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**American College of Radiology
ACR Appropriateness Criteria®**

Clinical Condition: Acute Nonspecific Chest Pain—Low Probability of Coronary Artery Disease

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9	X-ray, CTA, and US are generally nonoverlapping and can be used sequentially.	☼
CTA coronary arteries with IV contrast	7	X-ray, CTA, and US are generally nonoverlapping and can be used sequentially.	☼☼☼
CTA chest with IV contrast	7	X-ray, CTA, and US are generally nonoverlapping and can be used sequentially.	☼☼☼
US echocardiography transthoracic resting	7	X-ray, CTA, and US are generally nonoverlapping and can be used sequentially.	○
Tc-99m SPECT MPI rest and stress	6		☼☼☼☼
Tc-99m V/Q scan lung	5		☼☼☼
X-ray rib views	5		☼☼☼
MRA chest without and with IV contrast	5		○
MRI heart stress perfusion without and with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	○
MRI heart function and morphology without and with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	○
US echocardiography transthoracic stress	5		○
MRA chest without IV contrast	4		○
X-ray barium swallow and upper GI series	4		☼☼☼
X-ray thoracic spine	4		☼☼☼
US abdomen	4		○
MRI heart function and morphology without IV contrast	4		○
US echocardiography transesophageal	2		○
Arteriography coronary	1		☼☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

ACUTE NONSPECIFIC CHEST PAIN—LOW PROBABILITY OF CORONARY ARTERY DISEASE

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Summary of Literature Review

Introduction/Background

Patients who present to the emergency department (ED) with acute chest pain are stratified according to their probability of developing acute coronary syndrome (ACS) as follows: very low (<1%), low (1%–4%), intermediate (4%–8%), or high (>8%) probability [1].

This document outlines the usefulness of available diagnostic imaging for those patients without known coronary artery disease (CAD) and at low probability for having CAD who do not present with classic ACS signs, symptoms, or electrocardiogram (ECG) abnormalities, but rather with nonspecific chest pain leading to a differential diagnosis including aortic, pulmonary, gastrointestinal (GI), or musculoskeletal pathologies. Patients presenting to the ED with classic signs and/or symptoms of ACS, including those with unstable angina pectoris, non–ST-elevation myocardial infarction, diagnostic ST-segment changes, or elevated cardiac enzymes suggesting myocardial infarction, are not included in this discussion. The evaluation and treatment algorithms for these conditions have been well defined in the Scientific Statements and Practice Guidelines of the American Heart Association [2,3] and in the ACR Appropriateness Criteria[®] “[Chest Pain Suggestive of Acute Coronary Syndrome](#)” [4].

The following imaging modalities are available for evaluating patients presenting to the ED with low probability of CAD: chest radiography, multidetector computed tomography (MDCT), magnetic resonance imaging (MRI), ventilation/perfusion (V/Q) scans, cardiac perfusion scintigraphy, transesophageal and transthoracic echocardiography, positron emission tomography (PET), spine and rib radiography, barium esophageal and upper GI studies, and abdominal ultrasound (US) [5,6]. Traditionally, most of these examinations have been performed during the ED visit, but there is a trend to perform outpatient testing.

Variant: Acute Nonspecific Chest Pain—Low Probability of Coronary Artery Disease

Chest Radiography

The chest radiograph is the recommended initial imaging study [7]. Chest radiographs can help identify potential sources of previously undifferentiated chest pain such as pneumothorax, pneumomediastinum, fractured ribs, acute and chronic infections, and malignancies. Other conditions producing chest pain, such as pulmonary emboli (PE), can be suspected from the chest radiograph, but the overall sensitivities are low [8]. Thoracic calcifications, if present, can indicate pericardial disease, ventricular aneurysm, intracardiac thrombi, or aortic disease. Although chest radiographs are often normal for the presence of PE, the presence of a Hampton hump, Westermark sign, or pulmonary artery enlargement can suggest PE [9]. Mediastinal air can indicate a ruptured viscus or subpleural bleb or other acute pathology. In addition, widening of the mediastinum or an enlarged heart or aortic knob, as well as ill-defined aortic boundaries, can establish a differential diagnosis of acute aortic syndrome.

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Multidetector Computed Tomography

Coronary computed tomography angiography (CCTA): Both prospectively (mean radiation exposure, 3 [range, 1–5] mSv) and retrospectively (mean radiation exposure, 10 [range, 8–12] mSv) ECG-synchronized cardiac CT permits comprehensive assessment of aortic, coronary, and other causes of chest pain. Most importantly, in this low-risk population, cardiac CTA accurately detects and characterizes the presence and extent of CAD [6,10] and has nearly perfect negative predictive value to rule out significant CAD [11-18].

Additional assessment of global and regional left ventricular function and wall motion adds significant incremental value [19]. MDCT is also the primary method for diagnosing coronary anomalies, a rare cause of acute chest pain.

Recent advances in cardiac CT imaging technology allow for further radiation dose reduction in CCTA examinations [20]; new and available dose-reducing techniques include prospective triggering [21-23], adaptive statistical iterative reconstruction [24], and high-pitch spiral acquisition [25]. 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. The proper application of these new lower-dose techniques is scanner dependent and may depend on low heart rate (<65 bpm) and sinus rhythm. However, some scanners allow heart-rate-independent use of low-radiation protocols [26].

Chest CTA is the state-of-the-art method for detection of PE [27]. In addition, chest CTA has excellent accuracy in demonstrating noncardiac causes of chest pain, including pneumothorax, pneumonia, malignancies, pulmonary airspace abnormalities, and interstitial lung disease. Pericardial effusions, thickening, and/or calcifications are seen far more readily than with radiographs alone [28-30], and more importantly, other symptom-producing pathologies such as ventricular aneurysms and cardiac thrombi or tumors [31] can be detected. Pulmonary nodules represent >75% of incidentally detected findings [32].

With advanced CT technology, it is possible to perform a single-phase triple rule-out examination allowing comprehensive assessment of CAD, aortic dissection (AD), and PE by covering the entire thorax while enhancing both the aortic and pulmonary vascular tree [33-35]. The newest developments in CT technology permit this exam with minimally increased radiation exposure and contrast administration. Hence, such protocols can be useful in selected patients, especially those in whom ED physicians consider ACS as a secondary differential after PE has been ruled out. At this point, there are not enough data to conclude whether such practice would be efficient [36-38].

Transthoracic and Transesophageal Echocardiography

Transthoracic and transesophageal echocardiography, with or without pharmacologic stress, are frequently used to define abnormalities of ventricular wall motion as indicators of cardiac disease [39]. In addition, echocardiography can readily demonstrate pericardial effusion, valve dysfunction, and cardiac thrombus. Aortic pathology can be identified [40,41], but the findings of intramural hematoma, dissection, pulmonary embolus, and aneurysm are better seen with MDCT or MRI. Most importantly, transthoracic echocardiography without stress is a low-risk screening examination with high negative predictive value for ACS.

Magnetic Resonance Imaging

Magnetic resonance angiography (MRA) of the chest can be performed with either noncontrast (eg, time-of-flight, balanced steady-state free precession, phase-contrast, black-blood) or contrast-enhanced (eg, 3-D arterial-phase fast gradient-echo) protocols that are useful in identifying vascular pathology. These techniques can be used to identify aortic pathology and in specific scenarios can be used to evaluate for pulmonary artery pathology [42,43]. Cardiac MRI is typically more time consuming and less available in the ED setting. Its strength lies primarily in the assessment of myocardial ischemia, edema, and infarction in patients with known CAD [44]. In addition, cardiac MRI can be used in the imaging assessment for acute myocarditis as a cause of chest pain [45]. Cardiac MRI has not been well studied in low-risk undifferentiated chest pain populations and is uncommonly used in the

emergency setting because of the relatively long scan times and its inability to detect CAD and PE with reasonable efforts. The benefits of cardiac MRI, both with and without pharmacologic stress, in acute nonspecific chest pain, with the exception of patients in whom myocarditis is suspected, is likely of limited use [44,46,47].

Radiography of the Ribs, Cervical Spine, or Thoracic Spine

Rib or spine radiographs are indicated in patients with a clinical suspicion of skeletal pathology.

Radionuclide Studies

Radionuclide myocardial perfusion studies at rest, but more typically at stress, followed by rest examinations in those with positive stress with technetium 99m sestamibi or tetrofosmin are frequently used in identifying perfusion abnormalities as an indicator of ischemic chest pain, especially when a cardiac etiology is suspected [48-54]. A normal stress perfusion scan can be used to exclude the diagnosis of CAD in patients in whom myocardial infarction by enzymes has been ruled out.

PET is an alternative method for evaluating myocardial perfusion deficits, using N-13 ammonia or rubidium 82 agents. However, PET is not indicated in low-probability patients.

V/Q lung scintigraphy can be used in patients with clinically suspected PE, but this study has been largely replaced by MDCT.

Cardiac Catheterization

Cardiac catheterization with coronary digital subtraction angiography remains the gold standard in demonstrating CAD and can permit immediate therapeutic intervention. However, there is rarely an indication to use it in low-probability patients because of the unfavorable risk benefit ratio (0.46% major complication rate in diagnostic angiography, consisting of 0.13% death, 0.06% MI, 0.08% stroke, 0.07% major bleeding [>2 units], and 0.12% severe renal failure [$>50\%$ decrease in GFR]) [55]. This has become more relevant with the availability of CCTA, with its high negative predictive value to exclude CAD.

Barium Swallow or Endoscopy

Esophageal disorders can be the cause of chest pain. A water-soluble or barium contrast upper GI swallowing study or endoscopy can be helpful in establishing esophageal spasm or reflux as an etiology of the chest pain [56].

Abdominal Ultrasonography

Abdominal US may be indicated to document cholecystitis as a cause for the chest pain. US is also helpful in evaluating pancreatitis, other solid-organ pathology, intra-abdominal abscesses and fluid collections, and, less frequently, GI pathology.

Summary of Recommendations

- This document applies to patients at low risk for CAD who present with undifferentiated chest pain and without signs of ischemia in which a chest radiograph is almost universally obtained.
- Functional testing with exercise-based ECG, echocardiography, or low-dose single-photon emission CT (SPECT) myocardial perfusion imaging (MPI) can be conducted to exclude myocardial ischemia after rule-out of MI by consecutive troponin measurements, especially in patients with high exercise capacity.
- Cardiac CT, owing to its high negative predictive value, is a viable alternative to functional testing, is increasingly used in the evaluation of coronary disease in this population, and can be incorporated into the workup algorithm of those with low-probability chest pain.
- Triple-rule-out CT (CAD, PE, and AD) has become more technically feasible and can be helpful in selecting patients, but evidence is not conclusive whether this will improve efficiency of patient management.
- A number of diagnostic tests, among them US of the abdomen, MRA of the aorta with or without contrast, x-ray rib views, x-ray barium swallow, and upper GI series can also be appropriate to use in evaluating noncardiac causes of chest pain.
- Typically, more invasive imaging tests such as transesophageal echocardiography or coronary angiography, as well as advanced specific cardiac MRI examinations, are rarely indicated in diagnosing low-risk nonspecific chest pain.

Summary of Evidence

Of the 56 references cited in the *ACR Appropriateness Criteria® Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease* document, 55 are categorized as diagnostic references including 5 well designed studies, 13 good quality studies, and 18 quality studies that may have design limitations. Additionally, 1 reference is categorized as a therapeutic reference. There are 20 references that may not be useful as primary evidence.

The 56 references cited in the *ACR Appropriateness Criteria® Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease* document were published from 1988-2015.

While there are references that report on studies with design limitations, 18 well designed or good quality studies provide good evidence.

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.