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American College of Radiology ACR Appropriateness Criteria®

Clinical Condition: Chest Pain Suggestive of Acute Coronary Syndrome

Radiologic Procedure	Rating	Comments	RRL*
Tc-99m SPECT MPI rest and stress	8	This procedure is appropriate for intermediate-to-high likelihood for coronary artery disease. There is abundant literature available on clinical utility.	☼☼☼☼
Arteriography coronary	8	This procedure is the gold standard and is invasive.	☼☼☼
Tc-99m SPECT MPI rest only	7	In the setting of ongoing chest pain, this procedure has a high negative predictive value. Tc-99m is the most commonly used radionuclide agent for this test. RRL may be higher if Thallium (TI-201) used.	☼☼☼
US echocardiography transthoracic stress	7	Consider this procedure when resting echo and cardiac enzymes are normal.	○
US echocardiography transthoracic resting	6	This procedure is primarily used for evaluating wall-motion abnormalities and aortic dissection.	○
CTA coronary arteries with IV contrast	6	Consider this procedure for those patients with low-to-intermediate likelihood for coronary artery disease, in the absence of cardiac enzyme elevation and ischemic ST changes.	☼☼☼
X-ray chest	5	This procedure is primarily a survey for noncardiac etiologies of chest pain.	☼
CT chest with IV contrast	5	This procedure is primarily for noncardiac etiologies such as pulmonary embolism and aortic dissection.	☼☼☼
MRI heart function with stress without and with IV contrast	5	For this procedure there is limited experience in the clinical setting and lack of availability.	○
MRI heart function with stress without IV contrast	4	For this procedure there is limited experience in the clinical setting and lack of availability.	○
Rb-82 PET heart stress	4	For this procedure there is lack of widespread use and availability.	☼☼☼
MRI heart function and morphology without and with IV contrast	4	This procedure is primarily for the possibility of aortic dissection.	○
CT chest without and with IV contrast	3		☼☼☼
MRI heart function and morphology without IV contrast	3	This procedure is primarily for the possibility of aortic dissection.	○
US echocardiography transesophageal	3	This procedure has a relative contraindication for acute coronary syndrome.	○
CT coronary calcium	2	This procedure is not validated in the acute setting.	☼☼☼
MRA coronary arteries without IV contrast	2	This procedure is technically challenging and there is a lack of widespread use as well as protocol availability.	○
MRA coronary arteries without and with IV contrast	2	This procedure is technically challenging, and there is a lack of widespread use as well as protocol availability.	○
CT chest without IV contrast	2		☼☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

CHEST PAIN SUGGESTIVE OF ACUTE CORONARY SYNDROME

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Summary of Literature Review

Introduction/Background

Acute chest pain is a frequent presenting complaint in emergency departments. Along with other important disease entities such as aortic dissection and pulmonary embolus, such patient symptoms may question the possibility of acute myocardial ischemia. Acute coronary syndromes (ACS) include ST-segment elevation myocardial infarction (STEMI), non-STEMI (NSTEMI), and unstable angina (UA) [1]. Being able to establish the diagnosis rapidly and accurately may be lifesaving. The immediate cardiac workup consists of an electrocardiogram (ECG) and cardiac biomarkers. In the acute setting, even if there are no ischemic changes on ECG, a cardiac workup is often indicated. Because research has demonstrated that patients having a STEMI have improved outcomes if percutaneous intervention is performed within 90 minutes of arrival to a hospital, if the patient is suspected of having an ACS the patient will be urgently transferred to a cardiac catheterization laboratory for invasive angiography and potential coronary revascularization [2-4]. Depending on institutional policy, non-STEMI patients with ACS may only undergo coronary angiography during conventional operating hours of the catheterization laboratory.

In stable patients without ST elevation, an initially conservative approach may be considered [5]. In patients with active chest pain, an ECG with no ischemic changes, and an initial negative troponin, rest single-photon emission computed tomography (SPECT) has been demonstrated to be useful [6,7]. However, it has been shown to be less sensitive than stress SPECT imaging if the chest pain has subsided. Stress echocardiography may be equally considered in acute chest pain patients as well. Noninvasive imaging may be indicated for risk stratification before discharge in both low-risk and intermediate-risk patients who have been free of ischemia for a minimum of 12–24 hours. This approach also serves to identify patients with latent ischemia who could benefit from more aggressive revascularization [5,8-11].

In clinically stable UA/NSTEMI patients, cardiac catheterization in a nonemergent setting has advantages that may outweigh the benefits of performing urgent intervention. This select group of patients with UA/NSTEMI may be selected for “early but nonurgent angiography/intervention,” also referred to as “upstream therapy.” In the interval prior to angiography, these patients may benefit from aggressive antiplatelet therapy. In this group of patients selected for nonurgent invasive angiography, noninvasive imaging may be the intermediate step between the emergency department and discharge, improving confidence regarding the safety of the discharge [5].

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. Patients may have predisposing cardiac risk factors and pain characteristics that place them in the triage category of intermediate probability for coronary artery disease (CAD). Further cardiac risk stratification of this subgroup of patients is recommended before discharge, and noninvasive imaging is often necessary to exclude ischemia as an etiology [12-15].

The available noninvasive cardiac imaging modalities include chest radiography (CXR), rest SPECT myocardial perfusion imaging (MPI), stress SPECT MPI, echocardiography (transthoracic and transesophageal), multidetector computed tomography (MDCT), positron emission tomography (PET) (metabolic and perfusion), and magnetic resonance imaging (MRI).

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Chest Radiography

The utility of the CXR is primarily for ruling out conditions that may masquerade as acute myocardial ischemia as well as defining secondary findings that may accompany acute myocardial infarction. Acute pulmonary edema can be seen on a CXR without enlargement of the cardiac silhouette in patients with acute myocardial infarction and no prior history of ischemic damage or associated mitral valve disease. However, CXR is insufficient to confirm or exclude the presence of significant CAD. Other cardiovascular entities, such as aortic aneurysms, aortic dissections, and pulmonary embolism may be suggested from the CXR but with far lower sensitivity than other imaging modalities such as MDCT [16-18]. Noncardiac findings associated with chest pain that can be identified on the CXR include pneumothorax, fractured ribs, pleural effusions, and pneumonia.

Single-Photon Emission Computed Tomography/Myocardial Perfusion Imaging

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, rest SPECT has been demonstrated to be the test of choice [6,7,19]. It has been shown to be less sensitive than stress SPECT imaging, however, if performed after the chest pain has subsided. The commonly used radionuclide agents are Tl-201 (Thallium) chloride and (Technetium) 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. A perfusion defect that becomes apparent or becomes larger during exercise stress or pharmacologic stress defines ischemic myocardium.

Recently new software algorithms such as iterative reconstruction, maximum a posteriori noise regularization, and resolution recovery, and new hardware and detector materials have become available, allowing for image acquisitions at significantly shorter acquisition times (one-fifth to one-half of previous acquisition times) or alternatively at lower doses compared to conventional algorithms [20].

Echocardiography

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 a stress pharmacologic agent (such as dobutamine) inducing focal wall-motion abnormalities in the region(s) of ischemia [20-22]. Overall left ventricular function can also be assessed. The presence of left ventricular aneurysms, pseudoaneurysms, effusions, and valvular dysfunction can be determined as well.

The primary utility of 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 [23,24].

Multidetector Computed Tomography

In stable patients with suggested ACS with a low or intermediate probability of CAD, in whom follow-up ECG and cardiac biomarker measurements are normal, performance of a noninvasive coronary imaging test (ie, coronary CT angiography [CCTA]) is reasonable as an alternative to stress testing or selective coronary angiography [5,25,26]. CCTA has a very high negative predictive value for the detection of coronary atherosclerosis with or without significant stenosis and may be a potential alternative to stress imaging in the emergency department setting in patients at low to intermediate risk for CAD [25,27-35]. Although some of these studies have been criticized for including patients that have a very low pretest probability of CAD, large prospective trials attest to the high negative predictive value and good prognosis of a “normal” CTA in patients with low-risk acute chest pain. The advantages of cost and time savings while maintaining safety in the emergency department have also been pursued [36-41]. In addition, CT has a well-established role in identifying aortic aneurysms, aortic dissections, pulmonary embolism, pericardial disease, and lung parenchymal disease, all of which can also present with acute chest pain [13,42,43].

Evaluation of patients with CCTA results may be limited in patients with high heart rates (>65 beats/min) uncontrolled by beta blocker or other rate-limiting agents, and in patients who have intractable arrhythmias. Patients who have calcium scores greater than 400–600 Agatston Units have limitations, although the role of calcium score in the acute setting has not been established [44,45].

Recent advances in cardiac CT imaging technology allow for further radiation dose reduction in CCTA examinations [46]; new and available dose-reducing techniques include prospective triggering [47-49], adaptive statistical iterative reconstruction [50], and high-pitch spiral acquisition [51]. However, these newer low-dose techniques may not be appropriate in all patients due to their dependency on a combination of factors, including heart rate, rhythm, and large body size. Thus, although these techniques are promising in terms of reducing patient radiation dose, there may be patients for whom these radiation dose techniques are not optimal, such as an obese, elderly patient with an arrhythmia who might best benefit from retrospective gating in order to allow assessment of the coronary arteries at multiple phases of the cardiac cycle. In addition, not all scanners are capable of all radiation dose reduction techniques. In all cases, the imaging physician must select the appropriate combination of imaging parameters to acquire a diagnostic examination at a radiation dose that is as low as reasonably achievable (ALARA).

Positron Emission Tomography

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 [52]. PET can also document anaerobic metabolism using fluorine-18-2-fluoro-2-deoxy-D-glucose and other metabolic tracers. This technology is not universally available and, therefore, is less well studied in the workup of the acute chest pain patient [53].

Magnetic Resonance Imaging

MRI has modest utility in patients with suspected ischemia in the acute setting. The principal limitations to this technique are equipment availability and the high level of expertise required of technologists and interpreting physicians. Access to the patient may be more difficult in the magnetic environment if the patient's stability should deteriorate.

However, cardiac MRI with delayed postcontrast imaging and edema-weighted imaging provides definitive assessment of the size, distribution, and transmural extent of acute or remote myocardial infarction. Cine MRI has utility in demonstrating wall-motion abnormalities, which may accompany acute or chronic ischemic heart disease, and first-pass stress contrast-enhanced perfusion cardiac MRI can demonstrate myocardial perfusion abnormalities [54-58].

MRI, like CT, can also identify noncardiac findings of chest pain, such as aortic dissection. Cardiac MR has been shown to be cost-effective in the workup of intermediate-risk chest pain patients in the emergency department [59,60]. Although MR coronary angiography has not been established in general practice, both angiographic and phase-contrast flow continue to be developed for coronary artery assessment in research centers [61].

Summary

- A number of imaging modalities may be used in evaluating stable patients with chest pain suggestive of ACS and who are not selected for urgent cardiac catheterization.
- Although cardiac catheterization is the mainstay for evaluation of patients in whom a diagnosis of NSTEMI is made, in the clinically stable patient with angina or UA, alternative noninvasive imaging modalities may be appropriate.
- Noninvasive imaging in this setting includes MPI, coronary CT angiography, cardiac MRI, and stress echocardiography. These tests may be performed as an intermediate step and may improve confidence regarding the safety of discharge from the emergency department.

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, both because of 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 to 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.

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”.

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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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.