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		☢
CTA coronary arteries with contrast	7		☢☢☢
CTA chest with contrast	7		☢☢☢
US echocardiography transthoracic resting	7		O
SPECT MPI rest and stress	6		☢☢☢☢
Tc-99m V/Q scan lung	5		☢☢☢
MRA aorta without and with contrast	5	See statement regarding contrast in text under "Anticipated Exceptions."	O
X-ray rib views	5		☢☢☢
MRA chest without and with contrast	5	See statement regarding contrast in text under "Anticipated Exceptions."	O
MRA aorta without contrast	4		O
MRA chest without contrast	4		O
X-ray barium swallow and upper GI series	4		☢☢☢
X-ray thoracic spine	4		☢☢☢
US abdomen	4		O
MRI heart with or without stress without and with contrast	3		O
MRA pulmonary arteries without and with contrast	3		O
MRA coronary arteries without contrast	3		O
MRA coronary arteries without and with contrast	3		O
US echocardiography transthoracic stress	3		O
US echocardiography transesophageal	2		O
MRI heart with or without stress without contrast	2		O
MRA pulmonary arteries without contrast	2		O
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

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. 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 pulmonary, gastrointestinal (GI), or musculoskeletal pathologies [1,2]. In contrast, patients presenting to the ED with signs and/or symptoms [3] of ACS along with diagnostic ST-segment changes, and elevated cardiac enzymes suggesting myocardial infarction [4] are not included in this discussion as the evaluation and treatment algorithms have been well defined in the Scientific Statements and Practice Guidelines of the American Heart Association [5] and in the ACR Appropriateness Criteria® topic "Chest Pain, Suggestive of Acute Coronary Syndrome."

The following imaging modalities are available in 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 [6,7].

Chest Radiography

The chest radiograph is the recommended initial imaging study [8]. 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 such as pulmonary emboli (PE), may be suspected from the chest radiograph, but the overall sensitivities are low [9]. Thoracic calcifications, if present, may indicate pericardial disease, ventricular aneurysm, intracardiac thrombi, or aortic disease. While chest radiographs are often normal for the presence of PE, the presence of a Hampton hump, Westermark sign, or pulmonary artery enlargement may suggest PE [10]. Mediastinal air may indicate a ruptured viscus or subpleural bleb or other acute pathology.

Multidetector Computed Tomography

MDCT 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 [11-14]. In the setting of undifferentiated chest pain, CT angiography (CTA) with its high sensitivity and specificity can be considered the modality of choice to diagnose suspected PE and/or aortic pathology such as aortic dissection (AD) or aneurysm [15-18]. Both prospectively (mean radiation exposure <5 mSv) and retrospectively (mean radiation exposure <12 mSv) ECG-synchronized cardiac CT permits comprehensive assessment of the presence and extent of CAD [19,20]. Most importantly, in this low-risk population, cardiac CTA has nearly perfect negative predictive value to rule out significant CAD [21-24]. When coronary CTA is performed with retrospective ECG gating, additional

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assessment of wall motion adds significant incremental value [25]. MDCT is also the primary method for diagnosing coronary anomalies, a rare cause of acute chest pain [26-28].

Cardiac CT can also detect other symptom-producing pathologies such as ventricular aneurysms and cardiac thrombi or tumors [29]. Significant findings such as PE or AD appear to be rare in patients with undifferentiated chest pain, probably because of the low probability for any disease. However, pulmonary nodules are detected in a significant number of patients [30]. With advanced CT technology, it is possible to perform a single-phase triple rule-out examination allowing comprehensive assessment of CAD, AD, and PE [31-33]. However, its efficiency or effectiveness has not been demonstrated.

Recent advances in cardiac CT imaging technology allow for further radiation dose reduction in CCTA examinations [34]; new and available dose-reducing techniques include prospective triggering [35-37], adaptive statistical iterative reconstruction [38], and high-pitch spiral acquisition [39]. 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).

Transthoracic and Transesophageal Echocardiography

Transthoracic and transesophageal echocardiography, with or without pharmacologic stress, are frequently used to define abnormalities of ventricular wall motion as an indicator of cardiac disease [40]. In addition, echocardiography can readily demonstrate pericardial effusion, valve dysfunction, and cardiac thrombus. Aortic pathology can be identified [41,42], 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) can be performed with either noncontrast (eg, time-of-flight, balanced steady-state free precession, phase-contrast, black-blood) or contrast-enhanced (eg, 3D arterial-phase fast gradient-echo) protocols that are useful in identifying vascular pathology. These techniques can be used to accurately identify aortic pathology and in specific scenarios may also be used to evaluate for pulmonary artery pathology [43,44]. MRA is typically more time-consuming and less available in the ED setting, but it is an important alternative noninvasive imaging strategy in patients with a contraindication to CTA. 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. The benefits and role of cardiac MRI, both with and without pharmacologic stress, in this population remain uncertain and have yet to be subjected to large controlled trials [45-47].

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 with thallium 201, 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 may 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 the high negative predictive value of coronary CTA enables it to be used alone 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 may be helpful in establishing esophageal spasm or reflux as an etiology of the chest pain [55].

Abdominal Ultrasonography

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

Summary

- 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.
- Cardiac CT, as well as, rest and stress SPECT MPI, owing to its high negative predictive value, is increasingly used in the evaluation of coronary disease in this population and may be incorporated into the workup algorithm of those with low-probability chest pain.
- Chest CT and transthoracic echocardiography play an important role in evaluating noncoronary or consequences of coronary causes of chest pain.
- A number of diagnostic tests, among them ultrasound of the abdomen, MRA of the aorta with or without contrast, x-ray rib views, x-ray barium swallow, and upper GI series may 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.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m^2. For more information, please see the ACR *Manual on Contrast Media* [56].

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**
O	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

- ACR Appropriateness Criteria® Overview
- Procedure Information
- Evidence Table

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