tr>
<tr>
<td>9 to 12 months</td>
<td>37 (22-58)</td>
<td>128 (93-161)</td>
</tr>
<tr>
<td>12 to 18 months</td>
<td>35 (21-53)</td>
<td>123 (88-156)</td>
</tr>
<tr>
<td>18 to 24 months</td>
<td>31 (19-46)</td>
<td>116 (82-149)</td>
</tr>
<tr>
<td>2 to 3 years</td>
<td>28 (18-38)</td>
<td>110 (76-142)</td>
</tr>
<tr>
<td>3 to 4 years</td>
<td>25 (17-33)</td>
<td>104 (70-136)</td>
</tr>
<tr>
<td>4 to 6 years</td>
<td>23 (17-29)</td>
<td>98 (65-131)</td>
</tr>
<tr>
<td>6 to 8 years</td>
<td>21 (16-27)</td>
<td>91 (59-123)</td>
</tr>
<tr>
<td>8 to 12 years</td>
<td>19 (14-25)</td>
<td>84 (52-115)</td>
</tr>
<tr>
<td>12 to 15 years</td>
<td>18 (12-23)</td>
<td>78 (47-108)</td>
</tr>
<tr>
<td>15 to 18 years</td>
<td>16 (11-22)</td>
<td>73 (43-104)</td>
</tr>
</tbody>
</table>

* The respiratory and heart rates provided are based upon measurements in awake, healthy infants and children at rest. Many clinical findings besides the actual vital sign measurement must be taken into account when determining whether a specific vital sign is normal in an individual patient. Values for heart rate or respiratory rate that fall within normal limits for age may still represent abnormal findings that are caused by underlying disease in a particular infant or child (Fleming 2011; Fleegler, 2018).

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**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE-I</td>
<td>Angiotensin converting enzyme inhibitor</td>
</tr>
<tr>
<td>ARNI</td>
<td>combined angiotensin receptor inhibitor and neprilysin inhibitor</td>
</tr>
<tr>
<td>AV</td>
<td>Atrioventricular</td>
</tr>
<tr>
<td>CAD</td>
<td>Coronary artery disease, same as ischemic heart disease</td>
</tr>
<tr>
<td>CHF</td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>CRT</td>
<td>Cardiac resynchronization therapy (also known as biventricular pacing)</td>
</tr>
<tr>
<td>CHD</td>
<td>Congenital heart disease</td>
</tr>
<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>eGFR</td>
<td>Estimated glomerular filtration rate</td>
</tr>
<tr>
<td>EPS</td>
<td>Electrophysiologic Study</td>
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<tr>
<td>GDMT</td>
<td>Guideline-Directed Medical Therapy</td>
</tr>
<tr>
<td>HF</td>
<td>Heart Failure</td>
</tr>
<tr>
<td>HRS</td>
<td>Heart Rhythm Society</td>
</tr>
<tr>
<td>HV</td>
<td>His-ventricular</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>ICD</td>
<td>Implantable cardioverter-defibrillator</td>
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<tr>
<td>LBBB</td>
<td>left bundle-branch block</td>
</tr>
<tr>
<td>LV</td>
<td>Left ventricular/left ventricle</td>
</tr>
<tr>
<td>LVEF</td>
<td>Left ventricular ejection fraction</td>
</tr>
<tr>
<td>MI</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>ms</td>
<td>milliseconds</td>
</tr>
<tr>
<td>NYHA</td>
<td>New York Heart Association</td>
</tr>
<tr>
<td>STEMI</td>
<td>ST-elevation Myocardial Infarction</td>
</tr>
<tr>
<td>SND</td>
<td>Sinus node dysfunction</td>
</tr>
<tr>
<td>VT</td>
<td>Ventricular tachycardia</td>
</tr>
</tbody>
</table>
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**INTRODUCTION**

(Al-Khatib 2017; Priori 2015; Ganz 2018; Russo 2013; Epstein 2012; Yancy 2013; Ponikowski 2016; Shen 2017)
The implantable cardioverter defibrillator (ICD) has become valuable in the management of patients with ventricular arrhythmias (VA) capable of causing syncope, cardiac arrest, and sudden cardiac death (SCD), in either one of two scenarios:

- Secondary prevention of SCD due to previous ventricular arrhythmic events
- Primary prevention in patients at high risk for SCD due to ventricular arrhythmia

Patient eligibility for an ICD presumes all of the following:

- Anticipated reasonable quality of life for ≥ 1 year post implantation, with consideration of age and comorbidities, although age alone is not a contraindication (Katsumoto 2017)
- Patient’s ability to live with a shock-delivering device that requires management
- Absence of a completely reversible cause that led to VA for which an ICD is being considered (see Additional Information section on reversible causes) (Marine 2018a)
- Completion of ≥ 3 months of guideline directed medical therapy (GDMT) for heart failure (HF) in most, but not all, cases of primary prevention, unless a supervening indication for non-elective pacemaker implantation or ICD generator replacement arises (to avoid second implantation procedure) (see Additional Information section for definition of GDMT)
- ICD indications are present in the vast majority of scenarios in which cardiac resynchronization therapy (CRT) is appropriate
- Sustained VT is defined as having duration > 30 seconds or requiring termination due to hemodynamic compromise in < 30 seconds
- Elective replacement indicators support generator change if there is anticipated reasonable quality of life for ≥ 1 year (issues pertaining to reduction in VA risk associated with improved LVEF and/or absence of VA remain unresolved) (Al-Khatib 2017; Russo 2013)

Guidelines for the pediatric population are extrapolated from the adult population, due to a lack of relevant trials (Brugada 2013; Priori 2015)

**INDICATIONS FOR ICD INSERTION**

(Al-Khatib 2017; Priori 2015; Ganz 2018; Russo 2013; Epstein 2012; Yancy 2013; Ponikowski 2016; Shen 2017)

**General, Secondary Prevention of VT/VT/SCA**

(Al-Khatib 2017; Priori 2015; Ganz 2018)

- Patients with ventricular fibrillation (VF) or hemodynamically non-tolerated ventricular tachycardia (VT) after evaluation of etiology of event and exclusion of completely reversible causes (e.g. occurrence of myocardial infarction < 48 hours ago can often be considered a completely reversible cause; also see Ischemic Heart Disease section below) (O’Gara 2013).
- Spontaneous VT lasting > 30 seconds in patients with structural or ischemic heart disease (CAD) or with channelopathies, whether hemodynamically stable or unstable (Ganz 2018).
- Post resuscitation from sudden cardiac arrest due to coronary artery spasm (Montalescot 2013).

**Ischemic Heart Disease (CAD)**

(Al-Khatib 2017, Priori 2015, Ganz 2018, Russo 2013)
• Sustained VT (> 30 s or with hemodynamic non-tolerance)
• Syncope of undetermined origin, in ischemic heart disease or with prior myocardial infarction (MI), with either one of:
  o hemodynamically significant sustained monomorphic VT induced at electrophysiological study
  o LVEF ≤ 35%
• LVEF ≤ 35% due to ischemic heart disease or prior MI, NYHA class II or III, despite GDMT, and at least 40 days post-MI and at least 90 days post-revascularization
• LVEF ≤ 30% due to ischemic heart disease or prior MI, NYHA class I despite GDMT, and at least 40 days post-MI and at least 90 days post-revascularization (Al-Khatib 2017; Ganz 2018; Russo 2013)
• Non-sustained VT due to prior MI, LVEF ≤ 40%, and inducible sustained VT or inducible VF at electrophysiological study. Non-sustained ventricular tachycardia (NSVT) should have been ≥ 4 full days post MI or post coronary revascularization (Russo 2013)
• Newly found LVEF < 50% with VF or polymorphic VT < 48 hours post MI, NSVT ≥ 4 days later, and inducible VT or VF ≥ 4 days post complete coronary revascularization (Russo 2013)
• Newly found LVEF ≤ 35% with VF or polymorphic VT < 48 hours post MI, and not amenable to complete coronary revascularization (Russo 2013)
• VF or hemodynamically unstable VT < 48 hours following elective coronary revascularization, without evidence of acute coronary occlusion, provoking infarct, or any other clearly reversible cause (Russo 2013)

Nonischemic cardiomyopathy (NICM)
(Al-Khatib 2017)

• Sustained VT (> 30 s or with hemodynamic non-tolerance)
• Syncope in NICM (nonischemic cardiomyopathy) that is presumed to be due to ventricular arrhythmia, given the weak correlation between VT or VF inducibility and mortality
• NICM with LVEF ≤ 35% and NYHA functional Class I, II, or III, despite GDMT, and at least 90 days (or 3 months) after diagnosis of dilated cardiomyopathy (DCM).
• NICM due to a Lamin A/C mutation, who have ≥ 2 risk factors from the following list:
  a. NSVT
  b. LVEF < 45%
  c. Nonmissense mutation
  d. male sex
• In borderline uncertain indications for ICD in NICM, late gadolinium enhancement on cardiovascular magnetic resonance (CMR) provides evidence of mid wall fibrosis, indicating a higher risk for cardiac arrest and SCD. (Al-Khatib 2017; Halliday 2017; Kuruvilla 2014)
• Peripartum cardiomyopathy with LVEF ≤ 35% that persists > 3 months postpartum despite 3 months of GDMT. (Russo 2013)
• Familial dilated cardiomyopathy with LVEF > 35%, with family history associated with SCD OR with a LMNA mutation (Russo 2013; Hershberger 2018)

Advanced Heart Failure & Transplantation
(Al-Khatib 2017; Priori 2015)
• In NYHA class IV and/or using inotropes, awaiting transplantation or an LVAD, either non-hospitalized or planning imminent discharge, without other qualifying ICD criteria met (Al-Khatib 2017; Priori 2015; Russo 2013)

• In a patient with an LVAD, sustained ventricular arrhythmias (Al-Khatib 2017)

• Severe allograft vasculopathy, with severe LV dysfunction, with expected survival ≥1 year (Al-Khatib 2017)

• In NYHA ambulatory class IV, with appropriately indicated CRT implantation (see Additional Information section for definition of ambulatory NYHA class IV)

Myocardial Diseases

• Giant cell myocarditis with (Al-Khatib 2017; Priori 2015):
  a. VF or hemodynamically unstable VT, even if early in the course, OR
  b. Requires a pacemaker

• Chronic Chagas cardiomyopathy for one of the following (Priori 2015; Marin-Neto 2018):
  a. Cardiac arrest or sustained VT
  b. Ejection fraction < 40%

• Cardiac Sarcoidosis for one of the following (Al-Khatib 2017; Shen 2017; Priori 2015):
  a. Sustained VT or sudden cardiac arrest, even if early in the course
  b. LVEF ≤ 35%
  c. LVEF > 35% with inducible sustained ventricular arrhythmia
  d. Syncope
  e. Scar on CMR or positron emission tomography (PET)
  f. Require a permanent pacemaker, even if transient (Blankstein 2018)

• Neuromuscular Disorders for one of the following (Al-Khatib 2017):
  o Primary and secondary prevention as for NICM (Priori 2016)
  o Emery-Dreifuss or limb-girdle type I-B muscular dystrophy with progressive cardiac muscle involvement
  o Type 1 myotonic dystrophy (Steinert Disease) with an indication for a permanent pacemaker

• Hypertrophic cardiomyopathy (HCM) with ≥ 1 major risk factors for SCD (Al-Khatib 2017; Maron 2018; Shen 2017; Epstein 2012):
  a. Prior sudden cardiac arrest (SCA) due to VT or VF
  b. Sustained VT with syncope or hemodynamic compromise
  c. Maximum LV wall thickness ≥ 30 mm
  d. SCD ≥ 1 first degree relatives, presumably caused by HCM
  e. ≥ 1 episodes of unexplained syncope within the preceding 6 months
  f. NSVT
  g. Abnormal BP response to exercise in patients < 40 yr
     i. BP rise < 20 mm Hg or fall of > 20 from exercise peak during ongoing exercise
  h. Borderline evidence of the above risk factors plus one of the following:
     i. End stage HCM with LVEF < 50%
     ii. Left ventricular apical aneurysm
     iii. age < 30 years old
iv. Late gadolinium enhancement on CMR ≥ 15%
v. Marked left ventricular outflow tract (LVOT) gradient (at least ≥ 50 mm Hg peak at rest)
vi. Syncope > 5 years ago

i. Only if the above method is not helpful, the ESC HCM Risk-SCD Calculator can be used, according to the limitations on the web page (O’Mahoney 2017): Available at:
http://www.doc2do.com/hcm/webHCM.html

- **Arrhythmogenic right ventricular dysplasia cardiomyopathy** (ARVD/C) and ≥ 1 of the following risk factors for SCD:
  (Al-Khatib 2017; Shen 2017; McKenna 2018; Calkins 2017; Epstein 2012)
  a. Resuscitated cardiac arrest
  b. Sustained VT
  c. Right or left ventricular ejection fraction ≤ 35%
  d. Syncope with documented or presumed/suspected ventricular arrhythmia
  e. Electrocardiographic abnormalities such as any one of the following:
     i. T wave inversion in V1 to V3 during sinus rhythm
     ii. Frequent premature ventricular contractions (PVCs) (e.g. > 30/hour)
     iii. Nonsustained VT
     iv. Positive electrophysiologic study (EPS) for sustained VT
     v. High risk genotypes or multiple mutations
  o Borderline evidence of the above risk factors plus one of the following:
     - male sex
     - extensive/severe involvement/dilation of the right or left ventricle
     - continued vigorous exertion

- **Channelopathies**

  - **Congenital long QT syndrome** with one of the following (Al-Khatib 2017; Zimetbaum 2018; Priori 2015; Goldenberg 2008; Schwartz 2012; Epstein 2012; Schwartz 2012) [Diagnosis based upon the Schwartz score, if in question (see Additional Information section) (Schwartz 2011; Schwartz 2018)]:
    o Cardiac arrest
    o Sustained VT or recurrent syncope despite optimal beta blocker (or with beta blocker intolerance/noncompliance)
    o QTc > 500 ms on a beta blocker (Al-Khatib 2017)
    o Jervell and Lange-Nielson syndrome
    o Strong family history of SCD
    o High risk genotype

  - **Brugada syndrome** with one of the following:
  (Al-Khatib 2017; Priori 2015; Katsumoto 2017; Epstein 2012)
    a. Cardiac arrest
    b. Sustained ventricular arrhythmia
    c. Syncope with a spontaneous Brugada type I electrocardiogram (ECG)

  - **Catecholaminergic polymorphic VT** with one of the following (Al-Khatib 2017; Buxton 2018; Epstein 2012; Russo 2013):
    a. Cardiac arrest
    b. Syncope or sustained VT while receiving optimal dosing of beta blockers
c. Inducible VT or VF

- **Early Repolarization or Short QT Syndrome** with one of the following (Al-Khatib 2017; Priori 2015):
  a. Cardiac arrest
  b. Sustained ventricular arrhythmia

- **Idiopathic Polymorphic VT/VF** with one of the following (Al-Khatib 2017):
  a. Cardiac arrest due to polymorphic VT or VF
  b. Idiopathic VF (Russo 2013; Priori 2015)
  c. First degree relative with SCD (Russo 2013)

**Miscellaneous**

- **Unexplained syncope following appropriate thorough evaluation** with one of the following:
  a. Advanced structural heart disease (Epstein 2012)
  b. Hypertensive heart disease with LVH and LVEF ≤ 35% (Russo 2013)

**Adult & Pediatric Congenital (Structural) Heart Disease (ACHD)**

Main references: (Khairy 2014; Hernandez-Madrid 2018)
Secondary references: (Al-Khatib 2017; Priori 2015; Brugada 2013; Shen 2017)

- Cardiac arrest due to VF or hemodynamically unstable VT after evaluation to define the cause of the event and exclusion of a completely reversible etiology.

- Spontaneous symptomatic sustained VT, after undergoing hemodynamic and EP evaluation (hemodynamics impact arrhythmia risk and require optimization). Catheter ablation or surgery may offer a reasonable alternative or adjunct to ICD.

- Systemic LVEF ≤ 35%, biventricular physiology, and NYHA class II or III on GDMT.

- Tetralogy of Fallot with one of the following (Al-Khatib 2017; Shen 2017):
  o Spontaneous sustained VT
  o Inducible monomorphic or polymorphic sustained VT or VF
  o Multiple risks from the following list:
    - Left ventricular dysfunction
    - NSVT
    - QRS duration ≥ 180 ms
    - Extensive right ventricular scarring

Single or systemic right ventricular ejection fraction (RVEF) < 35%, in the presence of an additional risk factor such as:
  o NSVT
  o Unexplained syncope
  o NYHA class II or III, despite GDMT (Al-Khatib 2017; Priori 2015)
  o QRS duration ≥ 140 ms
  o Severe systemic AV valve regurgitation
Syncope of unknown origin in the presence of either advanced ventricular dysfunction (EF < 35%) or marked hypertrophy or inducible sustained VT or VF (Al-Khatib 2017; Shen 2017)

Syncope and moderate or complex congenital heart disease (CHD), with high clinical suspicion of ventricular arrhythmia despite thorough invasive and non-invasive evaluation not defining a cause

Non-hospitalized patients with CHD awaiting heart transplantation

Left ventricular noncompaction that meets same indications as NICM, including a familial history of SCD (Connolly 2018; Russo 2018).

**ICD NOT Recommended in CHD**

Patients with less than 1 year of expected survival, even if they otherwise meet ICD implantation criteria. Incessant VT or VF. Significant psychiatric illnesses that may be aggravated by device implantation or that may preclude systematic follow-up. NYHA Class IV symptoms with drug-refractory congestive heart failure and who are not eligible for cardiac transplantation, ventricular assist device, or cardiac resynchronization therapy defibrillator (CRT-D).

Advanced pulmonary vascular disease/Eisenmenger syndrome - generally not considered candidates for ICD therapy.

**Exemptions**

*Indications for ICD with an Appropriate Pacing Modality in Special Situations*

(Marine 2018b; Katsumoto 2014; Russo 2013) *

- ICD criteria met, and elevated troponin is deemed to not be due to a myocardial infarction (although troponin elevation can also be secondary to VT or VF, requiring judgment) (Al-Khatib 2017).
- ICD criteria met, except for myocardial infarction within 40 days or revascularization within 3 months, but a non-elective permanent pacemaker (new or replacement) is required, and recovery of left ventricular function to LVEF > 35% is uncertain or not expected (Russo 2013).**
- ICD criteria met, except NICM or ischemic cardiomyopathy has not had 3 months’ time for LVEF to improve on medical therapy, a non-elective permanent pacemaker is required, and recovery of LVEF is uncertain or not expected.**
- Pre-existing ICD (with or without pre-existing CRT) requiring non-elective generator replacement within <40 days post myocardial infarction or < 3 months post revascularization restrictions.**
- Patient met primary prevention criteria for an ICD prior to coronary revascularization, and it is unlikely that LVEF will recover to > 35% despite a 90 day wait (Katsumoto 2014).
- Listed for transplantation or received a LVAD within 3 months of revascularization, but not within 40 days of myocardial infarction (Katsumoto 2014).

* With these ICD indications, CRT would sometimes be the appropriate pacing modality. CRT is highly likely to be the appropriate modality when > 40% rhythm requires pacing.  
** These indications enable avoidance of a second implantation procedure within less than 3 months.

**ADDITIONAL INFORMATION**
Implantable cardioverter defibrillators (ICDs) are indicated for the treatment of life-threatening ventricular tachycardia and ventricular fibrillation. An ICD system includes a pulse generator and one or more leads. ICDs are indicated both for patients who have survived life threatening rhythm disturbances (secondary prevention) and for those who are at risk for them (primary prevention).

- An ICD continually monitors heart rhythm. If a rapid rhythm is detected, the device delivers electrical therapy directly to the heart muscle in order to terminate the rapid rhythm and restore a normal heart rhythm. There are two types of therapy that can be delivered:
  - Rapid pacing, which is painless, is often effective in terminating ventricular tachycardia.
  - High-voltage shocks, which are painful to the patient, are necessary for ventricular fibrillation and also for instances where rapid pacing has failed to correct ventricular tachycardia.
- In addition, all ICDs have pacing capability, and they deliver pacing therapy for slow heart rhythms (bradycardia).
- The parameters defining limits for pacing therapy and for tachycardia therapy are programmable using noninvasive radio signals on all available ICDs.

**Waiting Period** is an important issue in the timing of ICD insertion for primary prevention. This has resulted from guidelines and payment policies, predominantly on the part of CMS, which mirror the inclusion criteria of published primary and secondary prevention trials. For example, most primary prevention trials have excluded patients with recent coronary revascularization (under 3 months or 90 days) or recent myocardial infarction (under 40 days). Studies of patients who have received ICDs early after myocardial infarction have not demonstrated a mortality benefit.

- Most guidelines recommend waiting periods that are reasonable and appropriate, but there are certain clinical scenarios in which exemptions might be required. For example, a patient with a longstanding cardiomyopathy, who is a candidate for an ICD, might have a small non-revascularized non-ST-elevation myocardial infarction (STEMI). This patient’s LVEF will certainly not improve over the next 40 days, and withholding an ICD makes little sense.
- This scenario would be rendered even more problematic if the patient required a non-elective pacemaker, since waiting 40 days post myocardial infarction to upgrade a pacemaker to an ICD would subject the patient (and payer) to two procedures instead of one. Therefore, these guidelines adhere to the current waiting periods but also provide an opportunity to request exemptions where patient benefit is clearly documented (see “Exemptions” section above).

**Reversible Causes of Ventricular Arrhythmia**

(Marine 2018a)

In some survivors of SCA or sustained VT, a transient or reversible cause (e.g. acute myocardial ischemia, electrolyte disturbances, medication-related proarrhythmia) can be identified which is thought to have been the cause. Initial treatment should be directed at the underlying disorder. However, prior to concluding that the VA was entirely due to a reversible cause, a thorough evaluation should be performed, for which electrophysiologic consultation might be required. As opposed to completely reversible causes, a reversible condition might be only a precipitant of ventricular arrhythmia in a patient who is otherwise predisposed and therefore considered high risk for recurrence, especially in the context of possible recurrence of precipitating factors. A prime example is a patient who presents with VF and is found to have mild hypokalemia, in which case it is generally not appropriate to assign the entirety of the cause of the ventricular arrhythmia to the low potassium level alone.
Correction of a reversible cause of SCA or sustained VT is most likely to be adequate in one of several settings:

- **Polymorphic VT or VF** that is preceded by clear evidence of myocardial ischemia or acute myocardial infarction within the past 48 hours. In such cases, revascularization is often adequate for the purpose of reducing the risk of SCD. However, some of these patients will later qualify for a primary prevention ICD due to severe left ventricular systolic dysfunction or HF. Guideline-directed medical therapy should be applied, and follow-up evaluation with a cardiologist soon after discharge should be arranged for additional risk stratification. A repeat evaluation of LV function is recommended >40 days post-MI and >90 days after revascularization to determine if the patient qualifies for ICD implantation based on consideration for primary prevention indications.

An important caveat is that **sustained monomorphic VT** in the setting of prior myocardial infarction is typically due to scar-related (substrate) re-entry and is not due to the occurrence of ischemia. Thus, in patients with stable CAD and sustained monomorphic VT, coronary revascularization alone is considered an ineffective therapy to prevent such recurrent VT.

- **Polymorphic VT in the setting of acquired QT prolongation** - Withdrawal of the offending drug and avoidance of other QT prolonging medications may be adequate to reduce the risk of SCD.

- **VF in the setting of Wolff-Parkinson-White syndrome in patients with a structurally normal heart** – These patients are adequately treated with catheter ablation of the accessory pathway.

- **Idiopathic monomorphic VT in the setting of a structurally normal heart** – Such patients are usually adequately treated with medical therapy or catheter ablation (see VA in Structurally Normal Hearts, below).

- **VT/VF occurring in the setting of drug overdose** – Examples include cocaine, amphetamines, digoxin, tricyclic antidepressants, and antiarrhythmic drugs.

In most other cases, life-threatening ventricular arrhythmias should not be attributed solely to a reversible disorder, and patients should be managed according to guidelines for secondary prevention.

**Ventricular Arrhythmias in Structurally Normal Hearts**

Sustained VT is uncommon in patients with structurally normal hearts. In patients with structurally normal hearts, an ICD is generally not recommended in patients with monomorphic VT. When there are substantial symptoms (or adverse effect on LVEF or sustained VT) these patients can be treated with medical therapy or, more often, catheter ablation. An ICD would not be required since the risk of sudden cardiac death is typically low, especially following successful catheter ablation (e.g. atrial arrhythmias associated with the Wolff-Parkinson-White syndrome, RV or LV outflow tract VT, idiopathic VT, or fascicular VT in the absence of structural heart disease) (Ganz 2018; Al-Khatib 2017; Dukkipati 2017a; Callans 2018).

Reduced LVEF deemed solely due to a high burden of ventricular ectopy (PVCs, VT), comprising > 10% of QRS complexes, is considered a reversible cause for the reduced LVEF. When ablation can eradicate the ventricular ectopy and restore LVEF > 35%, an ICD would not be indicated; it should be considered if the LVEF remains < 35% (Dukkipati a&b 2017).

Some polymorphic VT or VF in structurally normal hearts can be treated with ablation of the triggering PVC, e.g. catecholaminergic polymorphic VT/VF, idiopathic VF, Congenital Long QT Syndrome, Brugada
Syndrome, and Early Repolarization Syndrome. In Brugada patients, the substrate of the VF can often be ablated by an epicardial approach. Generally, *an ICD is still required* in this group of patients with polymorphic VT or VF (given the complexity, any decision to avoid an ICD implant following such potential VA cures by ablation in structurally normal hearts is beyond the scope of this guideline) (Dukkipati a&b 2017).

**Wearable Cardioverter Defibrillator (WCD)**

The WCD will require additional clinical trials to determine its optimal place in the treatment of ventricular arrhythmia, since to date, only one randomized clinical trial, VEST, had been presented orally at the American College of Cardiology meeting in March, 2018. The WCD is addressed in a separate document.

**Unanswered Questions**

Additional issues need to be addressed with respect to vulnerability to SCD. While ventricular arrhythmia within the first 48 hours post myocardial infarction might not qualify for longer term risk that warrants an ICD, the presence of sustained monomorphic VT (as opposed to polymorphic VT or VF) in that time frame bespeaks underlying substrate for chronic risk of recurrence of the sustained monomorphic VT, in which case either an ICD versus WCD plus watchful waiting and/or EPS testing/ablation might prove helpful. Further study is necessary (Liang 2014).

**NYHA Class Definitions**

(Russo 2013; Colucci 2018)

- **Class I**: No limitation of functional activity or only at levels of exertion that would limit normal individuals (patient can carry 24 pounds up 8 stairs, play basketball, and shovel soil).
- **Class II**: Slight limitation of activity. Fatigue, palpitation, or dyspnea with moderate exercise (patient able to dance, garden, walk 4 MPH on level ground, and have sexual intercourse).
- **Class III**: Marked limitation of activity. Fatigue, palpitation, or dyspnea with minimal activity (patient able to shower, make bed, bowl or golf, dress, and walk 2.5 MPH on level ground).
- **Class IV**: Severe limitation of activity. Symptoms even at rest, worse with activity (patient unable to comfortably perform any significant activity).
- **Ambulatory Class IV**: Class IV heart failure with: 1) no active acute coronary syndrome; 2) no inotropes; and 3) on GDMT.

**Heart Block Definitions**

( Epstein 2012)

- **First Degree**: All atrial beats are conducted to the ventricles, but with a delay of > 200ms.
- **Second Degree**: Intermittent failure of conduction of single beats from atrium to ventricles.
  - Type I: Conducted beats have variable conduction times from atrium to ventricles.
  - Type II: Conducted beats have uniform conduction times from atrium to ventricles.
  - Advanced: Two or more consecutive non-conducted beats (premature atrial beats might not normally be conducted).
- **Third Degree**: No atrial beats are conducted from atrium to ventricle.
Guideline Directed (or Optimal) Medical Therapy for Heart Failure
(Yancy 2013; Yancy 2017)

- Angiotensin converting enzyme (ACE-I), angiotensin receptor blockers (ARB), or combined angiotensin receptor inhibitor and neprilysin inhibitor (ARNI)
- Beta blocker (might be less critical in permanent atrial fibrillation, still recommended) (Kotecha 2017).
- Addition of loop diuretic for all NYHA class II – IV patients
- Addition of hydralazine and nitrate for persistently symptomatic African Americans
- Addition of an aldosterone antagonist, provided eGFR is > 30 ml/mi
- n and K+ < 5.0
- Not required for consideration of ICD: Ivabradine for NYHA class II – III, when a beta blocker has failed to reduce a sinus rate to < 70 bpm. Ivabradine listed as a class IIa recommendation, while others are class I recommendations. CRT trials antedated routine use of ivabradine.

Schwartz score diagnostic criteria for long QT syndrome (LQTS) (Schwartz 2011)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrocadiographic findings*</td>
<td></td>
</tr>
<tr>
<td>QTc¶</td>
<td></td>
</tr>
<tr>
<td>▪ ≥480 ms</td>
<td>3</td>
</tr>
<tr>
<td>▪ 460 to 479 ms</td>
<td>2</td>
</tr>
<tr>
<td>▪ 450 to 459 ms (in males)</td>
<td>1</td>
</tr>
<tr>
<td>QTc¶ fourth minute of recovery from exercise stress test ≥480 ms</td>
<td>1</td>
</tr>
<tr>
<td>Torsades de pointes^A</td>
<td>2</td>
</tr>
<tr>
<td>T wave alternans</td>
<td>1</td>
</tr>
<tr>
<td>Notched T wave in 3 leads</td>
<td>1</td>
</tr>
<tr>
<td>Low heart rate for age^§</td>
<td>0.5</td>
</tr>
<tr>
<td>Clinical history</td>
<td></td>
</tr>
<tr>
<td>Syncope^A</td>
<td></td>
</tr>
<tr>
<td>▪ With stress</td>
<td>2</td>
</tr>
</tbody>
</table>
Without stress | 1
Congenital deafness | 0.5

**Family history**

Family members with definite LQTS§ | 1
Unexplained sudden cardiac death below age 30 among immediate family members§ | 0.5

**SCORE:**

- ≤1 point = low probability of long QT syndrome (LQTS).
- 1.5 to 3 points = intermediate probability of LQTS, requires addition of genotyping to further classify risk as low or high.
- ≥3.5 points = high probability of LQTS.

* In the absence of medications or disorders known to affect these electrocardiographic features.
¶ QTc calculated by Bazett’s formula where QTc = QT/√RR.
Δ Mutually exclusive.
◊ Resting heart rate below the second percentile for age.
§ The same family member cannot be counted in A and B.

**Abbreviations**

ACE-I Angiotensin converting enzyme inhibitor
ACHD Adult congenital heart disease
ARNI Combined angiotensin receptor inhibitor and neprilysin inhibitor
ARVD/C Arrhythmogenic right ventricular dysplasia cardiomyopathy
AV Atrioventricular
CAD Coronary artery disease, same as ischemic heart disease
CHD Congenital heart disease
CHF Congestive heart failure
CRT Cardiac resynchronization therapy
CRT-D Cardiac resynchronization therapy ICD system
DCM Dilated cardiomyopathy
ECG Electrocardiogram
EPS Electrophysiologic Study
GDMT Guideline-Directed Medical Therapy
HCM Hypertrophic cardiomyopathy
HF Heart failure
HRS Heart Rhythm Society
HV His-ventricle
ICD Implantable cardioverter-defibrillator
LBBB Left bundle-branch block
LV Left ventricular/left ventricle
LVAD Left ventricular assist device, mechanical heart
LVEF Left ventricular ejection fraction
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>ms</td>
<td>Milliseconds</td>
</tr>
<tr>
<td>NICM</td>
<td>Nonischemic cardiomyopathy</td>
</tr>
<tr>
<td>NYHA</td>
<td>New York Heart Association</td>
</tr>
<tr>
<td>RV</td>
<td>Right ventricular/right ventricle</td>
</tr>
<tr>
<td>STEMI</td>
<td>ST-elevation myocardial infarction</td>
</tr>
<tr>
<td>SND</td>
<td>Sinus node dysfunction</td>
</tr>
<tr>
<td>VT</td>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td>VF</td>
<td>Ventricular fibrillation</td>
</tr>
</tbody>
</table>
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INTRODUCTION

(Epstein 2013; Hayes 2018)

- Pacemaker implantation generally serves to address bradycardias, with the intention of ameliorating related symptoms, preventing complications of syncope, and/or reducing mortality risk.

- Guidelines for the pediatric and congenital heart disease population are provided in the latter portion of this guideline.

- This guideline is not intended to cover the type of bradycardia pacing device. CRT (cardiac resynchronization therapy or biventricular pacing) and ICD (implantable cardioverter defibrillator) implantation are covered in separate guidelines.

- Elective generator replacement indicators support generator change.

ADULT INDICATIONS FOR PACEMAKERS

(Epstein 2013; Hayes 2018)

(Excludes transient causes, such as unnecessary medication, temporary metabolic and inflammatory conditions, etc.)

Sinus Node Dysfunction

- Documented symptomatic sinus bradycardia, including frequent sinus pauses that produce symptoms
- Symptomatic chronotropic incompetence, documented by stress test or electrocardiography (ECG) recording data
- Symptomatic sinus bradycardia that results from required medication
- Heart rate less than 40, in the waking state, when a clear association between significant symptoms consistent with bradycardia and the actual presence of bradycardia has not been documented.
- Syncope of unexplained origin when clinically significant abnormalities of sinus node function are discovered (e.g. an asymptomatic ventricular pause > 6 s) or provoked by electrophysiologic study (EPS), such as a prolonged sinus node recovery time (Brignole 2013).
- Symptomatic sinus bradycardia (< 60 bpm), which includes syncope, near-syncope, dizziness, lethargy, congestive heart failure (CHF), fatigue, or dyspnea, whether spontaneous or as a result of clinically required medications or procedures (e.g. medical or catheter treatment for atrial fibrillation) that slow the heart rate, when symptoms can clearly be attributed to bradycardia (Brignole 2013).
- Ischemia-related life threatening bradyarrhythmias, when coronary spasm presents a poor or uncertain response to medical therapy (Montalescot 2013).

NOT Indicated for Sinus Node Dysfunction:
• Asymptomatic.
• Symptoms in the absence of bradycardia.
• Bradycardia resulting from nonessential drug therapy.

**Acquired Third-Degree and Advanced Second-Degree Atrioventricular (AV) Block:** (See definition of advanced atrioventricular (AV) Block in Additional Information section.)

• Persistent third-degree (complete) AV block, with or without symptoms
• Advanced second degree AV block at any anatomic level associated with bradycardia with symptoms (including heart failure) or ventricular arrhythmias presumed to be due to AV block
• Persistent third degree AV block or advanced second degree AV block that is due to clinically necessary medication
• In atrial fibrillation, while awake, pauses in heartbeat ≥ 5 seconds with or without symptoms
• In sinus rhythm (with AV block) and while awake, pauses in heartbeat ≥ 3 seconds or heart rates less than 40 beats per minute or an escape rhythm below the AV node, with or without symptoms
• Following catheter ablation of the AV junction
• Associated with neuromuscular diseases such as myotonic muscular dystrophy, Erb dystrophy (limb-girdle muscular dystrophy), Kearns-Sayre syndrome, and peroneal muscular atrophy
• Exercise-induced third degree AV block without myocardial ischemia

**NOT Indicated for Acquired Third-Degree and Advanced Second-Degree Atrioventricular Block:**

• AV block is expected to resolve and is unlikely to recur (e.g. drug toxicity, Lyme disease, or transient increases in vagal tone or during hypoxia in sleep apnea syndrome) and without symptoms
• AV block secondary to nonessential drug therapy

**First- and Second-Degree AV Block**

• Symptomatic bradycardia associated with second-degree AV block at any level of conduction, either Mobitz I or II, including patients on required medication
• Mobitz Type II second-degree AV block, with or without symptoms
• Second-degree AV block associated with a wide QRS, including isolated right bundle branch block, or if due to EP-documented infra-His conduction prolongation
• First- or second-degree AV block with “pacemaker syndrome” symptoms or hemodynamic compromise (i.e. hypotension, syncope, or pulmonary edema, particularly if PR > 0.30 s) (Brignole 2013)
• First or second degree AV block in neuromuscular diseases such as myotonic muscular dystrophy, Erb dystrophy (limb-girdle muscular dystrophy), Kearns-Sayre syndrome, and peroneal muscular atrophy
• AV block due to drug use and/or drug toxicity AND block is expected to recur after drug withdrawal
• Exercise-induced second degree heart block without myocardial ischemia

**NOT Indicated for Other Presentations of First- and Second-Degree AV Block:**

• AV block is expected to resolve and is unlikely to recur (e.g. drug toxicity, Lyme disease, or transient increases in vagal tone or during hypoxia in sleep apnea syndrome) and without symptoms
• AV Block secondary to nonessential drug therapy
Chronic Bifascicular Block

- Type II second-degree AV block, advanced second-degree AV block (see definitions section) or intermittent third-degree AV block
- Alternating bundle-branch block
- Syncope and bifascicular block when other likely causes have been excluded, specifically ventricular tachycardia
- Electrophysiologic study (EPS) documentation of an H-V interval ≥100 milliseconds, even in asymptomatic patients
- Electrophysiologic study (EPS) documentation of non-physiological, pacing-induced infra-His block
- In neuromuscular diseases such as myotonic muscular dystrophy, Erb dystrophy (limb-girdle muscular dystrophy), and peroneal muscular atrophy with bifascicular block or any fascicular block
- In bundle branch block with syncope and documentation of an HV interval ≥70 ms (Brignole 2013)

NOT Indicated for Permanent Pacing for Chronic Bifascicular Block:
- Asymptomatic fascicular block without AV block
- Asymptomatic fascicular block with first-degree AV block

After the Acute Phase of Myocardial Infarction
(UM usually not required due to inpatient status)

- Persistent second- or third-degree AV block after ST-elevation myocardial infarction (STEMI).
- Transient second- or third-degree AV block below the AV node after STEMI. If the site of block is uncertain, electrophysiologic study (EPS) may be necessary.

NOT Indicated for Permanent Pacing After the Acute Phase of Myocardial Infarction:
- Bradycardia secondary to nonessential drug therapy.
- Transient AV block without intraventricular conduction defects.
- Transient AV block with isolated left anterior fascicular block.
- New bundle-branch block or fascicular block without AV block.
- Asymptomatic first-degree AV block with bundle-branch or fascicular block.

Hypersensitive Carotid Sinus Syndrome and Neurocardiogenic Syncope

- Recurrent syncope due to spontaneously occurring carotid sinus stimulation AND carotid sinus pressure induces ventricular asystole ≥3 seconds.
- Syncope without clear, provocative events and with a hypersensitive cardioinhibitory response (asystole) of 3 seconds or longer.
- Neurocardiogenic syncope associated with bradycardia occurring spontaneously or at the time of tilt-table testing.

NOT Indicated for Permanent Pacing in Hypersensitive Carotid Sinus Syndrome and Neurocardiogenic Syncope:
- Hypersensitive cardioinhibitory response to carotid sinus stimulation without symptoms or with vague symptoms.
• Situational neurocardiogenic syncope in which avoidance behavior is effective and preferred.

**Following Cardiac Transplantation, Cardiac Surgery and Transcatheter Intervention**
(UM usually not required due to inpatient status.)

• Persistent inappropriate or symptomatic bradycardia not expected to resolve, such as one of the following (Brignole 2013):
  o Third degree AV block with low escape rate > 48 hours postoperative
  o All other AV Block, after a 5-7 day wait for improvement
  o 5 days - 3 weeks wait for inus node dysfunction (SND) to improve after surgery and transplantation.
• Prolonged bradycardia limiting rehabilitation or discharge post transplantation.
• Syncope after transplantation even when bradyarrhythmia has not been documented.

**NOT Indicated for Pacing following Cardiac Transplantation:**
• Bradycardia secondary to nonessential drug therapy.

**Antitachycardia Pacing**
(Pacing to Terminate Tachycardia)

• Symptomatic recurrent supraventricular tachycardia documented to be pacing terminated in the setting of failed catheter ablation and/or drug treatment (intolerance included).

**NOT Indicated for Permanent Pacemakers That Automatically Detect and Pace to Terminate Tachycardia:**
• Presence of an accessory pathway with capacity for rapid anterograde conduction.

**Tachycardia Prevention**
• Sustained pause-dependent ventricular tachycardia (VT), with or without QT prolongation.
• Type 3 congenital long-QT syndrome (ICD frequently preferred) (Zimetbaum 2018)
• For management of paroxysmal atrial fibrillation only when other indications for pacing are present (Passman 2018, January 2014)

**NOT Indicated for Pacing to Prevent Tachycardia:**
• Ventricular ectopy without sustained VT in the absence of the long-QT syndrome.
• Reversible, e.g., drug-related, Torsade de Pointes VT.

**Hypertrophic Cardiomyopathy**
• Symptomatic hypertrophic cardiomyopathy and hemodynamically significant resting (peak > 30 mm Hg) or provoked (peak > 50 mm Hg) LV outflow tract gradient, refractory to medical therapy, and suboptimal candidates for septal reduction therapy (including high risk for developing heart block post procedure) (Marin 2018).

**NOT Indicated for Pacing in Patients with Hypertrophic Cardiomyopathy:**
• Asymptomatic OR symptoms controlled on medical therapy.
• Without significant LV outflow tract obstruction.
Cardiac Sarcoidosis & Giant Cell Myocarditis

- Transient or permanent high degree or complete AV block (with additional recommendation to include ICD) (Blankstein 2018, Priori 2015)

Pediatric and Congenital Heart Disease Pacing Indications

(Epstein 2013; Brignole 2013; Brugada 2013, Silva 2018)

Children, Adolescents (<19 years), and Patients with Congenital Heart Disease

Sinus Bradycardia

- SND with symptomatic age- and activity-inappropriate bradycardia. The definition of bradycardia varies with the patient’s age and expected heart rate. For normal heart rates by age, please see the table in the Additional information section. (Correlation does not need to be completely conclusive) (Hernandez-Madrid 2018).
- Sinus bradycardia with complex congenital heart disease AND a resting heart rate < 40 bpm OR pauses in ventricular rate >3 seconds.
- Congenital heart disease and impaired hemodynamics due to sinus bradycardia or loss of AV synchrony (e.g. PR interval ≥ 0.30s)
- Asymptomatic sinus bradycardia following biventricular repair of congenital heart disease with an awake resting heart rate < 40 bpm or pauses in ventricular rate > 3 seconds.

Bradycardia-Tachycardia

- Bradycardia-tachycardia syndrome, when symptoms and bradycardia correlate (correlation does not need to be completely conclusive) (Brignole 2013; Hernandez-Madrid 2018).
- Congenital heart disease (CHD) and sinus node dysfunction (SND) or junctional bradycardia, for the prevention of recurrent episodes of intra-atrial reentrant tachycardia (IART), with SND or junctional bradycardia either intrinsic or secondary to necessary anti-arrhythmic treatment, when catheter ablation is not possible. Devices with atrial antitachycardia pacing are preferred. (Brugada 2013; Brignole 2013; Khairy 2014)
- Permanent pacing is reasonable in adults with complex CHD and an awake resting heart rate (sinus or junctional) <40 bpm or ventricular pauses >3 seconds. A device with antitachycardia pacing may be considered if the underlying anatomic substrate carries a high likelihood of developing IART (Khairy 2014)

AV Block

- Second- or third-degree AV block with symptomatic bradycardia, ventricular dysfunction, or low cardiac output.
- Advanced second degree AV block ((inadequate literature on asymptomatic Mobitz type II or prolonged HV interval in children, but it would appear reasonable when condition is permanent) (Brignole 2013; Silva 2018).
• Postoperative advanced second- or third-degree AV block that is expected to be permanent or that persists ≥ 7 days after cardiac surgery.
• Congenital third-degree AV block with a wide QRS escape rhythm, complex ventricular ectopy, prolonged QT interval, low cardiac output, or ventricular dysfunction (Hernandez-Madrid 2018).
• Congenital third-degree AV block in the infant with a ventricular rate <55 bpm or with congenital heart disease and a ventricular rate <70 bpm.
• Congenital third-degree AV block after age 1 year with an average heart rate <50 bpm, abrupt pauses in ventricular rate that are 2 or 3 times the basic cycle length, or associated with symptoms due to chronotropic incompetence.
• Unexplained syncope after prior congenital heart surgery complicated by transient complete heart block, with residual fascicular block after a careful evaluation to exclude other causes of syncope.
• Transient postoperative third-degree AV block that reverts to sinus rhythm with residual bifascicular block.
• Permanent pacemaker implantation may be considered for congenital third-degree AV block in asymptomatic children or adolescents with an acceptable rate, a narrow QRS complex and normal ventricular function.
• Permanent pacing is reasonable in adults with congenital complete AV block and an average daytime resting heart rate < 50 bpm (Khairy 2014).
• Any degree AV block in neuromuscular diseases such as myotonic muscular dystrophy, Erb dystrophy (limb-girdle muscular dystrophy), Kearns-Sayre syndrome, and peroneal muscular atrophy. (Epstein 2013; Brugada 2013)

Ventricular Tachyarrhythmia-Related

• Sustained, pause-dependent Ventricular tachycardia (VT), with QT prolongation, if ICD is not indicated (Epstein 2013; Hernandez-Madrid 2018).
• Type 3 congenital long-QT syndrome (ICD frequently preferred) (Zimetbaum 2018).

NOT Indicated for Pacing in Children, Adolescents, and Patients with Congenital Heart Disease

• Asymptomatic transient postoperative AV block with return of normal AV conduction.
• Asymptomatic bifascicular block +/-first-degree AV block after surgery for congenital heart disease in the absence of prior transient complete AV block.
• Asymptomatic Mobitz type I second-degree AV block.
• Asymptomatic sinus bradycardia with the longest RR interval < 3 seconds and a minimum heart rate > 40 bpm.
• Asymptomatic sinus bradycardia in a healthy child (Silva 2018)
• Bradycardia secondary to nonessential drug therapy.

ADDITIONAL INFORMATION

General
A pacemaker system is composed of a pulse generator and one or more leads. The pulse generator is implanted under the skin, usually below one of the collarbones (clavicles). It contains a battery, a microprocessor that governs timing and function, and a radio antenna to allow for noninvasive interrogation and reprogramming. The leads are insulated cables that conduct electricity from the pulse generator to the heart. Leads are most commonly inserted into a vein and then advanced under fluoroscopy (X-ray guidance) to within one or more heart chambers. The leads are fastened within the chambers to the heart muscle using either hooks or retractable/extendable screws, which are built into
their tips. Timed electrical impulses are delivered from the pulse generator via the leads to the heart, where stimulation results in heart muscle contraction.

The most recent guidelines stress that asymptomatic bradycardia rarely qualifies as an indication for pacemaker insertion. However, there are some asymptomatic bradycardic rhythms for which pacemaker insertion is indicated because they present a risk of injury or death. Thus, there are also a small number of situations in which the ECG or an invasive EPS can reveal evidence of specific disease in the cardiac electrical system that warrants pacemaker insertion in the absence of symptoms. Guidelines are fairly specific and technical in these instances.

In the case of dilated cardiomyopathy, near-simultaneous stimulation of both ventricles, referred to as cardiac resynchronization therapy (CRT) has been demonstrated to improve cardiac performance and quality of life and to decrease cardiac event rates and mortality, usually among symptomatic patients with systolic heart failure and a wide QRS complex. Device implantation requires the insertion of leads that pace both the right and left ventricles, most commonly with a coronary sinus lead for the LV pacing. The majority of these patients have a CRT device with ICD function as well (CRT-D). (See separate guidelines for ICD and CRT.)

**Heart Block Definitions**
(Epstein 2013)

- **First Degree**: All sinus or atrial beats are conducted to the ventricles, but with a delay (PR interval of > 200ms).
- **Second Degree**: Intermittent failure of conduction of single beats from atrium to ventricles.
  - (Mobitz) Type I: Conducted beats have variable conduction times from atrium to ventricles.
  - (Mobitz) Type II: Conducted beats have uniform conduction times from atrium to ventricles.
  - Advanced or high degree: Two or more consecutive non-conducted sinus or (non-premature) atrial beats.
- **Third Degree**: No atrial beats are conducted from atrium to ventricle

**Pediatric respiratory rate and heart rate by age**

<table>
<thead>
<tr>
<th>Age group</th>
<th>Respiratory rate</th>
<th>Heart rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (1st-99th percentile)</td>
<td>Median (1st-99th percentile)</td>
</tr>
<tr>
<td>0 to 3 months</td>
<td>43 (25-66)</td>
<td>143 (107-181); term newborn at birth: 127 (90-164)</td>
</tr>
<tr>
<td>3 to 6 months</td>
<td>41 (24-64)</td>
<td>140 (104-175)</td>
</tr>
<tr>
<td>6 to 9 months</td>
<td>39 (23-61)</td>
<td>134 (98-168)</td>
</tr>
<tr>
<td>9 to 12 months</td>
<td>37 (22-58)</td>
<td>128 (93-161)</td>
</tr>
<tr>
<td>12 to 18 months</td>
<td>35 (21-53)</td>
<td>123 (88-156)</td>
</tr>
<tr>
<td>18 to 24 months</td>
<td>31 (19-46)</td>
<td>116 (82-149)</td>
</tr>
<tr>
<td>Age Range</td>
<td>Respiratory Rate (Range)</td>
<td>Heart Rate (Range)</td>
</tr>
<tr>
<td>-------------------</td>
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</tr>
<tr>
<td>2 to 3 years</td>
<td>28 (18-38)</td>
<td>110 (76-142)</td>
</tr>
<tr>
<td>3 to 4 years</td>
<td>25 (17-33)</td>
<td>104 (70-136)</td>
</tr>
<tr>
<td>4 to 6 years</td>
<td>23 (17-29)</td>
<td>98 (65-131)</td>
</tr>
<tr>
<td>6 to 8 years</td>
<td>21 (16-27)</td>
<td>91 (59-123)</td>
</tr>
<tr>
<td>8 to 12 years</td>
<td>19 (14-25)</td>
<td>84 (52-115)</td>
</tr>
<tr>
<td>12 to 15 years</td>
<td>18 (12-23)</td>
<td>78 (47-108)</td>
</tr>
<tr>
<td>15 to 18 years</td>
<td>16 (11-22)</td>
<td>73 (43-104)</td>
</tr>
</tbody>
</table>

* The respiratory and heart rates provided are based upon measurements in awake, healthy infants and children at rest. Many clinical findings besides the actual vital sign measurement must be taken into account when determining whether a specific vital sign is normal in an individual patient. Values for heart rate or respiratory rate that fall within normal limits for age may still represent abnormal findings that are caused by underlying disease in a particular infant or child. (Fleming 2011; Fleegler, 2018)

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**Abbreviations**

- **AV**: Atrioventricular
- **CHF**: Congestive heart failure
- **CRT**: Cardiac resynchronization therapy (same as biventricular pacing)
- **ECG**: Electrocardiogram
- **EPS**: Electrophysiologic Study
- **GDMT**: Guideline-Directed Medical Therapy
- **HRS**: Heart Rhythm Society
- **HV**: His-ventricular
- **ICD**: Implantable cardioverter-defibrillator
- **LBBB**: Left bundle-branch block
- **LV**: Left ventricular/left ventricle
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEF</td>
<td>Left ventricular ejection fraction</td>
</tr>
<tr>
<td>MI</td>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>ms</td>
<td>Milliseconds</td>
</tr>
<tr>
<td>s</td>
<td>Seconds</td>
</tr>
<tr>
<td>STEMI</td>
<td>ST-elevation Myocardial Infarction</td>
</tr>
<tr>
<td>SND</td>
<td>Sinus node dysfunction</td>
</tr>
<tr>
<td>VT</td>
<td>Ventricular tachycardia</td>
</tr>
</tbody>
</table>
REFERENCES


Fleegler E. Pediatric advanced life support (PALS). UpToDate, Waltham, MA. Available at: https://www.uptodate.com/contents/image?imageKey=EM%2F78097&topicKey=EM%2F6392&source=see_link Retrieved May 31, 2018


INTRODUCTION

- Transthoracic echocardiography (TTE) uses ultrasound to image the complex structures of the heart in a real time format, providing 2-dimensional, cross sectional images.
- The addition of Doppler ultrasound derives hemodynamic data from flow velocity versus time measurements, as well as from color coded two dimensional representations of flow velocities.
- TTE's safety and versatility in examining cardiac structure, function, and hemodynamics lends to its utility for numerous indications in children and adults.
- TEE (transesophageal echocardiography) widens the scope of utility for echocardiographic imaging, and its indications are covered in a separate guideline.

ADULT PATIENTS
Indications for pediatric patients follow the section for adult patients.

Indications for Transthoracic Echocardiography (TTE)
(Douglas 2011)

<table>
<thead>
<tr>
<th>General Evaluation of Cardiac Structure and Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suspected Cardiac Etiology</strong></td>
</tr>
<tr>
<td>• Symptoms or conditions potentially related to suspected cardiac etiology including, but not limited to, chest pain, shortness of breath, palpitations, TIA, stroke, or peripheral embolic event</td>
</tr>
<tr>
<td>• Respiratory failure or hypoxemia of uncertain etiology if cardiac structural or myocardial disease is a consideration</td>
</tr>
<tr>
<td>• Prior testing that is concerning for heart disease or structural abnormality including but not limited to ECG, chest X-ray, baseline scout images from stress echocardiography, or cardiac biomarkers</td>
</tr>
<tr>
<td><strong>Arrhythmias</strong></td>
</tr>
<tr>
<td>• Frequent VPCs or exercise-induced VPCs</td>
</tr>
<tr>
<td>• Atrial fibrillation, SVT, or VT</td>
</tr>
<tr>
<td><strong>Presyncope/Syncope</strong> (Shen 2017; Benditt 2018; Doherty 2017)</td>
</tr>
<tr>
<td>• When clinical rationale supports a suspicion of structural or potentially structurally associated arrhythmic heart disease, i.e. a diagnosis known to cause such symptoms</td>
</tr>
<tr>
<td><strong>Perioperative Evaluation</strong> (Fleischer 2014; Lentine 2012; Cowie 2010)</td>
</tr>
<tr>
<td>• Preoperative left ventricular function assessment in patients who are candidates for kidney or liver transplantation: TTE might identify pulmonary hypertension and/or intrapulmonary arteriovenous shunt in candidates for liver transplantation</td>
</tr>
<tr>
<td>• Re-evaluation (&lt;1 yr) in patients with moderate or severe aortic stenosis, who will be subjected to increased hemodynamic demands (e.g. noncardiac surgery, pregnancy)</td>
</tr>
</tbody>
</table>
- Evaluation of patients prior to noncardiac surgery with clinically suspected moderate or greater degrees of valvular stenosis or regurgitation if there has been either
  - No prior echo within 1 year
  - OR
  - There has been a significant change in clinical status or physical examination since the last evaluation.

**Pulmonary Hypertension**

- Evaluation of suspected pulmonary hypertension including evaluation of right ventricular function and estimated pulmonary artery pressure
- Evaluation of pulmonary embolism patients with respect to right ventricular function and pulmonary hypertension, with intent to risk stratify and initiate appropriate therapy (Saric 2016).
- Routine surveillance (≥1 y) of known pulmonary hypertension without change in clinical status or cardiac exam
- Re-evaluation of known pulmonary hypertension if there is a change in clinical status or cardiac exam, or to guide therapy
- Surveillance for pulmonary hypertension during chemotherapy with dasatinib, every 3 months during and again at completion of therapy, and as required for subsequent symptoms or signs of pulmonary hypertension (Zamorano 2016).

**Evaluation of Valvular Function**

**INITIAL Evaluation of Valvular Function in an Asymptomatic Patient**

- Asymptomatic patient with unexplained heart murmur or abnormal heart sounds, with reasonable suspicion of valvular heart disease
- Continuous heart murmur (Warnes 2008)
- History of rheumatic heart disease
- Known systemic or acquired disease associated with valvular heart disease (Examples: Ankylosing spondylitis, Marfan’s, Turner’s, history tertiary syphilis, Ehlers Danlos or Loeys-Dietz syndromes, etc.) (Hiratzka 2010)
- First degree family member has history of bicuspid aortic valve (Warnes 2008)
- Patient with Turner syndrome, for evaluation of bicuspid aortic valve, as well as coarctation of the aorta and aortic root dilation
- Exposure to medications that could result in development of valvular heart disease (Examples: The prior use of the diet drug fenfluramine/phentermine, marketed as Fen Phen, and or dexfenfluramine alone, can cause aortic or mitral regurgitation. Bengluorex is another culprit diet drug. Ergot derivatives used for migraine, such as ergotamine and methysergide are a group. Bromocriptine (another ergot derivative) can cause valvular problems. Parkinson medications, such as pergolide and cabergoline are another group, both removed from the US market. Also, prior radiation to the heart valves can cause valvular disease. The vast majority of the disease is valvular regurgitation, mainly aortic, mitral, and tricuspid. There have even been reports of Ecstasy causing valvular regurgitation, but that appears to be less clear.)

**Murmur or Click**

- Initial evaluation when there is a reasonable suspicion of valvular or structural heart disease
- Re-evaluation of known valvular heart disease with a change in clinical status or cardiac exam, or to guide therapy

**Native Valvular Stenosis**
- Routine surveillance (≥3 yr) of bicuspid aortic valve, aortic sclerosis, or mild valvular stenosis, without a change in clinical status or cardiac exam
- Routine surveillance (≥1 yr) of moderate stenosis without a change in clinical status or cardiac exam
- Re-evaluation (<1 yr) in patients with moderate or severe aortic stenosis, who will be subjected to increased hemodynamic demands (e.g. noncardiac surgery, pregnancy)
- Re-evaluation of an asymptomatic patient with severe aortic stenosis 6-12 months without change in clinical status or cardiac exam
- Re-evaluation after control of hypertension in low flow – low gradient severe aortic stenosis with preserved ejection fraction
- In asymptomatic young adults, annual TTE for aortic stenosis with mean Doppler gradient > 30 mm Hg or peak instantaneous gradient >50 mm Hg, and every 2 years for patients with lesser gradients (Warnes 2008)
- In asymptomatic patient with pulmonic stenosis, with peak instantaneous gradient < 30 mm Hg, follow up TTE at 5 year intervals (Warnes 2008)
- In asymptomatic patient with pulmonic stenosis, with peak instantaneous gradient > 30 mm Hg, follow up TTE at 2-5 year intervals(Warnes 2008)

**Native Valvular Regurgitation With TTE** (aLancellotti 2013)

- Routine surveillance (≥1 yr) of moderate valvular regurgitation without change in clinical status or cardiac exam
- Re-evaluation of asymptomatic patient (6-12 months) with severe aortic regurgitation with preserved ejection fraction and normal left ventricular size
- Re-evaluation of asymptomatic patient (6-12 months) with severe mitral regurgitation

**Prosthetic Valves With TTE**

- Initial postoperative evaluation of prosthetic valve for establishment of baseline, typically 6 weeks to 3 months postoperative.
- Routine surveillance (≥3 y after valve implantation) of prosthetic valve if no known or suspected valve dysfunction
- Evaluation of prosthetic valve with suspected dysfunction or a change in clinical status or cardiac exam
- Re-evaluation of known prosthetic valve dysfunction when it would change management or guide therapy
- Evaluation prior to pregnancy in patients with a prosthetic valve and no echocardiography within the past year

**Infective Endocarditis (Native or Prosthetic Valves) With TTE**

- Initial evaluation of suspected infective endocarditis with positive blood cultures or a new murmur
- Re-evaluation of infective endocarditis at high risk for progression or complication or with a change in clinical status or cardiac exam, or when findings might change management
- Re-evaluation of prior TTE/TEE finding for interval change (e.g. resolution of vegetation after antibiotic therapy) when a change in therapy is anticipated or under consideration
- Re-evaluation of patient with infective endocarditis at high risk of progression of complication (e.g., extensive infective tissue/large vegetation on initial echocardiogram, or staphylococcal, enterococcal, or fungal infections) in the absence of clinical change

**Transcatheter Valvular Intervention**
- Transcatheter Aortic Valve Replacement (TAVR), one of the following: (Otto 2017; Doherty 2017)
  - For pre-TAVR evaluation: Assessment of number cusps and degree of calcification
  - Post TAVR at 30 days (6 weeks to 3 months also acceptable) and annually
  - Post TAVR evaluation: Assessment of aortic regurgitation when there is suspicion of valvular dysfunction (<30 days)
  - Post TAVR evaluation: Assessment of stroke with suspicion of valve dysfunction or thrombus

- Percutaneous Mitral Valve Repair, one of the following: (Doherty 2017)
  - Determination of patient eligibility
  - Reassessment for degree of MR and left ventricular function (pre-discharge, at 1, 6, and 12 months, and then annually to 5 yr)

### Additional Interventions or Noncardiac Procedures

- Guidance of and evaluation for percutaneous noncoronary cardiac procedures including but not limited to pericardiocentesis, septal ablation, right ventricular biopsy, cardiac valvular and structural interventions, radiofrequency ablation, or LVAD optimization or weaning (Wunderlich 2018; Porter 2015).
- Periprocedural cardiac monitoring of noncardiac procedures posing substantial hemodynamic or ischemic risk, procedures requiring fluid resuscitation, etc., when it can assist management (Porter 2015).

### Intracardiac and Extracardiac Structures

- Suspected cardiac mass (Saric 2016)
- Suspected cardiovascular source of embolus (Saric 2016)
- Suspected pericardial conditions
- Re-evaluation of known pericardial effusion to guide management or therapy

### Thoracic Aortic Disease

In the absence of recent computed tomography (CT) or cardiovascular magnetic resonance (CMR), which are preferred for imaging beyond the proximal ascending aorta (Hiratzka 2010; Hiratzka 2016; Erbel 2014; Schiller 2017; Wright a&b 2018; Woo a&b 2018; Svensson 2013' Bhave 2018)

(See table in Additional Information for top normal size of the thoracic aorta.)

- Screening first degree relatives of individuals with a history of thoracic aortic aneurysm (defined as $\geq$ 50% above normal) or dissection or an associated high risk mutation in common.
- Screening second degree relative of a patient with thoracic aortic aneurysm, when the first degree relative has aortic dilation, aneurysm, or dissection.
- Six month follow up after initial finding of a dilated thoracic aorta, for assessment of rate of change
- Annual follow up of enlarged thoracic aorta that is above top normal for age, gender, and size up to 4.4 cm
- Biannual (twice/yr) follow up of enlarged aortic root $\geq$ 4.5 cm or showing growth rate $\geq$ 0.5 cm/year
- Evaluation of the ascending aorta in the setting of a known or suspected connective tissue disease or genetic condition that predisposes to aortic aneurysm or dissection (e.g., Marfan syndrome, Ehlers Danlos or Loeys-Dietz syndromes).
- At time of diagnosis of Marfan’s syndrome and 6 months thereafter for growth rate assessment, followed by annual imaging, increased to biannual (twice yearly) if diameter $\geq$ 4.5 or expanding $\geq$ 0.5 cm/yr
• Evaluation of aortic root in patient with Turner syndrome, along with aortic valve and coarctation evaluation, with normal results followed up at 5-10 years with repeat TTE, with abnormalities followed annually.
• Re-evaluation of known ascending aortic dilation or history of aortic dissection to establish a baseline rate of expansion (at 6 months from last assessment) or when the rate of expansion is excessive (repeat at 6 months)
• Re-evaluation of known ascending aortic dilation or history of aortic dissection with a change in clinical status or cardiac exam or when findings may alter management or therapy
• Re-evaluation (<1 y, generally twice a year) of the size and morphology of the aortic sinuses and ascending aorta in patients with a bicuspid AV and an ascending aortic diameter >4 cm with 1 of the following:
  1. Aortic diameter >4.5 cm
  2. Rapid rate of change in aortic diameter when an annual growth rate of ≥0.5 cm is suspected.
  3. Family history (first-degree relative) of aortic dissection
• Evaluation of a ruptured sinus of Valsalva aneurysm and resultant shunting
• Follow up post aortic medical treatment:
  o Acute dissection: Discharge, 1 month, 6 months, then annually
  o Chronic dissection: Discharge, years 1, 2, and 3.
• Follow up post either root repair or AVR plus ascending aortic root/arch repair:
  Discharge and annual

**Hypertension, Heart Failure, or Cardiomyopathy**

**Hypertension**

• Initial evaluation of suspected hypertensive heart disease

**Heart Failure & LV Function (Nagueh 2016; Yancy 2013; Patel 2013)**

• Initial evaluation of known or suspected heart failure (HF) (systolic or diastolic) based on symptoms, signs, or abnormal test results
• Re-evaluation of known HF (systolic or diastolic) with a change in clinical status or cardiac exam without a clear precipitating change in medication or diet
• Prior to cardiotoxic chemotherapy, and subsequently for monitoring and follow up. (See Cardio-Oncology section under the Additional Information section.)
• Left ventricular function assessment at baseline prior to initiation of radiation to the anterior or left chest, at 5 years post initiation, and every 5 years thereafter (Lancellotti 2013b)
• Assessment in patients with a history of prior myocardial infarction and unknown left ventricular function.
• Re-evaluation of known HF (systolic or diastolic) when essential to guide therapy
• Worsening in ventricular arrhythmias, including after implantable cardioverter defibrillator (ICD) placement (Patel 2013)
• Unimproved heart failure symptoms in the first 6 months after cardiac resynchronization therapy (CRT initiation (Patel 2013))

**Device Candidacy (Pacemaker, ICD, or CRT)**
• Initial evaluation or re-evaluation after revascularization (≥ 3 months or 90 days) and/or myocardial infarction (≥ 40 days) and/or 3 months of optimal medical therapy to determine candidacy for device therapy and/or to determine optimal choice of device (Al-Khatib 2017)
• Initial evaluation for CRT device optimization after implantation
• Known implanted pacing device with symptoms possibly due to device complication or suboptimal pacing device settings

**Ventricular Assist Devices (VADs) and Cardiac Transplantation**  
(Stainback 2015)

<table>
<thead>
<tr>
<th>Sections</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>To determine candidacy for ventricular assist device</td>
<td></td>
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<tr>
<td>Optimization of ventricular assist device settings and assessment of response post device</td>
<td></td>
</tr>
<tr>
<td>Re-evaluation for signs/symptoms suggestive of ventricular assist device-related complications</td>
<td></td>
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<tr>
<td>Assessment of alterations in valvular function post assist device, particularly aortic regurgitation.</td>
<td></td>
</tr>
<tr>
<td>Assessment for myocardial recovery post assist device</td>
<td></td>
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<tr>
<td>Monitoring for rejection in a cardiac transplant recipient</td>
<td></td>
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<tr>
<td><strong>Follow up of transplanted heart patients’ allograft with TTE:</strong></td>
<td></td>
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<tr>
<td>o Every 3 months during the first year,</td>
<td></td>
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<tr>
<td>o Every 6 months during the second year,</td>
<td></td>
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<tr>
<td>o Alternatively, after each endomyocardial biopsy</td>
<td>(Badano 2015)</td>
</tr>
<tr>
<td>Cardiac structure and function evaluation in a potential heart donor</td>
<td></td>
</tr>
</tbody>
</table>

**Cardiomyopathies**  
(Yancy 2013)

<table>
<thead>
<tr>
<th>Sections</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Initial evaluation of known or suspected cardiomyopathy (e.g., restrictive, infiltrative, dilated, hypertrophic, or genetic cardiomyopathy)</td>
<td></td>
</tr>
<tr>
<td>Re-evaluation of known cardiomyopathy with a change in clinical status or cardiac exam or to guide therapy and manage post transplantation or post ventricular assist device (VAD) patients</td>
<td></td>
</tr>
<tr>
<td>Screening evaluation for structure and function in first-degree relatives of a patient with an inherited cardiomyopathy</td>
<td></td>
</tr>
<tr>
<td>Assessment of peripartum cardiomyopathy at onset and 3 months, then at 6 month intervals for minimum two years, longer if required for surveillance during and after trial of weaning medication, with additional follow up of 2 years after weaning trial completed. Follow up as needed, including for intended or actual recurrent pregnancy. (Tsang 2018; Hilfiker-Kleiner 2015)</td>
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**Adult Congenital Heart Disease**  
(Warnes 2008; Baumgartner 2010)

<table>
<thead>
<tr>
<th>Sections</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Initial evaluation of known or suspected adult congenital heart disease</td>
<td></td>
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<tr>
<td>Known adult congenital heart disease with a change in clinical status or cardiac exam</td>
<td></td>
</tr>
<tr>
<td>Re-evaluation to guide therapy in known adult congenital heart disease.</td>
<td></td>
</tr>
<tr>
<td>Evaluation of asymptomatic patients following repair of Atrial Septal Defect (ASD), Patent Foramen Ovale (PFO), Ventricular Septal Defect (VSD) or Patent Ductus Arteriosus (PDA), approvable within the first year following correction</td>
<td></td>
</tr>
<tr>
<td>Routine surveillance (≥1 yr) of adult congenital heart disease following incomplete or palliative repair with residual structural or hemodynamic abnormal, even without a change in clinical status or exam.</td>
<td></td>
</tr>
<tr>
<td>Asymptomatic, small ASD (&lt;10 mm) shunt with normal right ventricular size, TTE follow up at 2 year intervals, more frequently for larger shunts with normal right ventricle</td>
<td></td>
</tr>
<tr>
<td>Follow up after device closure of shunts, TTE at 24 hours, 2 month, 6 months, 1 year intervals thereafter.</td>
<td></td>
</tr>
<tr>
<td>Asymptomatic small coronary arteriovenous fistula , TTE every 3 years</td>
<td></td>
</tr>
<tr>
<td>After arterial switch repair of d-transposition of the great arteries, TTE at least every 2 years</td>
<td></td>
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</tbody>
</table>
In congenitally corrected transposition of the great arteries, TTE every 1-2 years.

PEDIATRIC PATIENTS
(PATIENTS UNDER THE AGE OF 18)

Indications for an Initial Transthoracic Echocardiography (TTE)
(Campbell 2014)

- Hypertension.

- Palpitations, if one:
  - EKG is markedly abnormal
  - Family history at age <50 of either:
    - sudden cardiac arrest or
    - death, pacemaker, or ICD
  - History or family history of cardiomyopathy

- Chest pain, if one of:
  - Exertional
  - Abnormal EKG
  - Family history with unexplained sudden death or cardiomyopathy
  - Associated features of the presentation are suspicious for cardiac origin (e.g. rheumatic fever, endocarditis)

- Syncope, if any one of:
  - History, exam, and/or EKG provide suspicion of structural heart disease
  - Exertional, especially mid exertional due to high correlation with structural heart disease and/or arrhythmic disorder
  - Unexplained post exertional
  - Family history at age <50 of either one:
    - sudden cardiac death/arrest or
    - a pacemaker or ICD
  - There is a family history of cardiomyopathy

- Presyncope, when all apply:
  (Salerno 2018; Anderson 2016; Cote 2001; Shen 2017)
  - When recurrent and well documented
  - With good documentation that neither neutrally mediated syncope (NMS) nor orthostasis is the etiology
  - When structural or arrhythmia related structural heart disease is a suspected cause
  - Without prior echocardiographic diagnosis during the course of the current clinical status

- Signs and/or symptoms of heart failure, including, but not limited to any one of:
  - Respiratory distress
  - Poor peripheral pulses
  - Feeding difficulty
  - Decreased urine output
  - Edema
- Hepatomegaly

- Abnormal physical findings, including any one of:
  - Clicks, snaps, or gallops
  - Fixed and/or abnormally split S2
  - Decreased pulses.
  - Central cyanosis without explanation.

- Arrhythmia, if one of:
  - Supraventricular tachycardia
  - Ventricular tachycardia
  - Frequent premature ventricular contractions (PVCs) (≥ 10% of beats/24 hours)

- Murmur
  - Pathologic sounding or harsh murmur, diastolic murmur, or continuous murmur, present in such a way as to have a reasonable belief that congenital heart disease might be present
  - An otherwise innocent murmur, but in the presence of signs, symptoms, or findings of cardiovascular disease

- Abnormal basic data, including any one of:
  - Clearly abnormal electrocardiogram (ECG)
  - Desaturation on pulse oximetry, with concern for cardiac cause
  - Abnormal cardiac structure on a chest x-ray

- Suspected pulmonary hypertension

- Patients with prosthetic valves

- Signs and symptoms of endocarditis, including either one of:
  - In the absence of positive blood cultures, including all patients with an indwelling catheter who present with unexplained fever
  - Positive blood cultures suggestive of infective endocarditis.

- Thromboembolic Related, either one:
  - Patients on anticoagulants, when required to evaluate for thrombus
  - Thromboembolic events or stroke (Saric 2016)

- Systemic hematologic diseases that are associated with cardiac findings, either one:
  - Sickle cell disease
  - HIV infection

- Oncologic Therapy, any one:
  - Cardiotoxic chemotherapy, before or following exposure
  - Radiation therapy to chest, before and long term follow up (Lancellotti 2013)
    (See Cardio-Oncology section under Additional Information section)

- Inflammatory & Autoimmune, any one:
  - Suspected Rheumatic Fever
  - Systemic lupus erythematosus
- Takayasu Arteritis
- Kawasaki Disease (Newburger 2004)

- Suspicion of Structural Disease, any one:
  - Premature birth where there is suspicion of a Patent Ductus Arteriosus.
  - Adopted children for whom there is a suspicion of congenital heart disease (e.g. HCM), based on physical or clinical findings when there is a lack of family history information.
  - Vascular Ring, based upon either one:
    - Difficulty breathing with stridor and eating solid foods that might suggest a vascular ring
    - Abnormal barium swallow or bronchoscopy suggesting a vascular ring
  - Ventricular pre-excitation with no clinical or Holter findings to suggest an arrhythmia, but with suspicion of Ebstein’s anomaly, Tumors, HCM or clinical signs of heart failure

- Genetic & Syndrome Related, any one:
  - Genotype positive for cardiomyopathy, family history of hypertrophic cardiomyopathy, other heritable cardiomyopathy, genetic disorder at high risk for cardiovascular involvement, heritable pulmonary arterial hypertension
  - Syndromic patients with a known syndrome associated with congenital or acquired heart disease (Down’s syndrome, Noonan’s syndrome, 22Q deficiency syndrome, William’s syndrome, Trisomy Thirteen, Trisomy Eighteen, Allagille syndrome, chromosomal abnormality associated with cardiovascular disease, abnormal viscera, or cardiac situs).
  - Known or suspected connective tissue diseases that are associated with congenital or acquired heart disease. (e.g. Marfan’s, Loeys-Dietz)
  - Known or suspected muscular dystrophies associated with congenital heart disease.
  - Mitochondrial or metabolic storage disease (e.g. Fabry’s disease)
  - Patients with a first degree relative who is known to have a genetic acquisition, such as cardiomyopathies (hypertrophic, dilated, arrhythmogenic right ventricular dysplasia, restrictive, left ventricular noncompaction).

- Maternal-Fetal Related, any one:
  - Maternal infection during pregnancy or delivery with potential fetal/neonatal cardiac sequelae
  - Maternal phenylketonuria
  - Suspected cardiovascular abnormality on fetal echocardiogram

- Previously normal echocardiogram with either one:
  - A change in cardiovascular status
  - A new family history suggestive of heritable heart disease

**Indications for Follow-up Echocardiography in Pediatric Patients**
(Davey 2004)

**General Indications for Postoperative/Post-Procedure Pediatric Patients:**
- Upon first outpatient visit, to establish the patient’s new hemodynamic baseline, and assess for potential complications such as pericardial effusions, residual shunts, obstruction at the site of repair, patency of surgical shunts, etc.
- On subsequent visits as needed to monitor as medications are weaned or to evaluate need for further surgical intervention.
Specific Indications for Follow-Up Echocardiograms in Pediatric Patients:

- Congenital Heart Disease (CHD) with a change in clinical status.
- Kawasaki Disease, upon diagnosis, two weeks later and 4 to 6 weeks later. If any coronary abnormalities are present, echocardiograms may need to be more frequent as clinically indicated. (Newburger 2004)
- Valvular regurgitation that is more than mild in asymptomatic child may require annual echocardiogram to assess chamber size and progressive regurgitation.
- Valvular stenosis: (Peak Doppler [mm Hg]: Mild < 40, Moderate 40-60, Severe >60)
  - Pulmonic Stenosis (PS): (Peng 2018)
    - Mild to moderate PS in an infant up to 1-2 year: repeat at 2 weeks and 6 weeks to assess for increasing gradient as PVR drops.
    - Mild stenosis post infancy (6 weeks): every 6 months until age 2 years, and
      - If the gradient regresses to < 25 mm Hg, reduce follow up to every 5 years.
      - If the gradient remains 25-40 after one year, follow up in one year and then every 3 years, if stable
    - Moderate stenosis post infancy (6 weeks): every 1-2 years
    - Post intervention for severe: every year for two years, then every 3-5 years, if stable; also depends on result of valvuloplasty
  - Aortic Stenosis (AS): (Aortic regurgitation rarely alone, usually with aortic stenosis) (Brown 2018)
    - Mean Gradients [mm Hg] mild < 25, moderate 25-40, severe > 40
    - Mild AS in an infant: every 6 months, or more depending on the patient’s clinical status and rate of progression.
    - Moderate AS in an infant: every 1-3 months to assess for progression and indication for valvuloplasty.
    - Mild in an asymptomatic child: every 1-2 years to assess for progression of stenosis
    - Moderate AS in an asymptomatic child: at least every 6-12 months to assess for progressive stenosis, left ventricular hypertrophy, post-stenotic dilation.
    - In asymptomatic adolescents, annual TTE for aortic stenosis with mean Doppler gradient > 30 mm Hg or peak instantaneous gradient >50 mm Hg, and every 2 years for patients with lesser gradients. (Warnes 2008)
  - Aortic valve prosthesis (Brown 2018)
    - Mechanical: every 6-12 months
    - Bioprosthetic: every 3-6 months
  - Mitral Stenosis (MS):
    - MS from Rheumatic Heart Disease on no meds with no symptoms may require an annual echocardiogram.
    - MS with CHF on medications may require an echocardiogram every three to 6 months.
  - Tricuspid Stenosis (TS):
    - A rare indication that would be based on the patient’s course of treatment and clinical symptoms.
- Shunt lesions:
  - Ventricular Septal Defect (VSD): (Fulton 2018)
    - (Pulmonary to systemic shunt ratio: small < 1.5, moderate 1.5-2.0, large > 2.0) (Oakley 2008)
    - Infants with VSD: repeat echocardiogram at 2 weeks and 6 weeks to assess for increasing shunt as the PVR drops.
    - Small VSD: annual echocardiogram to assess for associated lesions depending on location of defect, i.e. aortic regurgitation, development of DCRV (double chambered right ventricle); after 6 months, if the murmur is gone repeat echo is not necessary, if otherwise stable.
• Moderate to large VSD, asymptomatic: Close follow up in response to patient’s clinical status, to assess for LV dilation, mitral regurgitation, and associated lesions: if after one year, there is no pulmonary hypertension or left ventricular dilation, echo can be performed every 2 years, if stable.
  o Atrial Septal Defect (ASD): (Vick 2018)
    • Moderate to large secundum ASD (≥ 3 mm or shunt ≥ 1.5:1) and all primum, sinus venosus, and coronary sinus ASDs, at 6 months intervals to assess for progressive RV dilation, tricuspid regurgitation.
    • Small secundum (<3mm and shunt < 1.5: 1) ASD: every 1-3 years, depending on age of patient.

NOT INDICATED unless there is treating physician input during a peer-to-peer discussion that supports the need for an echocardiogram.
  • Chest pain that changes with inspiration.
  • Clear Orthostatic Hypotension.
  • Chest pain that increases upon palpation.
  • High cholesterol/triglycerides in children who have no other indication for an echocardiogram.
  • Isolated prolonged QT syndrome with no clinical or Holter evidence of an arrhythmia or other physical findings.

NOT INDICATED:
  • Attention Deficit Disorder with no other relevant findings.
  • A sports physical with normal history, physical and ECG.
  • Parental request as the sole reason for an echocardiogram.
  • All patients with a 1st degree relative with an inherited form of cardiomyopathy where the patient has been definitively excluded by genetic testing.

ADDITIONAL INFORMATION

I. Imaging Surveillance for Cardiotoxic Chemotherapy
   (Plana 2014; Zamorano 2016; Maleszewski 2018; Herrmann 2014)

TTE is the method of choice for the evaluation of patients before, during, and after cancer therapy. Ideally accuracy prefers that 3D and global longitudinal strain (GLS) are part of the exam, and serum troponin (Tn) should also be measured. However, GLS and Tn might not have been performed, in which case determinations might need to be made with LVEF only. Serum troponin (Tn) and GLS abnormalities constitute an abnormal assessment of LV function, because their abnormalities frequently herald an imminent fall in LVEF: (Plana 2014; Zamorano 2016)

CMR is recommended when TTE has been unreliable and/or candidacy for cardiotoxic chemotherapy based upon LVEF is questionable (Plana 2014) (MUGA can also be considered when TTE is inadequate and CMR is not available).

MUGA is accurate and reproducible, but lacks information about pericardium and valves, incurs repeated radiation exposure, and is inaccurate during an irregular cardiac rhythm (Plana 2014).

Surveillance guidelines are somewhat complex, possibly beyond the scope of this guideline, especially in patients with additional risk factors for LV dysfunction (Herrmann 2014). As with all guidelines, adequate information for complex decisions might be impractical to acquire. However, if the reader requires more rigorous recommendations, they are summarized concisely in the table below. Necessity
determinations might not require strict adherence to this table at this time, but it is here to serve as a helpful reference for the reader, if desired.

### TTE Surveillance Strategy for Cardiotoxic Chemotherapy (Optional Information)

<table>
<thead>
<tr>
<th>Suspected/Detected LV Status at Baseline, During, or After Completion of Therapy (LVEF is minimum information, GLS and Tn can reveal early LV dysfunction prior to LVEF)</th>
<th>Type I</th>
<th>Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal: EF is &gt; 55%, troponin is negative, and GLS &gt; lower limit of normal*</td>
<td>Anthracyclines: Doxorubicin, Epirubicin, Idarubicin Mitoxantrone (Asnani 2018)</td>
<td>Trastuzumab, Labatinib, Pertuzumab, Sorafenib, Sunitinib, Bevacizumab, Bortezomib **</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Normal assessment:</th>
<th>Normal assessment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assess after a cumulative dose &gt; 200mg/M^2 (or its anthracycline equivalent) and prior to each additional 50 mg/M^2, and at completion of therapy, and 6 months later, and for cumulative dose &gt; 300 mg/M^2 include assessment at 1 year and at 5 years post completion of therapy. (Zamorano 2016)</td>
<td>Assess every 3 months during therapy and at 6 months post completion of therapy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Abnormal assessment:</th>
<th>Abnormal assessment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assess after every cycle, and reassess for verification 2-3 weeks later if a drop in LV function has been detected/suspected; assess 6 months post completion of therapy, followed by reassessment every 6 months until stable, and for cumulative dose &gt; 300 mg/M^2 include assessment at 1 year and 5 years post completion of therapy. (Zamorano 2016)</td>
<td>Assess after every cycle, and reassess for verification 2-3 weeks later if a drop in LV function has been detected/suspected; assess 6 months post completion of therapy, and if still not stable re-assess every 6 months until stable.</td>
</tr>
</tbody>
</table>

* GLS of (negative) 20 is generally normal, but individual labs vary. (Collier 2017)
** Imatinib, rarely cardiotoxic, does not require surveillance of LV function. (Floyd 2018)

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### II. Aortic Root Disease

(Hiratzka 2010; Erbel 2014; Schiller 2017; Wright a&amp;b 2018; Woo a&amp;b 2018; Svensson 2013; Doherty 2017; Bhave 2018)

Indications for aortic root disease in this document are further explained in the section below:

- In asymptomatic stable patients with aortic dilation:
1. All 3 modalities of imaging, computed tomography (CT), magnetic resonance imaging (MRI), Echocardiography (TTE and TEE) appear to be reasonable alternatives for the diagnosis and surveillance of aortic pathology with 3 caveats:
   - TTE accuracy is limited to the aortic valve, aortic root, and proximal ascending aorta, so that conditions requiring evaluation of more distal portions are better imaged with CT or MRI. TEE's invasive nature and weak visualization of the distal ascending aorta, proximal arch, and abdominal aorta make it suboptimal as well. TTE might be satisfactory for surveillance in pathology with greatest prominence localized to the proximal ascending aorta (in bicuspid aortic valve disease or when prior CT or MRI showed the most dilated portion of the aorta to be visible on TTE), until its dimensions approach surgical indications, at which time more precise or comprehensive imaging with CT and MRI might be more appropriate.
   - MRI is recommended for Loeys Dietz, Ehlers-Danlos, and certain other noted genetic mutations, wherein surgical intervention is recommended at 4.2 cm.
   - While still usable for degenerative aortic dilation, echocardiography appears less favorable than CT or MRI for this indication.
   - CT and MRI were recommended for postoperative evaluation and periodic follow up. Echocardiography was not a noted recommendation for this category.

2. The flow diagram from the 2010 ACC Thoracic Aortic Disease Guideline gives reasonable recommendations for surveillance of degenerative aortic root disease, with annual imaging for enlargement above normal up to 4.4 cm, biannual for 4.5-5.4 or more cm (surgical intervention notwithstanding). See Table below for age, gender, and body size determined upper limits of normal for the thoracic aorta, ascending and descending:
An aneurysm is defined as \( >50\% \) greater than top normal. (Cikach 2018; Hiratzka 2010)

It would be reasonable to allow echocardiography as a less favorable alternative to CT and MRI, based upon the judgement of the ordering physician and local expertise with imaging (The definition of a thoracic aortic aneurysm is dilation of at least 50\% above the normal) (Cikach 2018; Hiratzka 2010).

3. An echocardiogram is recommended at the time of diagnosis of Marfan syndrome to determine the aortic root and ascending aortic diameters and 6 months thereafter to determine the rate of enlargement of the aorta. Subsequently, patients with Marfan’s require annual imaging, with increase to biannual imaging at a diameter of 4.5 cm or when \( >0.5\text{ cm/yr} \) expansion has been noted.

4. Patients with bicuspid aortic valve and aortic dilation over 4.0 cm require annual imaging. This would increase to biannual imaging in the event of any one of the additional conditions: diameter \( >4.5\text{ cm} \), rapid rate of change \( 0.5\text{ cm/yr} \), or a family history of a first degree relative with aortic

---

**Aortic diameters: Upper limits of normal**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>BSA (m²)</th>
<th>Ascending aorta (mm)</th>
<th>Descending aorta (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Women (n = 1,147)</td>
<td>Men (n = 1,805)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 45</td>
<td>&lt; 1.70</td>
<td>33.8</td>
<td>33.0</td>
</tr>
<tr>
<td></td>
<td>1.70–1.89</td>
<td>34.4</td>
<td>36.3</td>
</tr>
<tr>
<td></td>
<td>1.90–2.09</td>
<td>35.0</td>
<td>36.3</td>
</tr>
<tr>
<td></td>
<td>&gt; 2.1</td>
<td>NA</td>
<td>38.3</td>
</tr>
<tr>
<td>45–54</td>
<td>&lt; 1.70</td>
<td>35.2</td>
<td>38.6</td>
</tr>
<tr>
<td></td>
<td>1.70–1.89</td>
<td>37.2</td>
<td>38.1</td>
</tr>
<tr>
<td></td>
<td>1.90–2.09</td>
<td>38.9</td>
<td>39.7</td>
</tr>
<tr>
<td></td>
<td>&gt; 2.1</td>
<td>40.6</td>
<td>40.6</td>
</tr>
<tr>
<td>55–64</td>
<td>&lt; 1.70</td>
<td>36.9</td>
<td>36.3</td>
</tr>
<tr>
<td></td>
<td>1.70–1.89</td>
<td>37.0</td>
<td>39.7</td>
</tr>
<tr>
<td></td>
<td>1.90–2.09</td>
<td>39.0</td>
<td>41.2</td>
</tr>
<tr>
<td></td>
<td>&gt; 2.1</td>
<td>42.0</td>
<td>43.1</td>
</tr>
<tr>
<td>≥ 65</td>
<td>&lt; 1.70</td>
<td>37.5</td>
<td>38.5</td>
</tr>
<tr>
<td></td>
<td>1.70–1.89</td>
<td>39.2</td>
<td>41.0</td>
</tr>
<tr>
<td></td>
<td>1.90–2.09</td>
<td>42.7</td>
<td>42.2</td>
</tr>
<tr>
<td></td>
<td>&gt; 2.1</td>
<td>NA</td>
<td>42.4</td>
</tr>
</tbody>
</table>

*Upper limits of normal are 2 standard deviations above the mean. Not calculated if there were fewer than 6 patients in a group. BSA = body surface area; NA = not available.

(Table from Wolak 2008, as adapted by Cikach 2018)

An aneurysm is defined as \( \geq 50\% \) greater than top normal. (Cikach 2018; Hiratzka 2010)
dissection.

5. Patients with Loeys-Dietz syndrome or a confirmed genetic mutation known to predispose to aortic aneurysms and aortic dissections (TGFBR1, TGFBR2, FBN1, ACTA2, or MYH11) should undergo complete aortic imaging at initial diagnosis and 6 months thereafter to establish if enlargement is occurring. MRI is recommended in this setting.

6. Patients with Loeys-Dietz syndrome should have yearly magnetic resonance imaging from the cerebrovascular circulation to the pelvis.

7. Patients with Turner syndrome should undergo imaging of the heart and aorta for evidence of bicuspid aortic valve, coarctation of the aorta, or dilatation of the ascending thoracic aorta. If initial imaging is normal and there are no risk factors for aortic dissection, repeat imaging should be performed every 5 to 10 years or if otherwise clinically indicated. If abnormalities exist, annual imaging or otherwise appropriate follow-up imaging should be done.

8. Computed tomographic imaging or magnetic resonance imaging of the thoracic aorta is reasonable after a Type A or B aortic dissection or after prophylactic repair of the aortic root/ascending aorta.

9. Echocardiography is the primary modality for evaluation of the sinus of Valsalva aneurysms and associated shunting secondary to rupture (Schiller 2018).

10. Computed tomographic imaging or magnetic resonance imaging of the aorta is reasonable at 1, 3, 6, and 12 months post un-operated dissection and, if stable, annually thereafter so that any threatening enlargement requiring surgery/intervention can be detected in a timely fashion.

11. Postoperative surveillance recommendations are taken from the 2010 ACC Thoracic Aortic Disease Guideline: See Table below (Hiratzka 2010)
### III. General Information on TTE

*(Douglas 2011; Campbell 2014; Nishimura 2014; Doherty 2017)*

#### Frequency of Echocardiography Studies

- Judgement required, based upon:
  - Stability or change in patient symptoms, exam, lab, and/or X ray data
  - Stability of underlying condition being followed
  - Likelihood of repeat test affecting management
  - Specifics for cardio-oncology, valvular disease, etc.

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**Table 17. Suggested Follow-Up of Aortic Pathologies After Repair or Treatment**

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Interval</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute dissection</td>
<td>Before discharge, 1 mo, 6 mo, yearly</td>
<td>CT or MR, chest plus abdomen TTE</td>
</tr>
<tr>
<td>Chronic dissection</td>
<td>Before discharge, 1 y, 2 to 3 y</td>
<td>CT or MR, chest plus abdomen TTE</td>
</tr>
<tr>
<td>Aortic root repair</td>
<td>Before discharge, yearly</td>
<td>TTE</td>
</tr>
<tr>
<td>AVR plus ascending</td>
<td>Before discharge, yearly</td>
<td>TTE</td>
</tr>
<tr>
<td>Aortic arch</td>
<td>Before discharge, 1 y, 2 to 3 y</td>
<td>CT or MR, chest plus abdomen</td>
</tr>
<tr>
<td>Thoracic aortic stent</td>
<td>Before discharge, 1 mo, 2 mo, 6 mo, yearly Or 30 days*</td>
<td>CXR, CT, chest plus abdomen</td>
</tr>
<tr>
<td>Acute IMH/PAU</td>
<td>Before discharge, 1 mo, 3 mo, 6 mo, yearly</td>
<td>CT or MR, chest plus abdomen</td>
</tr>
</tbody>
</table>

*US Food and Drug Administration stent graft studies usually required before discharge or at 30-day CT scan to detect endovascular leaks. If there is concern about a leak, a predischarge study is recommended; however, the risk of renal injury should be borne in mind. All patients should be receiving beta blockers after surgery or medically managed aortic dissection, if tolerated. Adapted from Erbel et al (539).

AVR indicates aortic valve replacement; CT, computed tomographic imaging; CXR, chest x-ray; IMH, intramural hematoma; MR, magnetic resonance imaging; PAU, penetrating atherosclerotic ulcer; and TTE, transthoracic echocardiography.

(Table from Hiratzka 2010)
Examples of non-approvable repeat imaging:

- For same imaging test less than 52 weeks apart unless specific guideline criteria states otherwise.
- For different imaging tests of same anatomical structure but different imaging type less than six (6) weeks ago (i.e. CT, MRI and currently requesting echocardiogram) unless specific guideline criteria states otherwise, and/or there is approval following high level review.
- Additional images from same type of study (e.g. due to poor quality).

**Pediatric Post-Operative Patients**

Congenital heart disease, which requires surgical palliation, is, by its very nature, quite varied. No written consensus criteria currently exists for monitoring post-operative patients, but rather is based upon the clinical experience and training of the Pediatric Cardiologists caring for the patient. Criteria for performing an echocardiogram in the out-patient setting will vary greatly based upon whether the patient has a complex lesion, which must be repaired in stages, had post-operative complications, or is on medications which will be weaned over the ensuing weeks.

**Murmurs**

A harsh murmur, diastolic murmur, or continuous murmur would be an indication for an echocardiogram. Soft systolic murmurs and vibratory murmurs in general would not be indications for an echocardiogram. There is an important caveat in regards to age. Existent literature suggests that young children particularly under the age of three can have what appear to be unremarkable murmurs that result in organic heart disease even when examined by experts. Great leeway should therefore be given when echocardiograms are performed under the age of 3 years.

**TTE Accuracy**

In general, transthoracic echocardiography (TTE) is adequate for diagnosing infective endocarditis (IE) and for identifying vegetations when image quality is good. Contemporary TTE has improved the diagnostic accuracy of IE with enhanced image quality; it may reduce the need for TEE. However, accuracy may be reduced because of technical difficulties like obesity, chronic obstructive pulmonary disease, chest-wall deformities etc. Furthermore, the higher resolution of TEE can provided superior visualization of smaller vegetations.

**TTE versus TEE**

Specific situations where transesophageal echocardiography (TEE) is preferred over TTE and may be an appropriate initial study for evaluation of prosthetic device, suspected peri-annular complications, children with complex congenital cardiac lesions, selected patients with Staphylococcus aureus bacteremia, etc. Visualization of left atrial thrombus is far superior with TEE, which is the recommended strategy.

**Abbreviations**

- ASD: atrial septal defect
- CABG: coronary artery bypass grafting surgery
- CAD: coronary artery disease
- CMR: cardiovascular magnetic resonance
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRT</td>
<td>cardiac resynchronization therapy</td>
</tr>
<tr>
<td>CT</td>
<td>computed tomography</td>
</tr>
<tr>
<td>ECG</td>
<td>electrocardiogram</td>
</tr>
<tr>
<td>GLS</td>
<td>global longitudinal strain (measure of left ventricular function)</td>
</tr>
<tr>
<td>HCM</td>
<td>hypertrophic cardiomyopathy</td>
</tr>
<tr>
<td>HF</td>
<td>heart failure</td>
</tr>
<tr>
<td>ICD</td>
<td>implantable cardioverter-defibrillator</td>
</tr>
<tr>
<td>LV</td>
<td>left ventricular</td>
</tr>
<tr>
<td>LVEF</td>
<td>left ventricular ejection fraction</td>
</tr>
<tr>
<td>MI</td>
<td>myocardial infarction</td>
</tr>
<tr>
<td>PDA</td>
<td>patent ductus arteriosus</td>
</tr>
<tr>
<td>PFO</td>
<td>patent foramen ovale</td>
</tr>
<tr>
<td>SVT</td>
<td>supraventricular tachycardia</td>
</tr>
<tr>
<td>TAVR</td>
<td>transcatheter aortic valve replacement</td>
</tr>
<tr>
<td>TEE</td>
<td>transesophageal echocardiogram</td>
</tr>
<tr>
<td>TIA</td>
<td>transient ischemic attack</td>
</tr>
<tr>
<td>Tn</td>
<td>troponin</td>
</tr>
<tr>
<td>TTE</td>
<td>transthoracic echocardiogram</td>
</tr>
<tr>
<td>VPC</td>
<td>ventricular premature contraction</td>
</tr>
<tr>
<td>VSD</td>
<td>ventricular septal defect</td>
</tr>
<tr>
<td>VT</td>
<td>ventricular tachycardia</td>
</tr>
</tbody>
</table>
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Wright MJ, Connolly HM. Genetics, clinical features, and diagnosis of Marfan syndrome and related


INTRODUCTION

- Transesophageal echocardiography (TEE) enables cardiac ultrasonic imaging from within the esophagus, which provides a window for enhanced quality images as well as additional views, beyond that acquired by standard transthoracic echocardiography (TTE).

- TEE can be used as a complement to TTE or as a superior alternative, depending upon the clinical scenario.

INDICATIONS FOR TRANSESOPHAGEAL ECHOCARDIOGRAPHY (TEE)
(Ayres 2005; Douglas 2011; Hahn 2013; Flachskampf 2014; Manning, 2018)

<table>
<thead>
<tr>
<th>TEE as Initial or Supplemental Test—General Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Use of TEE after nondiagnostic TTE or when there is a high likelihood of a nondiagnostic TTE due to patient characteristics or inadequate visualization of relevant structures, such as valvular heart disease, prosthetic valve dysfunction, left atrial thrombus, patent foramen ovale, atrial baffles post Fontan, Senning, or Mustard procedures, etc. (Ogbara 2011; Flachskampf 2014; Lancellotti 2013)</td>
</tr>
</tbody>
</table>
| • Re-evaluation of prior TEE finding for interval change (e.g., resolution of thrombus after anticoagulation, resolution of vegetation after antibiotic therapy) when a change in therapy is would be based upon the findings Any ONE of the following for procedural and surgical guidance, especially when TEE is superior or complimentary to TTE (Thys 2010; Porter 2015):
  • Guidance during percutaneous/transcatheter noncoronary cardiac interventions including but not limited to closure device placement, left atrial appendage closure, ASD closure, radiofrequency ablation, and percutaneous valve procedures (Flachskampf 2014).
  • For intraoperative noncoronary cardiac repair, including, but not limited to, valve repair, congenital defect repair, unanticipated findings or complications of cardiac surgery requiring intraoperative imaging.
  • Suspected acute aortic pathology including but not limited to dissection/transsection when computed tomography angiogram (CTA) and magnetic resonance imaging (MRI) are either not available or not conclusive or not thought to be the optimal first imaging test for clinical reasons (Bhave 2018).
  • Dilated aortic sinuses or ascending aorta or a bicuspid aortic valve (stages A and B), to evaluate the presence and severity of AR, when TTE is inadequate. |

<table>
<thead>
<tr>
<th>TEE as Initial or Supplemental Test—Valvular Disease (Nishimura 2014; Doherty 2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation of valvular structure, native and prosthetic, and function to assess suitability for, and assist in planning of, an intervention</td>
</tr>
</tbody>
</table>
- Evaluation of the mean mitral gradient and pulmonary artery pressure in mitral stenosis, when there is a discrepancy between resting Doppler echocardiographic findings and clinical symptoms or signs, exercise stress echocardiography is not possible, AND TTE is inadequate

- Discordance between clinical assessment and TTE assessment of the severity of MR
- Discordance between clinical assessment and TTE assessment of the severity of AR
- To diagnose infective endocarditis and cardiac complications of infective endocarditis, with a moderate or high pretest probability (e.g., staph bacteremia, fungemia, prosthetic heart valve, or intracardiac device)
- Re-evaluation of infective endocarditis (IE) in a patient with a change in clinical status or cardiac examination (e.g., new murmur, embolism, persistent fever, heart failure (HF), abscess, or atrioventricular heart block (Saric 2016)
- Re-evaluation of IE if the patient is at high risk for progression/complications or for other potential treatment-altering changes, when TTE is inadequate.

**TEE as Initial or Supplemental Test—Embolic Event**

Evaluation of suspected cardiac mass, tumor, or thrombus, or for evaluation of potential cardiac source of embolism when there is no identified noncardiac source (Saric 2016)

**TEE as Initial Test—Atrial Fibrillation/Flutter**

Evaluation to facilitate clinical decision making with regards to anticoagulation, cardioversion, and/or radiofrequency ablation

**TAVR (Transcatheter Aortic Valve Replacement/Repair) (Doherty 2017, Otto 2017)**

- Accurate pre-procedural assessment of annular size and shape, number of cusps, and degree of calcification, when computed tomography (CT) cannot be performed (i.e. limited role)
- Pre-, peri- and post procedural assessment of degree of aortic regurgitation (including valvular and paravalvular) with suspicion of valve dysfunction, if TTE is inadequate
- Intraprocedural guidance of TAVR or paravalvular leak closure (Thys 2010; Porter 2015; Flachskampf 2014)
- Assessment of post procedural stroke with suspicion of valve dysfunction, if TTE is inadequate

**Percutaneous/Transcatheter Mitral Valve Repair/Replacement**

(Doherty 2017)

- Determination of patient eligibility for procedures such as PMBV, TMVR, edge-to-edge repair, artificial chord implantation, annuloplasty, PVML closure
- Pre-procedural evaluation for TMVR, mitral annuloplasty, or PVML closure can be performed in addition to CT imaging (Wunderlich 2018)
- Exclude the presence of intracardiac mass, thrombus, or vegetation prior to (within 3 days) the procedure
- Intraprocedural guidance of transcatheter mitral valve repair or replacement (Thys 2010; Porter 2015; Flachskampf 2014)

**Left Ventricular Assist Devices**

(Stainback 2015)

- Preoperative evaluation for suitability, intraoperative monitoring during placement, and immediate postoperative evaluation of function
ADDITIONAL INFORMATION

Frequency of Echocardiography Studies

- Judgement required, based upon:
  - Stability or change in patient symptoms, exam, lab, and/or X ray data
  - Stability of underlying condition being followed
  - Likelihood of repeat test affecting management

Examples of non-approvable repeat imaging:

- For same imaging test less than 52 weeks (1 year) apart unless specific guideline criteria states otherwise.

- For different imaging tests of same anatomical structure but different imaging type less than six (6) weeks ago (for example, a recent CT or MRI and currently requesting echocardiogram), unless specific guideline criteria states otherwise, and/or there is approval following high level review.

- Additional images from same type of study (e.g. due to poor quality).

Abbreviations

AR  aortic regurgitation
CABG coronary artery bypass grafting surgery
CAD coronary artery disease
CMR cardiovascular magnetic resonance
CT computed tomography
ECG electrocardiogram
HF heart failure
LV left ventricular
MI myocardial infarction
MR mitral regurgitation
PBMV percutaneous balloon mitral valvuloplasty
PVML paravalvular mitral leak
RV right ventricle
TEE transesophageal echocardiography
TIA transient ischemic attack
TTE transthoracic echocardiography
TMVR transcatheter mitral valve replacement
TR tricuspid regurgitation
REFERENCES


CPT Codes: 93350, 93351, +93320, +93321, +93325, +93352

Introduction

- Stress echocardiography (SE) refers to ultrasound imaging of the heart during exercise electrocardiography (ECG) testing, during which visualized wall motion abnormalities can provide evidence of significant coronary artery disease (CAD).

- While drug-induced stress with dobutamine can be a legitimate alternative to exercise stress testing in patients who are unable to exercise, this guideline does not require use of this modality for practical reasons with rare noted exceptions. Hence, reference in this document to SE almost always refers to exercise stress echocardiography.

- Although SE provides comparable accuracy without radiation relative to myocardial perfusion imaging (MPI), scenarios which do not permit safe and effective use of SE might be better suited for alternative stress imaging with MPI, rarely cardiovascular magnetic resonance imaging (CMR) or positron emission tomography (PET), and in some cases, non-stress imaging such as coronary computed tomography angiography (CCTA) (Askew 2018; Douglas 2011; Metz 2007; Einstein 2012; Fazel 2011; Fleischmann 1998; Heijenbrok-Kal 2007; Hirschfeld 2018; Marwick 2003; Pellikka 2007; Schinkel 2003; Scott-Moncrieff 2011; Sicari 2008; Sicari 2017; Yao 2003; Zhang 2014).

- Scenarios that support MPI over SE are detailed in the Additional Information section and include:
  - Poor quality echocardiographic images
  - Inability to exercise
  - Specific comorbidities
  - ECG-related wall motion abnormalities.
  - Elevated coronary risk

- CAD stenosis $\geq 50\%$ is considered clinically significant or obstructive CAD, where CAD and ischemic heart disease (IHD) are symptoms. Hemodynamically or functionally significant CAD means the degree of stenosis is severe enough to cause ischemia. This is discussed in more detail in the Additional Information section (Fihn 2012; Wolk 2013; Montalescot 2013; Gerber 2018; Tobis 2007).

- Stable patients without known CAD fall into 2 categories:
  - Asymptomatic patients, for whom Global Risk of CAD events can be determined from coronary risk factors using calculators available online. (see Part III in the Additional Information section)
  - Symptomatic patients, for whom we estimate the Pretest Probability that their chest-related symptoms are due to clinically significant ($\geq 50\%$) CAD (see below):
The 3 Types of Chest Pain or Discomfort

- **Typical Angina (Definite)** is defined as including all 3 of these characteristics:
  1) Substernal chest pain or discomfort with characteristic quality and duration
  2) Provoked by exertion or emotional stress
  3) Relieved by rest and/or nitroglycerine

- **Atypical Angina (Probable)** has only 2 of the above characteristics

- **Nonanginal Chest Pain/Discomfort** has only 0-1 of the above characteristics

Once the type of chest pain has been established from the medical record, the Pretest Probability of obstructive CAD is estimated from the **Diamond Forrester Table** below, recognizing that in some cases multiple additional coronary risk factors could increase pretest probability:

(Wolk 2013; Fihn 2012)

**Diamond Forrester Table**

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Nonanginal Chest Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=39</td>
<td>Men</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40–49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>&gt;=60</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

- **Very low:** < 5% pretest probability of CAD, usually not requiring stress evaluation (Fihn 2012)
- **Low:** 5-10% pretest probability of CAD
- **Intermediate:** 10% - 90% pretest probability of CAD
- **High:** > 90% pretest probability of CAD

**INDICATIONS for STRESS ECHO**

(Fihn 2012; Wolk 2013; Montalescot 2013; Pellikka 2007; Marwick 2003; Sicari 2008; Sicari 2017; Douglas 2011; Yao 2003)

**Suspected CAD**

(Without known history of CAD)

1. **Symptomatic patients without known CAD**

- Low pretest probability, if ECG is uninterpretable AND patient can exercise.
- Intermediate pretest probability
- High pretest probability
- Repeat testing in patient with recurrent symptomatic presentation and negative result over 2 years ago
- Repeat testing in patient with new or worse symptoms and negative result at least one year ago

2. Asymptomatic patients without known CAD:

- Previously unevaluated ECG evidence of possible myocardial ischemia such as substantial ischemic ST segment or T wave abnormalities
- Previously unevaluated pathologic Q waves or wall motion abnormality (evidence of prior myocardial infarction)
- Unevaluated complete left bundle branch block
- Following radiation therapy to the anterior or left chest, at 5 years post inception of radiation and every 5 years thereafter (Lancellotti 2013)

3. Incomplete or inconclusive CAD evaluation within the past 2 years, without known CAD:

- Exercise stress ECG with low risk Duke treadmill score but patient’s current symptoms indicate an intermediate or high pretest probability, which should include stress imaging
- Exercise stress ECG with intermediate Duke treadmill score
- Inconclusive/borderline CCTA (e.g. 40-70% lesions)
- An indeterminate (equivocal, borderline, or discordant) evaluation by prior stress imaging (MPI or CMR) within the past 2 years, in patients for whom a noninvasive approach is preferable to proceeding to invasive coronary arteriography (e.g. a patient presenting with unclear symptoms, ECG and imaging discordant, but with severe contrast allergy or chronic kidney disease.)

Known Major Vessel CAD
(Patel 2017)

- Validated concern for a previous acute coronary syndrome without subsequent invasive or non-invasive coronary evaluation
- Follow up SE at 2-year intervals is approvable, if it will affect consideration of coronary revascularization (initial or additional), in patients with one of the following:
  - History of silent ischemia with severe unrevascularized CAD and revascularization could be feasible (Deedwania 2018)
  - History of severe unrevascularized major multivessel CAD, without major wall motion abnormality, and revascularization could be feasible.

- Ischemia assessment following inconclusive findings of invasive coronary arteriography or CCTA, for the purpose of assessing extent of ischemia and need for additional medical, interventional, or surgical therapy

- Myocardial viability testing by low dose dobutamine stress echocardiography (myocardial perfusion imaging at rest is equally approvable) prior to coronary revascularization is reasonable in patients with left ventricular ejection fraction (LVEF) \( \leq 50\% \), if it could significantly alter the revascularization strategy. (Patel 2013; Yancy 2013).
• New or worsening symptoms of ischemia in the absence of an acute coronary syndrome, unless the most current stress imaging study would warrant invasive coronary arteriography instead (e.g., History of high risk stress test without subsequent invasive coronary arteriography might warrant invasive coronary angiography) (Patel 2012).

• De novo heart failure (HF) patients who have known CAD, even without angina, unless the patient is not eligible for revascularization of any kind, or unless invasive coronary arteriography is immediately planned (Yancy 2013).

Special Diagnostic Conditions, Requiring Coronary Evaluation

• Newly diagnosed systolic or diastolic HF, when invasive coronary angiography is not immediately planned, especially when symptoms or signs of ischemia are present or suspected (SE diversion not required) (Yancy 2013, Patel 2013, Fihn 2012).
• Newly found wall motion abnormality (Colucci 2018)
• Ventricular arrhythmias:
  o Sustained ventricular tachycardia (VT) > 100 bpm, ventricular fibrillation (VF), or exercise induced ventricular tachycardia (VT), when invasive coronary arteriography is not the initially required test (Al-Khatib 2018, in press)
  o Nonsustained VT, multiple episodes, each ≥ 3 beats at ≥ 100 bpm, without known cause or associated cardiac pathology, when an exercise ECG has shown an intermediate risk Duke Score or an exercise ECG could not be performed (Zimetbaum 2018)
  o Frequent premature ventricular contractions (PVCs) ≥ 30/hour, or any PVC on a 12 lead ECG, without known cause or associated cardiac pathology, when an exercise ECG has shown an intermediate risk Duke Score OR an exercise ECG is not feasible due to inability to exercise or due to an uninterpretable ECG (Cha 2012, Manolis 2018)
• Prior to Class IC antiarrhythmic drug initiation in intermediate and high global risk patients (Kumar 2018)
• Assessment of hemodynamic significance of known
  o Anomalous coronary arteries (Grani 2017),
  o Muscle bridging of a coronary artery (perform with exercise stress) (Sorajja 2018), OR
  o Coronary aneurysms in Kawasaki’s disease (Newburger 2018)

Chronic Valvular Disease
Evaluation with Inclusion of Doppler
(Nishimura 2014; Doherty 2017; Baumgartner 2017; Steiner 2017)

• Low dose dobutamine SE for the evaluation of aortic stenosis and flow (contractile) reserve in symptomatic patients with severe aortic stenosis by calculated valve area, low flow (stroke volume ≤ 35mL/square M) /low gradient (mean < 40 mm Hg or Doppler <4 M/sec), and ejection fraction < 50% (Contractile reserve is > 20% rise in stroke volume with dobutamine).
• Exercise echo Doppler evaluation for mitral stenosis when there is a discrepancy between resting Doppler and clinical signs or symptoms.
• Exercise echo Doppler evaluation for primary (also known as prolapse, degenerative, unrelated to wall motion abnormality, etc.) mitral regurgitation (MR) if there is:
- Discrepancy between exertional symptoms and severity of MR at rest
  OR
- Need to distinguish moderate from severe MR in the asymptomatic patient

- Evaluation of secondary MR (also known as ischemic, related to wall motion abnormality or left ventricular dilation in cardiomyopathy, etc.), with respect to establishing an ischemic etiology

**Prior to Elective Noncardiac Surgery**

(Fleischer 2014; Patel 2015)

- Patients who have no other indication for a non-invasive coronary evaluation, but are referred for preoperative cardiac evaluation, are eligible for SE, based upon cardiac risk ≥1%, if all 4 criteria are met:
  - Surgery is supra-inguinal vascular, intrathoracic, or intra-abdominal.
  - The patient has at least one of these additional cardiac complication risk factors:
    - Ischemic Heart Disease
    - History of stroke or trans ischemic attack (TIA)
    - History of congestive heart failure (CHF) or ejection fraction ≤ 35%
    - Insulin-requiring diabetes mellitus
    - Creatinine ≥ 2.0 mg/dl
  - The patient has limited functional capacity (< 4 metabolic equivalents) such as one of the following:
    - Cannot take care of their ADLs or ambulate
    - Cannot walk 2 blocks on level ground
    - Cannot climb 1 flight of stairs
    - Cannot vacuum, dust, do dishes, sweep, or carry small grocery bag
  - There has been no non-invasive coronary testing within one year, and the result of such a test would be likely to substantially alter therapy and/or preclude proceeding with the intended surgery

- Planning for solid organ transplantation is an indication for preoperative dobutamine SE, if there has not been a conclusive stress evaluation within the past year (Lentine 2012):
  - In a patient with poor or unknown functional capacity (4 metabolic equivalents, as characterized under preoperative evaluation for noncardiac surgery section above) (Wolk 2013)
  - In a patient with ≥ 3 of the following (Lentine 2012):
    - Age > 60
    - Smoking
    - Hypertension
- Dyslipidemia
- Left ventricular hypertrophy
- > 1 year on dialysis (for renal transplant patients)
- Diabetes mellitus
- Prior cardiovascular disease

- When the above risk calculators prove inadequate, and cardiac risk could be ≥ 1%, the American College of Surgeons NSQIP Cardiac Risk Calculator can be used as a less validated alternative. It is available at http://www.surgicalriskcalculator.com/miocardiacarrest, with an application download required.

**POST CARDIAC TRANSPLANTATION**

Dobutamine SE recommended, not exercise SE

(Gustafsson 2016)

- During the first five years post cardiac transplantation, patients with glomerular filtration rates less than 40 mL/min/1.73 body surface area (BSA), or who otherwise should not undergo annual invasive coronary arteriography, are appropriate for annual SE.
- After the first five years post cardiac transplantation:
  - Patients considered at low risk for transplant vasculopathy (i.e., with normal invasive coronary arteriography) can have annual SE,
  - Patients with transplant coronary vasculopathy can have annual SE, if the risk of annual invasive coronary arteriography is not acceptable (i.e. high risk of contrast nephropathy).

**ADDITIONAL INFORMATION**

(Fihn 2012; Wolk 2013; Montalescot 2013)

I. Scenarios that support MPI over SE

(Henzlova 2016; Askew 2018)

XI. Poor Quality Echo Image
- Obesity with body mass index (BMI) over 40 or poor acoustic imaging window

XII. Inability to Exercise
- Physical infirmities precluding a reasonable ability to exercise for at least 3 full minutes of Bruce protocol
- The patient has limited functional capacity (< 4 metabolic equivalents) such as one of the following:
  - Cannot take care of their activities of daily living (ADLs) or ambulate
  - Cannot walk 2 blocks on level ground
  - Cannot climb 1 flight of stairs
  - Cannot vacuum, dust, do dishes, sweep, or carry a small grocery bag
Patients who cannot walk up a single flight of stairs at even a slow pace or perform ADLs based upon documented limitations

XIII. Comorbidity Related
- Prior cardiac surgery (coronary artery bypass graft or valvular), CHF with left ventricular ejection fraction ≤ 40%
- Severe chronic obstructive pulmonary disease with pulmonary function test (PFT) documentation, severe shortness of breath on minimal exertion, or requirement of home oxygen during the day
- Poorly controlled hypertension, with systolic BP > 180 or Diastolic BP > 120
- Medical instability or serious acute illness, where maximal exercise is not recommended or appropriate (e.g. acute myocarditis or pericarditis, active infective endocarditis, acute aortic dissection, etc.)
- Resting wall motion abnormalities that would make exercise SE interpretation difficult, which includes left bundle branch block
- More than moderate valvular heart disease, when coronary data, not valvular hemodynamics, are required

XIV. ECG Related Uninterpretable Wall Motion
- Pacemaker or ICD
- Poorly controlled atrial fibrillation/ectopy
- Frequent ectopy, irregular rhythm
- Ventricular pre-excitation (e.g. Wolff Parkinson White)
- Complete LBBB (SE doable, but more difficult to interpret)

XV. Risk Related
- High pretest probability in suspected CAD
- Intermediate or high global risk in patients requiring type IC antiarrhythmic drugs
- Patients with prior coronary revascularization
- Arrhythmia risk with exercise and provocation of arrhythmia not required for test
- LVEF ≤ 40%

II. ECG Stress Test Alone versus Stress Testing with Imaging

Prominent scenarios suitable for an ECG stress test WITHOUT imaging (i.e. exercise treadmill ECG test) are inferred from the guidelines presented above, often (but not always) requiring that the patient can exercise for at least 3 minutes of Bruce protocol with achievement of near maximal heart rate AND has an interpretable ECG for ischemia during exercise (Wolk 2013):
- The (symptomatic) low pretest probability patient who is able to exercise and has an interpretable ECG
- The (asymptomatic) high global risk patient who is able to exercise and has an interpretable ECG
  - The patient who is under evaluation for exercise induced arrhythmia (or long QT interval evaluation when the resting QTc is normal), and coronary artery disease is not suspected (Al-Khatib 2017)
  - The patient who requires an entrance stress test ECG for a cardiac rehab program or for an exercise prescription.

Duke Exercise ECG Treadmill Score calculates risk from ECG treadmill alone:
• The equation for calculating the Duke treadmill score (DTS) is: \( DTS = \text{exercise time in minutes} \cdot (5 \times \text{ST deviation in mm or 0.1 mV increments}) \cdot (4 \times \text{exercise angina score}) \), with angina score being 0 = none, 1 = non-limiting, and 2 = exercise-limiting.

• The score typically ranges from -25 to +15. These values correspond to low-risk (with a score of \( \geq +5 \)), intermediate risk (with scores ranging from -10 to +4), and high-risk (with a score of \( \leq -11 \)) categories.

An uninterpretable baseline ECG includes (Fihn 2012):
• Abnormalities of ST segment depression of 0.1 mV (1 mm with conventional calibration) or more
• Ischemic looking T wave inversions of at least 0.25 mV (2.5 mm with conventional calibration)
• ECG findings of probable or definite LVH, WPW, a ventricular paced rhythm, or left bundle branch block
• Digitalis use or hypokalemia
• Resting HR under 50 bpm on a beta blocker and an anticipated suboptimal workload (e.g. rate-pressure product less than 20-25K) could render inconclusive result
• Prior false positive stress ECG

### III. Global Risk of Cardiovascular Disease

**Global risk** of CAD is defined as the probability of manifesting cardiovascular disease over the next 10 years and refers to asymptomatic patients without known cardiovascular disease. It should be determined using one of the risk calculators below. A high risk is considered greater than a 20% risk of a cardiovascular event over the ensuing 10 years. High global risk by itself generally lacks scientific support as an indication for stress imaging (Douglas 2018). There are rare exemptions, such as patients requiring a I-C antiarrhythmic drug, who might require coronary risk stratification prior to initiation of the drug, when global risk is moderate or high.

- **CAD Risk—Low**
  10-year absolute coronary or cardiovascular risk less than 10%.

- **CAD Risk—Moderate**
  10-year absolute coronary or cardiovascular risk between 10% and 20%.

- **CAD Risk—High**
  10-year absolute coronary or cardiovascular risk of greater than 20%.

**Links to Global Cardiovascular Risk Calculators**

*Patients who have already manifested cardiovascular disease are already at high global risk and are not applicable to the calculators.

(D’Agostino 2008; Ridker 2007; McClelland 2015; Goff 2014)

<table>
<thead>
<tr>
<th>Risk Calculator</th>
<th>Link to Online Calculator</th>
</tr>
</thead>
</table>
Reynolds Risk Score  
Can use if no diabetes  
Unique for use of family history  

Pooled Cohort Equation  

ACC/AHA Risk Calculator  

MESA Risk Calculator  
With addition of Coronary Artery Calcium Score, for CAD-only risk  

<table>
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<tr>
<th>Reynolds Risk Score</th>
<th>Can use if no diabetes</th>
<th>Unique for use of family history</th>
<th><a href="http://www.reynoldsriskscore.org/">http://www.reynoldsriskscore.org/</a></th>
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</thead>
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<tr>
<td>Pooled Cohort Equation</td>
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<td></td>
<td><a href="http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example">http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example</a></td>
</tr>
<tr>
<td>MESA Risk Calculator</td>
<td>With addition of Coronary Artery Calcium Score, for CAD-only risk</td>
<td></td>
<td><a href="https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx">https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx</a></td>
</tr>
</tbody>
</table>

IV. Definitions of Coronary Artery Disease  
(Fihn 2012; Montalescot 2013; Patel 2017; Mintz 2016 Tobis 2007)

1. Percentage stenosis refers to the reduction in diameter stenosis when angiography is the method and refers to cross sectional narrowing when IVUS (intravascular ultrasound) is the method of determination.
2. Coronary artery calcification is a marker of risk, as measured by Agatston score on coronary artery calcium imaging. It is not a diagnostic tool so much as it is a risk stratification tool. Its incorporation into Global Risk can be achieved by using the MESA risk calculator.
3. Stenoses ≥ 50% are considered obstructive coronary artery disease (also referred to as clinically significant), while stenoses ≤ 50% are considered nonobstructive coronary artery disease (Gerber 2018).
4. Ischemia-producing disease (also called hemodynamically or functionally significant disease, for which revascularization might be appropriate) generally implies at least one of the following:
   i. Suggested by percentage diameter stenosis ≥ 70% by angiography; borderline lesions are 40-70% (Fihn 2012, Tobis 2007)
   ii. For a left main artery, suggested by a percentage stenosis ≥ 50% or minimum lumen cross sectional area on IVUS ≤ 6 square mm (Fihn 2012, Mintz 2016)
   iii. FFR (fractional flow reserve) ≤ 0.80 for a major vessel (Mintz 2016)
   iv. Demonstrable ischemic findings on stress testing (ECG or stress imaging), that are at least mild in degree
5. A major vessel is a coronary vessel that would typically be substantial enough for revascularization, if indicated. Lesser forms of coronary artery disease would be labeled as “limited” and not major (i.e. A 50% lesion in a tiny septal or modest size mid PDA would be limited obstructive coronary artery disease.)
6. Microvascular ischemic coronary artery disease, as might be described by a normal FFR (fractional flow reserve) above 0.80 with a reduced CFR (coronary flow reserve less than 2.5), has not otherwise been addressed in this manuscript, because it is very rarely an issue in compliance determinations. However, it would constitute a form of ischemic heart disease.
7. FFR (fractional flow reserve) is the distal to proximal pressure ratio across a coronary lesion during maximal hyperemia induced by either intravenous or intracoronary adenosine. Less than or equal to 0.80 is considered a significant reduction in coronary flow. Newer iterations such as iFR (instantaneous wave free ratio) might supersede basic FFR technology in the near future.
8. New technology is evolving that estimates FFR from CCTA images. This is covered under the separate NIA Guideline for FFR-CT.
V. Anginal Equivalent

Development of an anginal equivalent (e.g., shortness of breath, fatigue, or weakness) either with or without prior coronary revascularization should be based upon the documentation of reasons to suspect that symptoms other than chest discomfort are not due to other organ systems (e.g., dyspnea due to lung disease, fatigue due to anemia, etc.), by presentation of clinical data such as respiratory rate, oximetry, lung exam, etc. (as well as d-dimer, chest CT(A), and/or PFTs, when appropriate), and then incorporated into the evaluation of coronary artery disease as would chest discomfort. Syncope per se is not an anginal equivalent (Moya 2009, Shen 2017, Fihn 2012).

XVI. Peripheral Arterial Disease/Cerebrovascular Disease

Arterial vascular disease below the renal arteries is generally referred to as peripheral arterial disease, when the ankle brachial index is < 0.9 or there is at least 50% vessel diameter narrowing on ultrasound or angiography (Hussain 2018).

Cerebrovascular disease generally refers to a history of TIA or stroke, or cerebrovascular lesions that put the patient at considerable risk for stroke (Caplan 2018).

There is no evidence to demonstrate that screening all patients with peripheral arterial disease for asymptomatic atherosclerosis in other arterial beds improves clinical outcome. Intensive treatment of risk factors through guideline directed medical therapy is the principal method for preventing adverse cardiovascular ischemic events secondary to atherosclerotic disease in other arterial beds (Gerhard-Herman 2016).

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAD</td>
<td>antiarrhythmic drug</td>
</tr>
<tr>
<td>ADLs</td>
<td>activities of daily living</td>
</tr>
<tr>
<td>BSA</td>
<td>body surface area in square meters</td>
</tr>
<tr>
<td>CAD</td>
<td>coronary artery disease</td>
</tr>
<tr>
<td>ECG</td>
<td>electrocardiogram</td>
</tr>
<tr>
<td>FFR</td>
<td>fractional flow reserve</td>
</tr>
<tr>
<td>LBBB</td>
<td>left bundle-branch block</td>
</tr>
<tr>
<td>LVEF</td>
<td>left ventricular ejection fraction</td>
</tr>
<tr>
<td>LVH</td>
<td>left ventricular hypertrophy</td>
</tr>
<tr>
<td>MI</td>
<td>myocardial infarction</td>
</tr>
<tr>
<td>MET</td>
<td>estimated metabolic equivalent of exercise</td>
</tr>
<tr>
<td>MPI</td>
<td>myocardial perfusion imaging</td>
</tr>
<tr>
<td>PFT</td>
<td>pulmonary function test</td>
</tr>
<tr>
<td>PVCs</td>
<td>premature ventricular contractions</td>
</tr>
<tr>
<td>SE</td>
<td>stress echocardiography</td>
</tr>
<tr>
<td>VT</td>
<td>Ventricular tachycardia</td>
</tr>
<tr>
<td>VF</td>
<td>Ventricular fibrillation</td>
</tr>
<tr>
<td>WPW</td>
<td>Wolf Parkinson White</td>
</tr>
</tbody>
</table>
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arteries?search=myocardial%20bridging&source=search_result&selectedTitle=1~14&usage_type=default&display_rank=1#H10

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Heart Catheterization is an invasive angiographic procedure used to evaluate the presence and extent of coronary artery disease (CAD).

In addition to angiography, it can also include ventriculography, aortography, acquisition of hemodynamic data, measurement of cardiac output, detection and quantification of shunts and flows, intravascular ultrasound (IVUS), and fractional flow reserve (FFR)/instantaneous wave free ratio (iFR) determination of a lesion’s hemodynamic severity.

This guideline applies to patients with a stable clinical presentation, not to those with acute coronary syndromes or acute valvular scenarios, who frequently manifest imminent need for catheter-based or surgical intervention.

In stable patients, prior to a recommendation for cardiac catheterization, preliminary evaluation with non-invasive cardiac testing is usually indicated.

CAD stenosis ≥ 50% is considered clinically significant or obstructive CAD (CAD and IHD [ischemic heart disease] mean the same thing. Hemodynamically or functionally significant CAD means the degree of stenosis is severe enough to cause ischemia. This is discussed in more detail in the Additional Information section) (Fihn 2012; Wolk 2013; Montalescot 2013; Gerber 2018; Tobis 2007).

INDICATIONS FOR INVASIVE CORONARY ARTERIOGRAPHY
(Patel 2012; Fihn 2012; Fihn 2014; Patel 2017; Wolk 2013)

Acute

- Reasonable documentation of acute coronary syndrome, which exempts it from this guideline.

Symptoms and Non-invasive Testing

- Based upon symptoms of ischemia, without known CAD, and with one of the following:
  - A high pretest probability of clinically significant coronary artery disease (See Additional Information section) (Wolk 2013; Patel 2012)
  - Patients with suspected symptomatic CAD, who cannot undergo stress testing or coronary computed tomographic angiography (CCTA), when there is a high likelihood that the findings will affect therapy (Fihn 2012; Fihn 2014; Montalescot 2013)

Noninvasive testing for CAD showing any of the following, which have not yet been addressed:
- Exercise electrocardiogram (ECG) stress test with Duke Score < negative 11, ST segment elevation, hypotension, exercise induced ventricular tachycardia (VT), or several minutes of ST segment depression post exercise (Patel 2012)
- Stress imaging with high risk findings (see Additional Information section)
- Stress imaging with intermediate risk (see Additional Information section) in a patient with one of the following
  - Symptoms consistent with CAD (Patel 2012)
  - Ejection fraction > 50% and unsatisfactory quality of life due to angina (Fihn 2012)
  - Ejection fraction < 50% (Fihn 2012)
- Discordant, equivocal, or inconclusive non-invasive evaluation in symptomatic patients, such as one of the following scenarios with appropriate stress imaging: (Wolk 2013; Montalescot 2013; Patel 2012)
  - Low risk stress imaging with ongoing symptoms of ischemia (Patel 2012)
  - Low risk stress imaging with high risk stress ECG response or stress induced typical angina (Patel 2012)
  - Equivocal/uninterpretable/inconclusive stress imaging due to issues of attenuation or other problems with interpretability (Patel 2012, Fihn 2012)
  - Otherwise appropriate noninvasive testing is inadequate or contraindicated
  - Moderate or greater sized area of infarction (≥ 5% myocardium), but limited or no ischemia (<5% myocardium), in a patient with symptoms of ischemia (Patel 2012)

- CCTA findings, not yet addressed: (Patel 2012; Patel 2017; Fihn 2012)
  - In appropriately chosen symptomatic patient for CCTA, with one of:
    - One vessel CAD with ≥ 70% stenosis
    - Moderate CAD stenosis (50% to 69% stenosis) in ≥ 2 arteries on CCTA
    - Stenosis ≥ 30% with FFR-CT ≤ 0.8. (Douglas 2016)

- Evaluation of patients with known major vessel CAD, with or without prior revascularization, who are amenable to, and candidates for, coronary revascularization or more aggressive coronary management of:
  - New, worsening, or limiting symptoms with non-invasive findings that are intermediate or high risk (Patel 2012)
  - New, worsening, or limiting symptoms, with reasonable suspicion of cardiac origin, despite optimal antianginal therapy (beta blocker and one additional antianginal medication, or necessary alternatives, as tolerated by side effects and vital signs), with non-invasive findings that are low risk (Fihn 2012; Fihn 2014; Patel 2012)
  - New, worsening, or limiting symptoms, with a history of prior unrevascularized significant or severe CAD, and the patient is eligible for coronary revascularization. (Fihn 2012; Fihn 2014)
  - Patients with suspected symptomatic CAD, who cannot undergo stress testing or CCTA, when there is a high likelihood that the findings will affect therapy (Fihn 2012; Fihn 2014; Montalescot 2013)
  - Asymptomatic or controlled symptoms, with unevaluated high risk non-invasive findings (Patel 2012)
Heart Failure and Left Ventricular Dysfunction/Abnormality

- New heart failure/ cardiomyopathy/wall motion abnormality, in patients who would be eligible for coronary revascularization or more aggressive coronary management:
  (Yancy 2013; Wolk 2013; Patel 2012; Patel 2013; Fihn 2012)
  
  o Newly recognized reduction in ejection fraction to ≤40%, with one of the following:
    - Any coronary risk factors, including age >45 in men, >55 in women
    - Symptoms or signs of ischemia
    - Evidence of ischemia (or hibernating myocardium) on non-invasive testing or ECG
    - Known history of significant CAD
  
  o Newly recognized reduction in ejection fraction to 41-49% and one of following:
    - Symptoms of or signs of ischemia
    - Evidence of ischemia on non-invasive testing or ECG
    - Known history of significant CAD
  
  o Symptomatic from HF and/or ischemia with new, unexplained, (≥ 5%) significant wall motion abnormality and normal ejection fraction (Patel 2012, Fihn 2012)
  
  o Structural abnormality (severe secondary MR or a VSD) with reason to suspect ischemic origin
  
  o Deterioration in clinical status of heart failure or cardiomyopathy requiring invasive evaluation for guidance and/or alteration in therapy, with reasonable likelihood and candidacy for coronary revascularization
  
  o Clarification of the diagnosis of myocarditis versus acute/subacute coronary syndrome (Cooper 2018)
  
  o When non-invasive coronary evaluation has been nondiagnostic or has not been feasible, and reasonable likelihood of CAD has been provided (Colucci 2018)
  
  o Diastolic heart failure, when symptoms, signs, or stress imaging provide evidence of contributory ischemia. (Borlaug 2018)

Ventricular Arrhythmias

- Ventricular Arrhythmias, without otherwise known explanatory diagnosis:
  
  o Following recovery from unexplained sudden cardiac arrest. (Al-Khatib 2017)
  
  o Significant ventricular arrhythmia such as sustained VT or VF (Patel 2012)
  
  o Exercise-induced nonsustained VT in a patient at significant risk for CAD, based upon signs or symptoms of ischemia (Patel 2012)

Prior to Non-Coronary Intervention and Cardiac Surgery

- Evaluation of coronary anatomy, with consideration of coronary revascularization, prior to cardiac surgical or transcatheter interventions (upon cardiac valves, great vessels/thoracic aorta, congenital disease, pericardial disease) in patients with any of the following:
  
  o Symptoms of angina
  
  o Objective evidence of ischemia
  
  o Decreased LV systolic function (EF < 50%)
  
  o History of CAD
  
  o Coronary risk factors, including men > 40 and postmenopausal women
  
  o Non-invasive data that is inconclusive or showing evidence of ischemia or clinically significant CAD (≥ 50% or FFR-CT ≤ 0.8) (Douglas 2016)
- Chronic severe secondary mitral regurgitation
- Requirement for more detailed assessment of coronary anomalies prior to aortic valve homograft surgery
- Requirement for better assessment of the origin of the coronary arteries than non-invasive data could provide, when prior to a pulmonary autograft (Ross procedure) or root procedure

**Indications Post Cardiac Transplantation**  
(Gustafsson 2018)

- Assessment for allograft vasculopathy on an annual basis for the first 5 years, followed by annual assessment in those with evidence of documented allograft vasculopathy, renal function permitting; estimated glomerular filtration rate (eGFR) ≥30 to 40 mL/min/1.73 square meter body surface area
- Assessment of change in clinical status, any one of the following:
  - Left ventricular dysfunction that has developed, but is not explained by graft dysfunction
  - Symptoms of angina/myocardial ischemia
  - Non-invasive findings of ischemia
- Annual assessment following diagnosis of allograft vasculopathy

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**Special Indications for Hemodynamic Assessment**

- Indications for angiographic and/or hemodynamic assessment of valvular function (Doherty 2017; Patel 2012)
  - Assessment of bioprosthetic valve when transthoracic echocardiography (TTE) and transesophageal electrocardiography (TEE) were inadequate, and cardiac magnetic resonance (CMR) and cardiac computed tomography (CCT) are not available
  - Assessment of mechanical valve prostheses when TTE and TEE are inadequate, CCT is not available, and fluoroscopy is not sufficient
  - Discordance between non-invasive data and clinical impression of severity of valvular disease
  - Evaluation of indeterminate shunt anatomy or shunt flows/ratio

- Indications for Hemodynamic Assessment Only (Patel 2012)
  - Assessment of pericardial hemodynamics and distinction from restrictive physiology
  - Assessment of pulmonary hypertension and when non-invasive data provides inadequate information for its management
  - Assessment of pulmonary hypertension response to intravenous drug therapy.
  - Assessment of hemodynamics in heart failure, valvular disease, or cardiomyopathy, when
    - Non-invasive data is discordant or conflicts with the clinical presentation
    - Non-invasive data is inadequate for clinical management

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**ADDITIONAL INFORMATION**

**Angina Symptoms**
Persistent symptoms indicative of CAD can include chest discomfort, arm or jaw symptoms thought to be ischemia related, and symptoms considered an anginal equivalent.

**Anginal Equivalent**
Development of an anginal equivalent (e.g. shortness of breath, fatigue, or weakness) either with or without prior coronary revascularization should be based upon the documentation of reasons to suspect that symptoms other than chest discomfort are not due to other organ systems (e.g. dyspnea due to lung
disease, fatigue due to anemia, etc.), by presentation of clinical data such as respiratory rate, oximetry, lung exam, etc. (as well as d-dimer, chest CT or CTA, and/or pulmonary function tests (PFTs) when appropriate), and then incorporated into the evaluation of coronary artery disease as would chest discomfort. Syncope by itself is not considered an anginal equivalent (Moya 2009; Shen 2017; Fihn 2012).

The Three Types of Chest Pain or Discomfort and Pretest Probability of CAD

- **Typical Angina (Definite)** is defined as including all 3 characteristics:
  1) Substernal chest pain or discomfort with characteristic quality and duration
  2) Provoked by exertion or emotional stress
  3) Relieved by rest and/or nitroglycerine

- **Atypical Angina (Probable)** has only 2 of the above characteristics

- **Nonanginal Chest Pain/Discomfort** has only 0-1 of the above characteristics

- Once the type of chest pain has been established from the medical record, the Pretest Probability of obstructive CAD is estimated from the **Diamond Forrester Table** below, recognizing that in some cases multiple additional coronary risk factors could increase pretest probability (Wolk 2013; Fihn 2012).

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Gender</th>
<th>Typical/Definite Angina Pectoris</th>
<th>Atypical/Probable Angina Pectoris</th>
<th>Nonanginal Chest Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=39</td>
<td>Men</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Very low</td>
<td>Very low</td>
</tr>
<tr>
<td>40–49</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>50–59</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>&gt;=60</td>
<td>Men</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>High</td>
<td>Intermediate</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

- **Very low**: < 5% pretest probability of CAD, usually not requiring stress evaluation
- **Low**: 5-10% pretest probability of CAD
- **Intermediate**: 10% - 90% pretest probability of CAD
- **High**: > 90% pretest probability of CAD
  (Fihn 2012)

**Coronary Risk Categories Derived from Non-invasive Testing**
(Fihn 2012; Patel 2017)

**High risk (>3% annual death or MI)**
1. Severe resting left ventricular (LV) dysfunction (LVEF <35%) not readily explained by noncoronary causes
2. Resting perfusion abnormalities ≥10% of the myocardium in patients without prior history or evidence of myocardial infarction (MI)
3. Stress ECG findings including ≥2 mm of ST-segment depression at low workload or persisting into recovery, exercise-induced ST-segment elevation, or exercise-induced ventricular tachycardia (VT)/ventricular fibrillation (VF)
4. Severe stress-induced left ventricular (LV) dysfunction (peak exercise LVEF <45% or drop in LVEF with stress ≥10%)
5. Stress-induced perfusion abnormalities encumbering ≥10% myocardium or stress segmental scores indicating multiple vascular territories with abnormalities
6. Stress-induced LV dilation
7. Inducible wall motion abnormality (involving >2 segments or 2 coronary beds)
8. Wall motion abnormality developing at low dose of dobutamine (#10 mg/kg/min) or at a low heart rate (<120 beats/min)
9. Coronary artery calcium (CAC) score >400 Agatston units (only for use in primary prevention, not for heart cath decision making) (Patel 2012; Fihn 2012; Montalescot 2013; Goff 2014)
10. Multivessel obstructive CAD (≥70% stenosis) or left main stenosis (≥50% stenosis) on CCTA

Intermediate risk (1% to 3% annual death or MI)
1. Mild/moderate resting LV dysfunction (LVEF 35% to 49%) not readily explained by noncoronary causes
2. Resting perfusion abnormalities in 5% to 9.9% of the myocardium in patients without a history or prior evidence of MI
3. ≥1 mm of ST-segment depression occurring with exertional symptoms
4. Stress-induced perfusion abnormalities encumbering 5% to 9.9% of the myocardium or stress segmental scores (in multiple segments) indicating 1 vascular territory with abnormalities but without LV dilation
5. Small wall motion abnormality involving 1 to 2 segments and only 1 coronary bed
6. CAC score 100 to 399 Agatston units (only for use in primary prevention, not for heart cath decision making) (Patel 2012; Fihn 2012; Montalescot 2013; Goff 2014)
7. One vessel CAD with ≥70% stenosis or moderate CAD stenosis (50% to 69% stenosis) in ≥2 arteries on CCTA

Low risk (<1% annual death or MI)
1. Low-risk treadmill score (score ≥5) or no new ST segment changes or exercise-induced chest pain symptoms; when achieving maximal levels of exercise
2. Normal or small myocardial perfusion defect at rest or with stress encumbering <5% of the myocardium (Note: Although the published data are limited, patients with these findings will probably not be at low risk in the presence of either a high-risk treadmill score or severe resting LV dysfunction (LVEF <35%)
3. Normal stress or no change of limited resting wall motion abnormalities during stress
4. CAC score <100 Agatston units (only for use in primary prevention, not for heart cath decision making) (Patel 2012; Fihn 2012; Montalescot 2013; Goff 2014)
5. No coronary stenosis >50% on CCTA
Abbreviations

CAC    coronary artery calcium
CAD    coronary artery disease
CCT    cardiac computed tomography
CCTA   coronary computed tomographic angiography
CMR    cardiac magnetic resonance
LV     left ventricular
LVEF   left ventricular ejection fraction
MI     myocardial infarction
MR     mitral regurgitation
TAVR   transcatheter aortic valve replacement
TTE    transthoracic echocardiography
TEE    transesophageal echocardiography
VT     ventricular tachycardia
VF     ventricular fibrillation
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Gustafsson F. Diagnosis and prognosis of cardiac allograft vasculopathy. UpToDate. Waltham, MA: March, 2018. Available at: http://www.uptodate.com/contents/diagnosis-and-prognosis-of-cardiac-allograft-vasculopathy?source=machineLearning&search=transplant+vasculopathy+follow+up&selectedTitle=1%7E150&sectionRank=1&anchor=H12357202#H12357202 Retrieved May 1, 2018


