

**American College of Radiology  
ACR Appropriateness Criteria®  
Chest Pain-Possible Acute Coronary Syndrome**

**Variant 1: Chest pain, low to intermediate probability for acute coronary syndrome. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CTA coronary arteries with IV contrast	Usually Appropriate	⊕⊕⊕
Radiography chest	Usually Appropriate	⊕
SPECT or SPECT/CT MPI rest and stress	Usually Appropriate	⊕⊕⊕⊕
US echocardiography transthoracic stress	Usually Appropriate	○
MRI heart with function and vasodilator stress perfusion without and with IV contrast	May Be Appropriate	○
Rb-82 PET/CT heart	May Be Appropriate (Disagreement)	⊕⊕⊕
SPECT or SPECT/CT MPI rest only	May Be Appropriate	⊕⊕⊕
US echocardiography transthoracic resting	May Be Appropriate	○
CT coronary calcium	May Be Appropriate	⊕⊕⊕
CTA chest with IV contrast	May Be Appropriate	⊕⊕⊕
MRI heart function and morphology without and with IV contrast	May Be Appropriate	○
MRI heart with function and inotropic stress without and with IV contrast	May Be Appropriate	○
MRI heart with function and inotropic stress without IV contrast	May Be Appropriate	○
CT chest with IV contrast	Usually Not Appropriate	⊕⊕⊕
CT chest without and with IV contrast	Usually Not Appropriate	⊕⊕⊕
MRI heart function and morphology without IV contrast	Usually Not Appropriate	○
Arteriography coronary	Usually Not Appropriate	⊕⊕⊕
CT chest without IV contrast	Usually Not Appropriate	⊕⊕⊕
MRA coronary arteries without and with IV contrast	Usually Not Appropriate	○
MRA coronary arteries without IV contrast	Usually Not Appropriate	○
US echocardiography transesophageal	Usually Not Appropriate	○

**Variant 2:****Chest pain, high probability for acute coronary syndrome. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Arteriography coronary	Usually Appropriate	⊕⊕⊕
Radiography chest	Usually Appropriate	⊕
MRI heart function and morphology without and with IV contrast	May Be Appropriate (Disagreement)	○
SPECT or SPECT/CT MPI rest only	May Be Appropriate (Disagreement)	⊕⊕⊕
US echocardiography transthoracic resting	May Be Appropriate	○
US echocardiography transthoracic stress	May Be Appropriate (Disagreement)	○
CTA coronary arteries with IV contrast	May Be Appropriate	⊕⊕⊕
SPECT or SPECT/CT MPI rest and stress	May Be Appropriate	⊕⊕⊕⊕
CT chest with IV contrast	Usually Not Appropriate	⊕⊕⊕
CTA chest with IV contrast	Usually Not Appropriate	⊕⊕⊕
MRI heart function and morphology without IV contrast	Usually Not Appropriate	○
CT chest without and with IV contrast	Usually Not Appropriate	⊕⊕⊕
CT chest without IV contrast	Usually Not Appropriate	⊕⊕⊕
CT coronary calcium	Usually Not Appropriate	⊕⊕⊕
MRA coronary arteries without and with IV contrast	Usually Not Appropriate	○
MRA coronary arteries without IV contrast	Usually Not Appropriate	○
MRI heart with function and inotropic stress without and with IV contrast	Usually Not Appropriate	○
MRI heart with function and vasodilator stress perfusion without and with IV contrast	Usually Not Appropriate	○
Rb-82 PET/CT heart	Usually Not Appropriate	⊕⊕⊕
US echocardiography transesophageal	Usually Not Appropriate	○
MRI heart with function and inotropic stress without IV contrast	Usually Not Appropriate	○

## CHEST PAIN-POSSIBLE ACUTE CORONARY SYNDROME

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### Summary of Literature Review

#### **Introduction/Background**

Cardiovascular disease is the leading cause of death in the United States. Annually, there are more than 8 million visits to emergency departments by patients with acute chest pain [1], with estimated health care costs of \$13 to \$15 billion [2]. Approximately 5% to 13% of those patients who present with acute chest pain are eventually found to have an acute coronary syndrome (ACS) [1]. ACS includes ST-segment elevation myocardial infarction (MI), non-ST-segment elevation (NSTEMI) MI, and unstable angina (acute ischemia without necrosis) [3]. Once diagnosed with ACS, the patient may be urgently transferred to a cardiac catheterization laboratory for invasive angiography and potential coronary revascularization [4,5]. For patients not identified immediately with ACS, categorizing low, intermediate, and high probability for ACS helps identify increasing risk for downstream major adverse cardiac events (MACE). Patients are predominantly stratified by clinical suspicion (including risk scores and risk stratification models), the evaluation of prompt electrocardiogram (ECG; serially if necessary), and the use of cardiac biomarkers (eg, serial troponins and B-type natriuretic peptide) [6,7]. Commonly used risk scores include the Thrombolysis in Myocardial Infarction risk score (TIMI RS), Global Registry of Acute Cardiac Events risk score (GRACE RS), the History, Electrocardiogram, Age, Risk factors, Troponin (HEART) score [8], and the Platelet glycoprotein IIb/IIIa in Unstable angina: Receptor Suppression Using Integrilin Therapy risk score (PURSUIT RS), among many others [9,10]. Risk stratification of patients into low, intermediate, and high probability for ACS may therefore differ according to available institutional resources and practice, but these categories generally correspond to increasing likelihood of downstream MACE due to ACS. Historical risk scores such as the TIMI score, the GRACE score, and the PURSUIT score are being replaced by more accurate risk stratification tools such as the HEART score, which was designed specifically for evaluation of patients with chest pain in the emergency department without a diagnosis of ACS [8].

High-risk patients with a convincing clinical picture may quickly progress to an invasive strategy or to the presumption of obstructive coronary artery disease (CAD) treated medically. In the setting of confirmed ACS, “time is myocardium and time is outcomes,” and prompt diagnosis can dramatically influence the downstream cardiovascular event rate [11-13]. However, ACS cannot be excluded in many patients with acute chest pain, even after initial clinical evaluation and diagnostic workup with ECG and cardiac biomarkers, and as many as 80% of these chest pain patients are admitted or observed for evaluation [14,15]. In the 1990s, studies showed 2% to 8% of emergency department patients were inappropriately discharged with a missed diagnosis of ACS, presenting a grave risk to those patients and the potential of litigation for physicians and healthcare facilities [16]. Although more recent studies have shown lower rates of missed diagnosis, appropriate identification of ACS remains an important issue.

Noninvasive imaging may therefore be indicated for risk stratification and clinical management in both low-risk and intermediate-risk patients [17]. This has continued to gain popularity since the first decade of the 2000s, with

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advanced medical imaging among chest pain patients quintupling [18]. This approach also serves to identify patients with a significant ischemic burden who could benefit from coronary revascularization [19-21]. Noninvasive imaging aids in the evaluation of the acute chest pain patients by either functionally determining a myocardial segment perfusion abnormality (eg, relative hypoperfusion, or a wall motion, or thickening abnormality, usually at stress testing) or anatomically visualizing an obstructive coronary artery stenosis. Although noninvasive imaging approaches have sensitivities and specificities in the 85% to 90% range, the corresponding false diagnosis rates are in the 10% to 15% range, and therefore consideration may be made to avoid diagnostic imaging altogether in patients at either end of the pretest probability spectrum [22]. Therefore, patient selection, as determined by clinical judgment and tools such as the HEART score, is critical because there has been historically a low yield of routine noninvasive cardiac imaging in low-risk patients [23-26].

Noncoronary etiologies for chest pain can also be established with imaging, the results of which may alter the patient's postdischarge care altogether. It is not uncommon for a patient to have acute chest pain occurring from other cardiovascular causes or noncardiac etiologies [17,27,28].

The available noninvasive cardiac imaging modalities include chest radiographs, rest single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI), stress SPECT MPI, echocardiography (transthoracic and transesophageal), multidetector CT, PET (metabolic and perfusion), and MRI.

### **Special Imaging Considerations**

For the purposes of distinguishing between CT and CT angiography (CTA), the ACR Appropriateness Criteria topics use the definition in the [ACR–NASCI–SIR–SPR Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography \(CTA\)](#) [29]:

*“CTA uses a thin-section CT acquisition that is timed to coincide with peak arterial or venous enhancement. The resultant volumetric dataset is interpreted using primary transverse reconstructions as well as multiplanar reformations and 3-D renderings.”*

All procedure elements are essential: 1) timing, 2) recons/reformats, and 3) 3-D renderings. Standard CTs with contrast also include timing issues and recons/reformats. Only in CTA; however, is 3-D rendering a **required** element. This corresponds to the definitions that CMS has applied to the CPT codes.

### **Discussion of Procedures by Variant**

#### **Variant 1: Chest pain, low to intermediate probability for acute coronary syndrome. Initial imaging.**

##### **Arteriography Coronary**

In patients with low to intermediate risk, arteriography is not the first-line evaluation or management. Patients with a nondiagnostic ECG and negative cardiac biomarkers should follow a clinical pathway beginning with a noninvasive approach [30].

##### **Radiography Chest**

Chest radiography is primarily used for ruling out conditions that may masquerade as acute myocardial ischemia, as well as defining secondary findings that may accompany acute MI. Acute pulmonary edema can be seen on chest radiographs without enlargement of the cardiac silhouette in patients with acute MI and no prior history of ischemic damage or associated mitral valve disease. Although chest radiography is insufficient to confirm or exclude the presence of significant CAD, it may be useful in demonstrating clinically important pathology in a significant minority of ACS-suspected patients [31]. Other cardiovascular entities, such as aortic aneurysms, aortic dissections, and pulmonary embolism, may be suggested from the chest radiograph but with far lower sensitivity than in other imaging modalities, such as multidetector CT. Noncardiac findings associated with chest pain that can be identified on chest radiography include pneumothorax, fractured ribs, pleural effusions, and pneumonia, among others.

##### **SPECT or SPECT/CT MPI Rest Only**

SPECT perfusion scintigraphy is an important test in the assessment for myocardial ischemia. In patients with active chest pain, an ECG with no ischemic changes, and an initial negative troponin, a promptly read rest SPECT has been demonstrated to be safe and clinically effective [32,33]. Rest-only MPI has been shown to be less sensitive than stress SPECT imaging if performed after the chest pain has subsided. The commonly used radionuclide agents are Tc-99m-labeled agents (eg, sestamibi, tetrofosmin). There is abundant literature describing the use of SPECT in ACS. The absence of a perfusion defect on an acute rest study is associated with a very high negative predictive value for ACS evaluation. As such, rest alone nuclear MPI has an American College of Cardiology/American Heart

Association class I, level A recommendation for evaluation of suspected ACS [34] and has a well-established, well-supported track record in evaluating acute chest pain patients [35,36].

### **SPECT or SPECT/CT MPI Rest and Stress**

SPECT perfusion scintigraphy is an important test in the assessment for myocardial ischemia. Rest-only MPI has been shown to be less sensitive than stress SPECT imaging if performed after the chest pain has subsided. The commonly used radionuclide agents are Tl-201 (thallium) chloride and Tc-99m–labeled agents (eg, sestamibi, tetrofosmin). There is abundant literature describing the use of SPECT in ACS. A perfusion defect that becomes apparent or becomes larger during exercise stress or pharmacologic stress suggests ischemic myocardium. Patients with negative stress nuclear MPI can be safely discharged, and those with positive stress nuclear MPI have a higher likelihood of obstructive disease on subsequent coronary angiography compared with those evaluated by stress ECG [37]. In addition, trials in patients with stable ischemic heart disease suggest that the degree of ischemic myocardium may be more important than the presence of anatomic stenosis alone, using, for example, a threshold of 10% ischemic myocardium to identify patients likely to benefit from revascularization [38,39]. As such, vasodilator stress nuclear MPI has an American College of Cardiology/American Heart Association class I, level B recommendation for evaluation of suspected ACS [34] and has a well-established, well-supported track record in evaluating acute chest pain patients [35,36].

### **US Echocardiography Transthoracic Stress**

Stress echocardiography has been shown to be a modality equivalent to stress SPECT MPI in the acute setting in low- to intermediate-risk patients, with either exercise or a stress pharmacologic agent (such as dobutamine) inducing focal wall-motion abnormalities in the region(s) of ischemia [40-42]. When compared with stress ECG, stress echocardiography of acute chest pain patients in the emergency department has been shown to lead to fewer late events, including rehospitalization and late percutaneous coronary intervention [43,44], as well as excellent accuracy in predicting obstructive CAD on coronary angiography or subsequent cardiovascular events [45]. Positive stress echocardiography has been shown to identify incrementally more patients requiring revascularization in patients suspected of ACS when compared with a standard of care without use of imaging [46,47].

### **US Echocardiography Transthoracic Resting**

Conventional resting echocardiography in the emergency department has some limited benefit for detection of ischemic myocardium with abnormal wall motion and thereby risk stratification of suspected ACS patients [48,49]; however, it is more widely used for the evaluation of heart failure, valvular dysfunction, and pericardial effusion [41]. Advances in contrast echocardiography to evaluate ischemic changes in wall thickening [50-53] and strain echocardiography to evaluate abnormal myocardial deformation [54-57] may provide an expanded role for resting echocardiography in the evaluation of ACS, particularly in patients with active chest pain at the time of imaging.

### **US Echocardiography Transesophageal**

The primary usefulness of resting transesophageal echocardiography (TEE) in the setting of acute chest pain is in ruling out aortic dissection in unstable patients. TEE is also used to further define valvular dysfunction or intracardiac thrombus, which can be sequelae of ischemic events in the subacute setting. Because of the semi-invasive nature of TEE and because there is limited information that can be added in the setting of acute chest pain, this modality is generally not indicated in the workup of patients with acute chest pain [58].

### **CTA Coronary Arteries**

In stable patients with suggested ACS at low or intermediate risk of adverse events, a noninvasive coronary imaging test (ie, coronary CTA [CCTA]) is a proven alternative to stress testing or selective coronary angiography [19,59,60]. CCTA has a very high negative predictive value for the detection of coronary atherosclerosis with or without significant stenosis and is an alternative to stress imaging in the emergency department and inpatient settings in patients at low to intermediate risk for CAD [59,61-64]. Large randomized controlled trials (eg, CT-STAT, ROMICAT I and II, ACRIN-PA, PROSPECT, CT-COMPARE, CATCH, and CATCH-2) have amply established the high negative predictive value (eg, safe discharge) and good prognosis of a negative CCTA in low- to intermediate-risk patients suspected of ACS when compared with standard pathways that predominantly involve stress nuclear MPI [65-72]. Normal CCTA has been shown to allow safe discharge from the emergency department without further workup, in both academic and community settings, with a negative predictive value for ACS over 95% [1,73-75], with equal or superior diagnostic performance when compared with stress echocardiography or nuclear MPI [76]. High-sensitivity troponin use has increased in Europe and in the United States to stratify patients with suspected ACS [77], but a CCTA strategy has still been found to be useful to avoid unnecessary downstream testing even when patients were first stratified by high-sensitivity troponin [78-80]. In a large multicenter study

comparing CCTA with multiple other modalities used for ACS (stress cardiac MR [CMR], stress echocardiography, stress nuclear MPI, and stress PET), CCTA was found to have the highest diagnostic accuracy in finding patients with a significant coronary artery stenosis [81].

Novel applications of CT technology include stress CT perfusion imaging and CT–fractional flow reserve (FFR), both of which have well-established research support and are beginning to supplement anatomic CCTA information in daily clinical practice at certain centers. Stress CT perfusion imaging allows functional assessment of myocardial segments and has been shown to have similar diagnostic performance and predictive values when compared with stress MPI [82-85]. Although stress CT perfusion represents the typical approach to CT diagnosis of inducible ischemia, resting CT perfusion interpretation of myocardial segments from a routine resting CCTA has also shown utility in the diagnosis of ACS [86,87]. FFR is an invasively derived ratio comparing flow at hyperemia proximal and distal with a stenosis at catheterization, with powerful discriminatory value in determining the hemodynamic significance of the stenosis. CT-FFR uses computational fluid dynamic modeling techniques and/or machine learning to simulate the FFR process, using resting CCTA data and yield a CT-FFR number shown to correlate reasonably well with catheter-derived FFR values and deliver equivalent clinical outcomes when using a CT-FFR-guided management pathway [88-92]. Research into the additive value of CT perfusion and CT-FFR is ongoing, particularly in chest pain patients presenting acutely to the emergency department rather than as stable outpatients [93].

### **CT Coronary Calcium**

The role of the calcium score as a standalone test in the acute setting has not been established [94]. Limited studies have been performed demonstrating that the absence of coronary artery calcium (CAC) has a high negative predictive value for ACS among lower-risk patients with chest pain [95]. Several studies have suggested that in young patients with chest pain, a calcium score of zero is not a reliable test to exclude CAD, and adverse events have been shown to occur in up to 6% of acute chest pain patients without coronary artery calcium [96]. The ability of a zero calcium score to allow safe discharge of low-risk acute chest pain patients continues to be actively studied [97-100].

### **CT Chest**

Nongated chest CT, although useful for evaluating noncardiac thoracic pathology, does not currently have a role in the evaluation of possible ACS, although perfusion defects can be seen on contrast-enhanced nongated chest CT in patients with ACS [101,102].

### **CTA Chest**

CTA of the chest has a well-established role for evaluating other etiologies that may mimic ACS, such as aortic dissection, acute pericarditis, pneumonia, and pneumothorax [27,103]. Nongated chest CTA intended to evaluate a patient for aortic dissection or pulmonary embolism may depict incidental coronary artery pathology, such as anomalous coronary arteries, obstructive CAD, and involvement of the coronary arteries by aortic dissection [104]. In particular, CTA for aortic dissection or pulmonary embolism may be performed with ECG-gating without specific intent to evaluate the coronary arteries (ie, gating intended to reduce pulsation artifact in the great vessels but the examination not otherwise tailored to the coronary arteries), and in those cases, coronary abnormalities may be even more readily apparent as an unexpected finding. Therefore, there is insufficient evidence to support nongated (or incidentally gated) CTA for the evaluation of ACS.

### **Rb-82 PET/CT Heart**

A stress PET examination can reliably demonstrate myocardial blood flow using rubidium-82 (Rb-82) or nitrogen-13 (N-13) ammonia. Limited data are available for PET perfusion studies in the setting of acute chest pain, although there is growing evidence for diagnostic and prognostic applications in chronic coronary disease [105,106]. PET can also document anaerobic metabolism using fluorine-18-2-fluoro-2-deoxy-D-glucose and other metabolic tracers. This technology is less well studied in the workup of the acute chest pain patient but may have a role when combined with CTA [105,107,108]. Meta-analysis has shown PET to demonstrate excellent diagnostic performance when compared with other methods of evaluating ischemic myocardium [109].

### **MRI Heart with Function and Inotropic Stress**

Although early ACS approaches of CMR included high-risk patients and tended to use rest-only CMR, more recent studies have demonstrated high negative predictive value and excellent diagnostic performance in a low- to intermediate-risk cohort when compared with nuclear MPI or stress echocardiography [110,111]. Multiple studies have shown that a vasodilator stress CMR strategy for chest pain patients can allow safe discharge and show similar

clinical performance to other stress perfusion techniques [45,112-114]. However, inotropic stress agents like dobutamine, although useful for the characterization of stable ischemic heart disease [115,116], are relatively contraindicated in patients with recent or active chest pain, and so limited literature exists on the use of inotropic stress MRI for the evaluation of ACS.

### **MRI Heart with Function and Vasodilator Stress Perfusion**

Although early ACS approaches of CMR included high-risk patients and tended to use rest-only CMR, more recent studies have demonstrated high negative predictive value and excellent diagnostic performance in a low- to intermediate-risk cohort when compared with nuclear MPI or stress echocardiography [110,111]. Multiple studies have shown that a stress CMR strategy for chest pain patients can allow safe discharge and show similar clinical performance to other stress-perfusion techniques [45,112-114]. In particular, CMR has been shown to have similar or better performance to nuclear MPI in determining the degree of ischemic myocardium, which may be an important predictor of outcomes after revascularization [117,118]. For example, several studies on outpatients with suspected CAD (eg, MR-IMPACT, CE-MARC, MR-INFORM) demonstrated superior performance of stress CMR when compared with nuclear SPECT MPI [119,120] and have recently reported noninferiority when compared with invasive FFR [121].

### **MRI Heart Function and Morphology**

CMR with delayed postcontrast imaging and edema-weighted imaging provides assessment of the size, distribution, and transmural extent of acute or remote MI. Cine CMR has usefulness in demonstrating wall-motion abnormalities, which may accompany acute or chronic ischemic heart disease, and first-pass contrast-enhanced perfusion CMR can demonstrate myocardial perfusion abnormalities [110,111,122-124]. The use of T2-weighted CMR to identify myocardial edema can help predict outcomes in patients with NSTEMI-ACS without affecting time to catheterization [125]. In addition, CMR has a role in elucidating the cause of myocardial necrosis in patients with elevated cardiac biomarkers presumed to have ACS but with nonobstructive coronary arteries by CT or catheter angiography [126,127]. MRI, like CT, can also identify noncardiac reasons for chest pain. Both contrast-enhanced and nonenhanced time-of-flight angiographic techniques can be used for aortic pathology, and CMR can be used for the evaluation of other mimics of ACS with troponin elevation, including pericarditis, myocarditis, and Takotsubo cardiomyopathy [128,129]. New techniques in CMR, for example, myocardial mapping, may provide additional methods that can be used to evaluate patients with acute chest pain [130,131].

### **MRA Coronary Arteries**

Although coronary MR angiography (MRA) has not been established in general practice, both angiographic and phase-contrast flow continue to be developed for coronary artery assessment in research centers [132]. Noncontrast angiographic whole-heart acquisition with 3-D steady-state free precession MRI technique can provide imaging of the coronary arteries and is particularly useful in the evaluation of coronary anomalies, bypass graft assessment, and coronary aneurysm formation [133]. Trials have demonstrated high sensitivity and moderate specificity of coronary MRA for the evaluation of obstructive coronary artery stenosis, particularly when used in combination with nonangiographic CMR sequences [119,134]. Future avenues of clinical use include reliable evaluation of coronary artery stenosis and characterization of plaque composition for the identification of vulnerable or high-risk plaques [135].

## **Variant 2: Chest pain, high probability for acute coronary syndrome. Initial imaging.**

### **Arteriography Coronary**

Prompt coronary angiography is the mainstay of diagnosis and management of patients at high risk for ACS, in particular those with an ischemic pattern on ECG [7]. By American College of Cardiology/American Heart Association guidelines, there is a class I, level A recommendation to direct ST-segment elevation patients suspected of ACS to the catheterization laboratory with a “door-to-device” time of  $\leq 90$  min [136-138]. The emphasis of timeliness in arteriography and reperfusion of the coronary arteries for ECG-positive ACS is such that the use of other modalities in the evaluation of high-risk ACS patients, particularly modalities with a significant time penalty (eg, MRI, PET, MPI), is limited.

In patients without ST-segment elevation, positive cardiac biomarkers may nonetheless suggest myocardial necrosis, and the ECG may demonstrate a NSTEMI ischemic pattern, including ST depression, transient ST-segment elevation, or prominent T-wave inversions [139]. ACS patients with unstable angina may have similar ECG patterns but demonstrate no biomarker evidence of myocardial necrosis (eg, troponin level within normal limits), though biomarker negativity in these patients may grow rarer as high-sensitivity biomarker tests become more widely



available [140]. Patients with NSTEMI-ACS do not require immediate emergent evaluation in the catheterization laboratory in the absence of shock or medically refractory symptoms but are admitted for inpatient stabilization, relief of ischemic symptoms, and guideline-directed medical therapy. NSTEMI-ACS patients may then be managed with an ischemia-guided strategy (ie, only proceed to catheterization if ischemic signs or symptoms persist despite aggressive medical therapy) or an invasive strategy (ie, routine catheterization with the goal of revascularization, either as an early invasive strategy within 24 h or a delayed invasive strategy in the 24–72 h time frame) [139,141-143]. The optimal timing and choice of invasive angiography in patients with ST-segment or non-ST-segment ACS continues to be an active area of research.

### **Radiography Chest**

Chest radiography is primarily used for ruling out conditions that may masquerade as acute myocardial ischemia as well as defining secondary findings that may accompany acute MI. Acute pulmonary edema can be seen on chest radiographs without enlargement of the cardiac silhouette in patients with acute MI and no prior history of ischemic damage or associated mitral valve disease. Although chest radiography is insufficient to confirm or exclude the presence of significant CAD, it may be useful in demonstrating clinically important pathology in a significant minority of ACS-suspected patients [31]. Other cardiovascular entities, such as aortic aneurysms, aortic dissections, and pulmonary embolism, may be suggested from the chest radiography but with far lower sensitivity than other imaging modalities such as multidetector CT. Noncardiac findings associated with chest pain that can be identified on the chest radiograph include pneumothorax, fractured ribs, pleural effusions, and pneumonia, among others.

### **CTA Coronary Arteries**

There is no relevant literature regarding the use of CCTA in the evaluation of ACS in high-probability patients.

### **CT Chest**

Nongated chest CT, although useful for evaluating noncardiac thoracic pathology, does not currently have a role in the evaluation of possible ACS, although perfusion defects can be seen on nongated chest CT in patients with ACS [101,102].

### **CTA Chest**

CTA of the chest has a well-established role for evaluating other etiologies that may mimic ACS, such as aortic dissection, acute pericarditis, pneumonia, and pneumothorax [27,103].

### **CT Coronary Calcium**

There is no relevant literature regarding the use of CT calcium scoring in the evaluation of ACS in high-probability patients.

### **MRA Coronary Arteries**

There is no relevant literature regarding the use of coronary MRA in the evaluation of ACS in high-risk patients.

### **MRI Heart Function and Morphology**

The use of T2-weighted CMR to identify myocardial edema can help predict outcomes in patients with NSTEMI-ACS, without impacting time to catheterization, and a combination of noncontrast and postcontrast resting CMR sequences can help inform prognosis and identify myocardial areas at risk [125,144]. In addition, CMR has a role in elucidating the cause of myocardial necrosis in patients with elevated cardiac biomarkers presumed to have ACS but with nonobstructive coronary arteries by CT or catheter angiography [126-128,145].

### **MRI Heart with Function and Inotropic Stress**

There is no relevant literature regarding the use of stress CMR in the evaluation of ACS in high-probability patients.

### **MRI Heart with Function and Vasodilator Stress Perfusion**

There is no relevant literature regarding the use of stress perfusion CMR in the evaluation of ACS in high-probability patients.

### **Rb-82 PET/CT Heart**

There is no relevant literature regarding the use of stress PET/CT in the evaluation of ACS in high-probability patients.

### **SPECT or SPECT/CT MPI Rest Only**

There is no relevant literature regarding the use of rest-only MPI in the evaluation of ACS in high-probability patients.



### **SPECT or SPECT/CT MPI Rest and Stress**

Noninvasive stress testing with nuclear SPECT-MPI may be helpful in NSTEMI-ACS patients for risk stratification before discharge in patients with an ischemia-guided strategy. High NSTEMI-ACS patients (eg, patients with left main disease, age >70, multivessel disease, diabetes mellitus, prior MI or revascularization, or depressed left ventricular function) may benefit from routine revascularization, but low-to intermediate-risk NSTEMI-ACS patients may receive less benefit from routine revascularization and therefore may benefit from risk stratification according to provocative testing with stress. In particular, nuclear MPI with stress can be used to identify low-risk patients suitable for early discharge [146,147].

### **US Echocardiography Transthoracic Stress**

There is no relevant literature regarding the use of stress echocardiography in the evaluation of ACS in high-probability patients.

### **US Echocardiography Transthoracic Rest**

Conventional resting echocardiography in the emergency department has some limited benefit for detection of ischemic myocardium with abnormal wall motion and thereby risk stratification of suspected ACS patients [48,49]; however, it is more widely used for the evaluation of heart failure, valvular dysfunction, and pericardial effusion [41]. Assessment of left ventricle function is necessary in patients with confirmed ACS in order to guide pharmacological therapies and help determine revascularization choices (eg, percutaneous coronary intervention versus bypass graft surgery). Advances in contrast echocardiography to evaluate ischemic changes in wall thickening [50-53] and strain echocardiography to evaluate abnormal myocardial deformation [54-57] may provide a new role for resting echocardiography in the evaluation of ACS.

### **US Echocardiography Transesophageal**

The primary usefulness of TEE in the setting of acute chest pain is in ruling out aortic dissection in unstable patients. TEE is also used to further define valvular dysfunction or intracardiac thrombus, which can be sequelae of ischemic events in the subacute setting. Because of the semi-invasive nature of TEE and because there is limited information that can be added in the setting of acute chest pain, this modality is generally not indicated in the workup of patients with acute chest pain [58].

### **Summary of Recommendations**

- **Variation 1:** CTA coronary arteries with IV contrast, Tc-99m SPECT or SPECT/CT MPI rest and stress, or ultrasound echocardiography transthoracic stress is usually appropriate for the initial imaging of chest pain in adults with low to intermediate probability for ACS. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care). Radiography chest is a complementary procedure used for rapid triage in chest pain patients who may then benefit from more definitive imaging with regard to ACS. The panel did not agree on recommending Rb-82 PET/CT heart for the initial imaging of chest pain in adults with low to intermediate probability for ACS. There is insufficient medical literature to conclude whether or not these patients would benefit from Rb-82 PET/CT heart for this clinical scenario. Rb-82 PET/CT heart in this patient population is controversial but may be appropriate.
- **Variation 2:** Arteriography coronary is usually appropriate for the initial imaging of chest pain in adults with high probability for ACS. Radiography chest is a complementary procedure used for rapid triage in chest pain patients who may then benefit from more definitive imaging with regard to ACS. The panel did not agree on recommending MRI heart function and morphology without and with IV contrast or SPECT or SPECT/CT MPI rest only or ultrasound echocardiography transthoracic stress for the initial imaging of chest pain with high probability for ACS. There is insufficient medical literature to conclude whether or not these patients would benefit from these examinations for this clinical scenario. MRI heart function and morphology without and with IV contrast or SPECT or SPECT/CT MPI rest only or ultrasound echocardiography transthoracic stress in this patient population is controversial but may be appropriate.

### **Supporting Documents**

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to [www.acr.org/ac](http://www.acr.org/ac).

### Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

### Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document [148].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
☼	<0.1 mSv	<0.03 mSv
☼☼	0.1-1 mSv	0.03-0.3 mSv
☼☼☼	1-10 mSv	0.3-3 mSv
☼☼☼☼	10-30 mSv	3-10 mSv
☼☼☼☼☼	30-100 mSv	10-30 mSv

\*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

## References

1. Raff GL, Hoffmann U, Udelson JE. Trials of Imaging Use in the Emergency Department for Acute Chest Pain. *JACC Cardiovasc Imaging* 2017;10:338-49.
2. Maffei E, Seitun S, Guaricci AI, Cademartiri F. Chest pain: coronary CT in the ER. *Br J Radiol* 2016;89:20150954.
3. Cannon CP, Battler A, Brindis RG, et al. American College of Cardiology key data elements and definitions for measuring the clinical management and outcomes of patients with acute coronary syndromes. A report of the American College of Cardiology Task Force on Clinical Data Standards (Acute Coronary Syndromes Writing Committee). *J Am Coll Cardiol* 2001;38:2114-30.
4. Antman EM, Hand M, Armstrong PW, et al. 2007 Focused Update of the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines: developed in collaboration With the Canadian Cardiovascular Society endorsed by the American Academy of Family Physicians: 2007 Writing Group to Review New Evidence and Update the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction, Writing on Behalf of the 2004 Writing Committee. *Circulation* 2008;117:296-329.
5. Nallamothu BK, Bates ER, Herrin J, Wang Y, Bradley EH, Krumholz HM. Times to treatment in transfer patients undergoing primary percutaneous coronary intervention in the United States: National Registry of Myocardial Infarction (NORMI)-3/4 analysis. *Circulation* 2005;111:761-7.
6. Haaf P, Reichlin T, Corson N, et al. B-type natriuretic peptide in the early diagnosis and risk stratification of acute chest pain. *Am J Med* 2011;124:444-52.
7. Thygesen K, Alpert JS, Jaffe AS, et al. Third universal definition of myocardial infarction. *Circulation* 2012;126:2020-35.
8. Six AJ, Backus BE, Kelder JC. Chest pain in the emergency room: value of the HEART score. *Neth Heart J* 2008;16:191-6.
9. de Araujo Goncalves P, Ferreira J, Aguiar C, Seabra-Gomes R. TIMI, PURSUIT, and GRACE risk scores: sustained prognostic value and interaction with revascularization in NSTEMI-ACS. *Eur Heart J* 2005;26:865-72.
10. Yan AT, Yan RT, Tan M, et al. Risk scores for risk stratification in acute coronary syndromes: useful but simpler is not necessarily better. *Eur Heart J* 2007;28:1072-8.
11. Fu Y, Goodman S, Chang WC, Van De Werf F, Granger CB, Armstrong PW. Time to treatment influences the impact of ST-segment resolution on one-year prognosis: insights from the assessment of the safety and efficacy of a new thrombolytic (ASSENT-2) trial. *Circulation* 2001;104:2653-9.
12. Gibson CM. Time is myocardium and time is outcomes. *Circulation* 2001;104:2632-4.
13. Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *Circulation* 2011;124:e574-651.
14. Pernes JM, Dupouy P, Labbe R, et al. Management of acute chest pain: A major role for coronary CT angiography. *Diagn Interv Imaging* 2015;96:1105-12.
15. Welch RD, Zalenski RJ, Frederick PD, et al. Prognostic value of a normal or nonspecific initial electrocardiogram in acute myocardial infarction. *Jama* 2001;286:1977-84.
16. Pope JH, Aufderheide TP, Ruthazer R, et al. Missed diagnoses of acute cardiac ischemia in the emergency department. *N Engl J Med* 2000;342:1163-70.
17. Amsterdam EA, Kirk JD, Bluemke DA, et al. Testing of low-risk patients presenting to the emergency department with chest pain: a scientific statement from the American Heart Association. *Circulation* 2010;122:1756-76.
18. Bhuiya FA, Pitts SR, McCaig LF. Emergency department visits for chest pain and abdominal pain: United States, 1999-2008. *NCHS Data Brief* 2010:1-8.
19. Anderson JL, Adams CD, Antman EM, et al. ACC/AHA 2007 guidelines for the management of patients with unstable angina/non-ST-Elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 2002 Guidelines for the Management of Patients With Unstable Angina/Non-ST-Elevation Myocardial Infarction) developed in collaboration with the American College of Emergency Physicians, the Society for

- Cardiovascular Angiography and Interventions, and the Society of Thoracic Surgeons endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation and the Society for Academic Emergency Medicine. *J Am Coll Cardiol* 2007;50:e1-e157.
20. de Winter RJ, Windhausen F, Cornel JH, et al. Early invasive versus selectively invasive management for acute coronary syndromes. *N Engl J Med* 2005;353:1095-104.
  21. Mehta SR, Cannon CP, Fox KA, et al. Routine vs selective invasive strategies in patients with acute coronary syndromes: a collaborative meta-analysis of randomized trials. *Jama* 2005;293:2908-17.
  22. 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. *Eur Heart J* 2013;34:2949-3003.
  23. Borges Santos M, Ferreira AM, de Araujo Goncalves P, et al. Diagnostic yield of current referral strategies for elective coronary angiography in suspected coronary artery disease-an analysis of the ACROSS registry. *Rev Port Cardiol* 2013;32:483-8.
  24. Cremer PC, Khalaf S, Agarwal S, et al. Myocardial perfusion imaging in emergency department patients with negative cardiac biomarkers: yield for detecting ischemia, short-term events, and impact of downstream revascularization on mortality. *Circ Cardiovasc Imaging* 2014;7:912-9.
  25. Hartsell S, Dorais J, Preston R, et al. False-positive rates of provocative cardiac testing in chest pain patients admitted to an emergency department observation unit. *Crit Pathw Cardiol* 2014;13:104-8.
  26. Patel MR, Peterson ED, Dai D, et al. Low diagnostic yield of elective coronary angiography. *N Engl J Med* 2010;362:886-95.
  27. Rubinshtein R, Halon DA, Gaspar T, et al. Impact of 64-slice cardiac computed tomographic angiography on clinical decision-making in emergency department patients with chest pain of possible myocardial ischemic origin. *Am J Cardiol* 2007;100:1522-6.
  28. Solinas L, Raucci R, Terrazzino S, et al. Prevalence, clinical characteristics, resource utilization and outcome of patients with acute chest pain in the emergency department. A multicenter, prospective, observational study in north-eastern Italy. *Ital Heart J* 2003;4:318-24.
  29. American College of Radiology. ACR–NASCI–SIR–SPR Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography (CTA). Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/body-cta.pdf>. Accessed September 30, 2019.
  30. Rybicki FJ, Udelson JE, Peacock WF, et al. 2015 ACR/ACC/AHA/AATS/ACEP/ASNC/NASCI/SAEM/SCCT/SCMR/SCPC/SNMMI/STR/STS Appropriate Utilization of Cardiovascular Imaging in Emergency Department Patients With Chest Pain: A Joint Document of the American College of Radiology Appropriateness Criteria Committee and the American College of Cardiology Appropriate Use Criteria Task Force. *J Am Coll Radiol* 2016;13:e1-e29.
  31. Goldschlager R, Roth H, Solomon J, et al. Validation of a clinical decision rule: chest X-ray in patients with chest pain and possible acute coronary syndrome. *Emerg Radiol* 2014;21:367-72.
  32. Kontos MC, Fratkin MJ, Jesse RL, Anderson FP, Ornato JP, Tatum JL. Sensitivity of acute rest myocardial perfusion imaging for identifying patients with myocardial infarction based on a troponin definition. *J Nucl Cardiol* 2004;11:12-9.
  33. Udelson JE, Beshansky JR, Ballin DS, et al. Myocardial perfusion imaging for evaluation and triage of patients with suspected acute cardiac ischemia: a randomized controlled trial. *Jama* 2002;288:2693-700.
  34. Klocke FJ, Baird MG, Lorell BH, et al. ACC/AHA/ASNC guidelines for the clinical use of cardiac radionuclide imaging--executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/ASNC Committee to Revise the 1995 Guidelines for the Clinical Use of Cardiac Radionuclide Imaging). *J Am Coll Cardiol* 2003;42:1318-33.
  35. Dedic A, Genders TS, Nieman K, Hunink MG. Imaging strategies for acute chest pain in the emergency department. *AJR Am J Roentgenol* 2013;200:W26-38.
  36. Ghatak A, Hendel RC. Role of imaging for acute chest pain syndromes. *Semin Nucl Med* 2013;43:71-81.
  37. Lim SH, Anantharaman V, Sundram F, et al. Stress myocardial perfusion imaging for the evaluation and triage of chest pain in the emergency department: a randomized controlled trial. *J Nucl Cardiol* 2013;20:1002-12.
  38. Hachamovitch R, Rozanski A, Shaw LJ, et al. Impact of ischaemia and scar on the therapeutic benefit derived from myocardial revascularization vs. medical therapy among patients undergoing stress-rest myocardial perfusion scintigraphy. *Eur Heart J* 2011;32:1012-24.

39. Shaw LJ, Weintraub WS, Maron DJ, et al. Baseline stress myocardial perfusion imaging results and outcomes in patients with stable ischemic heart disease randomized to optimal medical therapy with or without percutaneous coronary intervention. *Am Heart J* 2012;164:243-50.
40. Davies R, Liu G, Sciamanna C, Davidson WR, Jr., Leslie DL, Foy AJ. Comparison of the Effectiveness of Stress Echocardiography Versus Myocardial Perfusion Imaging in Patients Presenting to the Emergency Department With Low-Risk Chest Pain. *Am J Cardiol* 2016;118:1786-91.
41. Lancellotti P, Price S, Edvardsen T, et al. The use of echocardiography in acute cardiovascular care: recommendations of the European Association of Cardiovascular Imaging and the Acute Cardiovascular Care Association. *Eur Heart J Acute Cardiovasc Care* 2015;4:3-5.
42. Lim SH, Sayre MR, Gibler WB. 2-D echocardiography prediction of adverse events in ED patients with chest pain. *Am J Emerg Med* 2003;21:106-10.
43. Innocenti F, Cerabona P, Donnini C, Conti A, Zanobetti M, Pini R. Long-term prognostic value of stress echocardiography in patients presenting to the ED with spontaneous chest pain. *Am J Emerg Med* 2014;32:731-6.
44. Nucifora G, Badano LP, Sarraf-Zadegan N, et al. Comparison of early dobutamine stress echocardiography and exercise electrocardiographic testing for management of patients presenting to the emergency department with chest pain. *Am J Cardiol* 2007;100:1068-73.
45. Hartlage G, Janik M, Anadiotis A, et al. Prognostic value of adenosine stress cardiovascular magnetic resonance and dobutamine stress echocardiography in patients with low-risk chest pain. *Int J Cardiovasc Imaging* 2012;28:803-12.
46. Aldous S, Richards AM, Cullen L, Pickering JW, Than M. The incremental value of stress testing in patients with acute chest pain beyond serial cardiac troponin testing. *Emerg Med J* 2016;33:319-24.
47. Yao SS, Bangalore S, Chaudhry FA. Prognostic implications of stress echocardiography and impact on patient outcomes: an effective gatekeeper for coronary angiography and revascularization. *J Am Soc Echocardiogr* 2010;23:832-9.
48. Frenkel O, Riguzzi C, Nagdev A. Identification of high-risk patients with acute coronary syndrome using point-of-care echocardiography in the ED. *Am J Emerg Med* 2014;32:670-2.
49. Labovitz AJ, Noble VE, Bierig M, et al. Focused cardiac ultrasound in the emergent setting: a consensus statement of the American Society of Echocardiography and American College of Emergency Physicians. *J Am Soc Echocardiogr* 2010;23:1225-30.
50. Gaibazzi N, Squeri A, Reverberi C, et al. Contrast stress-echocardiography predicts cardiac events in patients with suspected acute coronary syndrome but nondiagnostic electrocardiogram and normal 12-hour troponin. *J Am Soc Echocardiogr* 2011;24:1333-41.
51. Kaul S, Senior R, Firschke C, et al. Incremental value of cardiac imaging in patients presenting to the emergency department with chest pain and without ST-segment elevation: a multicenter study. *Am Heart J* 2004;148:129-36.
52. Rinkevich D, Kaul S, Wang XQ, et al. Regional left ventricular perfusion and function in patients presenting to the emergency department with chest pain and no ST-segment elevation. *Eur Heart J* 2005;26:1606-11.
53. Wei K. Utility contrast echocardiography in the emergency department. *JACC Cardiovasc Imaging* 2010;3:197-203.
54. Dahlslett T, Karlsen S, Grenne B, et al. Early assessment of strain echocardiography can accurately exclude significant coronary artery stenosis in suspected non-ST-segment elevation acute coronary syndrome. *J Am Soc Echocardiogr* 2014;27:512-9.
55. Eek C, Grenne B, Brunvand H, et al. Strain echocardiography predicts acute coronary occlusion in patients with non-ST-segment elevation acute coronary syndrome. *Eur J Echocardiogr* 2010;11:501-8.
56. Sarvari SI, Haugaa KH, Zahid W, et al. Layer-specific quantification of myocardial deformation by strain echocardiography may reveal significant CAD in patients with non-ST-segment elevation acute coronary syndrome. *JACC Cardiovasc Imaging* 2013;6:535-44.
57. Schroeder J, Hamada S, Grundlinger N, et al. Myocardial deformation by strain echocardiography identifies patients with acute coronary syndrome and non-diagnostic ECG presenting in a chest pain unit: a prospective study of diagnostic accuracy. *Clin Res Cardiol* 2016;105:248-56.
58. Kuhl HP, Hanrath P. The impact of transesophageal echocardiography on daily clinical practice. *Eur J Echocardiogr* 2004;5:455-68.
59. Hendel RC, Patel MR, Kramer CM, et al. ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR 2006 appropriateness criteria for cardiac computed tomography and cardiac magnetic resonance imaging: a

report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group, American College of Radiology, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, American Society of Nuclear Cardiology, North American Society for Cardiac Imaging, Society for Cardiovascular Angiography and Interventions, and Society of Interventional Radiology. *J Am Coll Cardiol* 2006;48:1475-97.

60. Hoffmann U, Bamberg F, Chae CU, et al. Coronary computed tomography angiography for early triage of patients with acute chest pain: the ROMICAT (Rule Out Myocardial Infarction using Computer Assisted Tomography) trial. *J Am Coll Cardiol* 2009;53:1642-50.
61. Goldstein JA, Gallagher MJ, O'Neill WW, Ross MA, O'Neil BJ, Raff GL. A randomized controlled trial of multi-slice coronary computed tomography for evaluation of acute chest pain. *J Am Coll Cardiol* 2007;49:863-71.
62. Hoffmann U, Nagurney JT, Moselewski F, et al. Coronary multidetector computed tomography in the assessment of patients with acute chest pain. *Circulation* 2006;114:2251-60.
63. Rubinshtein R, Halon DA, Gaspar T, et al. Usefulness of 64-slice multidetector computed tomography in diagnostic triage of patients with chest pain and negative or nondiagnostic exercise treadmill test result. *Am J Cardiol* 2007;99:925-9.
64. Stillman AE, Oudkerk M, Ackerman M, et al. Use of multidetector computed tomography for the assessment of acute chest pain: a consensus statement of the North American Society of Cardiac Imaging and the European Society of Cardiac Radiology. *Eur Radiol* 2007;17:2196-207.
65. Levsky JM, Spevack DM, Travin MI, et al. Coronary Computed Tomography Angiography Versus Radionuclide Myocardial Perfusion Imaging in Patients With Chest Pain Admitted to Telemetry: A Randomized Trial. *Ann Intern Med* 2015;163:174-83.
66. Linde JJ, Hove JD, Sorgaard M, et al. Long-Term Clinical Impact of Coronary CT Angiography in Patients With Recent Acute-Onset Chest Pain: The Randomized Controlled CATCH Trial. *JACC Cardiovasc Imaging* 2015;8:1404-13.
67. Pena E, Rubens F, Stiell I, Peterson R, Inacio J, Dennie C. Efficiency and safety of coronary CT angiography compared to standard care in the evaluation of patients with acute chest pain: a Canadian study. *Emerg Radiol* 2016;23:345-52.
68. Truong QA, Schulman-Marcus J, Zakrotsky P, et al. Coronary CT Angiography Versus Standard Emergency Department Evaluation for Acute Chest Pain and Diabetic Patients: Is There Benefit With Early Coronary CT Angiography? Results of the Randomized Comparative Effectiveness ROMICAT II Trial. *J Am Heart Assoc* 2016;5:e003137.
69. Goldstein JA, Chinnaiyan KM, Abidov A, et al. The CT-STAT (Coronary Computed Tomographic Angiography for Systematic Triage of Acute Chest Pain Patients to Treatment) trial. *J Am Coll Cardiol* 2011;58:1414-22.
70. Hoffmann U, Truong QA, Schoenfeld DA, et al. Coronary CT angiography versus standard evaluation in acute chest pain. *N Engl J Med* 2012;367:299-308.
71. Litt HI, Gatsonis C, Snyder B, et al. CT angiography for safe discharge of patients with possible acute coronary syndromes. *N Engl J Med* 2012;366:1393-403.
72. Takakuwa KM, Keith SW, Estepa AT, Shofer FS. A meta-analysis of 64-section coronary CT angiography findings for predicting 30-day major adverse cardiac events in patients presenting with symptoms suggestive of acute coronary syndrome. *Acad Radiol* 2011;18:1522-8.
73. Budoff MJ, Dowe D, Jollis JG, et al. Diagnostic performance of 64-multidetector row coronary computed tomographic angiography for evaluation of coronary artery stenosis in individuals without known coronary artery disease: results from the prospective multicenter ACCURACY (Assessment by Coronary Computed Tomographic Angiography of Individuals Undergoing Invasive Coronary Angiography) trial. *J Am Coll Cardiol* 2008;52:1724-32.
74. Cury RC, Budoff M, Taylor AJ. Coronary CT angiography versus standard of care for assessment of chest pain in the emergency department. *J Cardiovasc Comput Tomogr* 2013;7:79-82.
75. Cury RC, Feuchtner GM, Battle JC, et al. Triage of patients presenting with chest pain to the emergency department: implementation of coronary CT angiography in a large urban health care system. *AJR Am J Roentgenol* 2013;200:57-65.
76. Romero J, Husain SA, Holmes AA, et al. Non-invasive assessment of low risk acute chest pain in the emergency department: A comparative meta-analysis of prospective studies. *Int J Cardiol* 2015;187:565-80.

77. Body R, Burrows G, Carley S, Lewis PS. Rapid exclusion of acute myocardial infarction in patients with undetectable troponin using a sensitive troponin I assay. *Ann Clin Biochem* 2015;52:543-9.
78. Dedic A, Lubbers MM, Schaap J, et al. Coronary CT Angiography for Suspected ACS in the Era of High-Sensitivity Troponins: Randomized Multicenter Study. *J Am Coll Cardiol* 2016;67:16-26.
79. Dedic A, Nieman K, Hoffmann U, Ferencik M. Is there still a role for cardiac CT in the emergency department in the era of highly-sensitive troponins? *Minerva Cardioangiol* 2017;65:214-24.
80. Ferencik M, Liu T, Mayrhofer T, et al. hs-Troponin I Followed by CT Angiography Improves Acute Coronary Syndrome Risk Stratification Accuracy and Work-Up in Acute Chest Pain Patients: Results From ROMICAT II Trial. *JACC Cardiovasc Imaging* 2015;8:1272-81.
81. Neglia D, Rovai D, Caselli C, et al. Detection of significant coronary artery disease by noninvasive anatomical and functional imaging. *Circ Cardiovasc Imaging* 2015;8.
82. Chen MY, Rochitte CE, Arbab-Zadeh A, et al. Prognostic Value of Combined CT Angiography and Myocardial Perfusion Imaging versus Invasive Coronary Angiography and Nuclear Stress Perfusion Imaging in the Prediction of Major Adverse Cardiovascular Events: The CORE320 Multicenter Study. *Radiology* 2017;284:55-65.
83. Feuchtner GM, Plank F, Pena C, et al. Evaluation of myocardial CT perfusion in patients presenting with acute chest pain to the emergency department: comparison with SPECT-myocardial perfusion imaging. *Heart* 2012;98:1510-7.
84. Linde JJ, Sorgaard M, Kuhl JT, et al. Prediction of clinical outcome by myocardial CT perfusion in patients with low-risk unstable angina pectoris. *Int J Cardiovasc Imaging* 2017;33:261-70.
85. Rochitte CE, George RT, Chen MY, et al. Computed tomography angiography and perfusion to assess coronary artery stenosis causing perfusion defects by single photon emission computed tomography: the CORE320 study. *Eur Heart J* 2014;35:1120-30.
86. Branch KR, Busey J, Mitsumori LM, et al. Diagnostic performance of resting CT myocardial perfusion in patients with possible acute coronary syndrome. *AJR Am J Roentgenol* 2013;200:W450-7.
87. Pursnani A, Lee AM, Mayrhofer T, et al. Early resting myocardial computed tomography perfusion for the detection of acute coronary syndrome in patients with coronary artery disease. *Circ Cardiovasc Imaging* 2015;8:e002404.
88. Coenen A, Rossi A, Lubbers MM, et al. Integrating CT Myocardial Perfusion and CT-FFR in the Work-Up of Coronary Artery Disease. *JACC Cardiovasc Imaging* 2017;10:760-70.
89. Douglas PS, De Bruyne B, Pontone G, et al. 1-Year Outcomes of FFRCT-Guided Care in Patients With Suspected Coronary Disease: The PLATFORM Study. *J Am Coll Cardiol* 2016;68:435-45.
90. Koo BK, Erglis A, Doh JH, et al. Diagnosis of ischemia-causing coronary stenoses by noninvasive fractional flow reserve computed from coronary computed tomographic angiograms. Results from the prospective multicenter DISCOVER-FLOW (Diagnosis of Ischemia-Causing Stenoses Obtained Via Noninvasive Fractional Flow Reserve) study. *J Am Coll Cardiol* 2011;58:1989-97.
91. Min JK, Leipsic J, Pencina MJ, et al. Diagnostic accuracy of fractional flow reserve from anatomic CT angiography. *Jama* 2012;308:1237-45.
92. Norgaard BL, Leipsic J, Gaur S, et al. Diagnostic performance of noninvasive fractional flow reserve derived from coronary computed tomography angiography in suspected coronary artery disease: the NXT trial (Analysis of Coronary Blood Flow Using CT Angiography: Next Steps). *J Am Coll Cardiol* 2014;63:1145-55.
93. Pontone G, Andreini D, Guaricci AI, et al. Rationale and design of the PERFECTION (comparison between stress cardiac computed tomography PERFusion versus Fractional flow rEserve measured by Computed Tomography angiography In the evaluation of suspected cOronary artery disease) prospective study. *J Cardiovasc Comput Tomogr* 2016;10:330-4.
94. Laudon DA, Behrenbeck TR, Wood CM, et al. Computed tomographic coronary artery calcium assessment for evaluating chest pain in the emergency department: long-term outcome of a prospective blind study. *Mayo Clin Proc* 2010;85:314-22.
95. Chaikriangkrai K, Palamaner Subash Shantha G, Jhun HY, et al. Prognostic Value of Coronary Artery Calcium Score in Acute Chest Pain Patients Without Known Coronary Artery Disease: Systematic Review and Meta-analysis. *Ann Emerg Med* 2016;68:659-70.
96. Nance JW, Jr., Schlett CL, Schoepf UJ, et al. Incremental prognostic value of different components of coronary atherosclerotic plaque at cardiac CT angiography beyond coronary calcification in patients with acute chest pain. *Radiology* 2012;264:679-90.



97. Hecht HS. Coronary artery calcium scanning: past, present, and future. *JACC Cardiovasc Imaging* 2015;8:579-96.
98. Hinzpeter R, Higashigaito K, Morsbach F, et al. Coronary artery calcium scoring for ruling-out acute coronary syndrome in chest pain CT. *Am J Emerg Med* 2017;35:1565-67.
99. Tota-Maharaj R, McEvoy JW, Blaha MJ, Silverman MG, Nasir K, Blumenthal RS. Utility of coronary artery calcium scoring in the evaluation of patients with chest pain. *Crit Pathw Cardiol* 2012;11:99-106.
100. Yerramasu A, Lahiri A, Venuraju S, et al. Diagnostic role of coronary calcium scoring in the rapid access chest pain clinic: prospective evaluation of NICE guidance. *Eur Heart J Cardiovasc Imaging* 2014;15:886-92.
101. Watanabe T, Furuse Y, Ohta Y, Kato M, Ogawa T, Yamamoto K. The Effectiveness of Non-ECG-Gated Contrast-Enhanced Computed Tomography for the Diagnosis of Non-ST Segment Elevation Acute Coronary Syndrome. *Int Heart J* 2016;57:558-64.
102. Yamazaki M, Higuchi T, Shimokoshi T, et al. Acute coronary syndrome: evaluation of detection capability using non-electrocardiogram-gated parenchymal phase CT imaging. *Jpn J Radiol* 2016;34:331-8.
103. Yoo SM, Chun EJ, Lee HY, Min D, White CS. Computed Tomography Diagnosis of Nonspecific Acute Chest Pain in the Emergency Department: From Typical Acute Coronary Syndrome to Various Unusual Mimics. *J Thorac Imaging* 2017;32:26-35.
104. Kanza RE, Allard C, Berube M. Cardiac findings on non-gated chest computed tomography: A clinical and pictorial review. *Eur J Radiol* 2016;85:435-51.
105. Kajander S, Joutsiniemi E, Saraste M, et al. Cardiac positron emission tomography/computed tomography imaging accurately detects anatomically and functionally significant coronary artery disease. *Circulation* 2010;122:603-13.
106. Nandalur KR, Dwamena BA, Choudhri AF, Nandalur SR, Reddy P, Carlos RC. Diagnostic performance of positron emission tomography in the detection of coronary artery disease: a meta-analysis. *Acad Radiol* 2008;15:444-51.
107. Groves AM, Speechly-Dick ME, Kayani I, et al. First experience of combined cardiac PET/64-detector CT angiography with invasive angiographic validation. *Eur J Nucl Med Mol Imaging* 2009;36:2027-33.
108. Namdar M, Hany TF, Koepfli P, et al. Integrated PET/CT for the assessment of coronary artery disease: a feasibility study. *J Nucl Med* 2005;46:930-5.
109. Jaarsma C, Leiner T, Bekkers SC, et al. Diagnostic performance of noninvasive myocardial perfusion imaging using single-photon emission computed tomography, cardiac magnetic resonance, and positron emission tomography imaging for the detection of obstructive coronary artery disease: a meta-analysis. *J Am Coll Cardiol* 2012;59:1719-28.
110. Lerakis S, McLean DS, Anadiotis AV, et al. Prognostic value of adenosine stress cardiovascular magnetic resonance in patients with low-risk chest pain. *J Cardiovasc Magn Reson* 2009;11:37.
111. Vogel-Claussen J, Skrok J, Dombroski D, et al. Comprehensive adenosine stress perfusion MRI defines the etiology of chest pain in the emergency room: Comparison with nuclear stress test. *J Magn Reson Imaging* 2009;30:753-62.
112. Ahmad IG, Abdulla RK, Klem I, et al. Comparison of stress cardiovascular magnetic resonance imaging (CMR) with stress nuclear perfusion for the diagnosis of coronary artery disease. *J Nucl Cardiol* 2016;23:287-97.
113. Macwar RR, Williams BA, Shirani J. Prognostic value of adenosine cardiac magnetic resonance imaging in patients presenting with chest pain. *Am J Cardiol* 2013;112:46-50.
114. Miller CD, Case LD, Little WC, et al. Stress CMR reduces revascularization, hospital readmission, and recurrent cardiac testing in intermediate-risk patients with acute chest pain. *JACC Cardiovasc Imaging* 2013;6:785-94.
115. Charoenpanichkit C, Hundley WG. The 20 year evolution of dobutamine stress cardiovascular magnetic resonance. *J Cardiovasc Magn Reson* 2010;12:59.
116. Korosoglou G, Elhmidi Y, Steen H, et al. Prognostic value of high-dose dobutamine stress magnetic resonance imaging in 1,493 consecutive patients: assessment of myocardial wall motion and perfusion. *J Am Coll Cardiol* 2010;56:1225-34.
117. Bodi V, Sanchis J, Lopez-Lereu MP, et al. Prognostic value of dipyridamole stress cardiovascular magnetic resonance imaging in patients with known or suspected coronary artery disease. *J Am Coll Cardiol* 2007;50:1174-9.

118. Bodi V, Sanchis J, Lopez-Lereu MP, et al. Prognostic and therapeutic implications of dipyridamole stress cardiovascular magnetic resonance on the basis of the ischaemic cascade. *Heart* 2009;95:49-55.
119. Greenwood JP, Maredia N, Younger JF, et al. Cardiovascular magnetic resonance and single-photon emission computed tomography for diagnosis of coronary heart disease (CE-MARC): a prospective trial. *Lancet* 2012;379:453-60.
120. Schwitter J, Wacker CM, van Rossum AC, et al. MR-IMPACT: comparison of perfusion-cardiac magnetic resonance with single-photon emission computed tomography for the detection of coronary artery disease in a multicentre, multivendor, randomized trial. *Eur Heart J* 2008;29:480-9.
121. Hussain ST, Paul M, Plein S, et al. Design and rationale of the MR-INFORM study: stress perfusion cardiovascular magnetic resonance imaging to guide the management of patients with stable coronary artery disease. *J Cardiovasc Magn Reson* 2012;14:65.
122. Kwong RY, Schussheim AE, Rekhraj S, et al. Detecting acute coronary syndrome in the emergency department with cardiac magnetic resonance imaging. *Circulation* 2003;107:531-7.
123. Plein S, Greenwood JP, Ridgway JP, Cranny G, Ball SG, Sivananthan MU. Assessment of non-ST-segment elevation acute coronary syndromes with cardiac magnetic resonance imaging. *J Am Coll Cardiol* 2004;44:2173-81.
124. Cury RC, Shash K, Nagurney JT, et al. Cardiac magnetic resonance with T2-weighted imaging improves detection of patients with acute coronary syndrome in the emergency department. *Circulation* 2008;118:837-44.
125. Raman SV, Simonetti OP, Winner MW, 3rd, et al. Cardiac magnetic resonance with edema imaging identifies myocardium at risk and predicts worse outcome in patients with non-ST-segment elevation acute coronary syndrome. *J Am Coll Cardiol* 2010;55:2480-8.
126. Lockie T, Nagel E, Redwood S, Plein S. Use of cardiovascular magnetic resonance imaging in acute coronary syndromes. *Circulation* 2009;119:1671-81.
127. Pufulete M, Brierley RC, Bucciarelli-Ducci C, et al. Formal consensus to identify clinically important changes in management resulting from the use of cardiovascular magnetic resonance (CMR) in patients who activate the primary percutaneous coronary intervention (PPCI) pathway. *BMJ Open* 2017;7:e014627.
128. Dastidar AG, Rodrigues JC, Ahmed N, Baritussio A, Bucciarelli-Ducci C. The Role of Cardiac MRI in Patients with Troponin-Positive Chest Pain and Unobstructed Coronary Arteries. *Curr Cardiovasc Imaging Rep* 2015;8:28.
129. Pathik B, Raman B, Mohd Amin NH, et al. Troponin-positive chest pain with unobstructed coronary arteries: incremental diagnostic value of cardiovascular magnetic resonance imaging. *Eur Heart J Cardiovasc Imaging* 2016;17:1146-52.
130. Dall'Armellina E, Piechnik SK, Ferreira VM, et al. Cardiovascular magnetic resonance by non contrast T1-mapping allows assessment of severity of injury in acute myocardial infarction. *J Cardiovasc Magn Reson* 2012;14:15.
131. Saremi F. Cardiac MR Imaging in Acute Coronary Syndrome: Application and Image Interpretation. *Radiology* 2017;282:17-32.
132. Bluemke DA, Achenbach S, Budoff M, et al. Noninvasive coronary artery imaging: magnetic resonance angiography and multidetector computed tomography angiography: a scientific statement from the american heart association committee on cardiovascular imaging and intervention of the council on cardiovascular radiology and intervention, and the councils on clinical cardiology and cardiovascular disease in the young. *Circulation* 2008;118:586-606.
133. Hundley WG, Bluemke DA, Finn JP, et al. ACCF/ACR/AHA/NASCI/SCMR 2010 expert consensus document on cardiovascular magnetic resonance: a report of the American College of Cardiology Foundation Task Force on Expert Consensus Documents. *J Am Coll Cardiol* 2010;55:2614-62.
134. Kato S, Kitagawa K, Ishida N, et al. Assessment of coronary artery disease using magnetic resonance coronary angiography: a national multicenter trial. *J Am Coll Cardiol* 2010;56:983-91.
135. Dweck MR, Puntman V, Vesey AT, Fayad ZA, Nagel E. MR Imaging of Coronary Arteries and Plaques. *JACC Cardiovasc Imaging* 2016;9:306-16.
136. Dracup K, Alonzo AA, Atkins JM, et al. The physician's role in minimizing prehospital delay in patients at high risk for acute myocardial infarction: recommendations from the National Heart Attack Alert Program. Working Group on Educational Strategies To Prevent Prehospital Delay in Patients at High Risk for Acute Myocardial Infarction. *Ann Intern Med* 1997;126:645-51.

137. Krumholz HM, Bradley EH, Nallamothu BK, et al. A campaign to improve the timeliness of primary percutaneous coronary intervention: Door-to-Balloon: An Alliance for Quality. *JACC Cardiovasc Interv* 2008;1:97-104.
138. O'Gara PT, Kushner FG, Ascheim DD, et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation* 2013;127:e362-425.
139. Amsterdam EA, Wenger NK, Brindis RG, et al. 2014 AHA/ACC Guideline for the Management of Patients with Non-ST-Elevation Acute Coronary Syndromes: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 2014;64:e139-e228.
140. Korley FK, Jaffe AS. Preparing the United States for high-sensitivity cardiac troponin assays. *J Am Coll Cardiol* 2013;61:1753-8.
141. Damman P, Hirsch A, Windhausen F, Tijssen JG, de Winter RJ. 5-year clinical outcomes in the ICTUS (Invasive versus Conservative Treatment in Unstable coronary Syndromes) trial a randomized comparison of an early invasive versus selective invasive management in patients with non-ST-segment elevation acute coronary syndrome. *J Am Coll Cardiol* 2010;55:858-64.
142. Mehta SR, Granger CB, Boden WE, et al. Early versus delayed invasive intervention in acute coronary syndromes. *N Engl J Med* 2009;360:2165-75.
143. O'Donoghue M, Boden WE, Braunwald E, et al. Early invasive vs conservative treatment strategies in women and men with unstable angina and non-ST-segment elevation myocardial infarction: a meta-analysis. *Jama* 2008;300:71-80.
144. Kim HW, Farzaneh-Far A, Kim RJ. Cardiovascular magnetic resonance in patients with myocardial infarction: current and emerging applications. *J Am Coll Cardiol* 2009;55:1-16.
145. Emrich T, Emrich K, Abegunewardene N, et al. Cardiac MR enables diagnosis in 90% of patients with acute chest pain, elevated biomarkers and unobstructed coronary arteries. *Br J Radiol* 2015;88:20150025.
146. Mahmariyan JJ, Shaw LJ, Filipchuk NG, et al. A multinational study to establish the value of early adenosine technetium-99m sestamibi myocardial perfusion imaging in identifying a low-risk group for early hospital discharge after acute myocardial infarction. *J Am Coll Cardiol* 2006;48:2448-57.
147. Shaw LJ, Hachamovitch R, Berman DS, et al. The economic consequences of available diagnostic and prognostic strategies for the evaluation of stable angina patients: an observational assessment of the value of precatheterization ischemia. *Economics of Noninvasive Diagnosis (END) Multicenter Study Group. J Am Coll Cardiol* 1999;33:661-9.
148. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf>. Accessed September 30, 2019.

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.