National Imaging Associates, Inc.*	
Clinical guidelines **MYOCARDIAL PERFUSION IMAGING** **(aka NUCLEAR CARDIAC IMAGING STUDY)**	**Original Date: October 2009**
CPT Codes: 78451, 78452, 78453, 78454, 78466, 78468, 78469, 78481, 78483, 78499	**Last Revised Date: March 2021**
Guideline Number: NIA_CG_024	**Implementation Date: January 2022**

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.

INDICATIONS for MPI

(Fihn 2012, Hendel 2009, Montalescot 2013, Wolk 2014)

SUSPECTED Coronary Artery Disease (CAD)

Symptomatic patients without known CAD (uUse Diamond Forrester Ttable)

- Low **or intermediate** pretest probability and unable to exercise
- ~~Intermediate pre-test probability with an uninterpretable ECG or unable to exercise (Wolk 2014)~~
- High pretest probability (Stress Echocardiogram [SE] diversion not required)
- Repeat testing in a patient with new or worsening symptoms and negative result at least one year prior AND meets one of the criteria above

Asymptomatic patients without known CAD (SE diversion not required)

- Previously unevaluated ECG evidence of possible myocardial ischemia including ischemic ST segment or T wave abnormalities (See Overview section)
- Previously unevaluated pathologic Q waves
- Previously unevaluated complete left bundle branch block

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- History of diabetes mellitus, > 40 years old, with calcium score >400 (Budoff, 2016)

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

- Exercise stress ECG with low--risk Duke treadmill score (≥5), (see **Overview**) but patient's current symptoms indicate an intermediate or high pretest probability (SE diversion not required for high pretest probability)
- Exercise stress ECG with an intermediate Duke treadmill score
- Intermediate coronary computed tomography angiography (CCTA) (e.g. 30 - 70% lesions)
- Non-diagnostic exercise stress test with inability to achieve target heart rate (THR)
- An indeterminate (equivocal, borderline, or discordant) evaluation by prior stress imaging (SE or CMR) within the past 2 years

FOLLOW-UP OF PATIENT'S POST CORONARY REVASCULARIZATION (PCI or CABG) (Wolk, 2014)

- **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 ~~only~~ 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 (e.g. 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 (MPI or SE), if it will alter management

FOLLOW-UP OF KNOWN CAD

- **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 ≤ 0.80 or stenosis ≥ 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

SPECIAL DIAGNOSTIC CONDITIONS REQUIRING CORONARY EVALUATION

- Prior acute coronary syndrome (with documentation in MD notes), without invasive or non-invasive coronary evaluation (SE diversion not required)

- Newly diagnosed systolic heart failure (EF < 50%) with symptoms or signs of ischemia unless invasive coronary angiography is immediately planned (SE diversion not required) (Fihn, 2012; Patel, 2013; Yancy, 2013)
- LVEF ≤ 50% requiring myocardial viability assessment to assist with decisions regarding coronary revascularization (Patel, 2013; Yancy, 2013)
- Ventricular arrhythmias
    - Sustained ventricular tachycardia (VT) > 100 bpm, ventricular fibrillation (VF), or ~~exercise~~ **exercise**-induced VT, when invasive coronary arteriography is not immediately planned (Al-Khatib 2018) (SE diversion not required)
    - Nonsustained VT, multiple episodes, each ≥ 3 beats at ≥ 100 bpm, or frequent PVCs (defined as greater than or equal to 30/hour on remote monitoring) without known cause or associated cardiac pathology, when an exercise ECG cannot be performed (Zimetbaum 2018)
- Prior to **initiation of** Class IC antiarrhythmic drug initiation (Propafenone or ~~Flecanide~~**Flecainide**~~),~~ **), as well as annually** in intermediate and high global risk patients (SE diversion not required) (Reiffel, 2015)
- Assessment of hemodynamic significance of one of the following documented conditions:
    - Anomalous coronary arteries (Grani, 2017)
    - Myocardial bridging of coronary artery
- Coronary aneurysms in Kawasaki's disease (Newburger, 2016) or due to atherosclerosis
- Following radiation therapy to the anterior or left chest, at 5 years post initiation and every 5 years thereafter (Lancellotti, 2013)

PRIOR TO ELECTIVE NON-CARDIAC SURGERY

- Patients who have no above indication for non-invasive coronary evaluation, but are referred for preoperative cardiac evaluation, are eligible for MPI if **all 4 criteria** are met:
    - Surgery is supra-inguinal vascular, intrathoracic, or intra-abdominal; **AND**
    - 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:
        - Unable to take care of their activities of daily living (ADLs) or ambulate
        - Unable to walk 2 blocks on level ground
        - Unable to 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 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 MPI, if there has not been a conclusive stress evaluation, CTA, or heart catheterization within the past year and with ≥ 3 of the following risk factors: (SE diversion not required) (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 TRANSPLANT (SE diversion not required)

- 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 documented transplant coronary vasculopathy can be screened annually **unless** ~~if~~ invasive coronary arteriography is ~~not~~ planned

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BACKGROUND

This guideline is for stress imaging, specifically myocardial perfusion imaging (MPI), with appropriate preference for alternatives, such as stress echocardiography (SE) or stress ECG alone when more suitable (see section below).

Radionuclide myocardial perfusion imaging (MPI) allows for evaluation of cardiac perfusion at rest and at exercise, as well as using pharmacologic agents for the diagnosis and management of coronary artery disease. With radionuclide MPI, pharmacologic stress may be performed with an inotropic agent or vasodilator. These agents are indicated for patients who cannot reach an adequate endpoint with physical exercise stress testing (Pagnanelli, 2017).

Stable patients without known CAD fall into 2 categories (Fihn, 2012; Montalescot, 2013; Wolk, 2013):

- **Asymptomatic**, 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,** for whom we estimate the pretest probability that their chest-related symptoms are due to clinically significant CAD (below):

The 3 Types of Chest Pain or Discomfort

- **Typical Angina (Definite)** is defined as including all **3** characteristics:
    - Substernal chest pain or discomfort with characteristic quality and duration
    - 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
- **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 METS) **such as one** of the following:
    - Unable to take care of their ADLs or ambulate
    - Unable to walk 2 blocks on level ground

- Unable to climb 1 flight of stairs

Other Comorbidities

- 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 (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/m2 or~~ Dd~~d~~ocumented poor acoustic imaging window
- Left ventricular ejection fraction ≤ 40%
- Pacemaker or ICD
- Persistent a~~A~~trial fibrillation
- Resting wall motion abnormalities that would make SE interpretation difficult
- Complete left bundle branch block (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 **and annually**)
- 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) require 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, 2014~~3~~):

- The (symptomatic) low or intermediate pretest probability patient who can exercise and has an interpretable ECG (Wolk, 2014)
- The patient who is under evaluation for exercise--induced arrhythmia
- The patient who requires an entrance stress test ECG for a cardiac rehab program or for an exercise prescription
- For the evaluation of syncope or presyncope during exertion (Shen, 2017)

Duke Exercise ECG Treadmill Score (Mark, 1987)
Calculates risk from ECG treadmill alone**:**

- The equation for calculating the Duke treadmill score (DTS) is: DTS = exercise time in minutes - (5 x ST deviation in mm or 0.1 mV increments) - (4 x 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):

- ST segment depression 1 mm or more; (not for non-specific ST- T wave changes)
- Ischemic looking T waves; at least 2.5 mm inversions (excluding V1 and V2)
- LVH with repolarization abnormalities, pre-excitation pattern such as WPW, ventricular paced rhythm, or LBBB
- Digitalis use with associated ST segment abnormalities

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 exceptions, 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*
(Arnett, 2019; D'Agostino, 2008; Goff, 2014; McClelland, 2015; Ridker, 2007)

*Patients who have already manifested cardiovascular disease are already at high global risk and are not applicable to the calculators.

Risk Calculator	Websites for Online Calculator
Framingham Cardiovascular Risk	https://reference.medscape.com/calculator/framingham-cardiovascular-disease-risk
Reynolds Risk Score Can use if no diabetes Unique for use of family history	http://www.reynoldsriskscore.org/

Pooled Cohort Equation	http://clincalc.com/Cardiology/ASCVD/PooledCohort.aspx?example
ACC/AHA Risk Calculator	http://tools.acc.org/ASCVD-Risk-Estimator/
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; Mintz, 2016; Montalescot, 2013; Patel, 2017)

Percentage stenosis refers to the reduction in diameter stenosis when angiography is the method and can be estimated or measured using angiography or more accurately measured with intravascular ultrasound (IVUS).

- 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 ≥ 70% by angiography; borderline lesions are 40 - 70% (Fihn, 2012)
    - For a left main artery, suggested by a percentage stenosis ≥ 50% (Fihn, 2012; Lofti, 2018; Mintz, 2016)
    - FFR (fractional flow reserve) ≤ 0.80 for a major vessel (Lofti, 2018; Mintz, 2016)
    - Demonstrable ischemic findings on stress testing (ECG or stress imaging), that are at least mild in degree
- FFR (fractional flow reserve) is the distal to proximal pressure ratio across a coronary lesion. Less than or equal to 0.80 is considered a significant reduction in coronary flow.

Anginal Equivalent
(Fihn, 2012; 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

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

Date	Summary
March 2021	• Wording changes for low and intermediate pretest probability patients • Added annual studies for patients on Flecainide • Added indication for Ca score in diabetic > 40 and calcium score > 400 with reference added • Removed BMI > 40 as indication for MPI
March 2020	• 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 ≥ 3 listed risk factors

	• Removed explanation of three vasodilators approved for stress testing from the background • Added edits to the Coronary Artery disease definition section • Updated and added new references
July 2019	• For special diagnostic consideration, prior acute coronary syndrome (as documented in MD notes), the following clause was added: 'without subsequent invasive or non-invasive coronary evaluation (SE diversion not required)' • For section on prior to elective non-cardiac surgery the following was added: 'There has not been a conclusive stress evaluation, CTA, or heart catheterization within the past year' • For section on prior to elective non-cardiac surgery indication 'Planning for solid organ transplantation is an indication for preoperative MPI, if there has not been a conclusive stress evaluation, CTA, or heart catheterization within the past year' • Added indication for follow-up every 2 years for patients with known CAD in high-risk occupations • Added prior left main stent in asymptomatic patients as follow-up every two years • Clarification of diversion to stress echo in suitable patients' post-revascularization • Clarification of post cardiac transplant • Removed section on Global Risk Calculator • Added "with EKG changes," as indication for stress echo in patients on digoxin or with LVH • Removed indication for ETT in asymptomatic patients • Added presyncope and syncope with exercise as an indication for ETT

~~July 23, 2019~~

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- ~~Added prior left main stent in asymptomatic patients as follow-up every two years~~
- ~~Clarification of diversion to stress echo in suitable patients~~patients' ~~post-revascularization~~

- Clarification of post cardiac transplant
- Removed section on Global Risk Calculator
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