

<b>National Imaging Associates, Inc.*</b>	
<b>Clinical Guidelines</b> <b>STRESS ECHOCARDIOGRAPHY</b>	<b>Original Date: February 2010</b>
<b>CPT Codes: 93350, 93351, +93320, +93321, +93325, +93352, +93356</b>	<b>Last Revised Date: March 2020</b>
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## INDICATIONS for STRESS ECHO

### GENERAL INFORMATION

It is an expectation that all patients receive care/services from a licensed clinician. All appropriate supporting documentation, including recent pertinent office visit notes, laboratory data, and results of any special testing must be provided. All prior relevant imaging results, and the reason that alternative imaging cannot be performed must be included in the documentation submitted.

### SUSPECTED CORONARY ARTERY DISEASE (CAD)

#### Symptomatic patients without known CAD (use Diamond Forrester table)

- Low or intermediate pretest probability, and electrocardiogram (ECG) is uninterpretable
- High pretest probability
- Repeat testing in patient with new or worsening symptoms and negative result at least one year ago AND meets one of the criteria above

#### Asymptomatic patients without known CAD

- Evidence of possible myocardial ischemia which was not seen on prior EKG including but not limited to:
  - Ischemic ST segment or T wave abnormalities (See Overview Section)
  - Q waves
  - Complete left bundle branch block

### INCONCLUSIVE CAD EVALUATION WITHIN THE PAST 2 YEARS AND OBSTRUCTIVE CAD REMAINS A CONCERN

- Exercise stress ECG with low risk Duke treadmill score  $\geq 5$ , but patient's current symptoms indicate an intermediate or high pretest probability
- Exercise stress ECG with an intermediate Duke treadmill score

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- Intermediate coronary computed tomography angiography (CCTA) defined as:
  - 30 -70% lesion

## **FOLLOW-UP OF PATENTS POST CORONARY REVASCULARIZATION (PCI or CABG)**

(Doherty, 2019)

- Asymptomatic follow-up stress imaging (MPI or SE), at a minimum of 2 years post coronary artery bypass grafting (CABG), or percutaneous coronary intervention (PCI), whichever is later, is appropriate for patients with a history of silent ischemia or a history of a prior left main stent (Wolk, 2014)  
OR
- For patients with high occupational risk including any of the following:
  - Associated with public safety
  - Airline and boat pilots
  - Bus and train drivers
  - Bridge and tunnel workers/toll collectors
  - Police officers and firefighters
- New, recurrent, or worsening symptoms post coronary revascularization is an indication for stress imaging

## **FOLLOW-UP OF KNOWN CAD**

- **Routine follow-up of asymptomatic or stable symptoms** when last invasive or non-invasive assessment of coronary disease showed hemodynamically significant CAD (ischemia on stress test or FFR  $\leq$  0.80 or stenosis greater than or equal to 70% of a major vessel), over two years ago without intervening coronary revascularization, is an appropriate indication for stress imaging (MPI or SE)

## **SPECIAL DIAGNOSTIC CONDITIONS REQUIRING CORONARY EVALUATION**

- Prior acute coronary syndrome (with documentation in MD notes), within last three months, without a prior stress test or coronary angiography performed since that time
- Newly diagnosed systolic heart failure (EF < 50%), when invasive coronary angiography has not been performed, especially when symptoms or signs of ischemia are present or suspected such as:
  - Chest pain
  - EKG changes such as new ST segment depression or T wave inversions
  - New wall motion abnormalities
- Ventricular arrhythmias:
  - Sustained ventricular tachycardia (VT) > 100 bpm, ventricular fibrillation (VF), or exercise induced VT, when invasive coronary arteriography has not been performed (Al-Khatib, 2018)
  - Nonsustained VT, multiple episodes, each  $\geq$  3 beats at  $\geq$  100 bpm, frequent VPC's (defined as greater than or equal to 30/hour on remote monitoring), when an exercise ECG cannot be performed (Zimetbaum, 2018)

- Prior to Class IC antiarrhythmic drug initiation (Propafenone or Flecainide), in intermediate and high global risk patients (Reiffel, 2015)
- Hemodynamic Assessment of ischemia in one of the following documented conditions:
  - Anomalous coronary arteries in an asymptomatic individual without prior stress echocardiography (Grani, 2017);
  - Myocardial bridging of a coronary artery (perform with exercise stress) (Tang, 2011);
- Coronary aneurysms in Kawasaki's disease (McCrindle, 2017)
- Following radiation therapy to the anterior or left chest, at 5 years post initiation and every 5 years thereafter (Lancellotti, 2013)

## CHRONIC VALVULAR DISEASE

### Evaluation with Inclusion of Doppler

(Baumgartner, 2017; Bonow, 2020; Nishimura, 2014; Steiner, 2017)

- 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 / low gradient, and ejection fraction < 50%
- Exercise echo Doppler evaluation for mitral stenosis (MS) if there is:
  - Exertional shortness of breath which suggests the amount of MS is worse than is seen on the resting echocardiogram
- Exercise echo Doppler evaluation for mitral regurgitation (MR) if there is:
  - Exertional shortness of breath which suggests the amount of MR is worse than is seen on the resting echocardiogram; **OR**
  - The echocardiogram is not able to distinguish whether the MR is moderate or severe in a patient that is asymptomatic

### PRIOR TO ELECTIVE NON-CARDIAC SURGERY

(Fleischer, 2014; Patel, 2015)

- Patients who would otherwise not be planned for a non-invasive coronary evaluation, but are referred for preoperative cardiac evaluation, are eligible for SE if **ALL 4** criteria are met:
  - Surgery is supra-inguinal vascular, intrathoracic, or intra-abdominal; **AND**
  - The patient has **at least one** of these additional cardiac complication risk factors:
    - Ischemic Heart Disease
    - History of stroke or transient ischemic attack (TIA)
    - History of congestive heart failure (CHF) or ejection fraction  $\leq$  35%
    - Insulin-requiring diabetes mellitus
    - Creatinine  $\geq$  2.0 mg/dl

#### **AND**

- The patient has limited functional capacity (< 4 metabolic equivalents) such as one of the following (would likely be requested as MPI):
  - Cannot take care of their ADLs which include but not limited to:
    - Independently eating, bathing or ambulating
    - Cannot walk 2 blocks on level ground

- Cannot climb 1 flight of stairs

**AND**

- There has not been a conclusive stress evaluation, CTA, or heart catheterization within the past year, and the results would be likely to preclude proceeding with the intended surgery
- Planning for solid organ transplantation (liver or kidney), is an indication for preoperative dobutamine SE, if there has not been a conclusive stress evaluation, CTA, or heart catheterization within the past year and **with  $\geq 3$**  of the following risk factors (Lentine, 2012):
  - Age > 60
  - Smoking
  - Hypertension
  - Dyslipidemia
  - Left ventricular hypertrophy
  - > 1 year on dialysis (for renal transplant patients)
  - Diabetes mellitus
  - Prior ischemic heart disease

## **POST CARDIAC TRANSPLANTATION**

- Annually, for the first five years post cardiac transplantation, in a patient not undergoing invasive coronary arteriography
- After the first five years post cardiac transplantation, patients with transplant coronary vasculopathy can be screened annually with **ONE** of the following:
  - MPI
  - SE
  - Left heart catheterization

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### **BACKGROUND:**

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 potential significant coronary artery disease (CAD).

While drug-induced stress with dobutamine can be an alternative to exercise stress testing in patients who are unable to exercise, this guideline does not require use of this modality. Hence, reference in this document to SE predominantly refers to exercise stress echocardiography.

Although SE provides comparable accuracy without radiation risk, relative to myocardial perfusion imaging (MPI), scenarios which do not permit effective use of SE might be better suited for stress imaging with MPI, cardiovascular magnetic resonance imaging (CMR) or positron emission tomography (PET), or coronary computed tomography angiography (CCTA).

**Stable patients without known CAD** fall into 2 categories:

(Fihn, 2012; Montalescot, 2013; Wolk, 2013)

- **Asymptomatic patients**, for whom Global Risk of CAD events can be determined from coronary risk factors using calculators available online (see Websites for Global Cardiovascular Risk Calculators section)
- **Symptomatic patients**, for whom we estimate the Pretest Probability that their chest-related symptoms are due to clinically significant CAD (see below):

**The 3 Types of Chest Pain or Discomfort:**

- **Typical Angina (Definite)** is defined as including all **3** of these characteristics:
  - Substernal chest pain or discomfort with characteristic quality and duration such as
    - Pressure-like
    - Radiating
    - Dull or aching
  - Provoked by exertion or emotional stress
  - 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 (Fihn, 2012; Wolk, 2013):

**Diamond Forrester Table**

Age (Years)	Gender	Typical/Definite Angina Pectoris	Atypical/Probable Angina Pectoris	Nonanginal Chest Pain
≤ 39	Men	Intermediate	Intermediate	Low
	Women	Intermediate	Very low	Very low
40 – 49	Men	High	Intermediate	Intermediate
	Women	Intermediate	Low	Very low
50 – 59	Men	High	Intermediate	Intermediate
	Women	Intermediate	Intermediate	Low
≥ 60	Men	High	Intermediate	Intermediate
	Women	High	Intermediate	Intermediate

- **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

**OVERVIEW**

MPI may be performed without diversion to SE in any of the following (Henzlova, 2016; Wolk, 2013):

- Inability to exercise
  - Physical limitations precluding ability to exercise for at least 3 full minutes of Bruce protocol
  - 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
- Other Comorbidities
  - 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 (and clinical urgency not to delay MPI)
    - ECG and Echo Related Baseline Findings
  - Prior cardiac surgery (coronary artery bypass graft or valvular)
  - Obesity with body mass index (BMI) over 40 kg/m<sup>2</sup> or documented poor acoustic imaging window
  - Left ventricular ejection fraction ≤ 40%
  - Pacemaker or ICD
  - Persistent atrial fibrillation
  - Resting wall motion abnormalities that would make SE interpretation difficult
  - Complete LBBB
- Risk related scenarios
  - High pretest probability in suspected CAD
  - Intermediate or high global risk in patients requiring type IC antiarrhythmic drugs (prior to initiation of therapy)
  - Arrhythmia risk with exercise

### **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 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 or intermediate pretest probability patient who is able to exercise and has an interpretable ECG
- The (asymptomatic) high global risk patient who can exercise and has an interpretable ECG
- The patient who is under evaluation for exercise induced arrhythmia (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 (Mark, 1987)**

Calculates risk from ECG treadmill alone:

- The equation for calculating the Duke treadmill score (DTS) is:  $DTS = \text{exercise time in minutes} - (5 \times \text{ST deviation in mm or } 0.1 \text{ mV increments}) - (4 \times \text{exercise angina score})$ , 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  $\geq + 5$ ), 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):

- ST segment depression 1 mm or more; (not for non-specific ST- T wave changes)
- Ischemic looking T wave -- at least 2.5 mm inversions (excluding V1 and V2)
- LVH, pre excitation pattern such as WPW, a ventricular paced rhythm, or left bundle branch block
- Digitalis use
- Resting HR under 50 bpm on a medication, such as beta-blockers or calcium channel blockers, that is required for patient's treatment and cannot be stopped, with an anticipated suboptimal workload

### **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. There are rare exemptions, such as patients requiring IC antiarrhythmic drugs, who might require coronary risk stratification prior to initiation of the drug, or patients with a CAC score  $> 400$  Agatston units, 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%.

### **Websites for Global Cardiovascular Risk Calculators\***

\*Patients who have known CAD are already at high global risk and are not applicable to the calculators (Arnet, 2019; D'Agostino, 2008; Goff, 2014; McClelland, 2015; Ridker, 2007).

Risk Calculator	Link to Online Calculator
Framingham Cardiovascular Risk	<a href="https://reference.medscape.com/calculator/framingham-cardiovascular-disease-risk">https://reference.medscape.com/calculator/framingham-cardiovascular-disease-risk</a>
ACC/AHA Risk Calculator	<a href="http://tools.acc.org/ASCVD-Risk-Estimator/">http://tools.acc.org/ASCVD-Risk-Estimator/</a>
MESA Risk Calculator With addition of Coronary Artery Calcium Score, for CAD- only risk	<a href="https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx">https://www.mesa-nhlbi.org/MESACHDRisk/MesaRiskScore/RiskScore.aspx</a>

### Definitions of Coronary Artery Disease

(Fihn, 2012; Mintz, 2016; Montalescot, 2013; Patel, 2017; Tobis, 2007)

- 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
- 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.
- Ischemia-producing disease (also called hemodynamically or functionally significant disease, for which revascularization might be appropriate), generally implies at least one of the following:
  - Suggested by percentage diameter stenosis  $\geq 70\%$  by angiography; borderline lesions are 40 - 70% (Fihn, 2012; Tobis, 2007)
  - 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; Lofti, 2018; Mintz, 2016)
  - FFR (fractional flow reserve)  $\leq 0.80$  for a major vessel (Lofti, 2018; Mintz, 2016)
  - iFR (instantaneous wave-free ratio)  $\leq 0.89$  for a major vessel (Davies, 2017; Gotberg, 2017; Lofti, 2018)
- A major vessel would be a coronary vessel that would be amenable to revascularization, if indicated. This assessment is made based on the diameter of the vessel and/or the extent of myocardial territory served by the vessel
- 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.
- iFR (instantaneous wave-free ratio)  $\leq 0.89$  for a major vessel (Davies, 2017; Gotberg, 2017)

### Anginal Equivalent

(Fihn, 2012; Moya, 2009; Shen, 2017)

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. This may include 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

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
LVEF	Left ventricular ejection fraction
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	Stress echocardiography
VT	Ventricular tachycardia
VF	Ventricular fibrillation
WPW	Wolf Parkinson White

## POLICY HISTORY:

**Review Date:** July 23, 2019

### Review Summary:

- Stress echo for suspected CAD deleted the following indication: Repeat testing in patient with recurrent symptomatic presentation and negative result over 2 years ago
- Added indications: 'For assessment of hemodynamic significance due to atherosclerosis or following radiation therapy to the anterior or left chest, at 5 years post initiation inception of radiation and every 5 years thereafter'; and 'Following radiation therapy to the anterior or left chest, at 5 years post initiation inception of radiation and every 5 years thereafter'
- Removed secondary mitral regurgitation indication under doppler evaluation section
- Clarified indication as follows: Routine follow-up of asymptomatic or stable symptoms when last invasive or non-invasive assessment of coronary disease showed hemodynamically significant CAD (ischemia on stress test or FFR less than or equal to 0.80 or stenosis greater than or equal to 70% of a major vessel) over two years ago without intervening coronary revascularization is an appropriate indication for stress imaging (MPI or SE) in patients if it will alter management

November 2019

- Added CPT code +93356

**Review Date:** March 2020

**Review Summary:**

- Added general information section as Introduction which outlines requirements for documentation of pertinent office notes by a licensed clinician, and inclusion of laboratory testing and relevant imaging results for case review
- Added clarification of repeat testing in a patient with new or worsening symptoms and negative result at least one year prior to include the statement “AND meets one of the criteria above”
- Added clarification of frequent PVCs under ventricular arrhythmias which states defined as greater than or equal to 30/hour to include “on remote monitoring”
- Edited indication of planning for solid organ transplantation to remove the requirement of limited functional capacity but maintaining requirement of  $\geq 3$  listed risk factors
- Added edits to the Coronary Artery Disease definition section
- Updated and added new references

**Review Date:** August, 2020

**Review Summary:**

- For asymptomatic patients without a history of CAD, the wording for previously unevaluated was changed for Q waves and complete BBB
- For newly diagnosed systolic heart failure (EF < 50%), when invasive coronary angiography has not been performed, especially when symptoms or signs of ischemia are present or suspected were further defined to state such as:
  - Chest pain
  - EKG changes such as new ST segment depression or T wave inversions
  - New wall motion abnormalities
- Stress echo with Doppler indication further defined as exertional shortness of breath which suggests the amount of MS is worse than is seen on the resting echocardiogram
- After the first five years post cardiac transplantation, patients with transplant coronary vasculopathy can be screened annually with ONE of the following:
  - MPI
  - SE
  - Left heart catheterization

## REFERENCES

- Acampa W, Assante R, Zampella E. The role of treadmill exercise testing in women. *J Nucl Cardiol*. 2016 Oct; 23(5):991-996.
- Al-Khatib SM, Stevenson WG, Ackerman MUJ, et al. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. *JACC*. 2018; 72(14):e91-e220.
- Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, Himmelfarb CD, Khera A, Lloyd-Jones D, McEvoy JW, Michos ED, Miedema MD, Muñoz D, Smith SC Jr, Virani SS, Williams KA Sr, Yeboah J, Ziaeian B. 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines *J Am Coll Cardiol*. 2019; 74:e177–232.
- Baumgartner H, Falk V, Bax JJ et al. 2017 ESC/EACTS guidelines for the management of valvular heart disease, The Task Force for the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Euro Heart J*. 2017; 38: 2739–2791.
- Bonow RO, O’Gara PT, Adams DH, et al. 2020 Focused Update of the 2017 ACC Expert Consensus Decision Pathway on the Management of Mitral Regurgitation. *J Am Coll Cardiol*. Epub 2020 Feb 14.
- Cha Y, Lee GK, Klarich KW, et al. Advances in Arrhythmia and Electrophysiology. Premature Ventricular Contraction-Induced Cardiomyopathy, A Treatable Condition. *Circulation: Arrhythmia and Electrophysiology*. 2012; 5:229-236. Available at: <http://circep.ahajournals.org/content/5/1/229.full>
- Crea F, Camici PG, Merz CN. Coronary microvascular dysfunction: an update. *Euro Heart J*. 2013; 35(17):1101–1111. Available at: <http://eurheartj.oxfordjournals.org/content/early/2013/12/21/eurheartj.eht513>
- D’Agostino RB Sr, Vasan RS, Pencina MJ, et al. General Cardiovascular Risk Profile for Use in Primary Care: The Framingham Heart Study. *Circulation*. 2008; 117:743-753.
- Doherty JU, Kort S, Mehran R. et al. ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/STS 2017 Appropriate Use Criteria for Multimodality Imaging in Valvular Heart Disease. A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. *JACC*. 2017; 70(13):1647-1672.

Doherty JU, Kort S, Mehran R, et al. ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/STS 2019 Appropriate Use Criteria for Multimodality Imaging in the Assessment of Cardiac Structure and Function in Nonvalvular Heart Disease : A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and the Society of Thoracic Surgeons. *J Nucl Cardiol*. 2019; 26(4):1392-1413.

Douglas PS et al. ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 Appropriate Use Criteria for Echocardiography. *J Am Soc Echocardiography*. 2011; 24:229-67.

Einstein, A. Effects of radiation exposure from cardiac imaging: how good are the data? *Journal of the American College of Cardiology*. 2012; 59(6):553-565. Available at: <http://content.onlinejacc.org/cgi/content/short/59/6/553>

Fazel R, Dilsizian V, Einstein, AJ, et al. ASNC INFORMATION STATEMENT, Strategies for defining an optimal risk-benefit ratio for stress myocardial perfusion SPECT. *Journal of Nuclear Cardiology*. Published Online: 24 March 2011:1-8. Available at: <https://www.asnc.org/files/Optimal%20Risk-Benefit%20Ratio%20for%20SPECT.pdf>

Fihn SD, Gardin JM, Abrams J, et al. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the diagnosis and management of patients with stable ischemic heart disease: A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. *Circulation*. 2012; 126(25): e354-471.

Fleischer LA, Fleischmann KE, Auerbach AD, et al. ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery. A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2014; 64(22): e77-e137. Available at: <http://content.onlinejacc.org/article.aspx?articleid=1893784>

Fleischmann KE, Hunink MG, Kuntz KM, et al. Exercise echocardiography or exercise SPECT imaging? A meta-analysis of diagnostic test performance. *JAMA*. 1998; 280:913-20.

Gerhard-Herman MD, Gornik HL, Barrett C, et al. 2016 AHA/ACC Guideline on the Management of Patients with Lower Extremity Peripheral Artery Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *JACC*. Nov 8, in press. Available at: [www.onlinejacc.org/content/early/2016/11/23/j.jacc.2016.11.007](http://www.onlinejacc.org/content/early/2016/11/23/j.jacc.2016.11.007)

Goff DC, Lloyd-Jones, DM, Bennett G, et al. 2013 ACC/AHA Guideline on the Assessment of Cardiovascular Risk, A Report of the American College of Cardiology/American Heart Association Task

Force on Practice Guidelines Endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation, American Society for Preventive Cardiology, American Society of Hypertension, Association of Black Cardiologists, National Lipid Association, Preventive Cardiovascular Nurses Association, and Women Heart: The National Coalition for Women With Heart Disease. *JACC*. 2014; 63(25): 2935-2959.

Grani C, Buechel RR, Kaufmann PA, et al. Multimodality Imaging in Individuals with Anomalous Coronary Arteries. *JACC*. 2017; 10(4): 471-581.

Heijenbrok-Kal MH<sup>1</sup>, Fleischmann KE, Hunink MG. Stress echocardiography, stress single-photon-emission computed tomography and electron beam computed tomography for the assessment of coronary artery disease: a meta-analysis of diagnostic performance. *Am Heart J*. 2007 Sep; 154(3):415-23.

Henzlova MJ, Duvall WL, Einstein, AJ, et al, ASNC imaging guidelines for SPECT nuclear cardiology procedures: Stress, protocols, and tracers, *J Nucl Cardiol*. 2016; 23:606–39. Available at: <https://link.springer.com/content/pdf/10.1007/s12350-015-0387-x.pdf>

Hirshfeld JW, Ferrari VA, Bengel FM, et al. 2018 ACC/HRS/NASCI/SCAI/SCCT Expert Consensus Document on Optimal Use of Ionizing Radiation in Cardiovascular Imaging: Best Practices for Safety and Effectiveness A Report of the American College of Cardiology Task Force on Expert Consensus Decision Pathways Developed in Collaboration with Mended Hearts. *JACC*. in press, May, 2018: e1-e69. Available at: <http://www.onlinejacc.org/content/early/2018/04/30/j.jacc.2018.02.016>

Hussain MA, AlOomram M, Creager MA, et al. Antithrombotic Therapy for Peripheral Artery Disease, Recent Advances. *JACC*. 2018; 71(21):2450-2467.

Lancellotti P, Knomo VT, Badano LP, et al. Expert consensus for multi-modality imaging evaluation of cardiovascular complications of radiotherapy in adults: a report from the European Association of Cardiovascular Imaging and the American Society of Echocardiography. *European Heart Journal – Cardiovascular Imaging*. 2013; 14:721–740.

Lentine KL, Costa SP, Weir MR. Cardiac disease evaluation and management among kidney and liver transplantation candidates. *JACC*. 2012; 60(5); 434-480.

Lotfi A, Davies JE, Fearon WF, Grines CL, Kern MJ, Klein LW. Focused update of expert consensus statement: Use of invasive assessments of coronary physiology and structure: A position statement of the society of cardiac angiography and interventions. *Catheter Cardiovasc Interv*. 2018 Jul 3.

Mark DB, Hlatky MA, Harrell FE Jr, Lee KL, Califf RM, Pryor DB. (1987) Exercise treadmill score for predicting prognosis in coronary artery disease. *Ann Intern Med*; 106(6):793-800.

Marwick, TH. Stress echocardiography. *Heart*. 2003; 89(1): 113-118. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1767520/>

McCrinkle BW, Rowley AH, Newburger JW, et al. Diagnosis, treatment, and long-term management of Kawasaki disease: A scientific statement for health professionals from the American Heart Association. *Circulation*. 2017; 135(17): e927.

Metz, LD, Beattie, M, Hom, R, et al. The prognostic value of normal exercise myocardial perfusion imaging and exercise echocardiography: A meta-analysis. *JACC*. 2007; 49:227-237. Available at: <http://content.onlinejacc.org/cgi/reprint/49/2/227.pdf>

Miller TD, Askew JW, Anavekar NS. Noninvasive Stress Testing for Coronary Artery Disease. *Heart Fail Clin*. 2016; 12(1):65-82.

Mintz GS. IVUS in PCI Guidance. *Am Coll Cardiol*, (online website) June 13, 2016. Available at: <http://www.acc.org/latest-in-cardiology/articles/2016/06/13/10/01/ivus-in-pci-guidance>

Montalescot G., Sechtem U., Achenbach S., et al. 2013 ESC guidelines on the management of stable coronary artery disease: The Task Force on the management of stable coronary artery disease of the European Society of Cardiology. *European Heart Journal*. 2013; 34(38): 2949–3003. Available at: <https://academic.oup.com/eurheartj/article/34/38/2949/442952>

Moya A, Sutton R., Ammirati F, et al, Guidelines for the diagnosis and management of syncope. Task Force for the Diagnosis and Management of Syncope. *Euro Heart J*. 2009; 30: 2631–71. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3295536/>

Mukundan S, Travin MI, Levsky JM, et al. Does ischemic burden on stress testing influence patient survival in subjects with known severe multi-vessel CAD? *Am J Cardiovasc Dis*. 2017;7(2):48-52.

Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC Guideline for the Management of Patients with Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2014; 63(22): e57-e185.

Patel AY, Eagle KA., Vaishnava P. Cardiac Risk of Noncardiac Surgery. *J Am Coll Cardiol*. 2015; 66(19):2140-2148. Available at: <http://content.onlinejacc.org/article.aspx?articleid=2468532>.

Patel MR, Bailey SR, Bonow RO, et al. ACCF/SCAI/AATS/AHA/ASE/ASNC/HFSA/HRS/SCCM/SCCT/SCMR/STS 2012 Appropriate Use Criteria for Diagnostic Catheterization  
A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, Society for Cardiovascular Angiography and Interventions, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society of Critical Care Medicine,

Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. *JACC*. 2012; 59(22):1995-2027.

Patel MR, Calhoun JH, Dehmer GJ, et al. ACC/AATS/AHA/ASE/ASNC/SCAI/SCCT/STS 2017 Appropriate Use Criteria for Coronary Revascularization in Patients with Stable Ischemic Heart Disease. *JACC*. 2017; 69(17):2212-2241.

Patel MR, White RD, Abbara S, et al. 2013 ACCF/ACR/ASE/ASNC/SCCT/SCMR Appropriate Utilization of Cardiovascular Imaging in Heart Failure, A Joint Report of the American College of Radiology Appropriateness Criteria Committee and the American College of Cardiology Foundation Appropriate Use Criteria Task Force. *JACC*. 2013; 61(21): 2207-2231.

Pellikka PA, Nagueh SF, Elhendy AA, et al. American Society of Echocardiography Recommendations for Performance, Interpretation, and Application of Stress Echocardiography. *Journal of the American Society of Echocardiography*. 2007; 20(9):1021-41.

Reiffel JA, Camm AJ, Belardinelli L, et al. The HARMONY trial: Combined ranolazine and dronedarone in the management of paroxysmal atrial fibrillation: Mechanistic and therapeutic synergism. *Circ Arrhythm Electrophysiol*. 2015; 8(5):1048.

Ridker PM, Buring JE, Rifai N, et al. NIH Estimate of 10 Year coronary artery disease risk from Framingham Risk Score: Development and validation of improved algorithms for the assessment of global cardiovascular risk in women: the Reynolds Risk Score. *JAMA*. 2007; 297(6):611-619. Available at: <http://jama.jamanetwork.com/article.aspx?articleid=205528>

Schinkel AFL, Bax JJ, Geleijnse ML, et al. Noninvasive evaluation of ischaemic heart disease: myocardial perfusion imaging or stress echocardiography? *Euro Heart J*. 2003; 24(9):789–800. Available at: [https://doi.org/10.1016/S0195-668X\(02\)00634-6](https://doi.org/10.1016/S0195-668X(02)00634-6)

Scott-Moncrieff, A, Yang J, Levine D, et al. Real-world estimated effective radiation doses from commonly used cardiac testing and procedural modalities. *The Canadian Journal of Cardiology*. 2011; 27(5):613-618. Available at: [http://www.unboundmedicine.com/medline/ebm/record/21652170/abstract/Real\\_world\\_estimated\\_effective\\_radiation\\_doses\\_from\\_commonly\\_used\\_cardiac\\_testing\\_and\\_procedural\\_modalities](http://www.unboundmedicine.com/medline/ebm/record/21652170/abstract/Real_world_estimated_effective_radiation_doses_from_commonly_used_cardiac_testing_and_procedural_modalities)

Shen W, Sheldon RS, Benditt DG, et al. 2017 ACC/AHA/HRS Guideline for the Evaluation and Management of Patients with Syncope: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. *JACC*. 2017; 70(5):620-663.

Sicari R, Cortigiani L. The clinical use of stress echocardiography in ischemic heart disease. *Cardiovascular Ultrasound*. 2017; 15(7):1-16. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5361820/>.

Sicari, R. Stress echocardiography expert consensus statement, European Association of Echocardiography (EAE) (a registered branch of the ESC). *European Journal of Echocardiography*. 2008; 9:415–443. Available at:

[https://www.esccardio.org/static\\_file/Escardio/Subspecialty/EACVI/position-papers/eae-sicari-stress-echo.pdf](https://www.esccardio.org/static_file/Escardio/Subspecialty/EACVI/position-papers/eae-sicari-stress-echo.pdf).

Steiner J, Rodes-Cabau J, Holmes D et al. Mechanical intervention for aortic valve stenosis in patients with heart failure and reduced ejection fraction. *JACC*. 2017; 70(24):3026-3041. Available at: <http://www.onlinejacc.org/content/70/24/3026>.

Tang K, Wang L, Shi R, et al. The role of myocardial perfusion imaging in evaluating patients with myocardial bridging. *J Nucl Cardiol*. 2011; 18(1):117.

Tobis J, Azarbal B, Slavin L. Assessment of Intermediate Severity Coronary Lesions in the Catheterization Laboratory. *JACC*. 2007; 49(8):839-848.

Wolk MJ, Bailey SR, Doherty JU, et al. ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 Multimodality Appropriate Use Criteria for the Detection and Risk Assessment of Stable Ischemic Heart Disease A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. *Journal of the American College of Cardiology*. 2014;63(4): 380-406. Available at: <http://content.onlinejacc.org/article.aspx?articleid=1789799>

Yancy C, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA Guideline for the Management of Heart Failure, A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *JACC*. 2013; 62(16): e147-237.

Yao S, Qureshi E, Sherrid M, et al. Practical Application in Stress Echocardiography, Risk Stratification and Prognosis in Patients with Known or suspected Ischemic Heart disease. *JACC*. 2003; 42(6):1084–90.

Zhang Y, Li X, Segars WP, et al. Comparison of patient specific dose metrics between chest radiography, tomosynthesis, and CT for adult patients of wide-ranging body habitus. *Med. Phys*. 2014; 41(2): 1-12. Available at: [https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3985882/pdf/MPHYA6-000041-023901\\_1.pdf](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3985882/pdf/MPHYA6-000041-023901_1.pdf).

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