American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Shortness of Breath — Suspected Cardiac Origin**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9	For evaluation of pulmonary vascularity and edema.	Min
US echocardiography transthoracic	8		None
SPECT MPI	7		High
Tc-99m ventriculography	6		Med
Arteriography coronary	6		Med
Left ventriculography	6		Med
CT heart function and morphology with contrast	5	Multidetector with maximal temporal and spatial resolution. For detection of coronary artery disease.	High
CT chest	5	For evaluation of pulmonary vascularity and edema.	Med
US echocardiography transesophageal	5		None
MRI heart function and morphology with or without contrast	4		None
US peripheral venous	3	Only if DVT or PE suspected.	None
Tc-99m V/Q scan lung	3	Only if PE suspected.	Med
Arteriography pulmonary	2	Only if PE suspected.	High
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Expert Panel on Cardiac Imaging: U. Joseph Schoepf, MD[1]; E. Kent Yucel, MD[2]; Michael A. Bettmann, MD[3]; Thomas Casciani, MD[4]; Antoinette S. Gomes, MD[5]; Julius H. Grollman, MD[6]; Stephen R. Holtzman, MD[7]; Joseph F. Polak, MD, MPH[8]; David Sacks, MD[9]; William Stanford, MD[10]; Michael Jaff, MD[11]; Gregory L. Moneta, MD.[12]

Summary of Literature Review

Shortness of breath, or dyspnea, has no precise definition, and patients vary in their attempts to describe the sensation. It may have a respiratory or cardiac origin and may be associated with deconditioning, anemia, or anxiety. 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). Dyspnea may have an acute onset or may be chronic and is more common in the elderly. Comroe described breathlessness as "...difficult, labored, uncomfortable breathing."

It is not always easy to distinguish between the various causes of dyspnea, although history, physical examination, and simple laboratory tests usually provide a working diagnosis. The electrocardiogram, plain chest radiograph, and complete blood count are part of the initial diagnostic workup. Simple 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.

Congestive heart failure (CHF) is the most common cardiac cause of dyspnea. 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. Some patients may have CHF and dyspnea with normal ejection fractions and can be classified as having diastolic heart failure. Ischemic heart disease is the most common cause of CHF, but other etiologies include valvular heart disease, left-to-right shunts, hypertension and hypertrophic myopathies, infiltrative disorders such as amyloid disease, right ventricular failure or overload with abnormal septal intrusion on the left ventricle, pericardial disease with restriction in diastolic filling of the left ventricle (LV) and cardiomyopathies due to alcohol, drugs, radiation, inflammation, peripartum, or unknown causes (idiopathic).

Imaging studies are invaluable for establishing the diagnosis and, in many instances, determining the appropriate management strategy. The plain chest film and echocardiography are the major imaging tools employed, but radionuclide imaging plays an important role. Computed tomography (CT) and magnetic resonance imaging (MRI) have much to offer but have not been used with much frequency to date. 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.

Radiography

The radiograph provides important information about the underlying etiology of dyspnea at a very moderate cost. Most of the noncardiac causes related to primary respiratory conditions can be identified. Cardiomegaly is seen in about half of patients with chronic CHF, and specific chamber enlargement is helpful in detecting valvular heart disease. CHF is fairly reliably manifested in the acute situation by alveolar pulmonary edema or in the chronic situation by interstitial edema. Elevation of left ventricle (LV) end-diastolic pressure (LVEDP), however, is not always accompanied by signs of interstitial edema, particularly in patients who have undergone treatment with diuretics and angiotensin-converting enzyme (ACE) inhibitors, whereas clinical symptoms and NYHA grade tend to parallel the radiographic findings of elevated pulmonary capillary wedge pressure (PCWP). Absence of the radiographic signs of congestion does not ensure a normal LVEDP or PCWP in patients with chronic CHF. Flow to the upper and lower zones of the lung can be determined in both upright and supine radiographs by comparing the ratio of a pulmonary artery to its accompanying bronchus. The pulmonary artery enlarges relative to the bronchus when flow is increased. Normally the flow to the lower lobes exceeds that to the upper lobes with a ratio of less than one in the upper zones and greater than one in the lower zones. Flow to both the upper and lower zones increases

[1]Principal Author, Medical University of South Carolina, Charleston, South Carolina.
[2]Panel Chair, Boston VA Healthcare System, West Roxbury, Massachusetts.
[3]Wake Forest University School of Medicine Radiology, Winston-Salem, North Carolina.
[4]Indiana University Hospital, Indianapolis, Indiana.
[5]UCLA School of Medicine, Los Angeles, California.
[6]Little Company of Mary Hospital, Torrance, California.
[7]Radiology Associates of San Luis Obispo, San Luis Obispo, California.
[8]New England Medical Center, Boston, Massachusetts.
[9]West Reading Radiology Associates, West Reading, Pennsylvania.
[10]University of Iowa Hospital & Clinics, Iowa City, Iowa.
[11]Massachusetts General Hospital, Boston, Massachusetts, American College of Cardiology.
[12]Oregon Health Sciences University, Portland, Oregon, Society for Vascular Surgery.

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Reprint requests to: Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

with pulmonary plethora, as occurs in renal failure or left-to-right shunts, whereas in impending CHF, upper-zone flow is increased and lower-zone flow is decreased. This results in what is commonly referred to as "pulmonary vascular redistribution."

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. LV size, systolic and diastolic function (contraction and relaxation), wall thickness and texture, and the presence of valve dysfunction are obtained with a combination of two-dimensional and color Doppler techniques. Serial studies are easily performed without radiation exposure. TTE has limitations in imaging certain body types, while TEE is somewhat invasive and should be reserved for cases that require better definition of the mitral valve or when TTE is unsatisfactory.

Stress echo studies are useful to detect regional wall motion abnormalities in ischemic situations. Abnormalities of diastolic function can be detected in patients with normal heart size. Pericardial restraint during relaxation can often be inferred. Pericardial effusion is easily detected, but pericardial thickening and calcification are not readily seen.

Radionuclide Imaging

Equilibrium-gated blood-pool imaging of the left ventricle in systole and diastole provides reliable and reproducible measurements of ejection fraction and regional wall motion abnormalities and is useful in assessing diastolic and systolic performance. 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. It is less dependent than echocardiography on assumptions of ventricular geometry. These studies are widely available and are relatively expensive. They require exposure to radiation, have poor spatial resolution, and may be hampered by cardiac dysrhythmias.

Studies can be performed after stress and at rest to assess ventricular function under conditions designed to provoke ischemia. Myocardial perfusion imaging with a variety of agents can be performed at rest and after stress with exercise, dobutamine, dipyridamole, or adenosine. These studies give generally reliable results that detect areas of ischemia, infarction, and hibernating myocardium. They may be useful in patients with dyspnea and suspected myocardial ischemia for demonstrating regional perfusion abnormalities.

Computed Tomography

Conventional CT with contrast infusion gives limited information about cardiac chamber enlargement. It can detect pericardial calcification and effusions 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 congestive heart failure. It has little utility in evaluating cardiac function.

Gated studies can be performed with multidetector row CT, which provides detailed information on cardiac and general thoracic pathology. Effusions and cardiac tumors are easily detected. Coronary calcium is visible, and several scoring systems have been developed that correlate loosely with severity of coronary artery disease. In addition, such studies can be viewed as multiple frames over a cardiac cycle or in a cine format. Precise and reproducible measurements of ventricular volumes, wall thickness, and regional contraction abnormalities can be made, although multidetector row CT should not be used primarily for evaluating cardiac function.

ECG-synchronized CT is also emerging as an important tool for the non-invasive detection of coronary artery stenosis. While currently there is no literature to support the use of CT for the detection of coronary artery disease in the setting of shortness of breath with suspected cardiac origin, it is anticipated that CT of the heart will prove beneficial in the management of patients with this presentation. 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 congestive heart failure due to contrast related volume overload.

Magnetic Resonance Imaging

To achieve adequate magnetic resonance images (MRI) of the heart, artifacts from cardiac and respiratory motion and the flow of blood within vessels need to be corrected. ECG and respiratory gating are required if images are to be acquired over several heartbeats. Current techniques suggest the feasibility of producing satisfactory image quality during a single breath-hold or even during a single heartbeat. Cine MRI reveals anatomic and functional abnormalities of the valves, pericardium, and myocardium without the need for radiation or contrast administration.

Currently there are few proven indications for MRI in the setting of acute dyspnea. Research into applying MRI to functional studies of myocardial contraction and diastolic relaxation have shown promise to accurately characterize the functional abnormality and to provide specific tissue characterization of certain infiltrative cardiomyopathies. Until these techniques are studied in more detail and become available to the general public, MRI's clinical applicability remains unproven.

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. Angiography may play a role in detecting normal coronary arteries in patients with heart failure due to cardiomyopathy or in revealing coronary disease when the clinical suspicion is low. Left ventricular function is more easily determined noninvasively, but left ventriculography may reveal regional wall motion abnormalities not detected by echocardiography or radionuclide angiography.

Summary

Dyspnea is a poorly understood symptom that may have pulmonary, cardiac, or psychological causes. The simple chest radiograph is most useful in separating cardiac from pulmonary disease, and the echocardiogram has emerged as the noninvasive modality of choice for determining left ventricular function. Radiographs and echocardiographs are widely available, have virtually no risk, and are suitable for serial studies. Nuclear imaging is widely used as a method for study of left ventricular function as well as myocardial perfusion. Multidetector row CT and cardiac MRI have a variety of limitations, and their efficacy has not been validated on sufficiently large populations, even though they have potential for evaluating anatomy and function.

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. 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	**Effective Dose Estimate Range**
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

Supporting Document(s)

- ACR Appropriateness Criteria® Overview
- Evidence table under review

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