

The Role of Conventional Chest X-Rays in Monitoring the Therapeutic Response in Patients with Congestive Heart Failure with Cardiomegaly and Pleural Effusion: A Literature Review

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Article Info

Article History:

Received July 21, 2026

Revised August 31, 2026

Accepted: September 27, 2026

Keywords:

Conventional Chest X-Ray,
Congestive Heart Failure,
Cardiomegaly, Pleural
Effusion, Therapy Monitoring,
Literature Review.

Abstract

Congestive heart failure is a progressive clinical syndrome with a global prevalence of 64.3 million cases. Cardiomegaly and pleural effusion are the main radiological manifestations requiring close monitoring during hospitalization. Conventional chest X-ray is an accessible, low-cost modality that can be performed serially to assess therapy response. The objective of the research to systematically review scientific evidence regarding the role of conventional chest X-ray in monitoring therapy response in Congestive heart failure patients with cardiomegaly and pleural effusion through a literature review approach. This study used a systematic literature review design. Literature searches were conducted in PubMed, Google Scholar, Cochrane Library, and Science Direct databases using keywords: conventional chest X-ray, congestive heart failure, cardiomegaly, pleural effusion, and therapy monitoring. Inclusion criteria included articles published from 2018-2024 with RCT, cohort, cross-sectional, systematic review, and meta-analysis designs. Literature selection used the PRISMA protocol. A total of 30 articles meeting the criteria were analyzed narratively and synthetically. Results showed that literature review showed that the Cardiothoracic Ratio (CTR) and pleural effusion grading on conventional chest X-ray are valid and reliable radiological parameters for monitoring CHF therapy response. CTR change ≥ 0.02 significantly correlates with hemodynamic and clinical improvement. Serial chest X-rays had sensitivity of 78-85% and specificity of 80-88% in detecting changes in congestion status. Pleural effusion grading significantly correlated with echocardiographic findings ($r=0.71$). Conventional chest X-ray is proven to play an important role in monitoring therapy response in CHF patients with cardiomegaly and pleural effusion. Systematic use of serial chest X-rays is recommended as part of the standard monitoring protocol for hospitalized Congestive heart failure patients.

Introduction

Congestive heart failure (CHF) is a complex and progressive clinical syndrome characterized by the heart's inability to maintain sufficient cardiac output to meet the metabolic demands of the body. It represents an advanced manifestation of various cardiovascular disorders and remains a major contributor to morbidity, mortality, repeated hospitalization, and reduced quality of life worldwide. The global burden of heart failure continues to increase as a consequence of population aging, improved survival from acute cardiovascular disease, and the persistent prevalence of major cardiovascular risk factors, including hypertension, diabetes mellitus, obesity, and coronary heart disease (Savarese et al., 2022; Shahim et al., 2023; Khan et al., 2024). Recent epidemiological evidence estimates that more than 64 million people worldwide are living with heart failure, highlighting the substantial public health implications of this condition (Savarese et al., 2023). The progressive nature of CHF also means that patients

frequently experience episodes of acute decompensation characterized by pulmonary and systemic congestion, requiring timely diagnosis, treatment, and objective monitoring of therapeutic response.

In Indonesia, heart failure constitutes an important component of the cardiovascular disease burden and is frequently encountered among hospitalized patients. Basic Health Research (Riskesdas) data demonstrated an increase in the prevalence of heart disease from 0.5% in 2013 to 1.5% in 2018, indicating a substantial and increasing cardiovascular health burden. This condition is particularly relevant in South Sulawesi, including Makassar, where cardiovascular disease represents an important clinical and public health concern (Ministry of Health of the Republic of Indonesia, 2022). The increasing burden of heart failure emphasizes the need for diagnostic and monitoring strategies that are not only clinically informative but also feasible in routine hospital settings. In this context, imaging examinations that can be repeatedly performed during hospitalization may provide valuable objective information regarding changes in cardiac size and pulmonary congestion following treatment.

Cardiomegaly and pleural effusion are among the important radiological manifestations associated with CHF. Cardiomegaly is commonly identified on a posteroanterior (PA) chest radiograph using the cardiothoracic ratio (CTR), with a CTR greater than 0.5 generally considered indicative of an enlarged cardiac silhouette. Cardiac enlargement may reflect chronic hemodynamic overload, ventricular remodeling, or chamber dilatation associated with the underlying cardiac disease. Meanwhile, pleural effusion develops when elevated pulmonary and systemic venous pressures promote movement of fluid into the pleural space. The presence and extent of pleural effusion may therefore provide indirect information regarding the patient's congestive state. Both cardiomegaly and pleural effusion are clinically relevant because their radiological evolution may accompany changes in the patient's volume status and response to decongestive treatment (Ponikowski et al., 2021).

Conventional chest X-ray (CXR) remains one of the most widely available imaging modalities for evaluating patients with suspected or established heart failure. Its clinical value is supported by several practical advantages. CXR is relatively inexpensive, widely accessible, rapidly performed, and can be obtained at the bedside in hospitalized patients who may be unable to undergo more complex imaging examinations. Furthermore, a single chest radiograph can provide simultaneous information regarding cardiac size, pulmonary vascular congestion, interstitial or alveolar edema, and pleural effusion. These characteristics make conventional radiography particularly relevant in acute and inpatient settings where serial assessment may be required. Current heart failure guidelines recognize chest radiography as an important component of the initial evaluation of patients with suspected or confirmed heart failure, although it should be interpreted together with clinical assessment and other diagnostic investigations (McDonagh et al., 2021).

The potential role of CXR extends beyond initial diagnosis to the monitoring of changes during treatment. In patients receiving diuretic and other heart failure therapies, reductions in fluid overload may result in gradual improvement in pulmonary congestion, reduction or resolution of pleural effusion, and changes in cardiac silhouette. Serial assessment of CTR may therefore provide an objective radiological indicator of changes occurring during treatment. Similarly, evaluating the degree of pleural effusion on sequential radiographs may help clinicians document the resolution of congestion over time. The manuscript's reviewed evidence indicates that changes in CTR and pleural effusion grading have been associated with hemodynamic and clinical improvement, suggesting that these radiological parameters may complement clinical indicators in assessing therapeutic response.

Nevertheless, the interpretation of serial chest radiographs requires careful consideration of technical and clinical limitations. The measurement of CTR can be affected by radiographic projection, particularly when an anteroposterior (AP) examination is performed in hospitalized patients, because cardiac magnification may result in an overestimation of cardiac size. Similarly, small pleural effusions may not be readily detected by conventional radiography, while radiological improvement may occur more slowly than clinical improvement. CXR also cannot directly assess ventricular systolic or diastolic function and therefore cannot replace echocardiography. Consequently, radiological findings should not be interpreted in isolation but should be integrated with symptoms, physical examination, laboratory parameters, echocardiography, and other relevant clinical information.

Although numerous studies have investigated the diagnostic and prognostic value of chest radiography in heart failure, the available evidence remains distributed across different study designs, populations, radiological parameters, and clinical outcomes. In particular, there is a need for a focused synthesis addressing how serial conventional chest radiographs can be used to monitor therapeutic response in CHF patients presenting with cardiomegaly and pleural effusion (Palazzuoli et al., 2020; Grigore et al., 2025). A comprehensive synthesis is important because the clinical usefulness of CXR depends not merely on its ability to identify abnormalities at baseline but also on whether changes in those abnormalities correspond meaningfully with improvements in congestion, functional status, and other clinical outcomes.

Therefore, this literature review was conducted to systematically and comprehensively examine the available scientific evidence regarding the role of conventional chest X-ray in monitoring therapeutic response among patients with congestive heart failure accompanied by cardiomegaly and pleural effusion. Specifically, the review focuses on the usefulness of serial CTR measurement and pleural effusion assessment, their relationship with clinical and hemodynamic parameters, and the limitations that should be considered when applying conventional chest radiography in clinical practice. The findings are expected to provide a stronger evidence base for the appropriate use of serial chest radiography as part of an integrated approach to monitoring patients with CHF during hospitalization and treatment.

Method

Research Design and Type

This study employed a systematic literature review (SLR) design. A systematic literature review is a research method that applies a systematic, transparent, and reproducible process to identify, assess, and synthesize scientific evidence relevant to a predefined research question. This design was selected because the present study aimed to comprehensively examine the available scientific evidence regarding the role of conventional chest radiography in monitoring therapeutic response among patients with congestive heart failure (CHF), particularly those presenting with cardiomegaly and pleural effusion. Unlike primary clinical research, this approach enables the synthesis of findings from previously published studies without requiring direct data collection from patients.

The systematic review focused on evidence concerning the use of conventional chest X-ray as a monitoring modality during CHF treatment. Attention was given to radiological parameters that can be evaluated serially, including the cardiothoracic ratio (CTR) and the presence and degree of pleural effusion. The review also considered evidence regarding the relationship between radiological changes and clinical or hemodynamic indicators of therapeutic response. The methodological framework was therefore designed to identify relevant studies, evaluate

their methodological quality, and synthesize their findings according to predefined thematic categories.

Literature Search Strategy

A systematic literature search was conducted using five electronic databases: PubMed/MEDLINE, Google Scholar, Cochrane Library, ScienceDirect, and Garuda/SINTA Portal. PubMed/MEDLINE was selected as the primary source for international biomedical literature, while Google Scholar was used to obtain broader academic coverage. The Cochrane Library was included because of its relevance to systematic reviews, meta-analyses, and evidence-based clinical research. ScienceDirect was used to identify relevant scientific publications indexed by Elsevier, while Garuda/SINTA Portal was included to capture relevant Indonesian-language literature and research conducted within the Indonesian context.

The search strategy employed keywords related to the principal concepts of the review, namely conventional chest radiography, congestive heart failure, cardiomegaly, cardiothoracic ratio, pleural effusion, and therapeutic monitoring. Both Indonesian and English terminology were considered to broaden the identification of potentially relevant literature. The keywords were combined using Boolean operators AND and OR to optimize the search strategy and identify studies containing combinations of the principal concepts. The literature search was limited to publications issued between 2018 and 2024.

The principal search terms included “*conventional chest X-ray*,” “*chest X-ray*,” “*chest radiograph*,” “*congestive heart failure*,” “*heart failure*,” “*cardiomegaly*,” “*cardiothoracic ratio*,” “*CTR*,” “*pleural effusion*,” “*therapy monitoring*,” and “*treatment response*.” These terms were selected to capture studies examining either the general role of chest radiography in CHF or specific radiological indicators relevant to monitoring treatment response.

Inclusion and Exclusion Criteria

The selection of literature was conducted according to predefined inclusion and exclusion criteria. Establishing these criteria before the selection process was intended to ensure that the studies included in the review were relevant to the research question and sufficiently comparable in terms of population, topic, publication period, and study design. Studies were considered eligible when they were published in Indonesian or English, published between 2018 and 2024, investigated adult patients with CHF, addressed chest X-ray or related radiological parameters, and provided full-text access.

The eligible study designs included randomized controlled trials (RCTs), cohort studies, cross-sectional studies, systematic reviews, and meta-analyses. Studies that did not directly address the review topic, including studies involving pediatric populations or populations without CHF, were excluded. Single case reports, editorials, and opinion pieces were also excluded because they were not considered appropriate for the intended synthesis of systematic evidence. The complete inclusion and exclusion criteria are presented in Table 1.

Table 1. Literature Inclusion and Exclusion Criteria

Criteria	Inclusions	Exclusions
Language	Indonesian / English	—
Year of Publication	2018–2024	Before 2018
Study Design	RCT, Cohort, Cross-sectional, Systematic Review, Meta-analysis	Single case reports, editorials, opinion pieces

Main Topic	Chest X-ray, CHF, CTR, pleural effusion, therapy monitoring	Not relevant to the topic
Subjects	Adult CHF patients (≥ 18 years)	Pediatric or non-CHF patients
Availability	Full text available	Abstract only

Literature Selection and Quality Assessment

The literature selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. The selection process consisted of four sequential stages: identification, screening, eligibility assessment, and inclusion. During the identification stage, potentially relevant articles were retrieved from all selected databases, and duplicate records were removed using reference management procedures. The remaining records were subsequently subjected to title and abstract screening according to the predefined inclusion and exclusion criteria.

During the eligibility stage, studies that passed the initial screening were assessed through full-text examination to determine whether they satisfied all eligibility requirements. Articles that met the predetermined criteria were subsequently included in the final review and analyzed in greater depth. This process was intended to minimize the inclusion of irrelevant studies and provide a transparent basis for reporting the number of articles identified, screened, assessed, and finally included in the synthesis.

In addition to eligibility assessment, the methodological quality of the included studies was evaluated using assessment instruments appropriate to each study design. For randomized controlled trials, the Cochrane Risk of Bias Tool (RoB 2.0) was used to assess potential sources of bias. Observational studies, including cohort studies, were assessed using the Newcastle-Ottawa Scale (NOS). For systematic reviews and meta-analyses, methodological quality was assessed using AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews). The use of design-specific assessment instruments was intended to provide a structured evaluation of the methodological strengths and limitations of the evidence included in the review.

Data Extraction and Synthesis

Data from each eligible article were systematically extracted using a standardized data extraction form. The extracted information included the author and year of publication, country and study setting, study design, sample size, population characteristics, intervention or exposure, primary outcome, and the authors' conclusions and recommendations. This structured extraction process was used to facilitate comparison across studies and ensure that relevant information concerning the role of conventional chest radiography in CHF monitoring was consistently captured.

Because the included studies were expected to demonstrate heterogeneity in terms of population characteristics, study designs, interventions or exposures, and outcome measures, the findings were synthesized using a narrative synthesis approach rather than a quantitative meta-analysis. The narrative synthesis enabled findings from different types of studies to be organized and interpreted according to their relevance to the research question. Four major thematic categories were established for the synthesis: (1) the role of cardiothoracic ratio (CTR) in monitoring CHF, (2) the role of pleural effusion grading in monitoring therapeutic response, (3) the correlation between chest radiographic findings and clinical parameters, and (4) the limitations of conventional chest radiography.

Through this thematic approach, the review sought to identify consistent findings across the literature while also recognizing differences in study design and clinical context. Emphasis was

placed on evidence describing changes in CTR and pleural effusion following treatment and on studies examining the relationship between radiological changes and clinical or hemodynamic improvement.

Results And Discussion

Literature Selection Results

A systematic search was conducted across five electronic databases to identify scientific publications relevant to the role of conventional chest X-ray in monitoring therapeutic response in patients with congestive heart failure (CHF), cardiomegaly, and pleural effusion. The initial search identified 847 articles. After duplicate records were removed, 612 unique articles remained for the subsequent screening process. Title and abstract screening resulted in 89 articles that met the initial eligibility criteria. These articles subsequently underwent full-text assessment, of which 45 articles passed the full-text review. Following the final assessment against the predefined inclusion and exclusion criteria, 30 articles were included in the final analysis. The complete literature selection process followed the PRISMA framework and is summarized in Table 2.

Table 2. Literature Selection Results (PRISMA Flow)

Selection Stage	Number of Articles
Total articles found (all databases)	847
After duplication removal	612
Passed title & abstract screening	89
Passed full-text reading	45
Final articles included	30

Characteristics of Included Studies

The 30 studies included in the final synthesis comprised a range of research designs. These consisted of 8 systematic reviews/meta-analyses, 9 prospective cohort studies, 7 cross-sectional studies, 4 randomized clinical trials (RCTs), and 2 multicenter registry studies. Most of the included studies were conducted in developed countries, particularly in Europe and the United States, while a smaller proportion originated from Asian countries. The diversity of study designs provides evidence from different methodological perspectives concerning the diagnostic and monitoring value of conventional chest radiography in patients with heart failure.

The included literature generally focused on cardiothoracic ratio (CTR), cardiomegaly, pulmonary congestion, pleural effusion, and the relationship between radiological findings and clinical or echocardiographic parameters. The principal characteristics and findings of the selected studies are presented in Table 3.

Table 3. Characteristics and Synthesis of Included Studies

Author (Year)	Title / Topic	Study Design	Key Results	Relevance
Platz et al. (2022)	Detection and prognostic value of pulmonary congestion	Prospective Cohort	Valid serial chest X-rays detect changes in CTR ≥ 0.02 correlating with	Supporting the validity of CTR as a radiological biomarker

			hemodynamic improvement	
Gluecker et al. (2022)	Radiological features of pulmonary edema in CHF	Systematic Review	CTR >0.5 is sensitive for cardiomegaly; interstitial edema appears as Kerley B lines	Technical basis for interpreting chest radiographs in CHF
Wrightson & Maskell (2021)	Pleural effusion: a guide to investigation and management	Narrative Review	Pleural effusion grading correlates with the degree of congestion	Justification of the effusion grading system used in the review
McDonagh et al. (2021)	ESC Guidelines for Heart Failure 2021	Guideline/Consensus	Chest X-rays are routinely recommended for patients with suspected heart failure; CTR >0.5 indicates cardiomegaly	Clinical basis for standards of care for CHF
Ponikowski et al. (2021)	Prevention of Heart Failure Disease and Death	Epidemiological Review	High HF mortality; radiological monitoring plays an important role	Global epidemiological context of CHF
Oudghiri et al. (2023)	Radiological Assessment of Heart Failure Pleural Effusion vs. Echocardiography	Cross-sectional	Significant correlation between chest radiograph effusion grading and echocardiographic findings (r=0.71)	Validation of chest radiography compared with echocardiographic assessment
Ferrante et al. (2022)	Chest X-ray in the ED for suspected heart failure	Retrospective	Chest radiographs have a sensitivity of 78% and specificity of 83% for detecting acute HF	Supporting the utility of chest X-ray in acute monitoring
Savarese et al. (2023)	Global burden of heart failure: a comprehensive review	Meta-analysis / Review	Prevalence of HF is 64.3 million; effective monitoring is important for	Justifying the importance of monitoring CHF therapy

			reducing rehospitalization	
Lam et al. (2023)	Regional differences in Asia: the ASIAN-HF registry	Multicenter Registry	Asian HF patients are younger, with an average age of 60 years; HFrEF accounts for approximately 60–70%	Regional epidemiological data for Asia, including Indonesia

The Role of Cardiothoracic Ratio in Monitoring Heart Failure Therapy

The synthesis of 18 articles addressing cardiothoracic ratio (CTR) demonstrated relatively consistent evidence supporting the use of serial CTR measurements on conventional chest radiographs as a parameter for monitoring therapeutic response in patients with heart failure. The findings indicate that changes in cardiac silhouette size may provide useful information concerning changes in hemodynamic status and congestion during treatment.

Platz et al. (2022), in a prospective cohort study, reported that a change in CTR of ≥ 0.02 was significantly associated with improvements in hemodynamic parameters, including a reduction in mean pulmonary artery pressure and an increase in cardiac index. These findings suggest that serial assessment of CTR may provide a practical radiological indicator of changes in cardiovascular and volume status during the treatment of heart failure.

Similarly, Gluecker et al. (2022) reported that a CTR greater than 0.5 on a posteroanterior projection demonstrated a sensitivity of 85% and a specificity of 83% for detecting cardiomegaly. Changes in CTR following adequate diuretic treatment may reflect reductions in cardiac chamber dilatation and fluid congestion. Taken together, these findings support CTR as a practical radiological parameter that can complement clinical assessment when monitoring patients with CHF.

The reviewed evidence further indicated that the magnitude of CTR change may be associated with the achievement of clinical euvolemia. In patients receiving intravenous diuretic therapy, chest radiographs obtained on the third and seventh days of treatment demonstrated a mean reduction in CTR of approximately 0.03–0.05 among patients who achieved clinical euvolemia. In addition, changes in CTR were significantly correlated with reductions in serum BNP and NT-proBNP levels, with reported correlation coefficients ranging from $r=0.62$ to 0.78 in several studies. These findings suggest that serial radiographic assessment may provide complementary information to biochemical indicators of congestion and treatment response.

The Role of Pleural Effusion Grading in Monitoring CHF Therapy

The analysis of 15 articles examining pleural effusion demonstrated that radiographic assessment and grading of pleural effusion can provide useful information for monitoring congestion and therapeutic response in patients with CHF. Wrightson and Maskell (2021) described a grading classification ranging from Grade 0 to Grade 3, based on the extent of pleural effusion identified on conventional chest radiographs. This classification provides a structured approach for documenting changes in pleural fluid burden during treatment.

Oudghiri et al. (2023) reported a significant correlation between chest radiograph-based pleural effusion grading and echocardiographic findings, with a Spearman correlation coefficient of $r=0.71$ ($p<0.001$). This finding supports the clinical relevance of radiographic assessment for

estimating pleural fluid burden. Furthermore, a reduction in pleural effusion grade of at least one grade following therapy was associated with improvement in NYHA functional class and a shorter hospital stay. These findings indicate that changes in pleural effusion on serial chest radiographs may provide an objective marker of treatment response.

In patients with acute heart failure, bilateral pleural effusion, with the right side generally more prominent than the left, was reported in approximately 60–75% of cases. This distribution is consistent with the pathophysiological mechanism of increased pulmonary venous pressure and subsequent fluid accumulation. Importantly, the resolution of pleural effusion on chest radiographs may take approximately 5–7 days following adequate diuretic treatment, whereas clinical symptoms may improve within approximately 2–3 days. This difference emphasizes the potential value of serial imaging in objectively documenting the radiological resolution of congestion, particularly when clinical improvement occurs before complete radiographic normalization.

Correlation of Chest X-ray Findings with Clinical Parameters

A total of 20 articles examined the relationship between chest radiographic findings and clinical parameters in patients with CHF. Overall, the findings indicate that radiological changes may correspond with several measures of clinical status, although the relationship should be interpreted within the broader clinical context.

Several cohort studies reported a significant association between CTR and NYHA functional class, with Spearman correlation coefficients ranging from $r=0.58$ to 0.72 . Higher CTR values were generally observed among patients with more severe NYHA functional classes. This relationship suggests that greater cardiac enlargement on chest radiography may occur in conjunction with greater functional limitation in patients with heart failure.

Changes in pleural effusion were also associated with clinical improvement. Improvement in the radiographic appearance of pleural effusion was associated with increased oxygen saturation (SpO_2) and reduced respiratory rate within 48–72 hours following diuretic therapy. These findings indicate that radiological resolution of pulmonary and pleural congestion may occur alongside improvements in respiratory status.

Ferrante et al. (2022) reported that chest radiography performed in the emergency department demonstrated a sensitivity of 78% and specificity of 83% for detecting acute heart failure. This finding supports the utility of conventional chest radiography during the acute phase, particularly as part of a broader diagnostic and monitoring strategy.

Importantly, the combined assessment of CTR and pleural effusion appeared to provide greater predictive information than either parameter individually. The combined change in CTR and pleural effusion grade demonstrated an AUC of 0.82 for predicting 30-day rehospitalization. In addition, normalization of chest radiographic findings, defined as $CTR \leq 0.5$ with no evidence of pleural effusion, was associated with a lower 90-day mortality compared with patients discharged with persistent radiographic abnormalities. These findings suggest that the simultaneous assessment of cardiac enlargement and pleural fluid may provide a more comprehensive representation of radiological congestion than either parameter alone.

Limitations of Conventional Chest X-ray

Despite the evidence supporting conventional chest radiography as a useful monitoring modality, several limitations should be considered when interpreting serial examinations in patients with CHF. One important limitation is interobserver variability. Several studies reported variability among observers when grading pleural effusion, with kappa values ranging

from 0.60 to 0.75. Such variability may influence the reproducibility of serial radiographic assessments and should be considered when interpreting relatively small changes between examinations.

Technical factors also affect the reliability of CTR measurements. In hospitalized patients, an anteroposterior (AP) projection is frequently used because patients may be unable to stand or undergo a standard PA examination. AP projection can produce greater magnification of the cardiac silhouette and consequently may lead to an overestimation of CTR compared with a standard PA projection. Therefore, changes in CTR should be interpreted cautiously, particularly when serial examinations are obtained using different projections.

Another limitation concerns the detection of small pleural effusions. Pleural effusions measuring less than approximately 200 mL may not be readily detected on PA chest radiographs, whereas lung ultrasound has greater sensitivity for detecting smaller volumes of pleural fluid. This limitation indicates that a negative or apparently improved chest radiograph does not necessarily exclude a small residual pleural effusion.

Conventional chest radiography also cannot directly assess cardiac systolic or diastolic function. Consequently, CXR cannot replace echocardiography when evaluation of ventricular function, cardiac structure, or hemodynamic characteristics is required. Its primary value lies in providing complementary information about cardiac silhouette, pulmonary congestion, and pleural fluid rather than directly measuring cardiac performance.

Radiation exposure is another consideration, particularly when repeated examinations are performed. Although the radiation dose associated with conventional chest radiography is relatively low, serial examinations should follow the ALARA (As Low as Reasonably Achievable) principle, particularly in younger patients. Finally, radiological improvement may lag clinical improvement. Patients may experience symptomatic and physiological improvement before complete resolution of radiographic abnormalities. Therefore, radiological findings should always be interpreted alongside clinical evaluation rather than being used as the sole determinant of therapeutic response.

Integrated Interpretation of the Findings

Overall, the findings of this literature review support conventional chest radiography as an important complementary modality for monitoring hospitalized patients with CHF. Its principal advantages include broad accessibility, relatively low cost, the ability to be performed serially, including at the bedside, and the capacity to simultaneously provide information concerning cardiac size, pulmonary congestion, and pleural effusion.

The evidence particularly supports the use of serial CTR measurement and pleural effusion assessment as radiological indicators that can complement clinical and laboratory monitoring. Changes in these parameters have been associated with hemodynamic improvement, changes in biomarkers such as BNP and NT-proBNP, improvement in NYHA functional status, respiratory improvement, and hospitalization outcomes. However, the limitations associated with technical factors, interobserver variability, limited sensitivity for small effusions, inability to directly assess cardiac function, radiation exposure, and radiological lag demonstrate that CXR should not be interpreted as an isolated assessment tool.

Accordingly, conventional chest radiography is most appropriately incorporated into a multimodal monitoring strategy that integrates radiological findings with clinical examination, laboratory parameters, and echocardiography when clinically indicated. Such an integrated

approach allows radiographic changes in cardiomegaly and pleural effusion to be interpreted in relation to the patient's overall therapeutic response and clinical condition.

Conclusion

Based on a systematic review of 30 studies that met the predefined inclusion criteria, conventional chest radiography has an important role in monitoring therapeutic response in patients with congestive heart failure, particularly through the assessment of the cardiothoracic ratio (CTR) and pleural effusion. Serial changes in CTR, particularly a reduction following therapy, are associated with improved hemodynamic status, decreased pulmonary congestion, and the achievement of clinical euvolemia. These findings indicate that CTR can serve as a practical and informative radiological parameter for evaluating treatment response in patients with congestive heart failure. In addition, conventional chest radiography provides useful information for monitoring pleural effusion through radiographic grading that reflects the degree of fluid congestion. A reduction in pleural effusion grade following therapy is associated with improvement in clinical symptoms, functional status, and hospital length of stay. Serial assessment of pleural effusion on chest radiographs may therefore provide an objective means of monitoring the resolution of congestion during treatment. Overall, radiological improvement, characterized by a reduction in CTR and resolution of pleural effusion, is associated with clinical improvement in patients with congestive heart failure, including better functional status, improved oxygen saturation, reduced respiratory rate, and lower risks of rehospitalization and mortality. However, radiological changes may occur more slowly than clinical improvement. Therefore, conventional chest radiography should not be interpreted as an isolated measure of therapeutic response but should be integrated with clinical assessment, laboratory parameters, echocardiographic findings, and other relevant investigations. This integrated approach can provide a more comprehensive assessment of treatment response and congestion status in patients with congestive heart failure.

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