

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

Clinical Condition: Chronic Chest Pain—Low to Intermediate Probability of Coronary Artery Disease

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
X-ray chest	9		Min
US echocardiography transthoracic stress	8	To exclude ischemic cardiac disease.	None
NUC myocardial perfusion scan	8	To exclude ischemic cardiac disease.	High
CTA chest (noncoronary)	8	Important exam for pulmonary embolism and thoracic aortic aneurysm/dissection. To rule out PE and evaluate lung pathology. Appropriate for chronic anginal chest pain.	Med
CTA coronary arteries	8	Can be used to assess for coronary atherosclerosis, anomalous coronary artery, and pericardial disease. High negative predictive value will exclude coronary artery disease and allow triage management to focus on more likely diagnoses. To eliminate unnecessary catheterizations.	High
MRI heart with stress with or without contrast	7	Generally less available than nuclear medicine studies. Analysis for myocardial contractile function, valve function, myocardial scar, and flow-limiting coronary artery stenosis. See comments regarding contrast in text under “Anticipated Exceptions.”	None
X-ray barium swallow and upper GI series	6	If gastroesophageal reflux, esophagitis, achalasia, or esophageal tumor is considered a likely source of chest pain.	Med
US echocardiography transthoracic	6	Can be used to assess for valve disease or pericardial disease as a cause for chronic chest pain.	None
US abdomen	6	If cholecystitis, stones, or biliary disease is considered a cause of referred chest pain.	None
CT chest without contrast	6		Med
INV coronary angiography with ventriculography	6	If ischemic cardiac disease remains in the differential.	Med
MRI heart function and morphology with or without contrast	5	To assess for myocardial contractile function, valve function, and myocardial scar. See comments regarding contrast in text under “Anticipated Exceptions.”	None
US echocardiography transesophageal	4	If TTE is inadequate and there is no suspicion of esophageal disease.	None
MRI chest with or without contrast	4	May be used instead of chest CT in patients with iodinated contrast contraindications, or if chest CT is inadequate. See comments regarding contrast in text under “Anticipated Exceptions.”	None
NUC Tc-99m V/Q scan lung	4	May be used in patients with suspected chronic PE in patients with iodinated contrast contraindications.	Med
NUC Tc-99m 3-phase bone scan area of interest	4		Med

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INV arteriography pulmonary	4	If CT or V/Q scan imaging is inadequate and chronic PE is principal suspected etiology, or if concurrent pulmonary arterial pressures are to be obtained.	High
CT coronary calcium	3	A zero score may be useful in excluding cardiac etiology.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

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CHRONIC CHEST PAIN—LOW TO INTERMEDIATE PROBABILITY OF CORONARY ARTERY DISEASE

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Summary of Literature Review

Chronic chest pain can arise from a variety of etiologies. However, of those potential causes, the most threatening arise from cardiac disease. Chronic noncardiac chest pain (NCCP) most commonly is related to gastroesophageal reflux disease (GERD) or other esophageal diseases [1]. Alternatively, it may be related to costochondritis, arthritic or degenerative diseases, old trauma, primary or metastatic tumors, or pleural disease. Rarely, NCCP may be referred pain from organ systems below the diaphragm, such as the gallbladder.

Nevertheless, cardiac disease must be a primary consideration. Chronic cardiac chest pain may be caused by either coronary artery disease (CAD) or non-CAD-related etiologies. The latter includes ischemic syndromes in the absence of epicardial CAD as well as nonischemic cardiac pain. Some examples of causes of non-CAD-related ischemia include aortic stenosis, hypertrophic cardiomyopathy [2], uncontrolled hypertension [3], the presence of an anomalous coronary artery, or syndrome X [4,5]. Non-ischemic etiologies of cardiac-related chest pain are most commonly related to the pericardium and include chronic pericarditis or primary or metastatic tumors.

In evaluating the patient presenting with chronic chest pain, the clinician must first determine whether the chest pain is anginal or nonanginal, (ie, myocardial ischemia must first be excluded). Typical angina is substernal chest pain or discomfort that is provoked by exertion or emotional stress and relieved by rest or nitroglycerin [6]. However a history of atypical angina (chest pain or

discomfort that lacks one of the characteristics of typical angina [6]) may be given. A history and physical examination, including laboratory tests for diabetes and hyperlipidemia and resting electrocardiography, will allow the clinician to estimate the patient's probability of CAD [4]. Patients with chronic chest pain and risk factors indicating a high to intermediate probability of CAD should undergo a stress nuclear medicine examination or stress echocardiography. If either of these are positive in a patient with risk factors indicating a high probability of CAD, coronary catheterization angiography (CCA) should be performed. In a patient with intermediate probability of CAD and positive stress imaging, multidetector computed tomography (MDCT), coronary angiography, or CCA can be performed. In patients unable to exercise, MDCT coronary angiography may be performed in lieu of a stress imaging examination. Those patients with a low probability of CAD and those in whom CAD has been excluded should be further evaluated for an alternative cause. The use of a screening chest radiograph should be used to further narrow potential etiologies in these low-risk patients.

Guidelines exist in the literature for diagnosing chronic stable angina (ischemia-related chest pain) [7]. Yet, there is no significant literature presentation of diagnostic algorithms for patients with chronic chest pain of determined non-ischemic etiology. There are procedure-related articles that include some of these patients [8,9], but no randomized, controlled trial to provide an evidence-based practice. When to order a chest x-ray, chest computed tomography (CT), barium swallow, bone scan, or virtually any diagnostic imaging in patients with chronic NCCP is poorly documented. The ordering of diagnostic tests is governed by the impression of the primary physician.

Approach to Patients with Chronic Chest Pain

In general, this category of patients is defined as having pain that does not change in character over a period of time; it may wax and wane, but the intensity and duration generally show little change. For this reason, acute coronary syndrome (ACS), myocardial infarction (MI) and aortic dissection are not considered in the differential.

However, findings of chronic chest pain may represent underlying CAD. A great many patients present with what has been characterized as "atypical chest pain." For this reason evaluation for CAD should be undertaken in patients with a high to intermediate pretest probability of CAD. The principal test used is single-photon emission computed tomography myocardial perfusion imaging (SPECT MPI) [10]. Evaluation with SPECT MPI is suitable for the patient with chronic chest pain. The

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intervention performed with a SPECT MPI scan is either mechanical stress or pharmacological intervention. If the patient is in an emergency department setting and has angina, then a simple resting myocardial perfusion imaging study with a technetium agent may suffice. Overall, echocardiography is competitive with SPECT MPI.

When echocardiography is performed, either stress or dobutamine is commonly used. In any situation where a SPECT MPI study could be performed, a stress or dobutamine echocardiogram may be substituted [11,12]. In certain cases, if aortic valvular stenosis is considered the cause of ischemia or if a pericardial effusion is in question, an echocardiogram at rest may be the preferred examination. Cardiac magnetic resonance imaging (MRI) without pharmacologic stress could also be performed if valve disease, pericardial disease, or tumor is thought to be the cause of the chest pain, especially if the echocardiogram is inadequate.

Most recently coronary 64-row multidetector computed tomography (MDCT) angiography has been used to assess both acute and chronic chest pain [13-15]. Like stress SPECT MPI or echocardiography, it can also be used to assess patients with a high to intermediate probability of CAD. It may be especially useful, and used instead of SPECT MPI or echocardiography in patients with atypical chest pain, where etiologies other than CAD are also in question [13,16]. It has particular utility for noninvasively and accurately demonstrating the origin and course of anomalous coronary arteries [17]. It may also be used in cases where the SPECT MPI or echocardiography examinations were nondiagnostic or the results were questionable.

Dobutamine stress functional cardiac MRI may also play a role in the assessment of chronic chest pain [18]. This is especially true in instances where the echocardiographic examination is nondiagnostic. In settings where the study may be adequately monitored, dobutamine stress functional cardiac MRI provides high sensitivity and specificity for ischemia by the induction of wall motion abnormality [19]. Adenosine stress cardiac MRI perfusion imaging is easier to perform and has been shown to be relatively sensitive for the presence of CAD, but slightly less specific [19,20], and it may be limited in its coverage of the left ventricle.

As described above, it should be noted that chronic chest pain can occur in ischemic syndromes in the absence of epicardial CAD. The diagnosis of syndrome X, in particular, has been shown to best be made with adenosine stress perfusion cardiac MRI, which demonstrates diffuse subendocardial hypoperfusion [21]. Its utility in comparison to SPECT MPI may be because of its higher spatial resolution.

Cardiac catheterization may be used if less invasive imaging was consistent with the presence of significant CAD.

Approach to Patients with Chronic Chest Pain of Determined Noncardiac Etiology

In attempting to stratify the diagnostic tests, a chest x-ray would almost certainly be indicated to exclude bony pathology or chest masses. As GERD is the most common cause of NCCP, a barium swallow could be performed or, alternatively, esophageal pH monitoring, manometry, or endoscopy [1,8]. The remainder of the diagnostic imaging progression depends strongly upon the clinical history and signs and symptoms of the patient. For instance, studies performed could include a chest CT scan (if coronary MDCT angiography was not already obtained) to exclude chest syndrome in a sickle cell patient or a lung mass in a patient with chest pain, cough, and weight loss. A right upper quadrant ultrasound might be obtained in a patient with suspected gallstones or chronic cholecystitis. A bone scan could be obtained in someone with a primary malignancy and pain upon rib palpation.

Chronic pulmonary emboli can also cause chest discomfort, and in these patients a contrast-enhanced pulmonary CT angiogram may be performed. A ventilation-perfusion scan may be performed as an alternative in patients with iodinated contrast contraindications. An invasive pulmonary angiogram is a second alternative, especially if the pulmonary CT angiogram is inadequate or pulmonary arterial pressure measurements are required.

Anticipated Exceptions

The description term “chest pain” is so amorphous and subjective that exceptions to the above plan may be justified in individual cases; so much depends on the judgment of the physician at the time the patient is seen and the particular presentation of the patient.

Nephrogenic systemic fibrosis (NSF), also known as nephrogenic fibrosing dermopathy) was first identified in 1997 and has recently generated substantial concern among radiologists, referring doctors and lay people. Until the last few years, gadolinium-based MR contrast agents were widely believed to be almost universally well tolerated, extremely safe and non-nephrotoxic, even when used in patients with impaired renal function. All available experience suggests that these agents remain generally very safe, but recently some patients with renal failure who have been exposed to gadolinium contrast agents (the percentage is unclear) have developed NSF [22-24], a syndrome that can be fatal. Further studies are necessary to determine what the exact relationships are between gadolinium-containing contrast agents, their specific components and stoichiometry, patient renal function and NSF. Current theory links the development of NSF to the administration of relatively high doses (eg, >0.2mM/kg) and to agents in which the gadolinium is

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least strongly chelated. The FDA has recently issued a “black box” warning concerning these contrast agents (http://www.fda.gov/cder/drug/InfoSheets/HCP/gcca_200705HCP.pdf).

This warning recommends that, until further information is available, gadolinium contrast agents should not be administered to patients with either acute or significant chronic kidney disease (estimated GFR <30 mL/min/1.73m²), recent liver or kidney transplant or hepato-renal syndrome, unless a risk-benefit assessment suggests that the benefit of administration in the particular patient clearly outweighs the potential risk(s) [23].

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. 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	Effective Dose Estimate Range
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

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