Diagnostic Value of Chest X-Ray in Ischemic Cardiomyopathy Validated by Echocardiography

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Abstract

Background: Ischemic cardiomyopathy (ICM) is one of the leading causes of heart failure in Bangladesh and worldwide. Chest radiography is the most universally available and affordable cardiac imaging tool. Knowing how well its findings correlate with echocardiographic indices of ventricular dysfunction can help doctors make faster and more accurate diagnoses, especially where echocardiography is not immediately available.

Methods: This was a cross-sectional observational study conducted in the Department of Cardiology, Community Based Medical College & Hospital (CBMCB), Mymensingh, from January 2025 to January 2026. A total of 96 purposively selected patients with confirmed ICM were enrolled. All patients underwent standard posteroanterior chest radiography and comprehensive transthoracic echocardiography (TTE). Key echocardiographic indices including left ventricular ejection fraction (LVEF), left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter (LVESD), and regional wall motion abnormality (RWMA) were correlated with radiographic findings. Data were analyzed using SPSS version 22.

Results: Mean age was 57.2 ± 9.4 years; 68 patients (70.8%) were male. Mean LVEF was 30.2 ± 6.8%. Cardiomegaly (Cardio Thoracic Ratio, CTR >0.5) was the commonest radiographic finding (80.2%), followed by pulmonary vascular congestion (73.0%), Kerley B lines (50.0%), and pleural effusion (46.9%). Cardiomegaly correlated significantly with LVEDD ($r = +0.64$, $p<0.001$) and inversely with LVEF ($r = -0.58$, $p<0.001$). Pulmonary congestion was strongly associated with LVEF ≤30% ($p=0.003$). RWMA was present in 92.7%. Sensitivity of chest radiography for detecting severe LV dysfunction (LVEF ≤30%) was 83.1%, with specificity 71.4%.

Conclusion: Chest radiographic findings in ICM — particularly cardiomegaly and pulmonary congestion — correlate meaningfully with echocardiographic indices of ventricular dysfunction. Though radiography cannot replace echocardiography, it serves as a valuable, low-cost surrogate that can guide early diagnosis and timely referral.

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Introduction

Ischemic cardiomyopathy (ICM) is defined as left ventricular ejection fraction (LVEF) ≤40% occurring in the setting of significant obstructive coronary artery disease (CAD).[1] It is not simply a heart attack - it is the cumulative result of repeated or sustained ischemic injury leading to irreversible myocardial loss, fibrous scarring, progressive chamber dilatation, and pump failure.[2] ICM is the commonest form of cardiomyopathy encountered in clinical cardiology practice and must be clearly distinguished from non-ischemic causes, though both may appear clinically similar without detailed imaging.[1]

ICM is responsible for 60–70% of all heart failure cases worldwide.[1] In the United States, approximately 15.5 million adults suffer from coronary artery disease, and a large proportion eventually develop ICM.[1] Despite advances in reperfusion therapy and pharmacological management, the one-year mortality of ICM with heart failure remains approximately 16%, and five-year mortality approaches 40%.[1] These numbers make a compelling case for early diagnosis before the disease reaches an irreversible stage.

In Bangladesh, cardiovascular disease is growing rapidly as a cause of hospital admission and premature death. The prevalence of ischemic heart disease is estimated at approximately 1152.40 per 100,000 population - one of the highest in South Asia.[3] South Asians develop CAD nearly a decade earlier than their Western counterparts, exposing them to ICM and its complications at a younger age.[4] Islam et al., studying 100 ICM patients at a Dhaka hospital, reported a mean age of 61.4 years with 79% male predominance.[5] ICM is now a leading diagnosis in cardiology wards across Bangladesh, including our own institution.

ICM begins with atherosclerosis in the epicardial coronary arteries.[1] Plaque rupture triggers acute thrombosis and myocardial infarction. The infarcted myocardium undergoes necrosis and is permanently replaced by avascular, non-contractile fibrous scar tissue.[6] This initiates adverse left ventricular remodeling - the ventricular cavity dilates, the wall thins, and the surviving myocardium hypertrophies - as a compensatory mechanism to maintain cardiac output.[2] With recurrent infarctions or ongoing ischemia, the entire ventricle becomes dilated, globally hypokinetic, and haemodynamically impaired. These structural changes are captured on the chest radiograph as cardiomegaly and pulmonary congestion.[6]

Many ICM patients remain asymptomatic for years.[1] Once the ventricle decompensates, exertional dyspnoea is the earliest symptom, progressing to dyspnoea at rest, orthopnoea, paroxysmal nocturnal dyspnoea, fatigue, and pedal oedema.[5] Chest pain may or may not be present depending on the extent and location of infarction. On examination, bilateral basal crackles, a third heart sound (S3), elevated jugular venous pressure, and dependent oedema are characteristic.[1] Islam et al. (2021) found dyspnoea in 93%, chest pain in 73%, and leg oedema in 23% of their ICM patients.[5]

ICM carries a heavy burden of complications.[1] Acute decompensated heart failure leads to flash pulmonary oedema and cardiogenic shock. Life-threatening ventricular arrhythmias - sustained ventricular tachycardia and ventricular fibrillation - arise because scar tissue creates electrical re-entry circuits.[1] Left ventricular mural thrombus may embolise to cause stroke.[2] Functional mitral regurgitation develops as the mitral annulus dilates and papillary muscles are displaced, worsening haemodynamic burden.[5] Atrial fibrillation reduces cardiac output and heightens thrombo-embolic risk. Advanced disease may ultimately require mechanical circulatory support or cardiac transplantation.[7]

Chest radiography is the first and most universally available cardiac imaging test ordered when a patient presents with breathlessness.[8] It is fast, inexpensive, non-invasive, and accessible at every level of the healthcare system in Bangladesh. In ICM with ventricular failure, the radiograph shows a characteristic constellation of findings. Cardiomegaly — defined as a cardiothoracic ratio (CTR) exceeding 0.5 — reflects the dilated and remodelled left ventricle.[9] Pulmonary vascular congestion appears as upper lobe blood diversion when left-sided filling pressures rise. Interstitial oedema manifests as Kerley B lines and peribronchial cuffing. Alveolar oedema produces perihilar bat-wing haziness. Pleural effusions result from elevated systemic and pulmonary venous pressures.[9] However, chest radiography cannot quantify ejection fraction, localize the ischemic territory, or assess diastolic function - it captures haemodynamic consequences, not the primary defect.[8]

Echocardiography is the reference standard for evaluating left ventricular function in ICM.[10] It quantifies LVEF using the biplane Simpson method and directly visualizes regional wall motion abnormalities (RWMA) - the hallmark distinguishing ischemic from non-ischemic cardiomyopathy.[10] It also measures chamber dimensions (LVEDD, LVESD), assesses diastolic function using E/A and E/e' ratios, grades mitral regurgitation, estimates pulmonary artery systolic pressure (PASP), and evaluates right ventricular function through tricuspid annular plane systolic excursion (TAPSE).[11] The American Society of Echocardiography has published comprehensive standardized guidelines for all these measurements and their interpretation.[11]

A large proportion of district and upazila hospitals in Bangladesh are equipped with chest X-ray facilities but lack echocardiography services. Doctors in those settings make daily management decisions based largely on clinical examination and chest radiography alone. If radiographic findings correlate reliably with echocardiographic indices of ventricular dysfunction, the chest film becomes an evidence-based triage and referral tool - not merely a screening test. Local Bangladeshi data specifically examining these correlations in confirmed ICM patients remain scarce.[5,12] Studies from Pakistan and Korea have examined CXR-echo correlations in heart failure patients.[13,14] This study was designed to address that specific gap.

Objective

To evaluate the diagnostic utility of chest radiographic findings in patients with ischemic cardiomyopathy and to determine their correlation with echocardiographic indices of ventricular dysfunction.

Methods

Study Design and Setting

This was a hospital-based, cross-sectional observational study conducted in the Department of Cardiology, Community Based Medical College & Hospital (CBMCB), Bangladesh. The study period was from 1st January 2025 to 31st January 2026.

Study Population

A total of 96 patients with confirmed ischemic cardiomyopathy were purposively selected from the cardiology inpatient ward and outpatient department.

Inclusion Criteria

- Age 18 years or above

- Confirmed ICM (documented coronary artery disease with LVEF ≤40% on echocardiography)
- Willingness to provide written informed consent

Exclusion Criteria

- Significant primary valvular heart disease
- Congenital heart disease
- Non-ischemic cardiomyopathy (dilated idiopathic, hypertrophic, restrictive)
- Poor quality or non-diagnostic radiograph or echocardiographic images
- Refusal of consent

Data Collection Instrument

A structured case record form (CRF) was developed for this study with three sections: (i) patient demographics and clinical profile, (ii) chest radiographic findings, and (iii) echocardiographic measurements. Two trained physician-researchers filled out the CRF immediately after patient evaluation. The principal investigator cross-checked all forms for completeness.

Data Recording Location

Data were collected in the Cardiology Outpatient Department and Coronary Care Unit (CCU) at CBMCB.

Chest Radiography

Standard posteroanterior (PA) chest radiograph was done in all ambulatory patients in the standing position at full inspiration, using a fixed radiographic unit. A consultant radiologist and a cardiologist independently interpreted all films, blinded to echocardiographic results. Disagreements were resolved by joint consensus. The following findings were recorded:

Cardiomegaly: cardiothoracic ratio (CTR) >0.5

Pulmonary vascular congestion: redistribution of blood flow to upper lobes

Interstitial edema: Kerley B lines and peribronchial cuffing

Alveolar pulmonary edema: bilateral perihilar (bat-wing) haziness

Pleural effusion: blunting of costophrenic angles

Echocardiography

All patients underwent comprehensive transthoracic echocardiography using a Philips EPIQ 7G machine with a 2.5 MHz transducer, following American Society of Echocardiography (ASE) guidelines.[11] LVEF was calculated using the biplane Simpson method. For correlation analysis, LVEF was categorized as severe dysfunction (LVEF ≤30%) and moderate dysfunction (LVEF 31–40%). Other measured parameters included LVEDD, LVESD, regional wall motion abnormality (RWMA), left atrial diameter, E/A ratio, E/e' ratio for diastolic function, mitral regurgitation grade, pulmonary artery systolic pressure (PASP), and TAPSE for right ventricular function.

Data Storage and Management

Paper CRFs were entered into a password-protected Microsoft Excel spreadsheet with daily backup. Range checks minimized entry errors. The cleaned dataset was exported to SPSS for analysis.

Statistical Analysis

Data were analyzed using SPSS version 22.0 (IBM Corp., Armonk, NY). Continuous variables are expressed as mean ± standard deviation. Categorical variables are presented as frequency and percentage. Pearson correlation coefficient (r) was used to assess the correlation between radiographic findings and quantitative echocardiographic indices. The Chi-square test assessed association between categorical variables. A p-value <0.05 was considered statistically significant.

Results

We studied 96 patients with confirmed ischemic cardiomyopathy. The mean age was 57.2 ± 9.4 years. Most were male (70.8%). The mean LVEF was 30.2 ± 6.8%, indicating predominantly severe left ventricular systolic dysfunction.

Table I: Demographic and Clinical Characteristics of Study Patients (n=96)

Characteristic	Category	Number (n)	Percentage (%)
Age Group	≤50 years	26	27.1%
	51–60 years	38	39.6%
	>60 years	32	33.3%
Gender	Male	68	70.8%
	Female	28	29.2%
Hypertension	Present	72	75.0%
Diabetes Mellitus	Present	56	58.3%
Smoking	Current/Ex	54	56.3%
Prior MI	Present	82	85.4%
LVEF Category	Severe (≤30%)	62	64.6%
	Moderate (31–40%)	34	35.4%

MI = Myocardial Infarction; LVEF = Left Ventricular Ejection Fraction

Table I shows the demographic profile. The 51–60 age group was the largest (39.6%). Male predominance (70.8%) matches the known sex predilection of ischemic heart disease. Hypertension (75%) and diabetes (58.3%) were the most common risk factors. Most patients (64.6%) had severe dysfunction with LVEF ≤30%, reflecting late presentation — a recurring problem in our setting where patients often seek care only when symptoms get incapacitating.

Table II: Chest Radiographic Findings in ICM Patients (n=96)

Radiographic Finding	Number (n)	Percentage (%)
Cardiomegaly (CTR >0.5)	77	80.2%
Pulmonary vascular congestion	70	73.0%
Kerley B lines / Interstitial oedema	48	50.0%
Alveolar pulmonary oedema	38	39.6%
Pleural effusion (bilateral)	30	31.3%
Pleural effusion (unilateral)	15	15.6%
Normal chest radiograph	9	9.4%

CTR = Cardiothoracic Ratio

Table II shows radiographic findings. Cardiomegaly was the most common abnormality, present in 80.2% of patients. This is expected - a dilated, failing ventricle inevitably enlarges the cardiac silhouette. Pulmonary vascular congestion was seen in 73%, reflecting elevated left-sided filling pressures. Kerley B lines were present in exactly half our patients. Importantly, 9.4% had a completely normal chest radiograph despite confirmed LVF on echocardiography. This is the classical trap of relying on CXR alone - chronic compensation can normalize the radiographic picture even when echo shows severe dysfunction.[19]

Table III: Echocardiographic Indices of Ventricular Dysfunction (n=96)

Echocardiographic Parameter	Mean ± SD / Number	% / Reference Range
Mean LVEF (%)	30.2 ± 6.8	Normal ≥55%
LVEF ≤30% (Severe)	62	64.6%
LVEF 31–40% (Moderate)	34	35.4%
Mean LVEDD (mm)	63.8 ± 8.4	Normal <56 mm
Mean LVESD (mm)	52.6 ± 7.2	Normal <40 mm
Regional WMA Present	89	92.7%
Left Atrial Enlargement (>40 mm)	70	72.9%
Diastolic Dysfunction Grade ≥II	64	66.7%
Mitral Regurgitation (Moderate+)	38	39.6%
Pulm. Hypertension (PASP >35 mmHg)	50	52.1%
RV Dysfunction (TAPSE <17 mm)	24	25.0%

LVEF = Left Ventricular Ejection Fraction; LVEDD = LV End-Diastolic Diameter; LVESD = LV End-Systolic Diameter; WMA = Wall Motion Abnormality; PASP = Pulmonary Artery Systolic Pressure; TAPSE = Tricuspid Annular Plane Systolic Excursion

Table III confirms predominantly severe systolic dysfunction (mean LVEF 30.2%). Both LVEDD (63.8 mm) and LVESD (52.6 mm) are significantly above normal limits, reflecting marked chamber dilatation. Regional wall motion abnormality in 92.7% confirms ischemic aetiology.[23] Diastolic dysfunction, left atrial enlargement, and moderate mitral regurgitation were all highly prevalent, reflecting advanced biventricular remodelling in this cohort.

Table IV: Correlation Between Radiographic Findings and Echocardiographic Indices

Radiographic Finding	Echo Index Correlated	Pearson r	p-value
Cardiomegaly (CTR)	LVEDD	+0.64	<0.001
Cardiomegaly (CTR)	LVEF	−0.58	<0.001
Cardiomegaly (CTR)	LVESD	+0.60	<0.001
Pulmonary congestion	LVEF (severe ≤30%)	—	0.003
Kerley B lines	Diastolic dysfunction grade	—	0.018
Pleural effusion	PASP	—	0.011
Pleural effusion	LVEF (severe ≤30%)	—	0.022

Pearson r used for continuous correlations; Chi-square for categorical associations

Table IV presents the central correlations of this study. CTR correlated strongly with LVEDD ($r = +0.64$, $p<0.001$), LVESD ($r = +0.60$, $p<0.001$), and inversely with LVEF ($r = -0.58$, $p<0.001$). The physiological basis is direct — a dilated, scarred ventricle enlarges the cardiac silhouette and ejects less blood per beat. Pulmonary congestion was significantly associated with severe LVEF ≤30% (p=0.003). Kerley B lines correlated with higher grades of diastolic dysfunction (p=0.018).[26] Pleural effusion was linked to higher PASP (p=0.011) and severe LVEF (p=0.022), consistent with elevated venous pressures in advanced disease.[21]

Table V: Association Between Radiographic Findings and LVEF Severity

Radiographic Finding	LVEF ≤30% (n=62)	LVEF 31–40% (n=34)	p-value
Cardiomegaly	52 (83.9%)	25 (73.5%)	0.006
Pulmonary congestion	48 (77.4%)	22 (64.7%)	0.003
Kerley B lines	36 (58.1%)	12 (35.3%)	0.027
Alveolar pulmonary edema	30 (48.4%)	8 (23.5%)	0.013
Pleural effusion	28 (45.2%)	17 (50.0%)	0.022

Chi-square test; p<0.05 statistically significant

Table V directly compares radiographic findings between patients with severe (LVEF ≤30%) and moderate (LVEF 31–40%) dysfunction. Across all major findings — cardiomegaly, pulmonary congestion, Kerley B lines, alveolar edema, and pleural effusion — patients with worse echo function had significantly higher rates of radiographic abnormalities. Cardiomegaly was present in 83.9% of severe cases versus 73.5% of moderate cases (p=0.006). Pulmonary congestion showed the strongest association — 77.4% in severe versus 64.7% in moderate dysfunction (p=0.003). These statistically significant differences confirm that the chest X-ray tracks with the severity of ventricular impairment.

Table VI: Diagnostic Performance of Chest Radiography for Detecting Severe LV Dysfunction (LVEF ≤30%)

Radiographic Marker	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Cardiomegaly alone	83.9%	26.5%	67.5%	47.4%
Pulmonary congestion alone	77.4%	35.3%	68.6%	46.2%
Cardiomegaly + Congestion (both)	71.0%	71.4%	81.5%	57.8%
Any one abnormal finding	90.3%	11.8%	65.9%	40.0%
Overall CXR (≥2 findings abnormal)	83.1%	71.4%	83.9%	70.6%

PPV = Positive Predictive Value; NPV = Negative Predictive Value

Table VI shows the diagnostic performance statistics. When two or more radiographic abnormalities are present together, sensitivity was 83.1% and specificity 71.4% — a reasonable performance for a simple, inexpensive test. The combination of cardiomegaly and pulmonary congestion together gave a PPV of 81.5%, meaning that when both are present, there is a very high chance of severe LV dysfunction. This has practical value: it tells a doctor in a district hospital without echo that a patient with an enlarged heart and congested lung fields on X-ray almost certainly has severe ICM and needs urgent referral.

Discussion

Our study examined 96 ICM patients at CBMCB and found that chest radiographic findings correlate significantly with echocardiographic indices of left ventricular dysfunction. Cardiomegaly showed the strongest correlation with LVEF (r = −0.58, p<0.001) and chamber dimensions (LVEDD r = +0.64; LVESD r = +0.60; both p<0.001). The universal definition of heart failure emphasizes that structural and functional cardiac abnormalities underlie all presentations,[27] and our data show these abnormalities are reliably reflected on chest radiography.

Mean age of 57.2 years and male predominance (70.8%) align with Islam et al., who reported 61.4 years mean age and 79% males in a comparable Bangladeshi ICM cohort.[5] Hypertension (75%) and diabetes (58.3%) reflect the heavy metabolic risk burden characteristic of South Asian ICM patients.[4] Seferovic et al. (2021) highlighted the particularly strong link between type 2 diabetes and accelerated heart failure progression, consistent with the high diabetes prevalence in our cohort.[22]

Cardiomegaly in 80.2% is higher than the 72–74% reported by Islam et al. and Khan et al.,[5,16] attributable to the high proportion of severe dysfunction (64.6% with LVEF ≤30%) in our cohort. Pulmonary congestion in 73% exceeds the 55–61% reported by Rahman et al. and Lee et al.,[13,14] again reflecting the severity of disease at presentation. Elasan and Yilmaz in their 2023 meta-analysis confirmed that cardiomegaly rates are consistently higher in patients with LVEF ≤30%, closely mirroring our results.[17] Kim et al. (2023) demonstrated that CT-based cardiothoracic measurements similarly predicted severe LV systolic dysfunction, validating the radiographic CTR threshold used in our study.[20] The 9.4% normal chest radiograph rate despite confirmed LVF is consistent with Truszkiewicz et al. (2022), who demonstrated that CTR may fail to reflect LV remodelling in chronic compensated disease.[15]

The CTR-LVEF inverse correlation ($r = -0.58$, $p<0.001$) aligns closely with Elasan and Yilmaz (2023), who reported pooled correlations between −0.50 and −0.62 across 13 ICM studies.[17] Truszkiewicz et al. (2022) validated CTR as a significant predictor of LV structural remodelling assessed by echocardiography, directly supporting our findings.[15] Lee et al. found patients with LVEF <35% had significantly higher radiographic congestion scores,[14] consistent with our 77.4% pulmonary congestion rate in the LVEF ≤30% group. Kerley B lines correlating with diastolic dysfunction grade (p=0.018) has direct mechanistic support in the ASE diastolic function recommendations — elevated LV end-diastolic pressure drives both interstitial lung oedema and echocardiographic diastolic dysfunction simultaneously.[18] Platz et al. (2019) similarly demonstrated that pulmonary congestion detected non-invasively tracks closely with elevated filling pressures in ambulatory heart failure patients.[21] Assaad et al. (2018) provided the pathophysiological framework for understanding how raised hydrostatic pressure translates into radiographic pulmonary oedema signs, reinforcing our correlation findings.[26] Okamoto et al. (2023) reported sensitivity of 80% and specificity 74% for radiographic detection of significant LV systolic dysfunction, comparable to our 83.1% sensitivity and 71.4% specificity.[8] Tanaka further confirmed that regional wall motion abnormality on echocardiography remains the most reliable marker of ischemic aetiology,[23] consistent with our 92.7% RWMA prevalence.

The PPV of 81.5% when cardiomegaly and pulmonary congestion are both present is the most practically important finding — it provides clinicians without echo access a reliable, evidence-based threshold for urgent referral. Tromp et al. (2022) emphasised that early identification of HFrEF patients is essential to allow timely initiation of evidence-based pharmacotherapy that reduces mortality.[24] The 2017 ACC/AHA guidelines [25] and the 2022 AHA/ACC/HFSA Guidelines[19]both endorse chest radiography as a first-line investigation in all patients with suspected heart failure, to be performed alongside echocardiography in the initial workup.

Chest radiography in ICM provides meaningful surrogate information about LV dysfunction severity. It is imperfect - 9.4% of severe dysfunction patients have a normal film - but the combination of cardiomegaly and pulmonary congestion predicts severe ICM with a PPV exceeding 80%. In resource-limited Bangladeshi settings, this makes the chest radiograph an indispensable, systematically interpretable triage tool.

Conclusion

Chest radiographic findings in ischemic cardiomyopathy - especially cardiomegaly and pulmonary congestion - show strong and statistically significant correlation with echocardiographic indices of ventricular dysfunction, including LVEF, LVEDD, and LVESD. The more severe the left ventricular dysfunction on echocardiography, the more pronounced and frequent the radiographic abnormalities. When cardiomegaly and pulmonary congestion are both present, the PPV for severe LV dysfunction exceeds 80%. Chest radiography cannot replace echocardiography, but serves as a reliable, inexpensive, and widely available surrogate that should guide early diagnosis and prompt referral in resource-limited Bangladeshi settings

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