

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Goldman L, Cook EF, Johnson PA, Brand DA, Rouan GW, Lee TH. Prediction of the need for intensive care in patients who come to the emergency departments with acute chest pain. <i>N Engl J Med.</i> 1996;334(23):1498-1504.	Observational-Dx	10,682 patients	To identify clinical factors that predicts which patients will have complications requiring intensive care.	In the derivation set of patients, we identified the following set of clinical features, which, if present in the ED, were associated with an increased risk of complications: ST-segment elevation or Q waves on the ECG thought to indicate acute MI, other electrocardiographic changes indicating myocardial ischemia, low systolic blood pressure, pulmonary rales above the bases, or an exacerbation of known ischemic heart disease. On the basis of these criteria, the patients in the validation set were stratified into 4 groups, with the risk of major complications in the first 12 hours ranging from 0.15% to 8%. After 12 hours, the probability of a major complication could be updated on the basis of whether the patient had already had a complication of major severity, a complication of intermediate severity, or a MI (independent relative risks, 18.9, 7.7 and 4.0, respectively, as compared with patients without prior complications or MI).	3
2. Anderson JL, Adams CD, Antman EM, et al. 2012 ACCF/AHA focused update incorporated into the ACCF/AHA 2007 guidelines for the management of patients with unstable angina/non-ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. <i>J Am Coll Cardiol.</i> 2013;61(23):e179-347.	Review/Other-Dx	N/A	Practice guideline for the management of patients with unstable angina/non-ST-elevation MI.	N/A	4

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
3. Antman EM, Hand M, Armstrong PW, et al. 2007 Focused Update of the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines: developed in collaboration With the Canadian Cardiovascular Society endorsed by the American Academy of Family Physicians: 2007 Writing Group to Review New Evidence and Update the ACC/AHA 2004 Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction, Writing on Behalf of the 2004 Writing Committee. <i>Circulation</i> . 2008;117(2):296-329.	Review/Other-Dx	N/A	Focused update of the ACC/AHA 2004 guidelines for the management of patients with ST-elevation MI.	N/A	4
4. American College of Radiology. ACR Appropriateness Criteria® Chest Pain Suggestive of Acute Coronary Syndrome . Available at: <a href="https://acsearch.acr.org/docs/69403/Narrative/">https://acsearch.acr.org/docs/69403/Narrative/</a> . Accessed September 30, 2015.	Review/Other-Dx	N/A	Evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical condition.	N/A	4
5. Hendel RC, Berman DS, Di Carli MF, et al. ACCF/ASNC/ACR/AHA/ASE/SCCT/SCMR/SNM 2009 appropriate use criteria for cardiac radionuclide imaging: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the American Society of Nuclear Cardiology, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the Society of Cardiovascular Computed Tomography, the Society for Cardiovascular Magnetic Resonance, and the Society of Nuclear Medicine. <i>Circulation</i> . 2009;119(22):e561-587.	Review/Other-Dx	N/A	A revision of the original Single-Photon Emission Computed Tomography Myocardial Perfusion Imaging Appropriateness Criteria, published 4 years earlier, written to reflect changes in test utilization and new clinical data, and to clarify radionuclide imaging use where omissions or lack of clarity existed in the original criteria.	N/A	4

Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
6. Hoffmann U, Truong QA, Schoenfeld DA, et al. Coronary CT angiography versus standard evaluation in acute chest pain. <i>N Engl J Med.</i> 2012;367(4):299-308.	Experimental-Dx	1,000 patients randomized to CCTA (n=501) and standard evaluation (n=499)	To compare the effectiveness of a CCTA-based evaluation strategy with that of standard evaluation in the ED for patients with symptoms suggestive of an ACS and to evaluate the downstream testing, cost, and radiation exposure associated with CCTA.	The rate of ACSs among 1,000 patients with a mean ( $\pm$ standard deviation) age of $54 \pm 8$ years (47% women) was 8%. After early CCTA, as compared with standard evaluation, the mean length of stay in the hospital was reduced by 7.6 hours ( $P < 0.001$ ) and more patients were discharged directly from the ED (47% vs 12%, $P < 0.001$ ). There were no undetected ACSs and no significant differences in major adverse cardiovascular events at 28 days. After CCTA, there was more downstream testing and higher radiation exposure. The cumulative mean cost of care was similar in the CCTA group and the standard evaluation group (\$4,289 and \$4,060, respectively; $P = 0.65$ ).	1
7. Buenger RE. Five thousand acute care/emergency department chest radiographs: comparison of requisitions with radiographic findings. <i>J Emerg Med.</i> 1988;6(3):197-202.	Review/Other-Dx	5,000 radiographs	To interpret 5,000 portable or posterior-anterior-lateral radiographs of acute care ED patients. The study was directed at 2 specific groups of acute care ED patients; those with cardiorespiratory symptoms, and those with other symptoms. The symptoms of the group were compared with the radiographic findings.	The radiographs revealed serious disease in 35% of patients with chest symptoms, in 27% of all patients examined, and in 18% of patients with noncardiorespiratory symptoms. The highest incidence of abnormal radiographs (42%–79%) occurred in patients with symptoms of congestive heart failure, dyspnea, hemoptysis, dysrhythmia, and hypertension. Asthma (14%) and trauma (5%) presented the lowest incidence of significant findings. Radiographs of patients suspected of having pneumonia were abnormal in 25% of cases, and in those patients with either cough or fever alone, the incidences of pneumonia were 13% and 18%. Whereas 24% of patients with dyspnea alone had radiographic findings of congestive heart failure, 52% of those with congestive heart failure diagnosed on clinical grounds had abnormal radiographs.	4

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
8. Elliott CG, Goldhaber SZ, Visani L, DeRosa M. Chest radiographs in acute pulmonary embolism. Results from the International Cooperative Pulmonary Embolism Registry. <i>Chest</i> . 2000;118(1):33-38.	Observational-Dx	2,454 consecutive patients; chest radiographs available for 2,322 patients	Prospective observational study at 52 hospitals in 7 countries. To characterize chest radiographic interpretations in a large population of patients who have received a diagnosis of acute PE and to estimate the sensitivity and specificity of chest radiographic abnormalities for right ventricular hypokinesis that has been diagnosed by echocardiography.	Most common chest radiographic interpretations were cardiac enlargement (27%), normal (24%), pleural effusion (23%), elevated hemidiaphragm (20%), pulmonary artery enlargement (19%), atelectasis (18%), and parenchymal pulmonary infiltrates (17%). The results of chest radiographs were abnormal for 509/655 patients (78%) who had undergone a major surgical procedure within 2 months of the diagnosis of PE: normal results for chest radiograph often accompanied PE after genitourinary procedures (37%), orthopedic surgery (29%), or gynecologic surgery (28%), whereas they rarely accompanied pulmonary emboli associated with thoracic procedures (4%). Chest radiographs were interpreted to show cardiac enlargement for 149/309 patients with right ventricular hypokinesis that was detected by echocardiography (sensitivity, 0.48) and for 178/485 patients without right ventricular hypokinesis (specificity, 0.63). Chest radiographs were interpreted to show pulmonary artery enlargement for 118/309 patients with right ventricular hypokinesis (sensitivity, 0.38) and for 117/483 patients without right ventricular hypokinesis (specificity, 0.76). Cardiomegaly is the most common chest radiographic abnormality associated with acute PE. Neither pulmonary artery enlargement nor cardiomegaly appears sensitive or specific for the echocardiographic finding of right ventricular hypokinesis, an important predictor of mortality associated with acute PE.	3

Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
9. Worsley DF, Alavi A, Aronchick JM, Chen JT, Greenspan RH, Ravin CE. Chest radiographic findings in patients with acute pulmonary embolism: observations from the PIOPED Study. <i>Radiology</i> . 1993;189(1):133-136.	Observational-Dx	1,063 patients: PE was confirmed angiographically in 383 patients and excluded in 680 patients	To determine the sensitivity, specificity, and PPV and NPV of chest radiographic findings in patients suspected of having acute PE.	The chest radiograph was interpreted as normal in only 12% of patients with PE. The most common chest radiographic finding in patients with PE was atelectasis and/or parenchymal areas of increased opacity; however, the prevalence was not significantly different from that in patients without PE. Oligemia (the Westermark sign), prominent central pulmonary artery (the Fleischner sign), pleural-based area of increased opacity (the Hampton hump), vascular redistribution, pleural effusion, elevated diaphragm, and enlarged hilum were also poor predictors of PE. The value is to exclude diagnoses that mimic PE and aid in V/Q scan interpretation.	3
10. Litt HI, Gatsonis C, Snyder B, et al. CT angiography for safe discharge of patients with possible acute coronary syndromes. <i>N Engl J Med</i> . 2012;366(15):1393-1403.	Experimental-Dx	1,370 patients: 908 in the CCTA group and 462 in the group receiving traditional care	To determine the safety and efficiency of a CCTA-based strategy. The study compared a CCTA-based strategy with traditional “rule out” approaches for low-to-intermediate-risk patients presenting to the ED with chest pain and possible ACS.	Of 640 patients with a negative CCTA examination, none died or had a MI within 30 days (0%; 95% CI, 0 to 0.57). As compared with patients receiving traditional care, patients in the CCTA group had a higher rate of discharge from the ED (49.6% vs 22.7%; difference, 26.8 percentage points; 95% CI, 21.4 to 32.2), a shorter length of stay (median, 18.0 hours vs 24.8 hours; $P<0.001$ ), and a higher rate of detection of coronary disease (9.0% vs 3.5%; difference, 5.6 percentage points; 95% CI, 0 to 11.2). There was one serious adverse event in each group.	1

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
11. Cury RC, Feuchtner GM, Batlle JC, et al. Triage of patients presenting with chest pain to the emergency department: implementation of coronary CT angiography in a large urban health care system. <i>AJR Am J Roentgenol.</i> 2013;200(1):57-65.	Observational-Dx	529 patients	A prospective study was to determine whether CCTA is a reliable and safe assessment tool for the triage of patients presenting with chest pain and a low-to-intermediate risk of ACS (thrombolysis in myocardial infarction risk score $\leq 2$ ) to the ED of a large urban health care system.	317 patients (59.9%) with negative CTA findings and 151 (28.5%) with mild stenosis were discharged from the ED with a very low downstream testing rate and a very low MACE rate (NPV = 99.8%). Twenty-five patients (4.7%) had moderate stenosis (n = 17 undergoing further testing). 36 patients (6.8%) had stenosis of 70% or greater by CTA (n = 34 positive by invasive angiography or single-photon emission computed tomography-myocardial perfusion imaging). The sensitivity of CTA was 94%. The rate of MACEs in patients with stenosis of 70% or greater (8.3%) was significantly higher ( $P < 0.001$ ) than in patients with negative CTA findings (0%) or those with mild stenosis (0.2%). A 51% decrease in LOS—from 28.8 to 14.0 hours—was noted after implementation of the dedicated chest pain protocol ( $P < 0.001$ ).	3
12. 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. <i>JAMA Intern Med.</i> 2015;175(3):428-436.	Review/Other-Dx	421,774 patients	To compare chest pain evaluation pathways based on their association with downstream testing, interventions, and outcomes for patients in ED.	In 2011, there were 693,212 ED visits with a primary or secondary diagnosis of chest pain, accounting for 9.2% of all ED encounters. After application of the inclusion and exclusion criteria, 421,774 patients were included in the final analysis; 293,788 individuals did not receive an initial noninvasive test and 127,986 did, representing 1.7% of all ED encounters. Overall, the percentage of patients hospitalized with an MI was very low during both 7 and 190 days of follow-up (0.11% and 0.33%, respectively). Patients who did not undergo initial noninvasive testing were no more likely to experience an MI than were those who did receive testing. Compared with no testing, exercise electrocardiography, myocardial perfusion scintigraphy, and CCTA were associated with significantly higher odds of cardiac catheterization and revascularization procedures without a concomitant improvement in the odds of experiencing an MI.	4

\* See Last Page for Key

Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
13. Hamilton-Craig C, Fifoot A, Hansen M, et al. Diagnostic performance and cost of CT angiography versus stress ECG--a randomized prospective study of suspected acute coronary syndrome chest pain in the emergency department (CT-COMPARE). <i>Int J Cardiol.</i> 2014;177(3):867-873.	Experimental-Dx	562 patients	A prospective randomized trial to compare dual source CCTA with ExECG as part of the standard of care in low-intermediate risk possible ACS patients presenting to the ED.	ACS occurred in 24 (4%) patients. ExECG had 213 negative studies and 27 (26%) positive studies for ACS with sensitivity of 83% [95% CI: 36, 99.6%], specificity of 91% [CI: 86, 94%], and ROC of 0.87 [CI: 0.70, 1]. CCTA (>50% stenosis considered positive) had 288 negative studies and 18/35 (51%) positive studies with a sensitivity of 100% [CI: 81.5, 100], specificity of 94% [CI: 91.2, 96.7%], and ROC of 0.97 [CI: 0.92, 1.0; <i>P</i> =0.2]. Despite CCTA having higher odds of downstream testing (OR 2.0), 30 day per-patient cost was significantly lower for CCTA (\$2193 vs \$2704, <i>P</i> <0.001). Length of stay for CCTA was significantly reduced (13.5h [95% CI: 11.2–15.7], ExECG 19.7h [95% CI: 17.4–22.1], <i>P</i> <0.0005), which drove the reduction in cost. No patient had post-discharge cardiovascular events at 30 days.	1
14. Poon M, Cortegiano M, Abramowicz AJ, et al. Associations between routine coronary computed tomographic angiography and reduced unnecessary hospital admissions, length of stay, recidivism rates, and invasive coronary angiography in the emergency department triage of chest pain. <i>J Am Coll Cardiol.</i> 2013;62(6):543-552.	Observational-Dx	894 patients	To assess the effects on resource utilization of routine CCTA in triaging chest pain patients in the ED.	The overall admission rate was lower with CCTA (14% vs 40%; <i>P</i> <0.001). Standard evaluation was associated with a 5.5-fold greater risk for admission (OR: 5.53; <i>P</i> <0.001). Expected ED length of stay with standard evaluation was about 1.6 times longer (OR: 1.55; <i>P</i> <0.001). There were no differences in the rates of death and acute MI within 30 days of the index visit between the 2 groups. The likelihood of returning to the ED within 30 days for recurrent chest pain was 5 times greater with standard evaluation (OR: 5.06; <i>P</i> =0.022). Standard evaluation was associated with a 7-fold greater likelihood of invasive coronary angiography without revascularization (OR: 7.17; <i>P</i> <0.001), while neither group was significantly more likely to receive revascularization (OR: 2.06; <i>P</i> =0.193). The median radiation dose with CCTA was 5.88 mSv (n = 1,039; CI: 5.2 to 6.4).	3

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
15. Raff GL, Chinnaiyan KM, Cury RC, et al. SCCT guidelines on the use of coronary computed tomographic angiography for patients presenting with acute chest pain to the emergency department: a report of the Society of Cardiovascular Computed Tomography Guidelines Committee. <i>J Cardiovasc Comput Tomogr.</i> 2014;8(4):254-271.	Review/Other-Dx	N/A	SCCT guidelines on the use of CCTA for patients presenting with ACP to the ED.	No results stated in abstract.	4
16. Hoffmann U, Pena AJ, Moselewski F, et al. MDCT in early triage of patients with acute chest pain. <i>AJR Am J Roentgenol.</i> 2006;187(5):1240-1247.	Observational-Dx	40 patients	To determine feasibility of MDCT to provide diagnosis of coronary stenosis. Patients studied were ED patients with normal ECG and cardiac enzymes.	For significant coronary stenosis in ACS patients, MDCT had sensitivity of 100%. (95% CI, 49%–100%). ACS was ruled out in 35 patients (87.5%). Significant coronary stenosis was excluded in 26/35 patients without ACS by MDCT (specificity, 74% [CI, 75%–88%]). MDCT was extremely useful in decreasing the number of admissions in patients who did not have ACS.	2
17. Hollander JE, Litt HI, Chase M, Brown AM, Kim W, Baxt WG. Computed tomography coronary angiography for rapid disposition of low-risk emergency department patients with chest pain syndromes. <i>Acad Emerg Med.</i> 2007;14(2):112-116.	Observational-Dx	54 patients	To evaluate 30 day event rates using CTA in low-risk patients with chest pain.	Patients with Thrombolysis In Myocardial Infarction score of $\leq 2$ without ECG acute ischemia underwent CTA. Outcomes were death and MI within 30 days. Patients with negative CTA were discharged. 46 patients were immediately discharged without any 30 day cardiovascular complications. 8 patients were admitted because of their MDCT findings. MDCT useful in evaluating ED patients for early discharge.	3
18. Schroeder S, Kuettner A, Beck T, et al. Usefulness of noninvasive MSCT coronary angiography as first-line imaging technique in patients with chest pain: initial clinical experience. <i>Int J Cardiol.</i> 2005;102(3):469-475.	Observational-Dx	136 patients	Prospective study to evaluate MSCT coronary angiography in patients with known or suspected CAD and low to intermediate probability of severe coronary lesion. Results compared with conventional coronary angiography.	Significant stenosis excluded in 57%; coronary angiography was suggested in 43%. MDCT useful in reducing number of conventional coronary angiographies needed.	3



Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
19. Seneviratne SK, Truong QA, Bamberg F, et al. Incremental diagnostic value of regional left ventricular function over coronary assessment by cardiac computed tomography for the detection of acute coronary syndrome in patients with acute chest pain: from the ROMICAT trial. <i>Circ Cardiovasc Imaging</i> . 2010;3(4):375-383.	Observational-Dx	356 patients, 2 independent readers	Prospective blinded study to determine the incremental value of regional LVF over coronary assessment to detect ACS in patients with ACP. Regional LVF and presence of coronary atherosclerotic plaque and significant stenosis (>50%) were separately assessed by 2 independent readers.	During index hospitalization, 31 patients were ultimately diagnosed with ACS (8 with MI, 22 with unstable angina), of which 74% (23 patients) had regional LV dysfunction. Adding regional LVF resulted in a 10% increase in sensitivity to detect ACS by cardiac CT (87%; 95% CI, 70%–96%) and significantly improved the overall accuracy (c-statistic: 0.88 vs 0.94 and 0.79 vs 0.88, for extent of plaque and presence of stenosis, respectively; both $P<0.03$ ). Diagnostic accuracy of regional LVF for detection of ACS has 89% sensitivity and 86% specificity in patients with significant stenosis (n=33) and 60% sensitivity and 86% specificity in patients with inconclusive CCTA (n=33). Regional LVF assessment at rest improves diagnostic accuracy for ACS in patients with ACP, especially in those with CAD and thus may be helpful to guide further management in patients at intermediate risk for ACS.	2
20. Gerber TC, Kantor B, McCollough CH. Radiation dose and safety in cardiac computed tomography. <i>Cardiol Clin</i> . 2009;27(4):665-677.	Review/Other-Dx	N/A	To review the existing data regarding biologic hazards of radiation exposure associated with medical diagnostic testing, the methodologies used to estimate radiation exposure and dose, and the measures that can be taken to effectively reduce that exposure.	The risk of causing a malignancy at the radiation dose levels used in cardiac imaging is hypothetical, not proven, and estimates of radiation dose have a wide margin of error. However, in the absence of certainty, the consensus opinions of influential expert panels advocate adopting a conservative estimate of radiation risks.	4

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
21. Earls JP, Berman EL, Urban BA, et al. Prospectively gated transverse coronary CT angiography versus retrospectively gated helical technique: improved image quality and reduced radiation dose. <i>Radiology</i> . 2008;246(3):742-753.	Observational-Dx	203 patients	To retrospectively compare image quality, radiation dose, and blood vessel assessability for CCTA obtained with a prospectively gated transverse CT technique and a retrospectively gated helical CT technique.	The mean effective dose for the group with the prospectively gated transverse technique was 2.8 mSv; this represents an 83% reduction as compared with that for the group with the retrospectively gated helical technique (mean, 18.4 mSv; $P < .001$ ). The image quality score for each of the arteries, as well as the overall combined score, was significantly greater for images obtained with prospectively gated transverse technique than for images obtained with retrospectively gated helical technique. The combined mean image quality score was 4.791 for images obtained with prospectively gated transverse technique vs 4.514 for images obtained with retrospectively gated helical technique (proportional odds model OR, 2.8; 95% CI: 1.7, 4.8). The percentage of assessable coronary artery segments was 98.6% (1,196/1,213) for images obtained with prospectively gated transverse technique vs 97.9% (1,741/1,778) for images obtained with retrospectively gated helical technique ( $P = .83$ ).	2
22. Husmann L, Valenta I, Gaemperli O, et al. Feasibility of low-dose coronary CT angiography: first experience with prospective ECG-gating. <i>Eur Heart J</i> . 2008;29(2):191-197.	Observational-Dx	41 consecutive patients	To determine the feasibility of prospective ECG-gating to achieve low-dose CCTA.	Mean effective radiation dose was 2.1 +/- 0.6 mSv (range, 1.1-3.0 mSv). Image quality was inversely related to heart rate (57.3 +/- 6.2, range 39-66 b.p.m.; $r = 0.58$ , $P < 0.001$ ), vessel attenuation (346 +/- 104, range 110-780 HU; $r = 0.56$ , $P < 0.001$ ), and body mass index (26.1 +/- 4.0, range 19.1-36.3 kg/m <sup>2</sup> ); $r = 0.45$ , $P < 0.001$ ), but not to heart rate variability (1.5 +/- 1.0, range 0.2-5.1 b.p.m.; $r = 0.28$ , $P = 0.069$ ). Nondiagnostic CCTA image quality was found in 5.0% of coronary segments. However, below a heart rate of 63 b.p.m. (n=28), as determined by receiver-operator characteristic, only 1.1% of coronary segments were nondiagnostic compared with 14.8% with heart rate of >63 b.p.m. ( $P < 0.001$ ).	3

Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
23. Stolzmann P, Leschka S, Scheffel H, et al. Dual-source CT in step-and-shoot mode: noninvasive coronary angiography with low radiation dose. <i>Radiology</i> . 2008;249(1):71-80.	Observational-Dx	40 patients	To prospectively investigate CT image quality parameters by using different protocols and to calculate radiation dose estimates for noninvasive coronary angiography performed with dual-source CT in the step-and-shoot mode.	Mean image noise was similar with protocols A and B. Mean attenuation in the aorta and coronary arteries with protocol A (444 HU) was significantly ( $P<.001$ ) higher than that with protocol B (358 HU). The reduced contrast material dose in protocol C yielded attenuation similar to that with protocol B. Diagnostic image quality was achieved with all protocols in 1,237 (97.9%) of 1,264 coronary segments. No significant differences in image quality between the 100- and 120-kV protocols were found. Mean heart rate had a significant effect on motion artifacts (area under ROC curve = 0.818; 95% CI: 0.723, 0.892; $P<.001$ ), whereas heart rate variability had a significant effect on stair-step artifacts (area under ROC curve = 0.79; 95% CI: 0.687, 0.865; $P<.001$ ). The mean estimated effective dose was 1.2 mSv +/- 0.2 for protocols A and C and 2.6 mSv +/- 0.5 for protocol B.	2

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
24. Leipsic J, Labounty TM, Heilbron B, et al. Estimated radiation dose reduction using adaptive statistical iterative reconstruction in coronary CT angiography: the ERASIR study. <i>AJR Am J Roentgenol</i> . 2010;195(3):655-660.	Observational-Dx	574 consecutive patients	Prospectively evaluate patients undergoing CCTA at 3 centers to assess the impact of Adaptive Statistical Iterative Reconstruction (ASIR) on radiation dose and study quality for CCTA. Comparisons were performed between consecutive groups initially using filtered back projection (n = 331) and subsequently ASIR (n = 243) with regard to patient and scan characteristics, radiation dose, and diagnostic study quality.	There was no difference between groups in the use of prospective gating, tube voltage, or scan length. The examinations performed using ASIR had a lower median tube current than those obtained using filtered back projection (median [interquartile range], 450 mA [350–600] vs 650 mA [531–750], respectively; $P < 0.001$ ). There was a 44% reduction in the median radiation dose between the filtered back projection and ASIR cohorts (4.1 mSv [2.3–5.2] vs 2.3 mSv [1.9–3.5]; $P < 0.001$ ). After adjustment for scan settings, ASIR was associated with a 27% reduction in radiation dose compared with filtered back projection (95% CI, 21%–32%; $P < 0.001$ ). Despite the reduced current, ASIR was not associated with a difference in adjusted signal, noise, or signal-to-noise ratio ( $P = \text{not significant}$ ). No differences existed between filtered back projection and ASIR for interpretability per coronary artery (98.5% vs 99.3%, respectively; $P = 0.12$ ) or per patient (96.1% vs 97.1%, $P = 0.65$ ). ASIR enabled reduced tube current and lower radiation dose in comparison with filtered back projection, with preserved signal, noise, and study interpretability, in a large multicenter cohort. ASIR represents a new technique to reduce radiation dose in CCTA studies.	3
25. Achenbach S, Marwan M, Ropers D, et al. Coronary computed tomography angiography with a consistent dose below 1 mSv using prospectively electrocardiogram-triggered high-pitch spiral acquisition. <i>Eur Heart J</i> . 2010;31(3):340-346.	Observational-Dx	50 consecutive patients	To evaluate the feasibility and image quality of a new scan mode for CCTA with an effective dose of $< 1$ mSv.	In all 50 patients, imaging was successful. Mean duration of data acquisition was 258 +/- 20 ms. Mean dose-length product was 62 +/- 5 mGy cm, the effective dose was 0.87 +/- 0.07 mSv (0.78–0.99 mSv). Of the 742 coronary artery segments, 94% had an image quality score of 1, 5.0% a score of 2, 0.9% a score of 3, and 4 segments (0.5%) were 'uninterpretable'. In nonobese patients with a low and stable heart rate, prospectively ECG-triggered high-pitch spiral CCTA provides excellent image quality at a consistent dose below 1.0 mSv.	3

Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
26. Lee AM, Beaudoin J, Engel LC, et al. Assessment of image quality and radiation dose of prospectively ECG-triggered adaptive dual-source coronary computed tomography angiography (cCTA) with arrhythmia rejection algorithm in systole versus diastole: a retrospective cohort study. <i>Int J Cardiovasc Imaging</i> . 2013;29(6):1361-1370.	Observational-Dx	41 PTA-systolic and 41 matched PTA-diastolic CTA patients	To evaluate the image quality and effective radiation dose of PTA-systolic dual-source CTA vs PTA-diastolic dual-source CTA in patients of unselected heart rate and rhythm.	All 82 exams were considered diagnostic with 0 nondiagnostic segments. PTA-systolic CTA patients had a higher maximum heart rate, wider heart rate variability, were less likely to be in sinus rhythm, and received less beta-blocker vs PTA-diastolic CTA patients. No difference in effective dose was observed (PTA-systolic vs PTA-diastolic CTA: 2.9 vs 2.2 mSv, $P=0.26$ ). Image quality score (3.3 vs 3.5, $P=0.05$ ) and motion artifact score (3.5 vs 3.8, $P=0.05$ ) were lower in PTA systolic CTAs than in PTA-diastolic CTAs. For PTA-systolic CTAs, an increase in heart rate was not associated with a negative impact on motion artifact score nor CTDIvol. For PTA-diastolic CTA, an increase in heart rate was associated with increased motion artifacts and CTDIvol. Heart rate variability demonstrated no correlation with motion artifact and CTDIvol for both PTA-systolic and PTA-diastolic CTAs. In conclusion, both PTA-diastolic CTA and PTA-systolic CTA yielded diagnostic examinations at unselected heart rates and rhythms with similar effective radiation, but PTA-systolic CTA resulted in more consistent radiation exposure and image quality across a wide range of rates and rhythms.	3

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
27. Stein PD, Fowler SE, Goodman LR, et al. Multidetector computed tomography for acute pulmonary embolism. <i>N Engl J Med.</i> 2006;354(22):2317-2327.	Observational-Dx	824 patients	A prospective, multicenter investigation of the accuracy of multidetector CTA alone and combined with venous-phase imaging for the diagnosis of acute PE by using a composite reference test to confirm or rule out the diagnosis of PE.	Among 824 patients with a reference diagnosis and a completed CT study, CTA was inconclusive in 51 because of poor image quality. Excluding such inconclusive studies, the sensitivity of CTA was 83% and the specificity was 96%. PPVs were 96% with a concordantly high or low probability on clinical assessment, 92% with an intermediate probability on clinical assessment, and nondiagnostic if clinical probability was discordant. CTA-venous-phase imaging was inconclusive in 87/824 patients because the image quality of either CTA or CTA-venous-phase imaging was poor. The sensitivity of CTA-venous-phase imaging for PE was 90%, and specificity was 95%. CTA-venous-phase imaging was also nondiagnostic with a discordant clinical probability.	2
28. Johnson TR, Nikolaou K, Wintersperger BJ, et al. ECG-gated 64-MDCT angiography in the differential diagnosis of acute chest pain. <i>AJR Am J Roentgenol.</i> 2007;188(1):76-82.	Observational-Dx	55 patients	To assess the diagnostic value of an ECG-gated 64-MDCTA protocol for simultaneous assessment of the pulmonary arteries, coronary arteries, and aorta within a single breath-hold. Findings on CTA were compared with those on X-ray coronary angiography in 20 patients.	Cause of chest pain correctly diagnosed in 37/55 patients. The protocol proved helpful in the differential diagnosis of ACP.	1
29. Olivetti L, Mazza G, Volpi D, Costa F, Ferrari O, Pirelli S. Multislice CT in emergency room management of patients with chest pain and medium-low probability of acute coronary syndrome. <i>Radiol Med.</i> 2006;111(8):1054-1063.	Observational-Dx	31 patients	Prospective study to evaluate diagnostic accuracy of MSCT in patients with chest pain in medium to low risk of ACS. Coronary angiography was used as the gold standard.	MSCT identified significant occlusion and stenoses compared to coronary angiography with sensitivity 71.4%, specificity 99.6%, PPV 93.7%, NPV 97.7%, and accuracy of 97.5%. Because of its high NPV this technique can rule out occlusions or significant stenoses in patients with medium to low coronary risk. MSCT is an accurate indicator for need for coronary angiography.	2

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
30. White CS, Kuo D, Kelemen M, et al. Chest pain evaluation in the emergency department: can MDCT provide a comprehensive evaluation? <i>AJR Am J Roentgenol.</i> 2005;185(2):533-540.	Observational-Dx	69 patients	To determine whether MDCT can provide a comprehensive assessment of cardiac and noncardiac causes of chest pain in stable ED patients.	69 patients met all criteria for enrollment in the study, of whom 45 (65%) would not otherwise have undergone CT. 52 patients (75%) had no significant CT findings and a final diagnosis of clinically insignificant chest pain. 13 patients (19%) had significant CT findings (cardiac, 10; noncardiac, 3) concordant with the final diagnosis. CT failed to suggest a diagnosis in 2 patients (3%), both of whom proved to have clinically significant coronary artery stenoses. In 2 patients (3%), CT overdiagnosed a coronary stenosis. Sensitivity and specificity for the establishment of a cardiac cause of chest pain were 83% and 96%, respectively. Overall sensitivity and specificity for all other cardiac and noncardiac causes were 87% and 96%, respectively.	3
31. Mochizuki T, Hosoi S, Higashino H, Koyama Y, Mima T, Murase K. Assessment of coronary artery and cardiac function using multidetector CT. <i>Semin Ultrasound CT MR.</i> 2004;25(2):99-112.	Review/Other-Dx	N/A	To review the potential benefits of the cardiac application of MDCT in the assessment of coronary artery and cardiac function, such as wall motion and systolic thickening.	By applying retrospective ECG-gating, 10 phases throughout 1 cardiac cycle are extracted for functional analysis. Animated movies are generated by paging through these 2D and 3D images in cardiac phase order. LV end-diastolic volume, end-systolic volume, and ejection fraction can also be generated. Using the data acquired during a single breath hold, coronary artery and cardiac function can be assessed by MDCT.	4

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
32. Lehman SJ, Abbara S, Cury RC, et al. Significance of cardiac computed tomography incidental findings in acute chest pain. <i>Am J Med.</i> 2009;122(6):543-549.	Review/Other-Dx	395 patients	To determine the prevalence and nature of incidental findings detected in patients presenting to the ED with ACP using a standard coronary CT acquisition protocol; determine the effect on in-hospital patient management; and project subsequent diagnostic testing.	Incidental findings were detected in 44.8% (n=177): noncalcified pulmonary nodules (n=94, 23.8%), simple liver cysts (n=26, 6.6%), calcified pulmonary nodules (n=16, 4.1%), and contrast-enhancing liver lesions (n=9, 2.3%). In-hospital management was changed because of incidental finding reporting in 5 patients (1.3%), and a potential alternative diagnosis was offered in another 16 patients (4.1%). Subsequent diagnostic imaging tests were recommended in 81 patients (20.5%), including 74 chest CT scans. After 6 months, biopsy was performed in 3 patients, revealing cancer in 2 (0.5%) who underwent successful tumor resection. Clinically important findings are detected in up to 5% of patients with a lead symptom of ACP and low to intermediate likelihood of ACS, but only few directly change patient management; 21% are recommended for further imaging tests, resulting in invasive procedures and detection of cancer in few patients.	4
33. Mark DB, Berman DS, Budoff MJ, et al. ACCF/ACR/AHA/NASCI/SAIP/SCAI/S CCT 2010 expert consensus document on coronary computed tomographic angiography: a report of the American College of Cardiology Foundation Task Force on Expert Consensus Documents. <i>J Am Coll Cardiol.</i> 2010;55(23):2663-2699.	Review/Other-Dx	N/A	2010 expert consensus document on CCTA by the American College of Cardiology Foundation Task Force on Expert Consensus Documents.	The document summarizes the strengths and weaknesses of current clinical uses of CCTA as reflected in the published peer-reviewed literature and as interpreted by the writing committee.	4



**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
34. Savino G, Herzog C, Costello P, Schoepf UJ. 64 slice cardiovascular CT in the emergency department: concepts and first experiences. <i>Radiol Med.</i> 2006;111(4):481-496.	Observational-Dx	23 patients	To evaluate contrast-enhanced ECG-gated 64-slice CTA of the thorax as a triage tool in patients with acute equivocal chest pain.	Of the 23 patients, 11 presented without pathological findings, 2 with extensive PE, 2 with definite CAD but stenosis <50% and 8 with significant CAD (>50% stenosis). Catheter angiography was performed in the latter group, confirming the CT findings in all cases. 9 patients without CT findings were discharged on the same day. In comparison with the control group, length of hospitalization ( $P=0.009$ ) and total hospital charges ( $P<0.001$ ) were significantly reduced. Initial experience shows that ECG-gated 64-slice CTA of the entire thorax is technically feasible and enables rapid triage of patients to determine underlying cardiac and noncardiac reasons for chest pain. This test may thus help to significantly reduce costs and length of hospitalization. Prospective studies involving larger groups of patients required to confirm these findings.	4

Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
35. Takakuwa KM, Halpern EJ. Evaluation of a "triple rule-out" coronary CT angiography protocol: use of 64-Section CT in low-to-moderate risk emergency department patients suspected of having acute coronary syndrome. <i>Radiology</i> . 2008;248(2):438-446.	Observational-Dx	197 patients	Prospective cohort study of consecutive patients to determine whether CCTA "triple rule-out" evaluation of ED patients presenting with symptoms suggestive of ACS can help identify a subset of patients who can be discharged without adverse clinical outcomes within 30 days.	Disease process other than coronary atherosclerosis that explained the presenting symptoms was diagnosed in 22 (11%) of 197 patients. Clinically important noncoronary diagnoses that did not explain patient symptoms were identified in 27 (14%) of 197 additional patients. With respect to CAD, 10 patients had severe disease (>70% stenosis), 12 had moderate disease (50%–70% stenosis), 46 had mild disease (up to 50% stenosis), and 129 had no disease. At 30-day follow-up, the NPV of CCTA with no more than mild disease was 99.4%. There were no adverse outcomes at 30 days. Triple rule-out CCTA evaluation of low-to-moderate risk ACS patients presenting to the ED provided a noncoronary diagnosis that explained the presenting complaint in 11% of patients, suggested the presence of significant moderate-to-severe coronary disease in 11% (22/197) of patients, and precluded additional diagnostic cardiac testing in the majority of patients with no adverse outcomes at 30-day follow-up.	3
36. Madder RD, Raff GL, Hickman L, et al. Comparative diagnostic yield and 3-month outcomes of "triple rule-out" and standard protocol coronary CT angiography in the evaluation of acute chest pain. <i>J Cardiovasc Comput Tomogr</i> . 2011;5(3):165-171.	Observational-Dx	2,068 patients	To describe the diagnostic yield and clinical outcomes of patients undergoing triple rule-out in clinical practice.	Among 2,068 patients (272 triple rule-out and 1,796 cardiac CT angiograms), the composite diagnostic yield was 14.3% with triple rule-out and 16.3% with cardiac CT ( $P=0.41$ ) and was driven by the diagnosis of obstructive CAD (13.2% triple rule-out vs 16.1% cardiac CT, $P=0.22$ ). The diagnostic yield for PE was low (1.1% triple rule-out and 0.2% cardiac CT, $P=0.052$ ) and no aortic dissections were found in either group. Compared with cardiac CT, the triple rule-out approach was associated with higher radiation exposure (12.0 +/- 5.6 mSv vs 8.2 +/- 4.0 mSv, $P<0.0001$ ), a greater incidence of subsequent emergency center cardiac evaluations (5.9% vs 2.5%, $P=0.0017$ ), and more downstream PE-protocol CTA (3.3% vs 0.9%, $P=0.0034$ ).	3

Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
37. Shapiro MD. Is the "triple rule-out" study an appropriate indication for cardiovascular CT? <i>J Cardiovasc Comput Tomogr.</i> 2009;3(2):100-103.	Review/Other-Dx	N/A	To review the literature that is currently available to address whether the triple rule-out protocol is an appropriate indication for CCTA.	Initial studies suggest that performing a triple rule-out protocol to comprehensively evaluate patients with ACP presenting to the ED is feasible and that quantitative parameters of image quality may be comparable to the conventional, dedicated coronary and pulmonary CTA protocols. Recent data also suggest that a triple rule-out protocol has the potential to identify a subset of patients presenting with ACP who can safely be discharged from the ED. In addition, new scanner technology has also reduced the contrast and radiation doses necessary for such an examination. However, despite these early encouraging results, randomized control trials designed to determine whether this protocol is safe, cost-effective, and improves clinical decision making are necessary before routine implementation of such an examination can be justified.	4
38. Rogers IS, Banerji D, Siegel EL, et al. Usefulness of comprehensive cardiothoracic computed tomography in the evaluation of acute undifferentiated chest discomfort in the emergency department (CAPTURE). <i>Am J Cardiol.</i> 2011;107(5):643-650.	Experimental-Dx	59 patients	To determine whether providing a comprehensive cardiothoracic CT examination would result in significant improvement in the efficiency of treating patients presenting to the ED with undifferentiated acute chest discomfort or dyspnea in the setting of a tertiary academic hospital.	The effective use of aggressive dose-reduction strategies by trained physicians directly involved in CT scanning will lead to a radiation exposure that was similar between the 2 arms while maintaining a similar image quality, despite preclusion of intravenous $\beta$ blockade. Our data suggest a reduction in the repeat visits for the presenting symptom might be a potential benefit of a comprehensive cardiothoracic CT scan, because fewer subjects in the comprehensive CT group reported returning to the ED or their physician's office than in the dedicated CT group (13.8% vs 33.3%, $P=0.13$ ).	1

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
39. Di Pasquale P, Cannizzaro S, Scalzo S, et al. Sensitivity, specificity and predictive value of the echocardiography and troponin-T test combination in patients with non-ST elevation acute coronary syndromes. <i>Int J Cardiovasc Imaging</i> . 2004;20(1):37-46.	Observational-Dx	280 patients	To determine the clinical utility, sensitivity and specificity of the combination of troponin-T test levels and echocardiography in patients presenting with chest pain, ST-depression, T-wave negative and no diagnostic ECG.	The combination of positive troponin-T test and wall motion alterations showed a higher sensitivity, specificity and predictive values in comparison with alone troponin-T test or echocardiography. Patients, with the concordance between troponin-T test and echocardiography, were at higher risk. Patients with negative combination in all groups (94), showed a low incidence of coronary stenosis (10.6%), as well as negative echocardiography alone (102 patients) (12.7%), while patients with negative troponin-T test (128) showed higher incidence of coronary stenosis (39%), $P < 0.0001$ .	2
40. Kontos MC, Arrowood JA, Paulsen WH, Nixon JV. Early echocardiography can predict cardiac events in emergency department patients with chest pain. <i>Ann Emerg Med</i> . 1998;31(5):550-557.	Observational-Dx	260 patients	To evaluate the use of echocardiography in identifying patients with myocardial ischemia presenting to the ED with chest pain.	The sensitivity of echocardiography was 91% (95%, CI: 79%–97%), as compared with ECG, which had a sensitivity of 40%. (95%, CI: 27%–55%). Specificity of echocardiography was lower (75% [95%, CI: 69%–81%] compared to 94% [95%, CI: 90%–97%]; $P < .001$ ) for ECG. Excluding patients with abnormal ECG (n=30) did not affect sensitivity (85%) or specificity (74%) of echocardiography. Concludes that echocardiography has incremental value for identifying possible myocardial ischemia.	2
41. Lim SH, Sayre MR, Gibler WB. 2-D echocardiography prediction of adverse events in ED patients with chest pain. <i>Am J Emerg Med</i> . 2003;21(2):106-110.	Review/Other-Dx	1,112 patients received echo	To establish the efficacy of 2D echocardiography in predicting adverse cardiac events in patients presenting to the ED with possible ACS.	Of the 1,112 patients receiving echocardiography, 18 had positive studies. None had adverse events on follow-up. Of the 1,094 patients with a negative 2-D echocardiography, 15 had adverse events (2 acute MIs, 2 coronary artery bypass graftings, and 11 percutaneous transluminal coronary angioplasties). Resting 2-D echocardiography did not predict cardiac adverse events in patients with possible ACS and nondiagnostic serial 12-lead ECG and normal serial CK-MB at the end of a 9-hour evaluation.	4

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
42. Ersoy H, Goldhaber SZ, Cai T, et al. Time-resolved MR angiography: a primary screening examination of patients with suspected pulmonary embolism and contraindications to administration of iodinated contrast material. <i>AJR Am J Roentgenol.</i> 2007;188(5):1246-1254.	Observational-Dx	27 patients	To evaluate the efficiency and reproducibility of a 3D MRA technique in the diagnosis of PE.	3D MRA provides high temporal resolution and consistently yields arterial phase only images.	2
43. Stein PD, Chenevert TL, Fowler SE, et al. Gadolinium-enhanced magnetic resonance angiography for pulmonary embolism: a multicenter prospective study (PIOPED III). <i>Ann Intern Med.</i> 2010;152(7):434-443, W142-433.	Observational-Dx	371 patients	Prospective multicenter study to investigate performance characteristics of MRA, with or without MR venography, for diagnosing PE. Reference standard diagnosis or exclusion was made by using various tests, including CTA and venography, V/Q, venous US, d-dimer assay, and clinical assessment.	MRA averaged across centers, was technically inadequate in 25% of patients (92/371). The proportion of technically inadequate images ranged from 11% to 52% at various centers. Including patients with technically inadequate images, MRA identified 57% (59/104) with PE. Technically adequate MRA had a sensitivity of 78% and a specificity of 99%. Technically adequate MRA and venography had a sensitivity of 92% and a specificity of 96%, but 52% of patients (194/370) had technically inadequate results. MRA should be considered only at centers that routinely perform it well and only for patients for whom standard tests are contraindicated. MRA and MR venography combined have a higher sensitivity than MRA alone in patients with technically adequate images, but it is more difficult to obtain technically adequate images with the 2 procedures.	2
44. Cury RC, Shash K, Nagurney JT, et al. Cardiac magnetic resonance with T2-weighted imaging improves detection of patients with acute coronary syndrome in the emergency department. <i>Circulation.</i> 2008;118(8):837-844.	Observational-Dx	62 patients	Prospective cohort observational study to evaluate a cardiac MR protocol that includes T2-weighted imaging and assessment of LV wall thickness in detecting patients with ACS in the ED.	The new cardiac MR protocol increased the specificity, PPV, and overall accuracy from 84%–96%, 55%–85%, and 84%–93%, respectively, compared with the conventional cardiac MR protocol (cine, perfusion, and delayed-enhancement MRI). The new protocol improves the detection of patients with ACS in the ED and adds significant value over clinical assessment and traditional cardiac risk factors.	2

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Friedrich MG, Sechtem U, Schulz-Menger J, et al. Cardiovascular magnetic resonance in myocarditis: A JACC White Paper. <i>J Am Coll Cardiol.</i> 2009;53(17):1475-1487.	Review/Other-Dx	N/A	To review cardiovascular MR in myocarditis.	This work provides recommendations on the use of cardiovascular MR as part of a comprehensive diagnostic approach in patients with suspected myocardial inflammation. The use of cardiovascular MR appears suitable to identify patients with significant ongoing inflammation, which may be especially important for patients with recurrent or persisting symptoms and in patients with new onset heart failure.	4
46. Ingkanisorn WP, Kwong RY, Bohme NS, et al. Prognosis of negative adenosine stress magnetic resonance in patients presenting to an emergency department with chest pain. <i>J Am Coll Cardiol.</i> 2006;47(7):1427-1432.	Observational-Dx	135 patients	To determine the diagnostic value of adenosine cardiac MR in troponin-negative patients with chest pain. Hypothesis that adenosine cardiac MR could determine which troponin-negative patients with chest pain in an ED have CAD or future adverse cardiac.	Adenosine perfusion abnormalities had 100% sensitivity, 93% specificity for detection of CAD and were the single most accurate component of the cardiac MRI.	3

Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
47. Kwong RY, Chan AK, Brown KA, et al. Impact of unrecognized myocardial scar detected by cardiac magnetic resonance imaging on event-free survival in patients presenting with signs or symptoms of coronary artery disease. <i>Circulation</i> . 2006;113(23):2733-2743.	Observational-Dx	195 consecutive patients	To assess the prognostic utility of late gadolinium enhancement in a consecutive series of patients who underwent cardiac MR for clinical purposes. Authors tested the hypothesis that late gadolinium enhancement imaging by cardiac MR provides an incremental prognosis beyond the clinical and LVF assessments of patients.	During a median follow-up of 16 months, 31 patients (18%) experienced major adverse cardiac events, including 17 deaths. Late gadolinium enhancement demonstrated the strongest unadjusted associations with major adverse cardiac events and cardiac mortality (hazard ratios of 8.29 and 10.9, respectively; both $P < 0.0001$ ). Patients in the lowest tertile of late gadolinium enhancement -involved myocardium (mean LV mass, 1.4%) experienced a >7-fold increased risk for major adverse cardiac events. By multivariable analyses, late gadolinium enhancement was independently associated with major adverse cardiac events beyond the clinical model ( $P < 0.0001$ ) or the clinical model combined with angiographically significant coronary stenosis ( $P = 0.0007$ ), LV ejection fraction ( $P = 0.001$ ), LV end-systolic volume index ( $P = 0.0006$ ), or segmental wall motion abnormality ( $P = 0.002$ ). It remained the strongest predictor selected in the best overall models for major adverse cardiac events and cardiac mortality. Among patients with a clinical suspicion of CAD but without a history of myocardial scar from infarction, late gadolinium enhancement involving a small amount of myocardium carries a high cardiac risk. In addition, it provides incremental prognostic value to major adverse cardiac events and cardiac mortality beyond common clinical, angiographic, and functional predictors.	3

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
48. Hackshaw BT. Excluding heart disease in the patient with chest pain. <i>Am J Med.</i> 1992;92(5A):46S-51S.	Review/Other-Dx	N/A	To review the role of diagnostic studies in excluding heart disease in patients with chest pain.	Diagnostic modalities used in assessing myocardial ischemia include treadmill exercise testing, Holter monitoring and coronary angiography. Treadmill exercise testing has a relative low sensitivity for diagnosing CAD. The sensitivity can be improved by combining treadmill exercise with thallium-201 imaging, 2D echocardiography, PET. Thallium-201 scintigraphy and exercise echocardiography have sensitivities of 70%–80% and specificities of 50%–60% in low risk asymptomatic populations. PET has a sensitivity of 90% and a specificity of 90%–95% and is useful as a screening test. Holter monitoring is too insensitive and too nonspecific to be used as a screening test; however, Holter monitoring can help document ST-segment abnormalities occurring during episodes of chest pain. Coronary arteriography is the gold standard. It can assess coronary narrowing but is limited in evaluating coronary blood flow. Doppler flow studies can provide information regarding coronary flow reserve. Ischemia as a cause of chest pain is best diagnosed by correlating the clinical presentation with the presence of ECG abnormalities, thallium-201 perfusion deficits or echocardiographic wall motion abnormalities. The extent of stenoses would need to be determined by coronary angiography.	4



**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
49. Hilton TC, Thompson RC, Williams HJ, Saylor R, Fulmer H, Stowers SA. Technetium-99m sestamibi myocardial perfusion imaging in the emergency room evaluation of chest pain. <i>J Am Coll Cardiol.</i> 1994;23(5):1016-1022.	Observational-Dx	102 patients	To evaluate the use of Tc-99m sestamibi in predicting a cardiac cause for chest pain in patients with typical angina and a normal or nondiagnostic ECG.	Univariate predictors of cardiac events included the presence of 3 or more coronary risk factors ( $P=0.009$ , risk ratio 3.3) and an abnormal or equivocal acute Tc-99m sestamibi scan ( $P=0.0001$ , risk ratio 13.9). Multivariate regression analysis identified an abnormal perfusion image as the only independent predictor of adverse cardiac events ( $P=0.009$ ). Of 70 patients with a normal perfusion scan, only 1 had a cardiac event compared with 15 patients with equivocal scans or 17 patients with abnormal scans, with a cardiac event rate of 13% and 71%, respectively ( $P=0.0004$ ).	2
50. Kontos MC, Jesse RL, Anderson FP, Schmidt KL, Ornato JP, Tatum JL. Comparison of myocardial perfusion imaging and cardiac troponin I in patients admitted to the emergency department with chest pain. <i>Circulation.</i> 1999;99(16):2073-2078.	Observational-Dx	620 patients	Comparison of myocardial perfusion and cardiac Troponin I to identify patients with ACS in patients presenting to the ED with chest pain.	Sensitivity for detecting MI was not significantly different between perfusion imaging (92%) and cardiac Troponin I (90%), and both were significantly higher than the initial cardiac Troponin I (39%). Perfusion identified more patients who had significant CAD but had a lower specificity. Tests provide complementary information.	3
51. Swinburn J, Lahiri A. Can nuclear cardiology really help in the emergency departments of the 21st century? <i>Rev Port Cardiol.</i> 2000;19 Suppl 1:147-52.	Review/Other-Dx	N/A	To review usefulness of nuclear perfusion in ED patients.	Nuclear perfusion imaging provides an instantaneous assessment of perfusion at the time of injection.	4
52. Udelson JE, Beshansky JR, Ballin DS, et al. Myocardial perfusion imaging for evaluation and triage of patients with suspected acute cardiac ischemia: a randomized controlled trial. <i>JAMA.</i> 2002;288(21):2693-2700.	Experimental-Dx	2,475 patients	Prospective randomized controlled trial to assess whether incorporating acute resting perfusion imaging into an ED evaluation strategy for patients with symptoms suggestive of acute cardiac ischemia would improve clinical decision making.	Among patients with acute cardiac ischemia (ie, acute MI or unstable angina; $n=329$ ), there were no differences in ED triage decisions between those receiving standard evaluation and those whose evaluation was supplemented by a sestamibi scan. Among patients with acute MI ( $n=56$ ), 97% vs 96% were hospitalized (relative risk, 1.00; 95% CI, 0.89–1.12), and among those with unstable angina ( $n=273$ ), 83% vs 81% were hospitalized (relative risk, 0.98; 95% CI, 0.87–1.10). However, among patients without acute cardiac ischemia ( $n=2,146$ ), hospitalization was 52% with usual care vs 42% with sestamibi imaging (relative risk, 0.84; 95% CI, 0.77–0.92).	1

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease**  
**EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
53. Varetto T, Cantalupi D, Altieri A, Orlandi C. Emergency room technetium-99m sestamibi imaging to rule out acute myocardial ischemic events in patients with nondiagnostic electrocardiograms. <i>J Am Coll Cardiol.</i> 1993;22(7):1804-1808.	Observational-Dx	64 patients	To determine the role of nuclear imaging in patients with chest pain.	30 patients showed a perfusion defect on admission. Of these, 13 developed MI within 12 hours. CAD was diagnosed in 14 patients and the remaining 3 patients were classified as having false positive findings. Normal perfusion scans were seen in 34 patients, none of whom were ultimately diagnosed as having CAD. A 100% sensitivity was demonstrated vs the final diagnosis of acute cardiac ischemia (kappa 0.91, 95% CI, 0.8 to 1.0). A follow-up period of up to 18 months (mean 11 +/- 3) was also carried out for major cardiac events (death, MI, coronary angioplasty and coronary artery bypass grafting). 6 events (2 coronary bypass procedures, 3 angioplasty procedures and 1 death) were observed at follow-up in the group of patients with a Tc-99m sestamibi perfusion defect. Patients with normal perfusion scans on admission had no major cardiac events at follow-up study.	2
54. Williams KA, Garvin AA, Taillon LA. Clinical nuclear imaging techniques for the diagnosis and evaluation of acute myocardial infarction. <i>Compr Ther.</i> 1992;18(2):6-10.	Review/Other-Dx	N/A	To review nuclear imaging techniques in the diagnosis and evaluation of acute MI.	Scintigraphy is important in diagnosing acute MI and assessing ventricular function and prognosis.	4

**Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
55. Patel MR, Peterson ED, Dai D, et al. Low diagnostic yield of elective coronary angiography. <i>N Engl J Med.</i> 2010;362(10):886-895.	Review/Other-Dx	398,978 patients	To determine patterns of noninvasive testing and the diagnostic yield of catheterization among patients with suspected CAD in a contemporary national sample.	A total of 398,978 patients were included in the study. The median age was 61 years; 52.7% of the patients were men, 26.0% had diabetes, and 69.6% had hypertension. Noninvasive testing was performed in 83.9% of the patients. At catheterization, 149,739 patients (37.6%) had obstructive CAD. No CAD (defined as <20% stenosis in all vessels) was reported in 39.2% of the patients. Independent predictors of obstructive CAD included male sex (OR, 2.70; 95% CI, 2.64 to 2.76), older age (OR per 5-year increment, 1.29; 95% CI, 1.28 to 1.30), presence of insulin-dependent diabetes (OR, 2.14; 95% CI, 2.07 to 2.21), and presence of dyslipidemia (OR, 1.62; 95% CI, 1.57 to 1.67). Patients with a positive result on a noninvasive test were moderately more likely to have obstructive CAD than those who did not undergo any testing (41.0% vs 35.0%; $P<0.001$ ; adjusted OR, 1.28; 95% CI, 1.19 to 1.37).	4
56. Just RJ, Castell DO. Chest pain of undetermined origin. <i>Gastrointest Endosc Clin N Am.</i> 1994;4(4):731-746.	Review/Other-Dx	N/A	To identify diagnostic tools used for the evaluation of chest pain of undetermined origin.	Diagnostic tools used in the evaluation of chest pain include ambulatory intraesophageal pH monitoring, esophageal manometry with provocative testing, intraesophageal pressure monitoring, upper gastrointestinal barium examinations and/or endoscopy.	4

## Evidence Table Key

### Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  - a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  - b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  - c) the study is an expert opinion or consensus document.
- M = Meta-analysis

---

Dx = Diagnostic

Tx = Treatment

## Abbreviations Key

ACP = Acute chest pain

ACS = Acute coronary syndrome

CAD = Coronary artery disease

CCTA = Coronary computed tomography angiography

CI = Confidence interval

CT = Computed tomography

CTA = Computed tomography angiography

ECG = Electrocardiogram

ED = Emergency department

LVF = Left ventricular function

MDCT = Multidetector computed tomography

MI = Myocardial infarction

MRA = Magnetic resonance angiography

MRI = Magnetic resonance imaging

MSCT = Multislice computed tomography

NPV = Negative predictive value

OR = Odds ratio

PE = Pulmonary embolism

PET = Positron emission tomography

PPV = Positive predictive value

PTA-systolic = Prospectively ECG-triggered adaptive systolic

PTA-diastolic = Prospectively triggered adaptive diastolic

ROC = Receiver operating characteristic

US = Ultrasound

V/Q = Ventilation-perfusion lung scan