Agency for Healthcare Research and Quality
Advancing Excellence in Health Care

NATIONAL GUIDELINE CLEARINGHOUSE

General

Guideline Title

ACR Appropriateness Criteria® dyspnea—suspected cardiac origin.

Bibliographic Source(s)

Vogel-Claussen J, Elshafee AS, Kirsch J, Brown RK, Hurwitz LM, Javidan-Nejad C, Julsrud PR, Kramer CM, Krishnamurthy R, Laroia AT, Leipsic JA, Panchal KK, Shah AB, White RD, Woodard PK, Abbara S, Expert Panel on Cardiac Imaging. ACR Appropriateness CriteriaÂ® dyspneaâ€“suspected cardiac origin. Reston (VA): American College of Radiology (ACR); 2016. 15 p. [85 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Abbara S, Ghoshhajra B, White RD, Woodard PK, Atalay MK, Haramati LB, Hendel RC, Khan AR, Martin ET III, Rozenshtein A, Steiner RM, Expert Panel on Cardiac Imaging. ACR Appropriateness Criteria® dyspnea -- suspected cardiac origin. [online publication]. Reston (VA): American College of Radiology (ACR); 2010. 8 p. [109 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: 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		☢☢☢

Radiologic Procedure	Rating	Comments	RRL*
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**

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 2: Dyspnea due to suspected nonischemic 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
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative**

Radiologic Procedure	Rating	Comments	RRL*
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**

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

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**

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

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

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☢

Radiologic Procedure	Rating	Comments	RRL*
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**

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

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		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Radiologic Procedure	Rating	Comments	RRL*
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**

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

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

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. 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. The challenge is to establish a timely and cost-effective diagnosis.

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

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. 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.

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. Stress echocardiography is uniquely positioned to help characterize most potential cardiovascular etiologies of dyspnea, including global or regional systolic dysfunction due to myocardial ischemia.

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.

Recent advances in CT imaging technology allow for further radiation dose reduction in CCTA examinations; new and available dose-reducing techniques include prospective triggering, adaptive statistical iterative reconstruction, and high-pitch spiral acquisition. However, these newer low-dose techniques 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 Appropriateness Criteria topics use the definition in the Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography :

> *"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-dimensional (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. 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.

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

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).

The diagnosis of CAD is broadly based on both anatomical and functional imaging, as not all anatomical lesions are functionally significant. 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.

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 optimal 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 (e.g., SPECT/positron emission tomography [PET]), stress echocardiography, or stress cardiovascular MR [CMR]).

SPECT, PET, and MRI

Stress SPECT myocardial perfusion imaging is the most commonly used stress imaging technique for patients with suspected or known CAD. Stress SPECT sensitivity and specificity for detection of obstructive CAD (≥50% diameter stenosis) are 88% and 61%, respectively. 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.

In a meta-analysis, the pooled sensitivity for cardiac stress MRI was 89% (95% confidence interval [CI], 88%–91%) and pooled specificity was 76% (95% CI, 73%–78%) for detecting perfusion deficits in CAD. Late gadolinium enhancement imaging of the myocardium and cine cardiac MRI, when combined with stress myocardial perfusion imaging, improves its specificity. A 3-D adenosine stress myocardial perfusion MRI study 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.

CT Coronary Calcium

The presence of coronary artery calcium is sensitive but not specific for diagnosis of significant CAD. 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.

Computed Tomography Angiography

CCTA demonstrates excellent ability to rule out coronary stenosis with a high degree of confidence in low- and intermediate-risk populations. 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. Its relatively low specificity in high-risk patients is due to impaired vessel visualization in the setting of heavy calcification, smaller vessels, and the presence of stents. 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.

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. 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. FFR is also an important index for the decision of revascularization of coronary artery stenosis. FFR techniques applicable to CCTA are undergoing validation.

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.

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

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.

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 (2-D) echocardiogram. Coupled with Doppler flow studies, the TTE can identify abnormalities of myocardium, heart valves, and pericardium. Similarly, Canadian HF guidelines recommend echocardiography as the initial noninvasive imaging test for all patients with suspected HF. Recent developments in myocardial strain, 3-D TTE, and echo contrast offer superior diagnostic and prognostic information. Strain is a measure of myocardial tissue displacement and is used to measure either systolic or diastolic function. 3-D TTE may be slightly superior to 2-D TTE for LVEF determination but is not as widely available. Doppler echocardiography is recommended for the assessment of diastolic function and intracardiac pressures.

SPECT, PET

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

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. 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. 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.

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.

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.

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.

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. Doppler echocardiography is also used for comprehensive evaluation of the valve morphology (i.e., 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.

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. CMR is used to measure flow and thus can estimate the pressure gradient across the valve using the Bernoulli equation. CT coronary calcium scoring and CCTA can quantify the amount of valve calcification and measure the anatomic (i.e., geometric) area of the valve orifice for grading severity of aortic stenosis according to the American College of Cardiology guidelines.

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. CMR is also a helpful modality to quantity valve regurgitation.

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. In recent years CTA/CCTA has become the method of choice for preoperative planning of transcatheter aortic valve replacement.

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. 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.

Echocardiography, MRI

The primary noninvasive imaging technique for the diagnosis of arrhythmias is echocardiography. However, CMR is commonly used to obtain additional diagnostic information. 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 (e.g., ARVC, Chagas disease). In CAD, infarct size is the strongest predictor of VT inducibility.

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.

Variant 5: Dyspnea Due to Suspected Pericardial Disease. Ischemia Excluded

Although pericardial effusion, calcification, 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.

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.

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.

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.

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.

Abbreviations

- CT, computed tomography
- CTA, computed tomography angiography
- IV, intravenous
- MPI, myocardial perfusion imaging
- MRI, magnetic resonance imaging
- PET, positron emission tomography
- Rb, rubidium
- SPECT, single photon emission computed tomography
- Tc-99m, technetium-99 metastable
- US, ultrasound

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

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
☢☢☢☢☢	30-100 mSv	10-30 mSv

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

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Dyspnea of suspected cardiac origin

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Cardiology

Emergency Medicine

Family Practice

Internal Medicine

Nuclear Medicine

Radiology

Intended Users

Advanced Practice Nurses

Health Plans

Hospitals

Managed Care Organizations

Physician Assistants

Physicians

Students

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of imaging procedures for patients with dyspnea of suspected cardiac origin

Target Population

Patients with dyspnea of suspected cardiac origin

Interventions and Practices Considered

1. X-ray, chest
2. Ultrasound (US)
    - Transthoracic echocardiography (TTE), resting
    - TTE, stress
    - Transesophageal echocardiography (TEE)
3. Technetium-99 metastable (Tc-99m) single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI), rest and stress
4. Rubidium (Rb)-82 positron emission tomography (PET), heart, stress
5. Magnetic resonance imaging (MRI), heart
    - Function and morphology without and with intravenous (IV) contrast
    - Function and morphology without IV contrast
    - With function and vasodilator stress perfusion, without and with IV contrast
    - With function and inotropic stress, without and with IV contrast
    - With function and inotropic stress, without IV contrast
6. Computed tomography (CT)
    - Heart function and morphology with IV contrast
    - Chest without IV contrast
    - Chest with IV contrast
    - Chest without and with IV contrast
    - Coronary calcium
7. Computed tomography angiography (CTA)
    - Coronary arteries with IV contrast
    - Chest with IV contrast
8. Coronary arteriography with ventriculography

Major Outcomes Considered

- Utility of imaging procedures in evaluating patients with dyspnea of suspected cardiac origin
- Sensitivity, specificity, and accuracy of imaging procedures in evaluating patients with dyspnea of suspected cardiac origin

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Summary

Of the 109 citations in the original bibliography, 6 were retained in the final document.

A literature search was conducted in July 2014, September 2016, and October 2016 to identify additional evidence published since the *ACR Appropriateness Criteria® Dyspnea–Suspected Cardiac Origin* topic was finalized. Using the search strategies described in the literature search companion (see the "Availability of Companion Documents" field), 38,963 articles were found. Fifty articles were added to the bibliography. The remaining articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, or the results were unclear or biased.

The author added 27 citations from bibliographies, Web sites, or books that were not found in the literature searches.

Two citations are supporting documents that were added by staff.

See also the American College of Radiology (ACR) Appropriateness Criteria® literature search process document (see the "Availability of Companion Documents" field) for further information.

Number of Source Documents

Of the 109 citations in the original bibliography, 6 were retained in the final document. The literature search conducted in July 2014, September 2016, and October 2016 identified 50 articles that were added to the bibliography. The author added 27 citations from bibliographies, Web sites, or books that were not found in the literature searches. Two citations are supporting documents that were added by staff.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Definitions of Study Quality Categories

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 - The study has important study design limitations.

Category 4 - The study or source is not useful as primary evidence. The article may not be a clinical study, the study design is invalid, or conclusions are based on expert consensus.

> 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);
>
> *Or*
>
> The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
>
> *Or*
>
> The study is an expert opinion or consensus document.

Category M - Meta-analysis studies are not rated for study quality using the study element method because the method is designed to evaluate individual studies only. An "M" for the study quality will indicate that the study quality has not been evaluated for the meta-analysis study.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author assesses the literature then drafts or revises the narrative summarizing the evidence found in the literature. American College of Radiology (ACR) staff drafts an evidence table based on the analysis of the selected literature. These tables rate the study quality for each article included in the narrative.

The expert panel reviews the narrative, evidence table and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the variant table(s). Each individual panel member assigns a rating based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Rating Appropriateness

The American College of Radiology (ACR) Appropriateness Criteria (AC) methodology is based on the RAND Appropriateness Method. The appropriateness ratings for each of the procedures or treatments included in the AC topics are determined using a modified Delphi method. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. The expert panel members review the evidence presented and assess the risks or harms of doing the procedure balanced with the benefits of performing the procedure. The direct or indirect costs of a procedure are not considered as a risk or harm when determining appropriateness. When the evidence for a specific topic and variant is uncertain or incomplete, expert opinion may supplement the available evidence or may be the sole source for assessing the appropriateness.

The appropriateness is represented on an ordinal scale that uses integers from 1 to 9 grouped into three categories: 1, 2, or 3 are in the category "usually not appropriate" where the harms of doing the procedure outweigh the benefits; and 7, 8, or 9 are in the category "usually appropriate" where the benefits of doing a procedure outweigh the harms or risks. The middle category, designated "may be appropriate," is represented by 4, 5, or 6 on the scale. The middle category is when the risks and benefits are equivocal or unclear, the dispersion of the individual ratings from the group median rating is too large (i.e., disagreement), the evidence is contradictory or unclear, or there are special circumstances or subpopulations which could influence the risks or benefits that are embedded in the variant.

The ratings assigned by each panel member are presented in a table displaying the frequency distribution of the ratings without identifying which members provided any particular rating. To determine the panel's recommendation, the rating category that contains the median group rating without disagreement is selected. This may be determined after either the first or second rating round. If there is disagreement after the second rating round, the recommendation is "May be appropriate."

This modified Delphi method enables each panelist to articulate his or her individual interpretations of the evidence or expert opinion without excessive influence from fellow panelists in a simple, standardized, and economical process. For additional information on the ratings process see the Rating Round Information document.

Additional methodology documents, including a more detailed explanation of the complete topic development process and all ACR AC topics can be found on the ACR Web site (see also the "Availability of Companion Documents" field).

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current medical evidence literature and the application of the RAND/UCLA appropriateness method and expert panel consensus.

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.

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

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

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. Therefore, advanced diagnostic imaging plays an important role in evaluating dyspnea.

Potential Harms

Computed tomography angiography's (CTA) relatively low specificity in high-risk patients is due to impaired vessel visualization in the setting of heavy calcification, smaller vessels, and the presence of stents. 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.

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. Additional information regarding radiation dose assessment for imaging examinations can be found in the American College of Radiology (ACR) Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

- The American College of Radiology (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 exams 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 U.S. Food and Drug Administration (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.
- ACR seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply society endorsement of the final document.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Living with Illness

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Vogel-Claussen J, Elshafee AS, Kirsch J, Brown RK, Hurwitz LM, Javidan-Nejad C, Julsrud PR, Kramer CM, Krishnamurthy R, Laroia AT, Leipsic JA, Panchal KK, Shah AB, White RD, Woodard PK, Abbara S, Expert Panel on Cardiac Imaging. ACR Appropriateness CriteriaÂ® dyspneaâ€“suspected cardiac origin. Reston (VA): American College of Radiology (ACR); 2016. 15 p. [85 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

2016

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Cardiac Imaging

Composition of Group That Authored the Guideline

Panel Members: Jens Vogel-Claussen, MD (*Principal Author*); Amany S. M. Elshafee, BCh, MB (*Research Author*); Jacobo Kirsch, MD; Richard K. J. Brown, MD; Lynne M. Hurwitz, MD; Cylen Javidan-Nejad, MD; Paul R. Julsrud, MD; Christopher M. Kramer, MD; Rajesh Krishnamurthy, MD; Archana T. Laroia, MD; Jonathon A. Leipsic, MD; Kalpesh K. Panchal, MD; Amar B. Shah, MD; Richard D. White, MD; Pamela K. Woodard, MD (*Specialty Chair*); Suhny Abbara, MD (*Panel Chair*)

Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Abbara S, Ghoshhajra B, White RD, Woodard PK, Atalay MK, Haramati LB, Hendel RC, Khan AR, Martin ET III, Rozenshtein A, Steiner RM, Expert Panel on Cardiac Imaging. ACR Appropriateness Criteria® dyspnea -- suspected cardiac origin. [online publication]. Reston (VA): American College of Radiology (ACR); 2010. 8 p. [109 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Available from the American College of Radiology (ACR) Web site .

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2015 Oct. 3 p. Available from the American

College of Radiology (ACR) Web site .
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 2015 Feb. 1 p. Available from the ACR Web site .
- ACR Appropriateness Criteria®. Evidence table development. Reston (VA): American College of Radiology; 2015 Nov. 5 p. Available from the ACR Web site .
- ACR Appropriateness Criteria®. Topic development process. Reston (VA): American College of Radiology; 2015 Nov. 2 p. Available from the ACR Web site .
- ACR Appropriateness Criteria®. Rating round information. Reston (VA): American College of Radiology; 2015 Apr. 5 p. Available from the ACR Web site .
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2016. 4 p. Available from the ACR Web site .
- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 2016. 128 p. Available from the ACR Web site .
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 2016 May. 2 p. Available from the ACR Web site
- ACR Appropriateness Criteria® dyspnea—suspected cardiac origin. Evidence table. Reston (VA): American College of Radiology; 2016. 45 p. Available from the ACR Web site .
- ACR Appropriateness Criteria® dyspnea—suspected cardiac origin. Literature search. Reston (VA): American College of Radiology; 2016. 2 p. Available from the ACR Web site .

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI on February 20, 2001. The information was verified by the guideline developer on March 14, 2001. This summary was updated by ECRI on August 11, 2006. This summary was updated by ECRI Institute on November 9, 2010. This summary was updated by ECRI Institute on January 13, 2011 following the U.S. Food and Drug Administration (FDA) advisory on gadolinium-based contrast agents. This summary was updated by ECRI Institute on March 17, 2017.

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