

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

**Clinical Condition:**                      **Dyspnea — Suspected Cardiac Origin**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b><u>RRL*</u></b>
X-ray chest	8		☼
US echocardiography transthoracic resting	8		O
US echocardiography transthoracic stress	7		O
SPECT MPI rest and stress	7		☼☼☼☼
PET heart stress	7		☼☼☼
MRI heart function and morphology with or without contrast	7	See statement regarding contrast in text under “Anticipated Exceptions.”	O
CTA coronary arteries	6		☼☼☼☼
CTA coronary arteries with advanced low dose techniques	6		☼☼☼
CTA chest (noncoronary)	6		☼☼☼
Cardiac catheterization with angiocardiology	6		☼☼☼
US echocardiography transesophageal	5		O
CT chest with or without contrast	5		☼☼☼
Radionuclide ventriculography	4		☼☼☼
Tc-99m V/Q scan lung	3		☼☼☼
CT coronary calcium	3		☼☼☼
Arteriography pulmonary	3		☼☼☼☼
<b><u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate</b>			<b>*Relative Radiation Level</b>

## DYSPNEA — SUSPECTED CARDIAC ORIGIN

Expert Panel on Cardiac Imaging: Suhny Abbara, MD<sup>1</sup>; Brian Ghoshhajra, MD, MBA<sup>2</sup>; Richard D. White, MD<sup>3</sup>; Pamela K. Woodard, MD<sup>4</sup>; Michael K. Atalay, MD, PhD<sup>5</sup>; Linda B. Haramati, MD, MS<sup>6</sup>; Robert C. Hendel, MD<sup>7</sup>; Arfa R. Khan, MD<sup>8</sup>; Edward T. Martin, III, MD<sup>9</sup>; Anna Rozenshtein, MD<sup>10</sup>; Robert M. Steiner, MD.<sup>11</sup>

### **Summary of Literature Review**

Comroe described breathlessness as “...difficult, labored, uncomfortable breathing.” Shortness of breath, also known as dyspnea, has no precise definition, and patients vary in their attempts to describe the sensation, as it is diffuse in etiology [1-4]. Dyspnea may be of neurogenic, respiratory, or cardiac origin and may be associated with disease states, as well deconditioning, anemia, or anxiety [5-8]. Some patients have a combination of these factors that produce dyspnea at rest, after exercise, or in certain positions (orthopnea, trepopnea, or platypnea, ie, recumbent, on one side, or in the upright position) [4,9]. Dyspnea may have an acute onset or may be chronic. It is more common in the elderly.

It is not always easy to distinguish between the various causes of dyspnea, although history, physical examination, and simple laboratory tests usually provide insights [10]. The electrocardiogram, chest radiograph, and complete blood count have traditionally been part of the initial diagnostic workup [11-12]. Pulmonary function testing and oximetry are important tests when chronic obstructive pulmonary disease (COPD) or asthma is suspected. Cardiopulmonary exercise testing, with measurement of peak oxygen uptake, is useful in this assessment when combinations of cardiac and respiratory causes are being considered [13-15].

Imaging can play a central role in the differentiation of the underlying cause of dyspnea. (See the ACR Appropriateness Criteria<sup>®</sup> on “[Chronic Dyspnea — Suspected Pulmonary Origin.](#)”)

Congestive heart failure (CHF) is the most common cardiac cause of dyspnea [16]. CHF may involve both systolic and diastolic left-ventricular dysfunction. Although we commonly think of systolic dysfunction as most important because it produces decreased cardiac output, it is the diastolic dysfunction that appears to be associated with the symptom of dyspnea and with reduced functional capacity under the New York Heart Association (NYHA) grading system in some cases [8,17]. Some patients may have CHF and dyspnea with normal ejection fractions and can be classified as having diastolic heart failure [18]. Ischemic heart disease is the most common cause of CHF, but other etiologies include valvular heart disease, intracardiac shunts, various cardiomyopathies (including hypertensive, hypertrophic, restrictive, or dilated), right ventricular failure or overload with abnormal septal intrusion on the left ventricle (LV), and pericardial disease with limited diastolic filling due to constriction.[19-25].

Imaging studies are invaluable for establishing the diagnosis and, in many instances, determining the appropriate management strategy in the setting of dyspnea [26-28]. Chest radiography and echocardiography have remained the major imaging tools employed for directly assessing patients with dyspnea; with peripheral ultrasound allowing further evaluation of potential venous thromboembolic disease. (See the ACR Appropriateness Criteria<sup>®</sup> on “[Suspected Lower Extremity Deep Vein Thrombosis.](#)”) In addition, radionuclide imaging has traditionally played an important role in evaluating myocardial perfusion and systolic function when ischemic heart disease is suspected and for inclusion or exclusion of pulmonary embolus [29]. Cardiac magnetic resonance imaging (MRI) is gaining acceptance for noninvasive evaluation of the myocardium, cardiac chambers, valves, and pericardium when cardiac causes of dyspnea are suspected. Computed tomography angiography (CTA) of the heart, pulmonary arteries, or thoracic aorta now play significant roles in the noninvasive workup of suspected low to intermediate-risk test of coronary artery disease (CAD), pulmonary embolism, or thoracic aortic disease associated with aortic valve dysfunction, respectively. Cardiac angiography and coronary arteriography are invasive imaging techniques that are used extensively for diagnosing or excluding ischemic disease and, together with cardiac hemodynamics and endomyocardial biopsy, are important for precise evaluation of cardiac function and etiology of cardiomyopathies.

### **Radiograph**

The radiograph remains readily available and may provide important information about the underlying etiology of dyspnea [30]. Most noncardiac causes related to primary respiratory conditions can be identified using radiography. In the acute setting, CHF is fairly reliably manifested by pulmonary vascular redistribution [31-32] with alveolar pulmonary edema, while in the chronic situation, cardiomegaly combined with vascular prominence and interstitial edema is more typical. In

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about half of patients with chronic CHF, cardiomegaly is seen on a radiograph, and evidence of specific chamber enlargement is helpful in detecting valvular heart disease. Elevation of LV end-diastolic pressure (LVEDP), however, is not always accompanied by signs of interstitial edema, particularly in patients who have undergone treatment, whereas clinical symptoms and NYHA grade tend to parallel the radiographic findings of elevated pulmonary capillary wedge pressure (PCWP) [26,33]. Absence of the radiographic signs of congestion does not ensure a normal LVEDP or PCWP in patients with chronic CHF.

### **Echocardiography**

Transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) are widely available techniques that play an extremely important role in evaluating patients with dyspnea of suspected cardiac origin [11,34-35]. LV size, global and regional systolic contraction, diastolic function (relaxation and filling), myocardial wall thickness and texture, and valve dysfunction are accurately evaluated with a combination of two-dimensional and color Doppler techniques. Abnormalities of diastolic function can be detected in patients with normal heart size [18,36]. Pericardial restraint during filling can often be inferred [37]. Pericardial effusion is easily detected, but pericardial thickening and calcification are not readily seen. Patterns of central venous flow during phases of respiration aid in the differentiation of constrictive and restrictive pathophysiology by echocardiography when Doppler imaging is applied [38]. Consequently, such TTE evaluations are invaluable to the evaluation of the dyspneic patient with suspected cardiac disease. Stress echocardiography is useful to detect regional wall motion abnormalities in ischemic situations [39]. Stress TTE is highly accurate for the detection of CAD and can be performed in combination with either exercise or pharmacologically induced stress [40-42].

Serial echocardiography studies are easily performed without cumulative risks from repetitive radiation exposure [43]. TTE has limitations related to acoustic window restrictions and certain body types, as well as operator experience. TEE is somewhat invasive and should be reserved for cases that require better definition of the mitral valve or when TTE is unsatisfactory [44].

### **Radionuclide Imaging**

Equilibrium-gated blood-pool imaging of the LV (radionuclide ventriculography) provides reliable and reproducible measurements of ejection fraction, regional wall motion abnormalities, and diastolic dysfunction [45-47]. In patients undergoing radionuclide imaging for dyspnea of suspected cardiac origin, dyspnea appears to be an independent predictor of an increased risk for death from cardiac causes and from any cause [5]. More recently, combined assessments of LV function and myocardial perfusion based on SPECT with a variety of agents can be performed at rest and after stress with exercise, dobutamine, dipyridamole, adenosine, or regadenoson [48-51]. These studies give reliable results

that detect areas of ischemia, infarction, and hibernating myocardium. Recently, new software algorithms such as iterative reconstruction, maximum a posteriori noise regularization and resolution recovery, and new hardware and detector materials have become available, allowing for image acquisitions at significantly shorter acquisition times (one fifth to one half), or alternatively at lower doses compared with conventional algorithms [52-53].

PET has many of the same attributes but with generally higher image quality. PET may be useful in patients with dyspnea and suspected myocardial ischemia for demonstrating abnormalities in regional perfusion and/or metabolic behavior of the myocardium. (See the ACR Appropriateness Criteria® on [“Chronic Chest Pain — High Probability of Coronary Artery Disease.”](#))

Limitations of SPECT and PET include decreased detection of ischemia in the presence of balanced disease and decreased sensitivity of chemical stress examinations when compared with exercise stress examinations. Artifacts from diaphragmatic and breast attenuation may complicate the interpretation of these examinations, although new CT attenuation correction algorithms address these difficulties.

Ventilation/perfusion (V/Q) scanning is a useful means of evaluation for suspected pulmonary embolism if contrast-enhanced CT is contraindicated. Disadvantages include lack of sensitivity and specificity in the presence of underlying cardiopulmonary disease (especially in the setting of an abnormal chest x-ray), increased fetal radiation dose in pregnant women, and the inability to diagnose alternative causes of chest pain. (See the ACR Appropriateness Criteria® on [“Acute Chest Pain — Suspected Pulmonary Embolism.”](#))

### **Computed Tomography**

Conventional CT with contrast infusion gives limited information about the cardiac chambers [41]. It can detect pericardial disease and is quite useful for detecting pulmonary causes of dyspnea. Compared to conventional radiography, CT enables superior assessment of pulmonary vascularity in the context of CHF. CTA of the chest with contrast timed to specifically enhance the pulmonary arteries has emerged as a first-line test to evaluate for pulmonary embolism and can differentiate causes of pulmonary hypertension such as chronic thromboembolic disease, underlying lung pathology, and their sequelae. (See the ACR Appropriateness Criteria® on [“Acute Chest Pain — Suspected Pulmonary Embolism.”](#)) When the contrast is timed to enhance the thoracic aorta, CTA can effectively detect aortic conditions predisposing to dyspnea (eg, Stanford Type A dissection), often due to aortic valve involvement. (See the ACR Appropriateness Criteria® on [“Acute Chest Pain — Suspected Aortic Dissection.”](#))

ECG-synchronized CT is also emerging as an important tool for the noninvasive detection of CAD, particularly in patients at low to intermediate risk [54-58]. There is a growing body of evidence that suggests that noninvasive coronary CTA (CCTA) is a test of high accuracy when

differentiating ischemic from nonischemic etiologies of dilated cardiomyopathy based on assessment for CAD [59-62], although the severity (number of stenotic lesions and degree of stenosis) of heavily calcified lesions may still be overestimated. (See the ACR Appropriateness Criteria® topics on “[Chronic Chest Pain — High Probability of Coronary Artery Disease](#)” and “[Chest Pain, Suggestive of Acute Coronary Syndrome](#).”)

ECG-gated studies can be performed with multidetector row CT, which provides detailed information on general cardiovascular and thoracic pathology. Effusions and pericardial calcification are easily detected. Precise and reproducible measurements of ventricular volumes, wall thickness, and regional contraction abnormalities can be made using multi-phasic reconstructions, although multidetector row CT should not be used primarily for evaluating cardiac function due to the radiation dose associated with retrospectively gated studies [63-67].

As with all imaging tests involving use of iodinated contrast material, the diagnostic benefit needs to be weighed against the risk of inducing or worsening CHF due to contrast-related volume overload. Recent advances in cardiac CT imaging technology allow for further reduction of the radiation dose from CCTA [68]; available new dose-reducing techniques include prospective triggering [69-71], adaptive statistical iterative reconstruction [72], and high-pitch spiral acquisition [73].

However, these newer low-dose techniques may not be the appropriate choice in all patients due to their dependency on a combination of factors, including heart rate, rhythm, and clinical indication. Thus, while these techniques are promising in terms of reducing patient radiation dose, their overall accuracy and utility as compared to standard CCTA techniques are not yet completely defined.

### **Magnetic Resonance Imaging**

Current ECG-gated MRI techniques routinely yield high-quality images that are acquired over a single breath-hold or even during a single heartbeat. Currently there are few established indications for MRI in the setting of acute dyspnea [74-75]. However, dynamic MRI techniques (eg, cine, tagging, flow mapping) reveal anatomic and functional abnormalities of the myocardium, cardiac chambers, valves, and pericardium without the need for radiation or contrast administration [54,76-77]. Valve lesions that may be responsible for dyspnea can be accurately characterized and quantified.

Applications of MRI to functional studies of myocardial contraction and diastolic relaxation have shown accurate characterization of functional abnormality. Thus, although MRI may not be the first-line imaging test in the workup of dyspnea, it is a valuable test for diagnosing several cardiac entities that may present with chronic dyspnea. Growing evidence exists that demonstrates the utility of MRI to differentiate ischemic from nonischemic cardiomyopathies, to detect nontransmural infarcts and missed infarcts, to characterize various nonischemic cardiomyopathies, to diagnose myocarditis or

endomyocardial fibrosis, to characterize congenital heart lesions (such as shunts), and to offer prognostic value in several situations [3,37,59,74,78-107].

### **Invasive Techniques**

Physiological studies with hemodynamic monitoring of right heart and pulmonary wedge pressures are often useful in detecting a cardiac cause of dyspnea when the etiology is obscure [44]. Coronary angiography is the reference imaging modality in patients with heart failure and anginal chest pain and continues to play a significant role in confirming absence of obstructive coronary disease in patients with heart failure due to nonischemic cardiomyopathy [108]. LV function is more easily determined noninvasively. Pulmonary arteriography is an invasive test that allows a sensitive evaluation of the pulmonary vasculature as well as functional information such as pulmonary-artery and right-heart pressure measurements, although the test is limited by interobserver variability. For the evaluation of pulmonary embolism as a cause of dyspnea, invasive pulmonary arteriography is usually reserved as a second-line test in rare cases. (See the ACR Appropriateness Criteria® on “[Acute Chest Pain — Suspected Pulmonary Embolism](#).”)

### **Summary**

- Dyspnea is a poorly understood symptom that may have pulmonary, cardiac, or psychological causes.
- The chest radiograph is often useful in initially differentiating between cardiac and pulmonary causes.
- The echocardiogram is the noninvasive modality of choice for assessing ventricular systolic and diastolic function and valve function.
- Radiographs and echocardiographs are widely available, have virtually no risk, and are suitable for serial studies.
- Radionuclide imaging (primarily SPECT, but with growing contribution by PET) is widely used as a method for study of myocardial perfusion at rest and under stress. Stress TTE can be employed to detect myocardial ischemia based on assessment of physiological changes in regional contraction.
- ECG-gated multidetector row CT has value in CAD detection in symptomatic patients with either low-to-intermediate CAD risk or equivocal echocardiographic or SPECT results for ischemia evaluation. Its diagnostic accuracy to noninvasively differentiate between ischemic and nonischemic causes of cardiomyopathies and its ability to determine ventricular volumes and function are supportive.
- CTA of the chest is now a first-line approach to the assessment of suspected pulmonary embolism or proximal thoracic aortic disease.
- Cardiac MRI has the ability to differentiate myocardial fibrosis from ischemic infarcts and nonischemic cardiomyopathies, as well as to

accurately evaluate global and regional function, and can characterize and quantify valvular dysfunction.

### Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m<sup>2</sup>), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m<sup>2</sup>. For more information, please see the [ACR Manual on Contrast Media](#) [109].

### 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<sup>®</sup> [Radiation Dose Assessment Introduction](#) document.

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☼	<0.1 mSv	<0.03 mSv
☼ ☼	0.1-1 mSv	0.03-0.3 mSv
☼ ☼ ☼	1-10 mSv	0.3-3 mSv
☼ ☼ ☼ ☼	10-30 mSv	3-10 mSv
☼ ☼ ☼ ☼ ☼	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as NS (not specified).		

### Supporting Document(s)

- [ACR Appropriateness Criteria<sup>®</sup> Overview](#)
- [Procedure Contrast Information](#)
- [Evidence Table](#)

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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.