

**American College of Radiology
ACR Appropriateness Criteria®
Dyspnea–Suspected Cardiac Origin**

Variant 1: Dyspnea due to heart failure. Ischemia not excluded.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☼
US echocardiography transthoracic resting	9		O
US echocardiography transthoracic stress	9		O
Tc-99m SPECT MPI rest and stress	9		☼ ☼ ☼ ☼
Rb-82 PET heart stress	8		☼ ☼ ☼
MRI heart function and morphology without and with IV contrast	8		O
MRI heart with function and vasodilator stress perfusion without and with IV contrast	8		O
CTA coronary arteries with IV contrast	8		☼ ☼ ☼
Arteriography coronary with ventriculography	8		☼ ☼ ☼
MRI heart with function and inotropic stress without and with IV contrast	7		O
US echocardiography transesophageal	5		O
MRI heart function and morphology without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
MRI heart with function and inotropic stress without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
CT heart function and morphology with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	☼ ☼ ☼ ☼
CT coronary calcium	5		☼ ☼ ☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2:**Dyspnea due to suspected nonischemic heart failure. Ischemia excluded.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☼
US echocardiography transthoracic resting	9		O
MRI heart function and morphology without and with IV contrast	9		O
MRI heart function and morphology without IV contrast	8		O
US echocardiography transesophageal	5		O
CT heart function and morphology with IV contrast	5		☼ ☼ ☼ ☼
US echocardiography transthoracic stress	3		O
Tc-99m SPECT MPI rest and stress	3		☼ ☼ ☼ ☼
Rb-82 PET heart stress	3		☼ ☼ ☼
MRI heart with function and inotropic stress without and with IV contrast	3		O
MRI heart with function and inotropic stress without IV contrast	3		O
MRI heart with function and vasodilator stress perfusion without and with IV contrast	2		O
CTA coronary arteries with IV contrast	2		☼ ☼ ☼
Arteriography coronary with ventriculography	2		☼ ☼ ☼
CT coronary calcium	1		☼ ☼ ☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 3:**Dyspnea due to suspected valvular heart disease. Ischemia excluded.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☼
US echocardiography transthoracic resting	9		O
US echocardiography transesophageal	8		O
MRI heart function and morphology without and with IV contrast	8		O
MRI heart function and morphology without IV contrast	7		O
CT heart function and morphology with IV contrast	6	This procedure can sometimes be used to assess valve disease. It may be appropriate for some clinical scenarios.	☼ ☼ ☼ ☼
US echocardiography transthoracic stress	4		O
CTA coronary arteries with IV contrast	3		☼ ☼ ☼
Tc-99m SPECT MPI rest and stress	2		☼ ☼ ☼ ☼
Rb-82 PET heart stress	2		☼ ☼ ☼
MRI heart with function and inotropic stress without and with IV contrast	2		O
MRI heart with function and inotropic stress without IV contrast	2		O
MRI heart with function and vasodilator stress perfusion without and with IV contrast	2		O
CT coronary calcium	2		☼ ☼ ☼
Arteriography coronary with ventriculography	2		☼ ☼ ☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 4:**Dyspnea due to suspected cardiac arrhythmia. Ischemia excluded.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☼
US echocardiography transthoracic resting	9		O
MRI heart function and morphology without and with IV contrast	9		O
MRI heart function and morphology without IV contrast	7		O
CT heart function and morphology with IV contrast	6		☼ ☼ ☼ ☼
US echocardiography transthoracic stress	5		O
US echocardiography transesophageal	3		O
CTA coronary arteries with IV contrast	3		☼ ☼ ☼
Arteriography coronary with ventriculography	3		☼ ☼ ☼
Tc-99m SPECT MPI rest and stress	2		☼ ☼ ☼ ☼
Rb-82 PET heart stress	2		☼ ☼ ☼
MRI heart with function and inotropic stress without and with IV contrast	2		O
MRI heart with function and inotropic stress without IV contrast	2		O
MRI heart with function and vasodilator stress perfusion without and with IV contrast	2		O
CT coronary calcium	1		☼ ☼ ☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 5:**Dyspnea due to suspected pericardial disease. Ischemia excluded.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☼
US echocardiography transthoracic resting	9		O
MRI heart function and morphology without and with IV contrast	9		O
MRI heart function and morphology without IV contrast	8		O
CT heart function and morphology with IV contrast	7		☼ ☼ ☼ ☼
CTA chest with IV contrast	7		☼ ☼ ☼
CT chest without IV contrast	7	This procedure may be appropriate if the patient cannot have contrast.	☼ ☼ ☼
CT chest with IV contrast	7		☼ ☼ ☼
US echocardiography transesophageal	5		O
CTA coronary arteries with IV contrast	5		☼ ☼ ☼
Arteriography coronary with ventriculography	4		☼ ☼ ☼
MRI heart with function and vasodilator stress perfusion without and with IV contrast	3		O
US echocardiography transthoracic stress	2		O
Rb-82 PET heart stress	2		☼ ☼ ☼
MRI heart with function and inotropic stress without and with IV contrast	2		O
MRI heart with function and inotropic stress without IV contrast	2		O
CT chest without and with IV contrast	2		☼ ☼ ☼
Tc-99m SPECT MPI rest and stress	1		☼ ☼ ☼ ☼
CT coronary calcium	1		☼ ☼ ☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

DYSPNEA–SUSPECTED CARDIAC ORIGIN

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Summary of Literature Review

Introduction/Background

Dyspnea is breathing discomfort that occurs at rest or at lower-than-expected levels of exertion [1,2]. In comparison to acute dyspnea, chronic dyspnea is shortness of breath lasting for more than 1 month [3].

Dyspnea may be due to new-onset acute disease, exacerbation of existing chronic illness, or new disease concomitant to chronic illness. Finding the cause of dyspnea is more difficult than it may appear [4]. Although multiple disorders may cause breathlessness, the majority are of cardiac and/or pulmonary origin. Every pulmonary or cardiac disease may induce dyspnea depending on disease progression [5]. The challenge is to establish a timely and cost-effective diagnosis [1].

Cardiac causes of dyspnea include myocardial disease (eg, ischemic and nonischemic cardiomyopathies), valvular heart disease (VHD) (eg, aortic stenosis/insufficiency, congenital heart disease, mitral valve stenosis/insufficiency), arrhythmia (eg, atrial fibrillation, inappropriate sinus tachycardia, sick sinus syndrome, bradycardia), and constrictive causes (eg, constrictive pericarditis, pericardial effusion/tamponade) [1,6].

Clinical diagnostic tools such as history, symptoms, and physical signs, along with chest radiography and electrocardiography, are used to discriminate cardiac causes from other causes of dyspnea in the emergency setting with high specificity (96%) but low sensitivity (59%) when using chest radiography alone [7,8]. Therefore, advanced diagnostic imaging plays an important role in evaluating dyspnea.

Overview of Imaging Modalities

Generally, computed tomography (CT) of the chest is the most appropriate imaging study to exclude suspected pulmonary causes of dyspnea. To confirm the diagnosis of pulmonary hypertension, right heart catheterization is needed [7].

Echocardiography is an important tool in the investigation of cardiac structure and function and should be performed in all patients with dyspnea of suspected cardiac origin [9,10]. Stress echocardiography is uniquely positioned to help characterize most potential cardiovascular etiologies of dyspnea, including global or regional systolic dysfunction due to myocardial ischemia [11,12].

Cardiac dyspnea may be also caused by ischemic heart disease. Although conventional catheter angiography remains the clinical gold standard technique to assess the coronary arteries, coronary CT angiography (CCTA) has emerged as an alternative noninvasive method for determining the presence, severity, burden, and composition of coronary artery plaque [13,14].

Recent advances in CT imaging technology allow for further radiation dose reduction in CCTA examinations [15]; new and available dose-reducing techniques include prospective triggering [16-18], adaptive statistical iterative reconstruction [19], and high-pitch spiral acquisition [20]. However, these newer low-dose techniques

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may not be appropriate in all patients because of their dependency on a combination of factors, including heart rate, rhythm, and body size.

For the purposes of distinguishing between CT and CTA, ACR AC topics use the definition in the [Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography](#) [21]:

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

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

Cardiac magnetic resonance imaging (MRI) is also helpful in specifying the etiology of cardiac dyspnea. It provides high-quality information on cardiac structure and function and allows the characterization of myocardial tissue and the pericardium in a wide range of disease states [22]. Cardiac stress MRI using either vasodilators or positive inotropic medication as a pharmacologic stress agent has emerged in the last decade and is now widely used. Cardiac stress perfusion MRI has been shown to be a radiation-free alternative to single-photon emission CT (SPECT) to detect ischemic heart disease [23,24].

Identifying the etiology of dyspnea in patients with complex comorbidities often requires multimodality imaging in order to establish a unifying diagnosis [25].

Discussion of Imaging Modalities by Variant

Variant 1: Dyspnea due to heart failure. Ischemia not excluded.

Ischemic heart disease occurs when myocardial oxygen supply is not adequate for myocardial oxygen demand. It is most commonly caused by coronary artery disease (CAD) [26].

The diagnosis of CAD is broadly based on both anatomical and functional imaging, as not all anatomical lesions are functionally significant [27]. A stenosis <50% is less likely to be functionally significant, whereas stenoses of severity between 50% and 90% may show a wide variability in functional significance [28].

The imaging techniques for CAD diagnosis include invasive techniques, including a) selective coronary angiography, the gold standard method to detect luminal stenosis, but with little information on vessel wall and plaque composition; b) intravascular ultrasound and optical coherence tomography, which provide wall and plaque characterization; and c) fractional flow reserve (FFR) analysis, which permits detection of flow-limiting lesions. Noninvasive imaging techniques, including a) direct visualization of coronary arteries with coronary CT or magnetic resonance (MR) coronary angiography; b) a surrogate assessment of plaque burden by coronary calcium scoring; and c) assessment of functional significance of coronary lesions by myocardial perfusion assessment using stress radionuclide imaging (eg, SPECT/positron emission tomography [PET]), stress echocardiography, or stress cardiovascular MR [CMR]) [29].

SPECT, PET, and MRI

Stress SPECT myocardial perfusion imaging is the most commonly used stress imaging technique for patients with suspected or known CAD [30]. Stress SPECT sensitivity and specificity for detection of obstructive CAD ($\geq 50\%$ diameter stenosis) are 88% and 61%, respectively [31]. PET has higher diagnostic accuracy than SPECT, with a sensitivity of 84% and a specificity of 81%; however, its high cost and limited availability of cardiac PET/CT systems, as well as the often limited cardiac perfusion radionuclide tracer availability, restricts its use [31,32].

In a meta-analysis, the pooled sensitivity for cardiac stress MRI was 89% (95% CI, 88%–91%) and pooled specificity was 76% (95% CI, 73%–78%) for detecting perfusion deficits in CAD [31]. Late gadolinium enhancement imaging of the myocardium and cine cardiac MRI, when combined with stress myocardial perfusion imaging, improves its specificity [33]. A 3-D adenosine stress myocardial perfusion MRI study [34] showed improved specificity values compared with catheter-derived FFR as the gold standard.

Stress forms of SPECT, PET, and CMR myocardial perfusion imaging all yield high sensitivity, with a broad range of specificity, in CAD diagnosis. SPECT is widely available and extensively validated, PET achieves the highest diagnostic performance, and CMR may provide an alternative without ionizing radiation and a similar

diagnostic accuracy as PET. Receiver operator characteristic curve analysis shows decreasing superiority of PET, CMR, and SPECT [31,35].

CT coronary calcium

The presence of coronary artery calcium is sensitive but not specific for diagnosis of significant CAD [36]. Absent coronary calcium is highly suggestive of absence of significant stenosis and very low risk of subsequent cardiac events. However, this has to be interpreted with caution in younger patients. The Multi-Ethnic Study of Atherosclerosis showed that individuals with zero or minimal coronary calcification who had cardiovascular events were more likely to be diabetic and smokers as compared with those who did not have any event [37].

Computed tomography angiography

CCTA demonstrates excellent ability to rule out coronary stenosis with a high degree of confidence in low- and intermediate-risk populations [38,39]. Sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios of CCTA are 91%, 50%, 68%, 83%, 1.82, and 0.18, respectively [40]. Its relatively low specificity in high-risk patients is due to impaired vessel visualization in the setting of heavy calcification [41], smaller vessels [42], and the presence of stents [43]. There is also a tendency to overestimate stenosis in high-risk populations by artifacts from high heart rates, arrhythmias, and motion, which may be falsely interpreted as stenosis [44].

Arteriography

In patients without a prior diagnosis, CAD should be considered as a potential etiology of impaired left ventricular (LV) function and should be excluded wherever possible. Invasive catheter coronary angiography remains the clinical gold standard to diagnose CAD [45]. FFR performed during coronary angiography represents a reliable and reproducible tool to functionally assess the severity of coronary lesions and predict prognosis, especially when used to guide percutaneous coronary intervention [46]. FFR is also an important index for the decision of revascularization of coronary artery stenosis [47]. FFR techniques applicable to CCTA are undergoing validation [48].

VARIANT 2: Dyspnea due to suspected nonischemic heart failure. Ischemia excluded.

Heart failure (HF) can be defined as systolic failure with reduced LV ejection fraction (LVEF) or diastolic dysfunction due to increased myocardial stiffness or VHD with preserved LVEF. HF is also classified as primarily left sided or right sided. Cardiac dyspnea due to pulmonary venous hypertension represents left-sided failure that manifests as LV dilatation and decreased contractility, as well as pulmonary congestion [49].

Several noninvasive imaging modalities are used to diagnose HF: chest radiography, transthoracic echocardiography (TTE), SPECT, PET, CMR, and cardiac CT [22].

Radiographs

Upper lung zone flow redistribution, lung interstitial or alveolar edema, bilateral pleural effusions, and cardiac enlargement are the most common abnormal signs of cardiac-related dyspnea on chest radiographs [50].

Echocardiography

According to the 2013 American College of Cardiology/American Heart Association Guideline for the Management of Heart Failure, the most useful diagnostic test in the evaluation of patients with or at risk for HF is a comprehensive 2-dimensional echocardiogram. Coupled with Doppler flow studies, the TTE can identify abnormalities of myocardium, heart valves, and pericardium [45]. Similarly, Canadian HF guidelines recommend echocardiography as the initial noninvasive imaging test for all patients with suspected HF [51]. Recent developments in myocardial strain, 3-D TTE, and echo contrast offer superior diagnostic and prognostic information [22]. Strain is a measure of myocardial tissue displacement and is used to measure either systolic or diastolic function [52]. 3-D TTE may be slightly superior to 2-D TTE for LVEF determination but is not as widely available [53]. Doppler echocardiography is recommended for the assessment of diastolic function and intracardiac pressures [54].

SPECT, PET

SPECT/PET imaging is employed to detect global and regional ventricular function, myocardial perfusion, and viability in patients with HF [55]. However, compared to SPECT, the availability of cardiac PET is currently limited to specialized centers [51].

Magnetic resonance imaging

CMR provides information on cardiac structure and function and allows the characterization of myocardial tissue. With the combined use of “cine” (functional) imaging, T2-weighted (“edema”) imaging, and late gadolinium enhancement (LGE, or “scar”) imaging, a majority of HF etiologies can be characterized [22]. Cine CMR provides highly accurate measures of biventricular volumes and thus is the gold standard imaging modality for assessing biventricular function in patients with HF [56-58]. T1- and T2-mapping MRI techniques are emerging quantitative MR methods for evaluation of myocardial tissue characteristics and will likely play a future role in the diagnosis and treatment response monitoring of HF patients [59].

Computed tomography angiography

CCTA is primarily used to evaluate the coronary arteries. However, it also allows for accurate assessment of global and regional LV function assessment in patients with HF, although it requires higher radiation doses for the latter application [60-62].

Variant 3: Dyspnea due to suspected valvular heart disease. Ischemia excluded.

In VHD, imaging plays a key role to 1) identify valve dysfunction and quantify its severity, 2) assess the effect of valve dysfunction on cardiac function and the patient’s prognosis, 3) determine optimal timing and type (surgical or transcatheter) of valve repair/replacement, and 4) help valve procedure planning, guiding, and follow-up [63].

Radiographs

The chest radiograph is often one of the initial imaging tests to detect valve-related abnormalities based on changes in cardiac configuration or calcification collections; this may guide subsequent diagnostic testing.

Echocardiography, MRI, CTA, CT coronary calcium

Doppler echocardiography is the primary imaging modality for VHD. Other imaging modalities, such as cardiac CT or MRI, may then be needed to confirm or complement the findings from Doppler echocardiography [63].

In patients with aortic or mitral stenosis, the presence and severity of valve obstruction is generally assessed with the use of peak transvalvular flow velocity, peak and mean transvalvular pressure gradients, and valve effective orifice area measured by Doppler echocardiography [64,65]. Doppler echocardiography is also used for comprehensive evaluation of the valve morphology (ie, presence of congenital anomaly, degree of leaflet thickening and calcification, presence and extent of commissural fusion, fibrocalcific remodeling of mitral subvalvular apparatus), which is also essential to document the presence and/or severity of valve stenosis, to predict rapid progression, and to aid therapeutic decision-making [66].

3-D transesophageal echocardiography, CCTA, and CMR may be used to corroborate the measurements of LV outflow tract dimension, stroke volume, and aortic valve area in selected patients with poor echocardiographic image quality [67]. CMR is used to measure flow and thus can estimate the pressure gradient across the valve using the Bernoulli equation [68]. CT coronary calcium scoring and CCTA can quantify the amount of valve calcification and measure the anatomic (ie, geometric) area of the valve orifice for grading severity of aortic stenosis according to the American College of Cardiology guidelines [69].

Doppler echocardiography is the primary imaging technique used for accurate assessment of the severity and mechanism(s) of valve regurgitation as it provides precise information on the type and extent of anatomic lesions, mechanisms of regurgitation, etiology, and amount of regurgitation in order to distinguish between organic (primary) versus functional (secondary) mitral regurgitation, which differ in their prognosis and therapeutic management [70,71]. CMR is also a helpful modality to quantify valve regurgitation [72].

Besides the accurate assessment of the severity of valve dysfunction, imaging also has an important role in assessing effects of valve dysfunction on dimensions and function of cardiac chambers. Transthoracic or transesophageal echocardiography is the primary imaging technique used for this purpose; CMR and CCTA may also be used to confirm and complement the echocardiographic findings [63]. In recent years CTA/CCTA has become the method of choice for preoperative planning of transcatheter aortic valve replacement [73,74].

Variant 4: Dyspnea due to suspected cardiac arrhythmia. Ischemia excluded.

Ventricular tachycardia (VT) is the commonest cause of sudden cardiac death (SCD) in developed countries. CAD is the most frequent cause of VT in patients >30 years of age, in comparison to hypertrophic cardiomyopathy, myocarditis, and congenital heart disease in patients <30 years of age [75]. Arrhythmogenic right ventricular cardiomyopathy/dysplasia (ARVC/D) is caused by genetic mutations leading to fibrofatty infiltration of the myocardium (most commonly the right ventricular [RV] wall and to a lesser extent the LV

wall); associated RV dilatation and dysfunction are hallmarks of ARVC/D and set the stage for life-threatening arrhythmias [76].

Echocardiography, MRI

The primary noninvasive imaging technique for the diagnosis of arrhythmias is echocardiography. However, CMR is commonly used to obtain additional diagnostic information [77]. The capability of CMR to perform tissue characterization and detect edema, fat, and fibrotic myocardial tissue using LGE images can help predict the likelihood of VT/SCD in both ischemic and nonischemic myocardial disease (eg, ARVC, Chagas disease) [78]. In CAD, infarct size is the strongest predictor of VT inducibility [79].

Computed tomography

Cardiac CT also provides a role in morphologic evaluation of the RV, particularly in patients with implantable cardioverter defibrillators who often cannot undergo MRI examination [80-82].

Variant 5: Dyspnea due to suspected pericardial disease. Ischemia excluded.

Although pericardial effusion, calcification [83], gas, and masses can be detected by chest radiography, the 3 imaging modalities most commonly used for evaluation of pericardial disease are echocardiography, cardiac CT, and CMR [84].

Echocardiography, CT, MRI

TTE remains the initial diagnostic imaging modality of choice. It performs particularly well in diagnosis and follow-up of pericardial effusions, tamponade, and constrictive pericarditis. Cardiac CT and CMR provide complementary information with respect to the morphologic and functional features of the diseased pericardium, although they should not replace echocardiography as first-line imaging. They can be used when findings on TTE are difficult to interpret or conflict with clinical findings [85].

The main indications for the use of cardiac CT in the setting of constrictive pericarditis are the need of better anatomic description of the pericardium and detection and extent of pericardial calcifications and evaluation of associated cardiac or extracardiac disease [84].

For distinction between constrictive pericardial disease and restrictive cardiomyopathy, which is often a clinical dilemma, CMR is recommended over cardiac CT in part because of its better myocardial tissue characterization. It is used also for assessment of the pericardium, myocardial structure, and cardiac function [84].

Summary of Recommendations

- For patients with dyspnea of suspected cardiac origin, diagnostic imaging should usually be started with chest radiography followed by resting TTE.
- To exclude ischemia in patients with dyspnea due to HF, stress echocardiography, stress MRI, stress SPECT, or stress PET can be used as equivalent alternatives. In low- and intermediate-risk populations, CT coronary angiography can be used. Invasive catheter coronary angiography remains the clinical gold standard to diagnose CAD.
- MRI heart function and morphology with intravenous contrast is used in patients with dyspnea due to nonischemic HF with excluded ischemia to characterize the etiology of nonischemic HF.
- In patients with dyspnea due to suspected VHD with excluded ischemia, transesophageal echocardiography or MRI can be used to further evaluate structure and function of cardiac valves and ventricles. CT heart function with intravenous contrast is appropriate for some clinical scenarios.
- In patients with dyspnea due to suspected cardiac arrhythmia and excluded ischemia, MRI heart function and morphology with intravenous contrast is a valuable imaging method to obtain additional diagnostic information.
- In patients with dyspnea due to suspected pericardial disease and excluded ischemia, MRI heart function and morphology or CT heart function or CTA chest provides complementary information with respect to the morphologic and functional features of the diseased pericardium.

Summary of Evidence

Of the 85 references cited in the *ACR Appropriateness Criteria® Dyspnea–Suspected Cardiac Origin* document, all of them are categorized as diagnostic references including 5 well-designed studies, 17 good-quality studies,

and 10 quality studies that may have design limitations. There are 46 references that may not be useful as primary evidence. There are 7 references that are meta-analysis studies.

The 85 references cited in the *ACR Appropriateness Criteria[®] Dyspnea–Suspected Cardiac Origin* document were published from 2004 through 2015.

Although there are references that report on studies with design limitations, 22 well-designed or good-quality studies provide good evidence.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the *ACR Appropriateness Criteria[®] Radiation Dose Assessment Introduction* document.

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊗	<0.1 mSv	<0.03 mSv
⊗ ⊗	0.1-1 mSv	0.03-0.3 mSv
⊗ ⊗ ⊗	1-10 mSv	0.3-3 mSv
⊗ ⊗ ⊗ ⊗	10-30 mSv	3-10 mSv
⊗ ⊗ ⊗ ⊗ ⊗	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies”.

Supporting Documents

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

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.