American College of Radiology
ACR Appropriateness Criteria®
Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease

<u>**Variant: 1**</u> **Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
CTA coronary arteries with IV contrast	Usually Appropriate	☢☢☢
US echocardiography transthoracic resting	May Be Appropriate (Disagreement)	O
Radiography ribs and thoracic spine	May Be Appropriate	☢☢
CT chest with IV contrast	May Be Appropriate	☢☢☢
CT chest without and with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate	☢☢☢
CTA chest with IV contrast	May Be Appropriate	☢☢☢
V/Q scan lung	May Be Appropriate	☢☢☢
US echocardiography transesophageal	Usually Not Appropriate	O
US echocardiography transthoracic stress	Usually Not Appropriate	O
Arteriography coronary	Usually Not Appropriate	☢☢☢
Fluoroscopy barium swallow and upper GI series	Usually Not Appropriate	☢☢☢
MRA chest without and with IV contrast	Usually Not Appropriate	O
MRA chest without IV contrast	Usually Not Appropriate	O
MRA coronary arteries without and with IV contrast	Usually Not Appropriate	O
MRA coronary arteries without IV contrast	Usually Not Appropriate	O
MRI heart function and morphology without and with IV contrast	Usually Not Appropriate	O
MRI heart function and morphology without IV contrast	Usually Not Appropriate	O
MRI heart with function and inotropic stress without and with IV contrast	Usually Not Appropriate	O
MRI heart with function and inotropic stress without IV contrast	Usually Not Appropriate	O
MRI heart with function and vasodilator stress perfusion without and with IV contrast	Usually Not Appropriate	O
Nuclear medicine scan gallbladder	Usually Not Appropriate	☢☢
CT heart function and morphology with IV contrast	Usually Not Appropriate	☢☢☢☢
SPECT or SPECT/CT MPI rest and stress	Usually Not Appropriate	☢☢☢☢

Panel Members

Garth M. Beache, MD[a]; Tan-Lucien H. Mohammed, MD[b]; Lynne M. Hurwitz Koweek, MD[c]; Brian B. Ghoshhajra, MD, MBA[d]; Richard KJ Brown, MD[e]; Andrew M. Davis, MD, MPH[f]; John Heitner, MD[g]; Joe Y. Hsu, MD[h]; Amer M. Johri, MD, MSc[i]; Faisal Khosa, MD, MBA[j]; Seth J. Kligerman, MD[k]; Diana Litmanovich, MD[l]; Christopher D. Maroules, MD[m]; Nandini Meyersohn, MD[n]; Christian A. Tomaszewski, MD, MS, MBA[o]; Todd C. Villines, MD[p]; Samuel Wann, MD[q]; Suhny Abbara, MD.[r]

Summary of Literature Review

Introduction/Background

Patients who present with acute chest pain in the setting of nonspecific signs and symptoms, and a low pretest probability for coronary disease, remain an important clinical management dilemma. This is largely related to the competing imperatives of the medical and legal implications of an undiagnosed acute cardiac event as well as the impact on patient flow and hospital use of efficaciously triaging such low-risk cardiac patients, especially in the emergency room [1]. In the current era, there is great imperative to bring to bear a range of advances, including improved clinical algorithms such as the HEART (history electrocardiogram age risk factors troponin) scoring system [2-5], newer biochemical tests, such as high sensitivity troponins [6-11], and newer advanced imaging modalities, such as coronary artery CT [12-14]. Patient management approaches are exploring integration of these procedure advances in the context of clinical decision units/observational units [15,16]. This publication will focus on the evidence for use of individual imaging approaches, in the context of an integrated decision-making setting.

This document focuses on use of imaging to exclude obstructive or functionally significant coronary artery disease (CAD) and its complications, as well as diseases of the myocardium and pericardium that may mimic an acute coronary event in the context of clinical symptoms of chest pain in patients with a low probability for CAD. Although there are life threatening conditions such as pulmonary embolism and aortic dissection that can present with similar symptoms, in the integrated clinical decision-making framework, incorporation of biochemical markers such as D-dimer and troponins do serve to target the imaging approach. See the ACR Appropriateness Criteria® topics on "[Acute Chest Pain — Suspected Aortic Dissection](#)" [17], "[Suspected Pulmonary Embolism](#)" [18], and "[Acute Nonlocalized Abdominal Pain](#)" [19] for further information. As nonspecific chest pain could also include nonischemic etiologies that arise from adjacent sources such as within the bony thorax, gastrointestinal (GI) system, or upper abdomen [20], a careful history and physical examination are paramount to target any subsequent imaging to the coronaries and heart structures.

Special Imaging Considerations

For the purposes of distinguishing between CT and CT angiography (CTA), ACR Appropriateness Criteria topics use the definition in the [ACR–NASCI–SIR–SPR Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography (CTA)](#) [21]:

> "*CTA uses a thin-section CT acquisition that is timed to coincide with peak arterial or venous enhancement. The resultant volumetric data set is interpreted using primary transverse reconstructions as well as multiplanar reformations and 3-D renderings.*"

All elements are essential: 1) timing, 2) reconstructions/reformats, and 3) 3-D renderings. Standard CTs with contrast also include timing issues and recons/reformats. Only in CTA, however, is 3-D rendering a **required** element. This corresponds to the definitions that CMS has applied to the Current Procedural Terminology codes.

Initial Imaging Definition

Imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously in which each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
A. Radiography Chest

Radiographs of the chest remain an important imaging tool in the workup of patients presenting with acute, nonspecific, low cardiac probability of chest pain, albeit as an indirect indicator of an acute cardiac event, such as the documentation of heart failure. Although there is no relevant literature to support the use of chest radiographs for the evaluation of the coronaries or the heart in the setting of acute nonspecific chest pain with low probability of CAD, this is still a helpful examination.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
B. US Echocardiography Transthoracic Stress

In a national study of 24,000 patients evaluated in chest pain units, two-thirds of patients, mostly those experiencing acute chest pain, underwent echocardiography (not specified whether resting or stress), with high reliability in guiding further invasive management [15]. This is in keeping with the European Association of Cardiovascular Imaging and the Acute Cardiovascular Care Association guidelines [22]. A single-center study of 250 patients specifically addressing stress imaging with low-risk presentation documented prognostic significance for major adverse cardiovascular events (MACE) at 1-year follow-up [23]. A single-center randomized control study of 400 consecutive participants comparing coronary artery CT with stress echocardiography for early emergency room discharge of low- to intermediate-risk patients documented a smaller percentage of patients being hospitalized, the primary endpoint, and shorter duration of emergency room observation or hospitalization for stress echocardiography. Major adverse cardiac events at 24 months were comparable for the modalities [24].

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
C. SPECT or SPECT/CT MPI Rest and Stress

Although stress single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) has comparable utility to stress echocardiography for the overall detection of

ischemia in the emergency room setting [25], there is no relevant literature supporting its use in the setting of acute nonspecific chest pain with low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
D. US Echocardiography Transthoracic Resting

Resting transthoracic echocardiography is of utility to document anatomic abnormalities that may be the cause of nonischemic cardiac pains in the acute setting, such as diseases of the myocardium or pericardium or cardiac masses, to improve diagnostic accuracy and efficiency [22]. Resting transthoracic echocardiography has the ability to characterize wall contractile function, and because of its ability to be deployed at the bedside, this consensus report by the European Association of Cardiovascular Imaging and the Acute Cardiovascular Care Association supports its use to triage patients with acute chest pain [22].

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
E. US Echocardiography Transesophageal

Transesophageal echocardiography is typically reserved for instances when nonischemic causes of acute chest pain, such as thoracic dissection, are under clinical consideration. It may be used as a follow-up to a nondiagnostic transthoracic study but is sometimes chosen initially when transthoracic echocardiography is anticipated to be nondiagnostic, such as related to patient body habitus or inability to comply with breathing instructions [22]. There is no relevant literature supporting its use in the setting of acute nonspecific chest pain with low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
F. CTA Chest With IV Contrast

Non–electrocardiogram-gated chest CT angiography (CTA) with acquisition triggering optimized for contrast agent delivery to the target vessel is the clinical standard for excluding a pulmonary embolism or aortic dissection [26]. There is no relevant literature to support the use of CTA chest with intravenous (IV) contrast in the evaluation of acute nonspecific chest pain of suspected cardiac etiology as an initial imaging test.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
G. V/Q Scan Lung

Tc-99m ventilation-perfusion (V/Q) lung scan may be performed to detect a pulmonary embolism. There is no relevant literature to support the use of V/Q scanning in the evaluation of acute nonspecific chest pain of a cardiac etiology as an initial imaging test.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
H. CTA Coronary Arteries With IV Contrast

Coronary CTA (CCTA) affords direct visualization of the coronaries, with a negative predictive value approaching 100% to exclude CAD. A multicenter trial of 1,000 participants with acute chest pains, but negative for electrocardiogram changes or an initial elevated troponin, documented an advantage of CCTA over standard care, with reduction of the length of stay by 7.6 hours ($P < .001$) and more patients discharged directly from the emergency room without increased subsequent MACE (47% versus 12%) ($P < .001$) [12]. Another multicenter trial of 1,370 participants with low to

intermediate risk that compared CCTA with standard care also documented a higher rate of discharge (50% versus 23%; 95% confidence interval, 21–32) and a shorter length of stay (18 hours versus 25 hours; *P* < .001), with one subsequent serious adverse event in each cohort [13]. Such anatomic evaluation has proved to be of higher diagnostic performance to evaluate for significant stenosis (>50%) versus ischemia testing with dobutamine-stress echocardiography, as shown in a multicenter, low-risk (negative for electrocardiogram changes or elevated troponins) cohort of 217 patients, validated against invasive coronary angiography. Dobutamine-stress echocardiography sensitivity was 52%, specificity 47%, positive likelihood ratio 1.03, and negative likelihood ratio 1.10. CCTA sensitivity was 97%, specificity 48%, positive likelihood ratio 2.06, and negative likelihood ratio 0.07 [27].

Alternatively, evaluating CCTA versus stress MPI, a randomized controlled single-center study of 400 patients, validated against invasive angiography, documented a comparable length of stay (CCTA 28.9 hours versus MPI 30.1 hours) as well as no differences in major cardiovascular events at 40 months [28]. Another randomized controlled study comparing CCTA with SPECT MPI in 598 participants with low to intermediate risk documented time to diagnosis (CCTA 8.1 hours versus MPI 9.4 hours) and length of stay (CCTA 19.7 hours versus MPI 23.5 hours) (both *P* = .002) [29]. The CATCH (CArdiac cT in the treatment of acute CHest pain) trial examined long-term outcomes of CCTA versus standard care in the setting of low-risk acute chest pains in a randomized cohort of 600 participants, with the outcome being MACE at 19 months. Overall occurrence of a primary endpoint was CCTA (n = 16) versus standard care (n = 47) (*P* = .04) [30]. A meta-analysis of 37 trials (involving 7,800 patients), compared CCTA, stress echocardiography, and MPI SPECT validated against invasive angiography, or late MACE, in the acute chest pain setting. Weighted mean sensitivity, specificity, positive predictive value, negative predictive value, and total diagnostic accuracy were as follows: CCTA 95%, 99%, 84%, 100%, 99%, respectively; stress echocardiography 84%, 94%, 73%, 96%, 96%, respectively; and SPECT 85%, 86%, 57%, 95%, 88%, respectively. The investigators concluded there was no difference in negative predictive value but that CCTA had superior performance over stress echocardiography and MPI for the other indexes [31]. A meta-analysis of randomized controlled trials evaluating CCTA versus usual care for triaging patients in the emergency room setting documented efficiencies of CCTA for discharge disposition but increased downstream invasive coronary angiography and revascularization [32].

Hemodynamic assessment using flow indexes, derived from biophysical modeling of CTA-derived data, is a recent development. A small, single-center study was validated in animals (with CT-documented flow correlated with microsphere-determined flow; R-squared = 0.90, *P* < .001) and also explored in 39 human participants with acute chest pain and normal coronaries, documenting excellent interobserver correlation (R = 0.96, *P* < .0001) and agreement [33]. Although a report on the initial 1,000 participants in the international, multicenter, prospective, real-world registry, ADVANCE (Assessing Diagnostic Value of Non-invasive FFRCT in Coronary Care), has documented that CTA stenosis severity had an increased likelihood of an abnormal fractional flow reserve-CT, the utility of this measure was limited in practice, given that mild lesions could result in ischemia whereas intermediate to severe lesions could be nonflow limiting [34]. In addition, in common with the preponderant focus of other leading existing clinical trials exploring the utility of fractional flow reserve-CT, these studies were evaluated in stable chest pain cohorts, as opposed to the acute chest pain setting of the present discussion. Alternate approaches use concurrent CT perfusion (CTP) assessment to augment the anatomic data with functional characterization. In a subanalysis of 183 ROMICAT I (Rule Out Myocardial Infarction by Computer Assisted Tomography)

participants, rest CTP predicted ACS independently of obstructive anatomic assessment, and sensitivity for detection of obstructive disease increased from 77% to 90%, with the addition of rest CTP (*P* = .05) [35]. CATCH-2, a six-center trial that enrolled 600 participants with acute chest pain who were ruled out for myocardial infarction by electrocardiogram, enzymes, and resolution of symptoms and who had a clinical indication for invasive angiography, explored whether CCTA augmented with CTP provides additional diagnostic utility over CCTA alone [36]. An updated 2018 report has documented that 41 (14%) of the CCTA plus CTP group were referred for invasive angiography versus 89 (30%) of the CTA alone group (*P* = .85). The total number of revascularizations was significantly lower in the CTA plus CTP group versus CTA alone (7% versus 14%; *P* = .0045). At 1.5 years' follow-up, secondary endpoints were comparable. The investigators have concluded that CTA plus CTP safely reduces the need for invasive evaluation in this cohort.

One specialized protocol of coronary CTA is the triple rule out examination, which uses a specific contrast acquisition scanning protocol to enable assessment of the pulmonary arteries, the aorta and the coronary arteries [37]. For the purpose of this document, the triple rule out is considered part of the CTA coronary arteries.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
I. CT Chest Without IV Contrast

Noncontrast chest CT can assess for the presence of a pericardial effusion, epipericardial fat necrosis, and other noncardiac causes of chest pain. There is no relevant literature to support the use of CT chest without IV contrast in the evaluation of acute nonspecific chest pain with low probability of CAD as an initial imaging test.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
J. CT Chest With IV Contrast

Noncontrast chest CT can assess for the presence of a pericarditis, epipericardial fat necrosis, and other noncardiac causes of chest pain. There is no relevant literature to support the use of CT chest with IV contrast in the evaluation of acute nonspecific chest pain with low probability of CAD as an initial imaging test.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
K. CT Chest Without and With IV Contrast

Chest CT without and with IV contrast as a follow-up to a suspicious finding suggested by radiographs of the chest is typically not used [20,38]. There is no relevant literature to support the use of CT chest without and with IV contrast in the initial imaging evaluation of acute nonspecific chest pain with low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
L. CT Heart Function and Morphology With IV Contrast

In a single-center retrospective analysis of 225 patients, heart morphology and function indexes, as a derivative of a CCTA study, have been shown to correlate with MACE at 13 months [39]. There is no relevant literature to support use of this test as an initial imaging strategy. See the CTA coronary arteries section above for coronary artery assessment.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
M. MRA Chest Without and With IV Contrast

MR angiography (MRA) has potential uses in the nonischemic setting if acute thoracic aorta conditions, including dissection or intramural hematoma, or aneurysm or pulmonary embolism are being considered [40]. There is no relevant literature to support the use of MRA chest without and with IV contrast for the evaluation of the coronaries or the heart structures in the setting of acute nonspecific chest pain with low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
N. MRA Chest Without IV Contrast

MRA has potential uses in the nonischemic setting if acute thoracic aorta conditions, including dissection or intramural hematoma, or aneurysm or pulmonary embolism are being considered [40]. There is no relevant literature to support the use of MRA chest without IV contrast for the evaluation of the coronaries or the heart structures in the setting of acute nonspecific chest pain with low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
O. MRI Heart Function and Morphology Without IV Contrast

Pericarditis, as a cause of chest pain, can be potentially excluded by direct assessment of pericardial thickness on noncontrast MRI heart function and morphology images [41]. Characterization of other myocardial and pericardial conditions would optimally require administration of a gadolinium contrast agent. There is no relevant literature to support the use of MRI as an initial imaging test in the patient with acute nonspecific chest pain with a low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
P. MRI Heart Function and Morphology Without and With IV Contrast

Although there has been increasing use of MRI with a contrast agent to document clinically suspected myocarditis in patients who have been ruled out for acute myocardial infarction, these are typically patients who have had elevated troponins and thus would not fall in the low probability category [42,43]. A recent review article has reported on the utility of MRI heart function and morphology without and with IV contrast as a prognosticator of myocardial damage and its complications in the clinical setting of acute coronary syndrome; however, such patients typically present with signs or symptoms of myocardial ischemia, unlike the nonspecific signs and symptoms of the cohort of the present topic [41]. There is no relevant literature to support the use of MRI as an initial imaging test in the patient with acute nonspecific chest pain with a low probability of CAD. In this clinical scenario, the presentation and etiology, although not common, can be occasionally useful in the appropriate setting.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
Q. MRI Heart With Function and Vasodilator Stress Perfusion Without and With IV Contrast

Vasodilator stress challenge with first-pass perfusion imaging, rather than inotropic stress, can be used to assess for the evaluation of myocardial ischemia [31]. There is no relevant literature to

support the use of MRI as an initial imaging test in the patient with acute nonspecific chest pain with a low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
R. MRI Heart With Function and Inotropic Stress Without IV Contrast

An inotropic stress challenge with assessment of wall contractile function, rather than vasodilator stress, can be used to assess for the evaluation of myocardial ischemia [31]. There is no relevant literature to support the use of MRI as an initial imaging test in the patient with acute nonspecific chest pain with a low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
S. MRI Heart With Function and Inotropic Stress Without and With IV Contrast

There is no relevant literature to support the use of MRI as an initial imaging test in the patient with acute nonspecific chest pain with a low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
T. MRA Coronary Arteries Without and With IV Contrast

There is no relevant literature to support the use of MRA coronary arteries without and with IV contrast in the initial imaging evaluation of acute nonspecific chest pain with low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
U. MRA Coronary Arteries Without IV Contrast

There is no relevant literature to support the use of MRA coronary arteries without IV contrast in the initial imaging evaluation of acute nonspecific chest pain with low probability of CAD.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
V. Arteriography Coronary

In the acute chest pain setting, invasive coronary angiography is typically undertaken in patients with elevated troponins when there is concern for an acute myocardial infarction/ischemia. There are limited data on its use in the low pretest probability setting of CAD without signs of myocardial ischemia or infarction. Recent studies have proposed triaging of patients for invasive coronary angiography using ischemia stress testing or, alternatively, CCTA coronary anatomy characterization prior to invasive angiography to increase the diagnostic yield [44].

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
W. Radiography Ribs and Thoracic Spine

Musculoskeletal conditions such as rib fractures can be identified using radiographs, ideally justified by localized pain symptoms. Conditions that may cause thoracic pain such as scoliosis or diffuse idiopathic skeletal hyperostosis are findings that may be detected incidentally on such an examination. There is no relevant literature to support the use of radiographs of the ribs or thoracic spine in the evaluation of acute nonspecific chest pain with low probability of CAD as an initial imaging test.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
X. Nuclear Medicine Scan Gallbladder

History, physical examination, and subsequent laboratory markers may implicate upper abdomen solid organs as a potential source of nonspecific chest pain. Abdominal ultrasonography is an efficient means of excluding acute cholecystitis as a source of chest pain in the acute setting. As a functional assessment of the biliary system, Tc-99m cholescintigraphy may be performed. There is no relevant literature to support the use of Tc-99m cholescintigraphy in the evaluation of acute nonspecific chest pain with low probability of CAD as an initial imaging test.

Variant 1: Acute nonspecific chest pain; low probability of coronary artery disease. Initial imaging.
Y. Fluoroscopy Upper GI Series

Barium studies can detect upper GI anatomic causes of chest pain such as hiatal hernia or ulcer and can also demonstrate functional disorders such as gastroesophageal reflux. There is no relevant literature to support the use of barium swallow and upper GI series in the evaluation of acute nonspecific chest pain with low probability of CAD as an initial imaging test.

Summary of Recommendations

- **Variant 1**: The dilemma of this clinical presentation is the imperative to exclude obstructive or functionally significant CAD and its complications in the setting of low clinical pretest probability for CAD. CTA coronary arteries with IV contrast is usually appropriate for the initial imaging of a patient with acute nonspecific chest pain with low probability of CAD, related to its documented utility to directly exclude significant lesions of the coronaries. Radiography chest is complementary to exclude complications of an acute coronary event. Although echocardiography must be acknowledged as a widely deployed imaging modality in the general acute chest pain setting, the panel opined that for the initial imaging of a patient with acute nonspecific chest pain and low probability of CAD, ultrasound resting echocardiography transthoracic resting may be appropriate (but with disagreement, related to insufficient medical literature).

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-

		benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

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, because of both 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 with 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 (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

References

1. Foy AJ, Liu G, Davidson WR Jr, Sciamanna C, Leslie DL. Comparative effectiveness of diagnostic testing strategies in emergency department patients with chest pain: an analysis of downstream testing, interventions, and outcomes. JAMA Internal Medicine. 175(3):428-

36, 2015 Mar.JAMA Intern Med. 175(3):428-36, 2015 Mar.

2. Dai S, Huang B, Zou Y, et al. The HEART score is useful to predict cardiovascular risks and reduces unnecessary cardiac imaging in low-risk patients with acute chest pain. Medicine (Baltimore). 97(22):e10844, 2018 Jun.

3. Kolff AQ, Bom MJ, Knol RJ, van de Zant FM, van der Zee PM, Cornel JH. Discriminative Power of the HEART Score for Obstructive Coronary Artery Disease in Acute Chest Pain Patients Referred for CCTA. Critical Pathways in Cardiology: A Journal of Evidence-Based Medicine. 15(1):6-10, 2016 Mar.Crit. pathw. cardiol.. 15(1):6-10, 2016 Mar.

4. Mahler SA, Riley RF, Hiestand BC, et al. The HEART Pathway randomized trial: identifying emergency department patients with acute chest pain for early discharge. Circ Cardiovasc Qual Outcomes. 8(2):195-203, 2015 Mar.

5. Stopyra JP, Miller CD, Hiestand BC, et al. Chest Pain Risk Stratification: A Comparison of the 2-Hour Accelerated Diagnostic Protocol (ADAPT) and the HEART Pathway. Crit. pathw. cardiol.. 15(2):46-9, 2016 06.

6. Dedic A, Lubbers MM, Schaap J, et al. Coronary CT Angiography for Suspected ACS in the Era of High-Sensitivity Troponins: Randomized Multicenter Study. Journal of the American College of Cardiology. 67(1):16-26, 2016 Jan 05.

7. Ferencik M, Hoffmann U, Bamberg F, Januzzi JL. Highly sensitive troponin and coronary computed tomography angiography in the evaluation of suspected acute coronary syndrome in the emergency department. [Review]. European Heart Journal. 37(30):2397-405, 2016 08 07.

8. Ferencik M, Mayrhofer T, Lu MT, et al. High-Sensitivity Cardiac Troponin I as a Gatekeeper for Coronary Computed Tomography Angiography and Stress Testing in Patients with Acute Chest Pain. Clin Chem. 63(11):1724-1733, 2017 Nov.

9. Januzzi JL, Sharma U, Zakroysky P, et al. Sensitive troponin assays in patients with suspected acute coronary syndrome: Results from the multicenter rule out myocardial infarction using computer assisted tomography II trial. American Heart Journal. 169(4):572-8.e1, 2015 Apr.

10. Liu T, Wang G, Li P, Dai X. Risk classification of highly sensitive troponin I predict presence of vulnerable plaque assessed by dual source coronary computed tomography angiography. The International Journal of Cardiovascular Imaging. 33(11):1831-1839, 2017 Nov.

11. Smulders MW, Kietselaer BL, Schalla S, et al. Acute chest pain in the high-sensitivity cardiac troponin era: A changing role for noninvasive imaging?. [Review]. American Heart Journal. 177:102-11, 2016 07.Am Heart J. 177:102-11, 2016 07.

12. Hoffmann U, Truong QA, Schoenfeld DA, et al. Coronary CT angiography versus standard evaluation in acute chest pain. N Engl J Med. 367(4):299-308, 2012 Jul 26.

13. Litt HI, Gatsonis C, Snyder B, et al. CT angiography for safe discharge of patients with possible acute coronary syndromes. N Engl J Med. 2012; 366(15):1393-1403.

14. Raff GL, Hoffmann U, Udelson JE. Trials of Imaging Use in the Emergency Department for Acute Chest Pain. [Review]. Jacc: Cardiovascular Imaging. 10(3):338-349, 2017 Mar.

15. Breuckmann F, Hochadel M, Voigtlander T, et al. The Use of Echocardiography in Certified Chest Pain Units: Results from the German Chest Pain Unit Registry. Cardiology. 134(2):75-

83, 2016.

16. Hollander JE, Than M, Mueller C. State-of-the-Art Evaluation of Emergency Department Patients Presenting With Potential Acute Coronary Syndromes. [Review]. Circulation. 134(7):547-64, 2016 Aug 16.

17. American College of Radiology. ACR Appropriateness Criteria®: Acute Chest Pain — Suspected Aortic Dissection. Available at: https://acsearch.acr.org/docs/69402/Narrative/

18. American College of Radiology. ACR Appropriateness Criteria®: Suspected Pulmonary Embolism. Available at: https://acsearch.acr.org/docs/69404/Narrative/.

19. Scheirey CD, Fowler KJ, Therrien JA, et al. ACR Appropriateness Criteria® Acute Nonlocalized Abdominal Pain. J Am Coll Radiol 2018;15:S217-S31.

20. Yoo SM, Chun EJ, Lee HY, Min D, White CS. Computed Tomography Diagnosis of Nonspecific Acute Chest Pain in the Emergency Department: From Typical Acute Coronary Syndrome to Various Unusual Mimics. [Review]. J Thorac Imaging. 32(1):26-35, 2017 Jan.

21. American College of Radiology. ACR–NASCI–SIR–SPR Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography (CTA). Available at: https://gravitas.acr.org/PPTS/GetDocumentView?docId=164+&releaseId=2.

22. Lancellotti P, Price S, Edvardsen T, et al. The use of echocardiography in acute cardiovascular care: recommendations of the European Association of Cardiovascular Imaging and the Acute Cardiovascular Care Association. European heart journal cardiovascular Imaging. 16(2):119-46, 2015 Feb.

23. Merchan Ortega G, Bonaque Gonzalez JC, Sanchez Espino AD, et al. Long-term prognostic value of peak exercise echocardiogram in patients hospitalized with acute chest pain. Echocardiography. 34(6):869-875, 2017 Jun.

24. Levsky JM, Haramati LB, Spevack DM, et al. Coronary Computed Tomography Angiography Versus Stress Echocardiography in Acute Chest Pain: A Randomized Controlled Trial. Jacc: Cardiovascular Imaging. 11(9):1288-1297, 2018 09.

25. Tragardh E, Tan SS, Bucerius J, et al. Systematic review of cost-effectiveness of myocardial perfusion scintigraphy in patients with ischaemic heart disease: A report from the cardiovascular committee of the European Association of Nuclear Medicine. Endorsed by the European Association of Cardiovascular Imaging. [Review]. European heart journal cardiovascular Imaging. 18(8):825-832, 2017 May 01.

26. Kirsch J, Brown RKJ, Henry TS, et al. ACR Appropriateness Criteria® Acute Chest Pain-Suspected Pulmonary Embolism. J Am Coll Radiol 2017;14:S2-S12.

27. Durand E, Bauer F, Mansencal N, et al. Head-to-head comparison of the diagnostic performance of coronary computed tomography angiography and dobutamine-stress echocardiography in the evaluation of acute chest pain with normal ECG findings and negative troponin tests: A prospective multicenter study. Int J Cardiol. 241:463-469, 2017 Aug 15.

28. Levsky JM, Spevack DM, Travin MI, et al. Coronary Computed Tomography Angiography Versus Radionuclide Myocardial Perfusion Imaging in Patients With Chest Pain Admitted to Telemetry: A Randomized Trial. Annals of Internal Medicine. 163(3):174-83, 2015 Aug 04.Ann Intern Med. 163(3):174-83, 2015 Aug 04.

29. Nabi F, Kassi M, Muhyieddeen K, et al. Optimizing Evaluation of Patients with Low-to-Intermediate-Risk Acute Chest Pain: A Randomized Study Comparing Stress Myocardial Perfusion Tomography Incorporating Stress-Only Imaging Versus Cardiac CT. J Nucl Med. 57(3):378-84, 2016 Mar.

30. Linde JJ, Hove JD, Sorgaard M, et al. Long-Term Clinical Impact of Coronary CT Angiography in Patients With Recent Acute-Onset Chest Pain: The Randomized Controlled CATCH Trial. Jacc: Cardiovascular Imaging. 8(12):1404-1413, 2015 Dec.JACC Cardiovasc Imaging. 8(12):1404-1413, 2015 Dec.

31. Romero J, Husain SA, Holmes AA, et al. Non-invasive assessment of low risk acute chest pain in the emergency department: A comparative meta-analysis of prospective studies. Int J Cardiol. 187:565-80, 2015.

32. Hulten E, Pickett C, Bittencourt MS, et al. Outcomes after coronary computed tomography angiography in the emergency department: a systematic review and meta-analysis of randomized, controlled trials. J Am Coll Cardiol. 61(8):880-92, 2013 Feb 26.

33. Lardo AC, Rahsepar AA, Seo JH, et al. Estimating coronary blood flow using CT transluminal attenuation flow encoding: Formulation, preclinical validation, and clinical feasibility. Journal of cardiovascular computed tomography. 9(6):559-66.e1, 2015 Nov-Dec.

34. Kitabata H, Leipsic J, Patel MR, et al. Incidence and predictors of lesion-specific ischemia by FFRCT: Learnings from the international ADVANCE registry. J Cardiovasc Comput Tomogr 2018;12:95-100.

35. Pursnani A, Lee AM, Mayrhofer T, et al. Early resting myocardial computed tomography perfusion for the detection of acute coronary syndrome in patients with coronary artery disease. Circulation. Cardiovascular imaging. 8(3):e002404, 2015 Mar.

36. Sorgaard M, Linde JJ, Hove JD, et al. Myocardial perfusion 320-row multidetector computed tomography-guided treatment strategy for the clinical management of patients with recent acute-onset chest pain: Design of the CArdiac cT in the treatment of acute CHest pain (CATCH)-2 randomized controlled trial. American Heart Journal. 179:127-35, 2016 Sep.Am Heart J. 179:127-35, 2016 Sep.

37. Burris AC 2nd, Boura JA, Raff GL, Chinnaiyan KM. Triple Rule Out Versus Coronary CT Angiography in Patients With Acute Chest Pain: Results From the ACIC Consortium. JACC Cardiovasc Imaging. 8(7):817-25, 2015 Jul.

38. Lehman SJ, Abbara S, Cury RC, et al. Significance of cardiac computed tomography incidental findings in acute chest pain. Am J Med. 122(6):543-9, 2009 Jun.

39. Takx RAP, Vliegenthart R, Schoepf UJ, et al. Prognostic value of CT-derived left atrial and left ventricular measures in patients with acute chest pain. European Journal of Radiology. 86:163-168, 2017 Jan.Eur J Radiol. 86:163-168, 2017 Jan.

40. Mussa FF, Horton JD, Moridzadeh R, Nicholson J, Trimarchi S, Eagle KA. Acute Aortic Dissection and Intramural Hematoma: A Systematic Review. [Review]. JAMA. 316(7):754-63, 2016 Aug 16.

41. Saremi F.. Cardiac MR Imaging in Acute Coronary Syndrome: Application and Image Interpretation. [Review]. Radiology. 282(1):17-32, 2017 Jan.

42. Friedrich MG, Sechtem U, Schulz-Menger J, et al. Cardiovascular magnetic resonance in

myocarditis: A JACC White Paper. J Am Coll Cardiol. 2009;53(17):1475-1487.

43. Haaf P, Garg P, Messroghli DR, Broadbent DA, Greenwood JP, Plein S. Cardiac T1 Mapping and Extracellular Volume (ECV) in clinical practice: a comprehensive review. [Review]. Journal of Cardiovascular Magnetic Resonance. 18(1):89, 2016 Nov 30.

44. Marwick TH, Cho I, O Hartaigh B, Min JK. Finding the Gatekeeper to the Cardiac Catheterization Laboratory: Coronary CT Angiography or Stress Testing?. [Review]. J Am Coll Cardiol. 65(25):2747-56, 2015 Jun 30.

45. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: https://edge.sitecorecloud.io/americancoldf5f-acrorgf92a-productioncb02-3650/media/ACR/Files/Clinical/Appropriateness-Criteria/ACR-Appropriateness-Criteria-Radiation-Dose-Assessment-Introduction.pdf.

Disclaimer

[a]University of Louisville School of Medicine, Louisville, Kentucky. [b]Research Author, University of Florida College of Medicine, Gainesville, Florida. [c]Panel Chair, Duke University Medical Center, Durham, North Carolina. [d]Panel Vice-Chair, Massachusetts General Hospital, Boston, Massachusetts. [e]University of Michigan Health System, Ann Arbor, Michigan; Commission on Nuclear Medicine and Molecular Imaging. [f]The University of Chicago Medical Center, Chicago, Illinois; American College of Physicians. [g]New York Presbyterian Methodist Hospital, Brooklyn, New York; Society for Cardiovascular Magnetic Resonance. [h]Kaiser Permanente, Los Angeles, California. [i]Queen's University, Kingston, Ontario, Canada; American Society of Echocardiography. [j]Vancouver General Hospital, Vancouver, British Columbia, Canada; Committee on Emergency Radiology-GSER. [k]University of California San Diego, San Diego, California. [l]Harvard Medical School, Boston, Massachusetts. [m]Naval Medical Center Portsmouth, Portsmouth, Virginia. [n]Massachusetts General Hospital, Boston, Massachusetts. [o]American College of Emergency Physicians. [p]University of Virginia Health Center, Charlottesville, Virginia; Society of Cardiovascular Computed Tomography. [q]Ascension Healthcare Wisconsin, Milwaukee, Wisconsin; American Society of Nuclear Cardiology. [r]Specialty Chair, UT Southwestern Medical Center, Dallas, Texas.