

## American College of Radiology ACR Appropriateness Criteria®

**Clinical Condition:** Congestive Heart Failure

**Variant 1:** New CHF, suspected based on symptoms and physical examination.

Radiologic Procedure	Rating	Comments	<a href="#"><u>RRL*</u></a>
X-ray chest	9		Min
CT chest	2	CHF is readily diagnosed on CT obtained for other indications.	Med
MRI chest	2		None
<b><u>Rating Scale:</u></b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 2:** Previous CHF, currently stable.

Radiologic Procedure	Rating	Comments	<a href="#"><u>RRL*</u></a>
X-ray chest	4		Min
CT chest	2	CHF is readily diagnosed on CT obtained for other indications.	Med
MRI chest	2		None
<b><u>Rating Scale:</u></b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 3:** Previous CHF, new-onset signs and symptoms.

Radiologic Procedure	Rating	Comments	<a href="#"><u>RRL*</u></a>
X-ray chest	9		Min
CT chest	2	CHF is readily diagnosed on CT obtained for other indications.	Med
MRI chest	2		None
<b><u>Rating Scale:</u></b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

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## CONGESTIVE HEART FAILURE

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### **Summary of Literature Review**

A variety of definitions exist as to what constitutes congestive heart failure (CHF). An accepted physiologic definition is the failure of the heart to pump sufficient blood to supply the needs of the metabolizing tissues. Either systolic or diastolic dysfunction can lead to CHF. It is most commonly due to ischemic heart disease. Other causes include valvular heart disease, cardiomyopathies, hypertension, and left-to-right shunts. Clinically, heart failure is recognized by the occurrence of signs and symptoms in combination with objective evidence of cardiac dysfunction. Signs and symptoms of heart failure include dyspnea on exertion or orthopnea, elevation of the jugular venous pressure, and pitting edema of the ankles. A third heart sound is often heard, but this finding is subject to substantial interobserver variability. Objective methods of evaluating cardiac function include chest radiography, nuclear cardiology, echocardiography, cardiac catheterization, computed tomography (CT), magnetic resonance imaging (MRI), electrocardiography, and exercise testing. This document will deal predominately with the usefulness of the chest radiograph for evaluating patients with known or suspected CHF. It is important to note that patients with diseases other than CHF may have one or several of its signs and symptoms.

### **Chest Radiography**

The chest radiograph is a useful technique to screen patients who exhibit the signs and symptoms of CHF. Several typical findings of CHF occur in patients who undergo radiography in an erect position. At an early stage, the normally gravity- dependent blood flow may become equalized, with upper and lower lung vessels of similar caliber. Later, upward diversion of blood flow

may be present such that the upper lobe vessels are larger than those in the lower lungs.

If pulmonary wedge pressure is higher, signs of interstitial pulmonary edema may be seen. These include thickened interlobular septa, perihilar and perivascular haziness, peribronchial cuffing and increased artery-bronchus (A-B) ratio.

Several studies have assessed the relationship between findings of pulmonary venous hypertension and measures of left ventricular function. Madsen et al [1] assessed the value of chest radiography to predict abnormal left ventricular function following acute myocardial infarction. The sensitivity of radiographic pulmonary venous congestion for depressed ejection fraction was 52%; specificity was 74%. Herman et al [2] evaluated 104 patients with varying degrees of left ventricular dysfunction. They reported that while most patients with elevated left ventricular end diastolic pressure had radiographic evidence of CHF, 38% did not. Baumstark et al [3], Costanzo et al [4], and Balbarini et al [5] have all reported a significant but imperfect correlation between radiographic findings of pulmonary venous hypertension and left ventricular dysfunction.

The cardiac silhouette is variably enlarged in CHF. The size of the heart has only a weak, clinically insignificant correlation with severity of CHF as measured by ejection fraction. Patients with an initial myocardial infarction who have severe cardiac dysfunction may have a nearly normal cardiac size because the heart may not dilate acutely. Dash et al [6] investigated 82 patients with CHF and found that the cardiothoracic ratio correlated best ( $r=0.70$ ) with the degree of elevation of capillary wedge pressure. In the study of Madsen et al [1], enlargement of cardiothoracic ratio (threshold=0.5) had a sensitivity of 47% for detecting an abnormal ejection fraction ( $\geq 0.51$ ). Philbin et al [7] assessed the utility of cardiothoracic ratio to estimate ejection fraction in 7,476 patients with left-sided heart failure and found only a limited correlation ( $r=0.18$ ).

An enlarged vascular pedicle is also often present in CHF. The vascular pedicle is defined as the sum of the distance of the right mediastinum at the level of the azygos arch to the midline and base of left subclavian artery to midline. This method of evaluating fluid status has been advocated by Milne et al [8] and Pistolessi et al [9]. It does thus reflect fluid status in both the arterial and venous system. However, variability in mediastinal widths between patients mitigates some advantages of this technique. In practice, the use of the vascular pedicle is best applied to assessment of volume status of an individual patient, provided changes in patient positioning, depth of inspiration, and tube position are taken into account.

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Pleural effusions are common in patients with CHF. Other radiographic findings that may aid in the diagnosis of CHF are a relative increase in pulmonary artery–bronchus ratio in the upper as compared with lower lung zones [10] and thickening of the posterior wall of the bronchus intermedius on the lateral radiograph.

In patients who are unable to cooperate for an erect posteroanterior and lateral radiograph, particularly those in the intensive care unit (ICU), portable radiography may be necessary [11]. Portable radiography is most often obtained with the patient in a semi-erect or supine position, which alters the appearance of radiographic findings of CHF. In a supine position, equalization of vasculature or flow inversion is physiologically normal. Thus, recognition of CHF depends to a greater extent on the presence of pulmonary edema, which occurs only in more severe cases. In the ICU, airspace edema caused by CHF is often difficult to distinguish from noncardiogenic edema and diffuse pulmonary infection.

Pleural effusions are also more difficult to recognize in the recumbent patient. Free pleural effusions layer in the posterior pleural cavity, creating a homogeneous opacity that may show a gradient of opacity from a caudal to cephalic direction, depending on the degree of patient recumbency. Bronchovascular markings are often visible through the hazy opacity. The presence of effusion can be confirmed by obtaining a lateral decubitus view.

The chest radiograph may occasionally show an atypical pattern in CHF. The best-characterized situation is in patients who develop acute mitral regurgitation, in which a strikingly asymmetric edema pattern occurs with predominant opacity in the right upper lobe [12]. This pattern is caused by the flow vector in mitral regurgitation, which is usually directed toward the right superior pulmonary vein. In patients who have chronic lung disease due to parenchymal fibrosis or emphysema, the appearance of CHF can be atypical. With emphysema, the chest radiograph may show an accentuation of preexisting interstitial lines rather than airspace edema because of alveolar destruction in emphysematous areas.

The chest radiograph is also useful for diagnosing diseases other than CHF in patients with dyspnea. The radiographic distinction of CHF from increased permeability edema, of which the adult respiratory distress syndrome is the prototype, may be difficult. Findings that favor CHF are an enlarged cardiac silhouette, Kerley lines, and pleural effusions [13]. Lobar pneumonia and abscess, pulmonary infarction, lung masses or nodules, and focal pleural disease are usually readily distinguishable from CHF.

### **Computed Tomography**

The role of CT scanning in patients is increasing due to the development of multidetector CT with better spatial

and temporal resolution and ECG gating [14]. These advances permit assessment of left ventricular function, including stroke volume and ejection fraction. Short and long axis imaging obtained throughout the cardiac cycle allows determination of wall motion abnormalities, which may be an ischemic cause for the heart failure [15]. Moreover, stenotic coronary artery lesions can be delineated using coronary computed tomography angiography (CTA) [16]. Disadvantages include the increased radiation dose associated with retrospective ECG-gating and nephrotoxicity due to intravenous contrast administration. Despite much early enthusiasm, there are as yet few studies documenting the value of cardiac CTA in assessing CHF. Thus, the role of cardiac CT as compared to nuclear cardiology is in evolution.

A second clinical scenario is CT scanning that is obtained for other indications that may show evidence of CHF, and thus recognition of findings in this entity is important. In CHF, animal studies have shown an increase in arterial and venous size and increased parenchymal opacification [17]. In patients, gravity-dependent flow inversion causes enlargement of nondependent vessels (anterior vessels in supine patients). Interstitial edema produces thickening of interlobular septa and the peribronchovascular and subpleural interstitia. In patients with airspace edema, ground glass opacity is evident on standard and high-resolution CT [18]. Pleural and pericardial effusions are more apparent and are easier to quantify on CT than on chest radiography.

### **Magnetic Resonance Imaging**

MRI provides a large quantity of morphologic and physiologic information in the evaluation of the heart [19–21]. Wall thickness and cavity size are easily measured. Cine MRI permits assessment of cardiac function, increased ejection fraction, and wall motion abnormalities. Recent work highlights the value of MRI perfusion viability imaging. In particular, recent investigation suggests that ischemic and nonischemic causes of cardiomyopathy can be distinguished by MRI, allowing appropriate selection of patients who may benefit from coronary revascularization [22]. Despite its considerable promise, MRI has yet to be widely adopted for this role in clinical practice.

### **Summary**

The various studies on the utility of chest radiography for CHF draw conclusions that are inconsistent and even contradictory. Nevertheless, the preponderance of data show that most patients with CHF have radiographic abnormalities that may suggest the diagnosis. Thus use of chest radiography as part of the initial assessment of patients with suspected CHF seems appropriate. Similarly, in patients with known CHF whose clinical picture deteriorates from baseline, the data suggest that chest radiography is beneficial. Both CT and MRI may

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ultimately prove valuable to evaluate CHF, but should be regarded as technologies in evolution accompanying more established methods to evaluate cardiac status.

### 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

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