

## Review Article

# Comparison of echocardiography and chest X-ray for initial diagnosis of heart failure: bibliographic review

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## ABSTRACT

Heart failure is a common pathology that continues to be one of the leading causes of cardiovascular death worldwide. Timely and accurate detection is essential to provide adequate treatment and improve the patient's clinical evolution. This review seeks to analyze the initial diagnostic potential of heart failure between transthoracic echocardiography versus chest X-ray, two tools commonly used in medical practice. For this purpose, studies published between 2000 and 2024 were reviewed, taking sensitivity, specificity, strengths and weaknesses of each diagnostic study as main indicators. The results indicate that transthoracic echocardiography offers a sensitivity between 80-95% and a specificity between 85-98%, whereas chest X-ray presents lower sensitivity data with 59-79% and a specificity close to 96%. Although transthoracic echocardiography proves to be more accurate for confirming the diagnosis of heart failure, chest X-ray retains its utility as an initial evaluation method due to its accessibility, speed, and low cost.

**Keywords:** Heart failure, Transthoracic echocardiography, Chest X-ray, Diagnosis, Sensitivity, Specificity

## INTRODUCTION

Heart failure (HF) is part of a highly complex clinical syndrome that derives from any structural or functional cardiac condition that limits ventricular filling or blood ejection.<sup>1</sup> With an estimated prevalence of 2% in the adult population, which rises markedly in individuals over 70 years of age to 10%, heart failure represents a predominant cause of hospitalization and cardiovascular mortality globally.<sup>2</sup>

The diagnosis of heart failure is complicated; clinical symptoms and signs are not specific 1, 2, and the early stage of the disease can be particularly challenging. Pulmonary crackles, increased jugular venous pressure, and peripheral edema are common findings; symptoms are usually dyspnea or fatigue, but may present at rest with paroxysmal nocturnal dyspnea or even diurnal dyspnea and orthopnea.<sup>3</sup>

There are various tools for diagnosing heart failure, including laboratory tests, electrocardiogram, chest X-ray, and echocardiography along with ejection fraction assessment. Of these, the two imaging studies most commonly used in patients with suspected heart failure are chest X-ray (CXR) and transthoracic echocardiography (TTE).<sup>4</sup>

In many clinical scenarios, chest X-ray is often the initial test, because it is a widely available, low-cost study and is useful for detecting indirect findings such as cardiomegaly, signs of pulmonary congestion, or even pleural effusion in advanced stages. Despite this, this technique has important limitations; its sensitivity is low in early stages of the disease and may not show alterations in patients with compensated heart failure.<sup>5,6</sup>

On the other hand, transthoracic echocardiography is considered a more accurate tool for directly assessing the

structural and functional aspects of the heart. This is because it allows observation of both systolic and diastolic function of the left ventricle, valve status, and intracardiac pressures. Furthermore, its utility is not limited only to diagnosis; it also facilitates identification of the underlying cause that led the patient to heart failure, which is extremely important as it improves and specifically guides individualized treatment for each patient.<sup>7</sup>

Although echocardiographic methods are superior to CXR, there is ongoing discussion about how to best utilize each testing modality in the initial evaluation of patients suspected of having heart failure.<sup>8</sup> The choice of which test is performed first is affected by many considerations, including availability, cost, clinical urgency, and level of operator expertise.<sup>9</sup>

The purpose of this review is to compile current evidence on the relative effectiveness of both diagnostic tests, not only in terms of diagnostic performance, but also with respect to practical aspects such as accessibility, cost-effectiveness, and clinical relevance in different healthcare settings.<sup>10</sup>

The purpose of this review is to perform a comparative evaluation of existing scientific literature to assess the diagnostic accuracy of transthoracic echocardiography compared to chest X-ray for the initial diagnosis of heart failure. We will evaluate the sensitivity, specificity, capabilities and limitations, and clinical applicability of these techniques considering current evidence.

## METHODS

### *Study design*

A descriptive review of scientific sources was carried out, based on methodological guidelines used for systematic bibliographic reviews.

### *Search strategy*

The bibliographic search was conducted in four electronic databases: PubMed/MEDLINE, EMBASE, Cochrane Library, and Scopus, covering the period from January 2000 to December 2024.

Search Terms: MeSH terms and keywords in English and Spanish were used, combined with Boolean operators: ("heart failure" OR "cardiac failure" OR "congestive heart failure"), AND ("transthoracic echocardiography" OR "echocardiogram" OR "cardiac ultrasound"), OR ("chest X-ray" OR "chest radiography" OR "thoracic radiography"), AND ("diagnosis" OR "diagnostic accuracy" OR "sensitivity" OR "specificity").

### *Inclusion criteria*

Original studies (observational studies, clinical trials, cohort studies), systematic reviews and meta-analyses,

studies evaluating the diagnostic performance of TTE and/or CXR in HF, research with data on sensitivity and/or specificity, adult population ( $\geq 18$  years), articles published in English or Spanish, full text available.

### *Exclusion criteria*

Pediatric studies ( $< 18$  years), isolated case reports and case series  $< 10$  patients, letters to the editor, editorials, and brief communications, studies without sufficient data on diagnostic performance, duplicate articles, studies with inadequate methodology or incomplete data.

### *Study selection*

Selection was performed in two phases: (1) evaluation of titles and abstracts by two independent reviewers, and (2) full-text review of potentially eligible articles. Discrepancies were resolved by consensus.

### *Data extraction*

Information was extracted on: study characteristics (author, year, design, sample size), study population, diagnostic methods employed, diagnostic performance parameters (sensitivity, specificity, predictive values), and methodological limitations.

### *Quality assessment*

The assessment of methodological quality of the studies was performed based on recognized criteria for diagnostic test studies, including design, representativeness of the study population, reference standard definition, and strategies to minimize bias.

## RESULTS

### *Diagnostic performance of chest X-ray*

Chest X-ray is the most investigated initial diagnostic tool in heart failure (HF). In this regard, its frequency increases with age: it should be noted that chest X-ray has been found to be correctly interpreted in the diagnosis of HF in only 79% of cases, with a sensitivity of 59% and a specificity of 96%. This high specificity indicates that if the radiograph shows positive findings of HF, it is very likely that the patient has this disease.

Common radiological signs in HF are cardiomegaly (CTR $>0.5$ ), pulmonary vascular redistribution, Kerley B lines, pleural effusion, and alveolar pulmonary edema. CTR is a valuable and useful index in chest X-ray interpretation, especially for middle-aged men with ischemic heart disease and high mortality.

However, radiography has very low sensitivity. It has been demonstrated that electrocardiographic and radiographic features are inadequate for reliable prediction of heart failure in a community and there is justification for all

patients suspected of having heart failure to undergo echocardiography.<sup>11,12</sup>

**Diagnostic accuracy of transthoracic echocardiography**

Transthoracic echocardiography is currently the modality of choice for assessing cardiac structure and function. Doppler echocardiography is of recognized utility in the evaluation of diastolic function and the diagnosis of diastolic heart failure, which involves 30-40% of patients presenting with clinical heart failure.<sup>13</sup>

TTE has several advantages over radiography, as it provides immediate information on left ventricular performance (ejection fractions, ventricular volumes, diastolic function, and filling pressures). It can also assess

valvular function, ventricular wall thickness, and structural abnormalities.<sup>14</sup>

Radiography is not as diagnostic as echocardiography but is widely available. Nevertheless, TTE remains diagnostically superior, as there are several published studies showing sensitivity greater than 80% and specificity greater than 90% in identifying left ventricular dysfunction.<sup>15</sup>

Table 1 comprehensively summarizes the comparison between both diagnostic techniques, including their performance parameters, advantages, disadvantages, and specific clinical applications according to the reviewed evidence.

**Table 1: Comparison between transthoracic echocardiography and chest X-ray for the diagnosis of heart failure.**

Characteristic	Chest X-ray	Transthoracic echocardiography
<b>Sensitivity</b>	59-79%	80-95%
<b>Specificity</b>	96%	85-98%
<b>Diagnostic accuracy</b>	79% <sup>2</sup>	>90% <sup>15</sup>
<b>Advantages</b>	Wide availability Low cost Rapid results Useful in emergencies High specificity (96%) Detection of pulmonary alterations Does not require specialized operator	Direct evaluation of cardiac function Information on ejection fraction Evaluation of valvular function Identification of underlying cause Measurement of intracardiac pressures Guide for individualized treatment Superior sensitivity (80-95%)
<b>Disadvantages</b>	Low sensitivity (59-79%) Limited in compensated HF Indirect information Does not evaluate specific function Limited in early stages Does not identify underlying cause	Higher cost Requires expert operator Lower immediate availability Affected by acoustic window Prolonged study time Operator-dependent
<b>Main indication</b>	Initial evaluation and screening	Definitive diagnosis
<b>Ideal context</b>	Low pre-test probability of HF	High clinical suspicion of HF
<b>Diagnostic role</b>	Initial screening test	Gold standard

**DISCUSSION**

**Clinical interpretation of diagnostic performance**

The results indicate that transthoracic echocardiography demonstrates superior diagnostic accuracy compared to chest X-ray. However, radiography has very low sensitivity. It has been demonstrated that electrocardiographic and radiographic features are inadequate for reliable prediction of heart failure in a community and there is justification for all patients suspected of having heart failure to undergo echocardiography.

**Use of artificial intelligence and other new technologies**

The advancement of new techniques has expanded the diagnostic versatility of both procedures. A deep learning

model has been developed to detect heart failure on chest X-rays with 82% accuracy, 75% sensitivity, and 94.4% specificity. These developments indicate that AI has the potential to revolutionize diagnostic accuracy with radiography.

**Clinical and practical considerations**

The decision between performing a chest X-ray or transthoracic echocardiography takes into consideration multiple factors, both clinical and logistical. On one hand, radiography stands out for its wide availability, low cost, and its utility in identifying pulmonary alterations secondary to heart failure. For these reasons, it is usually especially useful in emergency contexts, where immediate patient assessment is required.<sup>16</sup>

On the other hand, although TTE represents a more expensive technique and requires greater operator expertise, its diagnostic capability is superior. This study allows detailed evaluation of cardiac function and is valuable when seeking the underlying cause of heart failure and defining the most appropriate treatment.<sup>17</sup>

### **Limitations and future perspectives**

In this review, both radiography and echocardiography present their own limitations. In initial phases of heart failure or when compensated, the radiographic image may not show diagnostically useful findings. Unlike this, TTE can be affected by having a poor acoustic window in certain patients, which reduces the quality of the obtained image. These limitations reinforce the idea that clinical criteria must go hand in hand with appropriate diagnostic tools according to each patient's context.

### **Evidence-based recommendations**

The comparative evidence reviewed here indicates not an "either-or" relationship, but rather a complementary relationship between the two modalities. Radiography can be used as a cost-effective option for initial screening, as it is more widely available, especially if TTE is not immediately available.

However, TTE should be considered the gold standard for the diagnosis of heart failure and its proper management. In patients with high clinical suspicion of heart failure, TTE is suggested as the first-line investigation, using chest X-ray only when rapid initial assessment is needed or not feasible.

In patients with low pre-test probability of heart failure, radiography can serve as a reasonable screening test, but a normal result does not rule out heart failure.

### **CONCLUSION**

Transthoracic echocardiography has been established as the best diagnostic tool in the diagnosis of heart failure, with clearer sensitivity and specificity compared to chest X-ray, providing immediate and direct visualization of ventricular function and volumes along with cardiac structure. However, chest X-ray continues to play a key clinical role as the initial method of choice, especially in those situations where patient evaluation needs to be rapid and easily accessible, given its high specificity, to confirm what clinical suspicion predominantly indicates, although its sensitivity is limited, so it will only be used as a complementary diagnostic test. There is ample evidence for a diagnostic strategy in which radiography is the primary screening test in patients with low prior clinical probability of heart failure, while echocardiography is proposed as the confirmatory test for high clinical suspicion. The choice of method between the two should be based on factors including availability, cost-effectiveness, and distinct clinical characteristics, with

radiography being quite convenient for emergency services and echocardiography for both definitive diagnosis and therapeutic direction. Future directions could be the increasing implementation of artificial intelligence in radiographic interpretation, which offers a new opportunity for image interpretation and improved ability to define using deep learning algorithms that could potentially increase diagnostic performance, particularly in resource-limited settings and negative echocardiography.

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