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American College of Radiology
ACR Appropriateness Criteria®

<u>Clinical Condition:</u> **Chronic Chest Pain — Low to Intermediate Probability of Coronary Artery Disease**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☢
US echocardiography transthoracic stress	8	To exclude ischemic cardiac disease.	O
Tc-99m SPECT MPI rest and stress	8	To exclude ischemic cardiac disease.	☢☢☢☢
CTA chest with IV contrast	8	For pulmonary embolism and thoracic aortic aneurysm/dissection. To rule out pulmonary embolism and evaluate lung pathology.	☢☢☢
CTA coronary arteries with IV contrast	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.	☢☢☢
MRI heart with stress without and with IV contrast	8	Can be used in patients with poor echocardiography window, or indeterminate stress test.	O
Rb-82 PET heart stress	8	N-13 ammonia may be used if a cyclotron is available.	☢☢☢
MRI heart with stress without IV contrast	6	Dobutamine MRI heart stress test might be used in patients with poor echocardiography window or indeterminate stress test. Useful when MRI is desired, but renal insufficiency precludes use of gadolinium-based MRI contrast agents. Availability limited to centers with expertise.	O
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, then indication is higher.	☢☢☢
US echocardiography transthoracic resting	6	Can be used to assess for valve disease or pericardial disease as a cause for chronic chest pain.	O
US abdomen	6	If referred chest pain is thought to be caused by cholecystitis, stones, or biliary disease.	O
CT chest without IV contrast	6		☢☢☢
Arteriography coronary with ventriculography	6	If ischemic cardiac disease remains in the differential.	☢☢☢
MRI heart function and morphology without and with IV contrast	4	For determination of constrictive pericarditis.	O
US echocardiography transesophageal	4	If TTE is inadequate and there is no suspicion of esophageal disease.	O
Tc-99m V/Q scan lung	4	May be used in patients with suspected chronic pulmonary embolism in patients with iodinated contrast contraindications.	☢☢☢
Tc-99m 3-phase bone scan area of interest	4		☢☢☢

Arteriography pulmonary	4	If CT or V/Q scan imaging is inadequate and chronic pulmonary embolism is the principal suspected etiology, or if concurrent pulmonary arterial pressures are to be obtained.	☢☢☢☢
MRI heart function and morphology without IV contrast	3	For determination of constrictive pericarditis. If contrast cannot be given.	O
MRI chest without and with IV contrast	3	Possibly for chronic pulmonary embolism in patients unable to undergo chest CTA.	O
CT coronary calcium	3	May be used in patient risk stratification. Zero score alone cannot be used to exclude ischemia.	☢☢☢
MRI chest without IV contrast	2	For noncardiac etiologies, including pleural disease.	O
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

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) is most commonly 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 during the evaluation of chronic chest pain. Chronic cardiac chest pain (CCP) may be caused by either atherosclerotic coronary artery disease (CAD) or other cardiac-related etiologies. The latter include ischemic syndromes in the absence of epicardial CAD as well as nonischemic cardiac pain. Some causes of non-CAD-related ischemia include aortic stenosis, hypertrophic cardiomyopathy [2], uncontrolled hypertension [3], interarterial anomalous coronary artery, and syndrome X [4,5]. Nonischemic etiologies of chronic CCP 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 the clinical probability of CAD, defined as the likelihood of having a >50% coronary stenosis. This is done by judging whether the chest pain is typical angina, atypical angina, or “noncardiac” and comparing it with the patient’s age and gender according to previously reported findings [6,7] . Typical angina is characterized by substernal chest pain or discomfort that is provoked by exertion or emotional stress and relieved by rest or nitroglycerin [7]. However, a history of atypical angina (chest pain or discomfort that lacks one of the characteristics of typical angina [7]) may also be given.

In order to estimate the patient’s probability of CAD, a history and physical examination, including laboratory tests for diabetes and hyperlipidemia and a resting electrocardiogram, are of value [4]. Patients whose age, gender, and type of chest pain indicate a high to intermediate probability of CAD should undergo a stress physiology assessment, either an exercise treadmill, a stress nuclear medicine myocardial perfusion imaging examination, or a stress echocardiography for contractility assessment [8]. If any of these are positive in a patient with symptoms indicating a high probability of CAD, coronary catheterization angiography (CCA) should be considered. In some cases, however, a patient with stable angina may be treated medically [9].

In a patient with intermediate probability of CAD and positive stress imaging, multidetector coronary computed tomography angiography (CCTA) or CCA can be performed for direct coronary artery evaluation [10]. In patients unable to either exercise or receive pharmacologic stress agents, CCTA 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 of their chest pain. A screening chest radiograph may be used to further narrow potential etiologies in these low-risk patients.

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Guidelines exist in the literature for diagnosing chronic stable angina (ischemia-related chest pain) [11], yet there are no significant literature presentations of diagnostic algorithms that consider patients with chronic chest pain of determined nonischemic etiology. There are procedure-related reports that include such patients [12,13], but no randomized, controlled trial to provide an evidence-based practice is available. When to order a chest radiograph, chest CT, barium swallow, bone scan, or virtually any diagnostic imaging in patients with chronic nCCP is poorly documented. As a result, the ordering of diagnostic tests is governed by the impression of the primary physician.

Approach to Patients with Chronic Chest Pain

In general, chronic chest pain is defined as chest discomfort that does not change 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." Moreover, 1-year mortality among patients with nonspecific or atypical chest pain has been shown to be higher than for control subjects [14]. For this reason evaluation for CAD should be undertaken in patients with chronic chest pain in the setting of intermediate to high pretest probability of CAD. The principal imaging test used is stress single-photon-emission computed tomography myocardial perfusion imaging (SPECT MPI) [15]. The intervention performed with a SPECT MPI scan is either exercise- or pharmacologically-induced to invoke perfusion or contraction abnormalities.

Overall, stress echocardiography is competitive with SPECT MPI. When echocardiography is performed, stress contraction abnormalities are induced by either exercise or inotropic stimulation (ie, dobutamine). In any situation where a SPECT MPI study could be performed, an exercise-stress or dobutamine-stress echocardiogram may be substituted [16,17]. 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.

Dobutamine-stress functional cardiac magnetic resonance imaging (MRI) may also play a role in the assessment of chronic CCP [18]. This is especially when 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]. However, adenosine-stress cardiac MRI perfusion imaging is easier to perform and also has been shown to have relatively high sensitivity and specificity for the presence of CAD [19-21]. Positron emission tomography/computed tomography (PET/CT) may play a role similar to cardiac MRI in assessing patients with chronic indeterminate chest pain and at low to intermediate risk for CAD. Cardiac PET/CT has been shown to provide incremental prognostic value to historical and clinical variables [22], and may be of particular use in patients with equivocal or sub-optimal SPECT-MPI or echocardiographic results.

As described above, it should be noted that chronic CCP 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 [23]. Its utility in comparison to SPECT MPI may be because of its higher spatial resolution. Cardiac MRI without pharmacologic stress could also be performed if valve disease, pericardial disease, or tumor is thought to be the cause of the CCP, especially if the echocardiogram is inadequate.

Most recently coronary 64-slice CCTA has been used to assess both acute and chronic CCP [24-26]. Like stress SPECT MPI or echocardiography, it can also be used to assess patients with intermediate to high probability of CAD. However, it is especially useful, and used instead of SPECT MPI or echocardiography in patients with atypical chest pain and or low to intermediate probability of CAD, where etiologies other than CAD are also in question [24,27]. It has particular utility for noninvasively and accurately demonstrating the origin and course of anomalous coronary arteries [28]. It may also be used in cases where the SPECT MPI or echocardiography examinations were nondiagnostic or the results were questionable.

Recent advances in cardiac CT imaging technology allow for further radiation dose reduction in CCTA examinations [29]; new and available dose-reducing techniques include prospective triggering [30-32], adaptive statistical iterative reconstruction [33], and high-pitch spiral acquisition [34]. 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).

Coronary calcium scoring (CCS) is most commonly used for risk stratification in asymptomatic patients. A large study of 10,377 subjects showed that CCS provides independent incremental information in addition to traditional risk factors in the prediction of all-cause mortality [35]. While a patient's calcium score provides independent information regarding a patient's baseline probability of the presence of CAD, a high calcium score cannot be used as strong evidence of myocardial ischemia and a zero calcium score cannot exclude it.

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 radiograph would almost certainly be indicated to exclude bony pathology or chest masses. As GERD is the most common cause of nCCP (found in almost 60% of cases) [14,36], a barium swallow could be performed or, alternatively, esophageal pH monitoring, manometry, or endoscopy [1,12]. The remainder of the diagnostic imaging progression depends strongly on the clinical history and signs and symptoms of the patient. For instance, studies performed could include a chest CT scan (if CCTA 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.

Summary

- Whether or not the chest pain is anginal should be initially determined.
- Patient's risk factors for CAD should be determined.
- If a patient is at high risk for atherosclerotic CAD and/or chest pain is determined to be anginal, chronic ischemia should be excluded by stress forms of SPECT or echocardiography, or the presence of flow-limiting CAD can be determined by CCTA. CCTA may be particularly useful in patients with atypical chest pain in whom other etiologies are being considered.
- In patients with low to intermediate probability for CAD and for whom the chest pain is determined by either history or imaging to be nonanginal, further testing depends on the clinical history, signs, and symptoms. Imaging may include assessment for cardiac disease of noncoronary origin, including valvular or pericardial disease.
- GERD is the most common cause of nCCP. If it is suspected, a barium swallow, esophageal pH monitoring, manomatry, or endoscopy could be ordered.

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

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

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