The Correlation between Chest X-ray and Cardiac Magnetic Resonance Imaging in the Assessment of Left Atrial Enlargement

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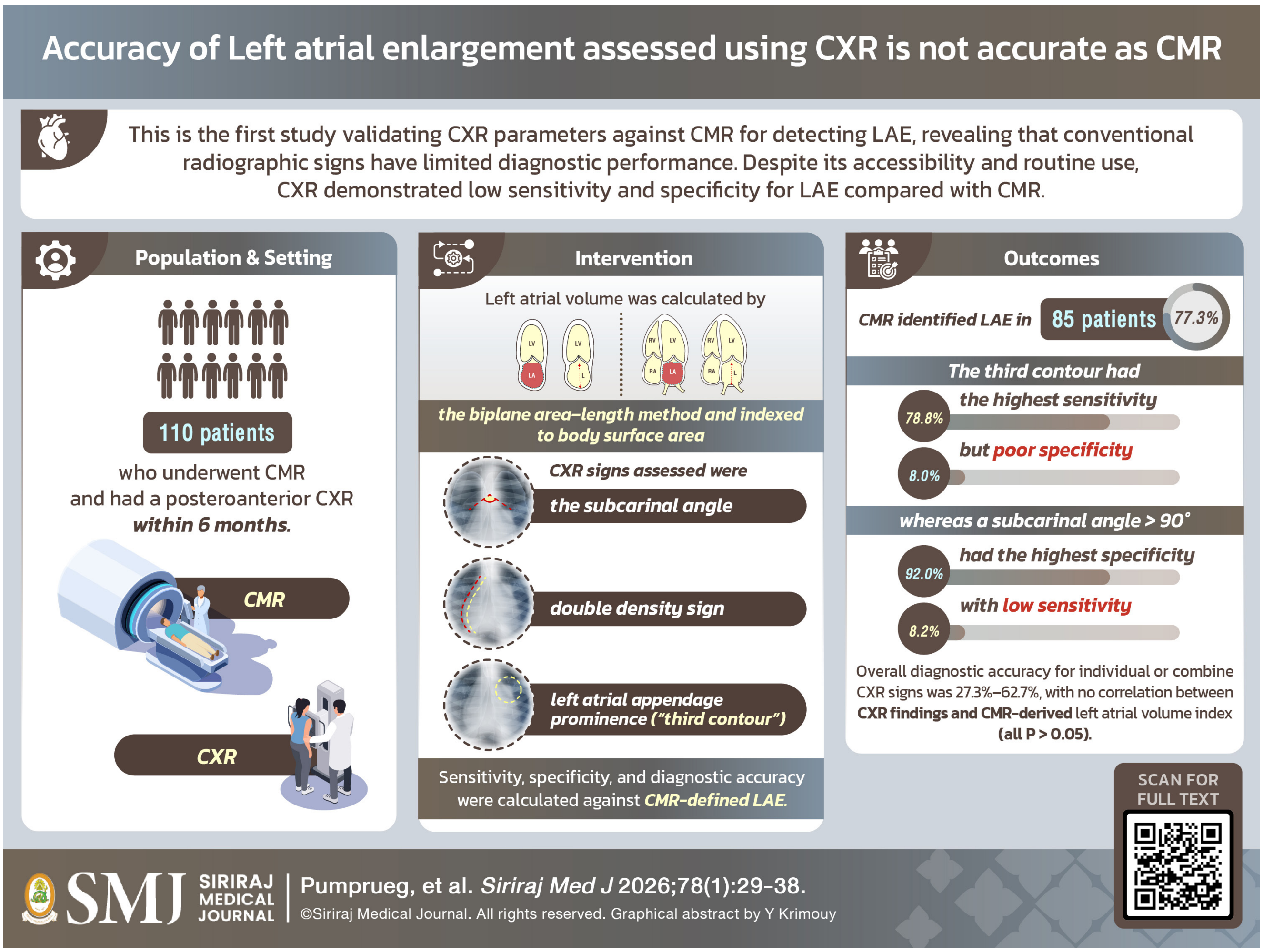

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ABSTRACT

Objective: Left atrial enlargement (LAE) is common in cardiovascular disease and is associated with heart failure, atrial fibrillation, and stroke. Chest X-ray (CXR) is widely available; however, its diagnostic value for LAE has not been validated against cardiac magnetic resonance imaging (CMR). We evaluated the correlation and diagnostic performance of conventional CXR signs for detecting LAE using CMR as the reference standard.

Materials and Methods: We retrospectively analyzed 110 patients who underwent CMR and had a posteroanterior CXR within 6 months. Left atrial volume was calculated by the biplane area–length method and indexed to body surface area. CXR signs assessed were the subcarinal angle, double density sign, and left atrial appendage prominence ("third contour"). Sensitivity, specificity, and diagnostic accuracy were calculated against CMR-defined LAE.

Results: CMR identified LAE in 85 patients (77.3%). The third contour had the highest sensitivity (78.8%) but poor specificity (8.0%), whereas a subcarinal angle > 90° had the highest specificity (92.0%) with low sensitivity (8.2%). Overall diagnostic accuracy for individual or combined CXR signs was 27.3%–62.7%, with no correlation between CXR findings and CMR-derived left atrial volume index (all $P > 0.05$).

Conclusions: To our knowledge, this is the first study validating CXR parameters against CMR for detecting LAE, revealing that conventional radiographic signs have limited diagnostic performance. Despite its accessibility and routine use, CXR demonstrated low sensitivity and specificity for LAE compared with CMR.

Keywords: Left atrial enlargement; cardiac magnetic resonance imaging; chest X-ray (Siriraj Med J 2026;78(1):29-38)

INTRODUCTION

Left atrial enlargement (LAE) is common across cardiovascular conditions, including heart failure, valvular heart disease, and atrial fibrillation.[1,2] It also occurs in disorders linked to cardiovascular pathology, such as hypertension, obesity, and obstructive sleep apnea.[3,4]

LAE can be assessed with chest X-ray (CXR), electrocardiogram (ECG), echocardiography, cardiac magnetic resonance (CMR), or cardiac computed tomography (CT). Despite limitations, CXR remains simple, accessible, and widely used.[5,6] Radiographic criteria include measuring the subcarinal angle, evaluating left atrial prominence along the left heart border ("third contour"), and identifying the double density sign. CMR provides highly precise chamber quantification, including the left atrium, right atrium, left ventricle, and right ventricle.[7-9]

LAE is strongly associated with increased risk of heart failure, stroke, and atrial fibrillation, as well as elevated cardiovascular mortality.[10-13] Consequently, accurate left atrial sizing is essential for risk stratification, outcome prediction, and disease monitoring.

Prior studies have compared LAE assessment by electrocardiogram with CMR[14,15], but none have directly compared CXR with CMR. Therefore, we investigated the diagnostic performance of conventional CXR signs for detecting LAE, using CMR as the reference standard.

MATERIALS AND METHODS

Study population

We consecutively enrolled 110 patients who underwent CMR at the Division of Cardiology, Department of Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand. Eligibility required a posteroanterior upright CXR of adequate quality performed within 6 months before or after the CMR examination. Patients with significant valvular heart disease, post-cardiothoracic surgery, or pulmonary conditions affecting lung volume (such as atelectasis or pleural effusion) were excluded. Baseline clinical characteristics and medical history were obtained from medical records. The study protocol was approved by the Siriraj Institutional Review Board.

CMR acquisition and measurements

Acquisition

CMR examinations were performed on a 1.5T Achieva XR scanner (Philips, Best, Netherlands). After localizer scouts, cine steady-state free precession balanced turbo field echo images were obtained in 2-, 3-, and 4-chamber and short-axis views. Imaging parameters were: repetition time/echo time/number of excitations, 3.7/1.8/1; slice thickness, 8 mm with no gap; flip angle, 60°; and 25 cardiac phases per cardiac cycle. Field of view was 350×320 mm for long-axis and 270×320 mm for short-axis views, with reconstructed voxel size 1.25×1.25×8 mm^3

Left atrial volume measurement and indexing

CMR images were analyzed offline using cardiovascular imaging software (Extended Brilliance Workspace; Philips Healthcare, Best, Netherlands). The left atrial volume was derived with the biplane area–length method at end-atrial diastole, including the left atrial appendage and excluding the 4 pulmonary veins. The left atrial area was manually contoured on mid-atrial slices in 2- and 4-chamber cine views. The atrioventricular junction was defined by a line connecting the mitral valve insertion points. The atrial long-axis length was measured as the perpendicular distance from the midpoint of the mitral annular plane to the superior left atrial border. Left atrial volume (LAV) was calculated by the biplane area–length formula:

$$LAV = (8 \times A_1 \times A_2) / (3\pi \times L).$$

A_1 and A_2 denote maximal planimetered left atrial areas from the vertical and horizontal long-axis views, and L denotes the long-axis length. The LAV index (LAVI) was obtained by normalizing LAV to body surface area.

Reproducibility and additional left ventricular metrics

To assess intra- and interobserver variability, the primary investigator repeated measurements after 1 week in 20 randomly selected patients; an independent investigator performed the same measurements. Left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), left ventricular ejection fraction (LVEF), and left ventricular mass index were measured according to current guidelines.

CXR acquisition and measurements

CXRs were performed using standard technique with posteroanterior projection. Patients with uninterpretable films owing to inappropriate exposure, severe kyphoscoliosis, severe pulmonary disease, or inadequate inspiration were excluded. Three left atrial enlargement signs were evaluated: left atrial appendage prominence ("third contour"), double density sign, and subcarinal angle. Third contour was defined as protrusion of the left heart border between the left pulmonary artery and the ventricular border, graded as 1+ (slight protrusion) or 2+ (obvious protrusion). The double density sign was a curvilinear line along the right heart border with a distance from the mid-inferior left bronchus to that border > 7 cm. The subcarinal angle was measured on a dedicated workstation.

Statistical analysis

Analyses were performed with PASW Statistics version 18 (SPSS Inc, Chicago, IL, USA). Categorical variables are presented as counts and percentages; continuous variables are expressed as mean (SD) for normally distributed data and median (IQR) for nonnormally distributed data. Normality was assessed with the Kolmogorov–Smirnov test. We calculated accuracy, sensitivity, specificity, positive and negative likelihood ratios, and positive and negative predictive values for each criterion and for all 3 combined, using CMR-derived LAVI as the reference. Group comparisons used the chi-square test or Fisher's exact test for categorical variables, and Student's *t* test or the Mann–Whitney *U* test for continuous variables, as appropriate. A P value < 0.05 was considered statistically significant.

RESULTS

Baseline characteristics

A total of 110 patients were included in the analysis. The mean age was 68.8 ± 10.1 years, and 40.0% were male. Mean body mass index and body surface area were 25.8 ± 4.8 kg/m^2 and 1.67 ± 0.20 m^2, respectively. Hypertension, dyslipidemia, diabetes mellitus, and coronary artery disease were present in 87.3%, 83.6%, 42.7%, and 36.4%, respectively. Current smoking was reported in 16.4% of participants. The mean systolic and diastolic blood pressures were 137.0 ± 21.3 mm Hg and 68.0 ± 11.3 mm Hg, respectively (Table 1).

CMR findings

CMR demonstrated a median LVEDV of 122.8 mL (IQR 101.8–154.4 mL) and a median LVESV of 36.8 mL (IQR 23.3–56.5 mL). The mean LVEF was 65.9% ± 16.6%, and the mean LAVI was 52.6 ± 17.8 mL/m^2 (Table 2). Using cutoffs of LAVI > 40 mL/m^2 for men and > 39 mL/m^2 for women, LAE was present in 85 patients (77.3%). Among CMR-derived volumetric parameters, LAVI correlated significantly with LVEDV but not with LVESV or LVEF.

CXR findings

On CXR, a third contour was presented in 81.8% of patients (score 1+ to 2+), whereas 18.2% had no visible contour (score 0). A prominent third contour (score 2+) was identified in 20.9% of patients, and a double density sign in 13.6% of patients. The mean subcarinal angle was 73.4 ± 11.7°, with 42.7% exceeding 75° and 8.2% exceeding 90°.

Using subcarinal angle thresholds of > 75° and > 90°, the presence of any radiographic criterion (third contour, double density sign, or widened subcarinal angle) was noted in 88.2% and 82.7% of patients, respectively. The combined presence of all 3 findings was detected in

TABLE 1. Baseline characteristics.

Variables	Values	LAVI > 40 mL/m² in men or >39 mL/m² in women (n = 85)	LAVI ≤ 40 mL/m² in men or ≤ 39 mL/m² in women (n = 25)	*p* - value
Age (years)	68.8 ± 10.1	70.0 ± 10.1	64.9 ± 9.4	0.028
Male gender	44 (40.0%)	35 (41.2%)	9 (36.0%)	0.642
Height (cm)	157.7 ± 8.6	156.8 ± 8.7	160.8± 7.8	0.042
Weight (kg)	64.2 ± 13.7	64.2 ± 12.9	64.1 ± 16.5	0.966
Body mass index (kg/m²)	25.8 ± 4.8	26.1 ± 4.6	24.7 ± 5.3	0.191
Body surface area (m²)	1.7 ± 0.2	1.7 ± 0.2	1.7 ± 0.2	0.720
Systolic BP (mmHg)	137.0 ± 21.3	140.0 ± 21.4	127.0 ± 17.9	0.007
Diastolic BP (mmHg)	68.0 ± 11.7	67.7 ± 11.5	69.3 ± 10.4	0.533
Hypertension	96 (87.3%)	78 (91.8%)	18 (72.0%)	0.016
Dyslipidemia	92 (83.6%)	77 (90.6%)	15 (60.0%)	0.001
Diabetes mellitus	47 (42.7%)	36 (42.4%)	11 (44.0%)	0.884
Coronary artery disease	40 (36.4%)	33 (38.8%)	7 (28.0%)	0.323
Smoking	18(16.4%)	13 (15.3%)	5 (20.0%)	0.552

Data are mean ± SD or n (%).
Abbreviations: LV = left ventricular; LAVI = left atrial volume index; cm = centimeter; kg = kilogram; BP = blood pressure; mL = milliliter; mL/m² = milliliter per square meter

TABLE 2. CMR-derived left ventricular and left atrial parameters.

Variables	Values	LAVI > 40 mL/m² in men or >39 mL/m² in women (n = 85)	LAVI ≤ 40 mL/m² in men or ≤ 39 mL/m² in women (n = 25)	*p* - value
LV end diastolic volume (ml)	122.8 (101.8 - 154.4)	135.0 (104.5-155.5)	106.7 (87.0-121.1)	0.001
LV end systolic volume (ml)	36.8 (23.3 - 56.5)	40.5 (25.5-59.7)	30.4 (18.7-43.5)	0.052
LV ejection fraction (%)	65.9 ± 16.6	65.3 ± 17.2	67.7 ± 14.3	0.525
LA volume index (ml/m²)	52.6 ± 17.8	58.8 ± 15.2	31.8 ± 6.3	-

Data are mean ± SD or median (percentile 25th – percentile 75th).
Abbreviations: LV = left ventricular; LA = left atrial; LAVI = left atrial volume index; mL = milliliter; mL/m² = milliliter per square meter

9.1% of patients for the > 75° threshold and in 3.6% for the stricter > 90° threshold (Table 3). None of the CXR parameters—including third contour, double density sign, or subcarinal angle thresholds—correlated significantly with CMR-defined LAE (all $P > 0.05$).

Diagnostic performance of CXR parameters

The diagnostic performance of CXR parameters for detecting LAE (LAVI > 40 mL/m² in men and > 39 mL/m² in women) is summarized in Table 4.

When evaluated individually, the presence of a

TABLE 3. Radiographic characteristics of chest X-ray findings.

Variables	Values	LAVI > 40 mL/m² in men or >39 mL/m² in women (n = 85)	LAVI ≤ 40 mL/m² in men or ≤ 39 mL/m² in women (n = 25)	*p* - value
3rd Contour				
0	20 (18.2%)	18 (21.2%)	2 (8.0%)	0.285
1	67 (60.9%)	49 (57.6%)	18 (72.0%)	
2	23 (20.9%)	18 (21.2%)	5 (20.0%)	
3rd Contour				
0	20 (18.2%)	18 (21.2%)	2 (8.0%)	0.236
1 - 2	90 (81.8%)	67 (78.8%)	23 (92.0%)	
3rd Contour				
0 - 1	87 (79.1%)	67 (78.8)	20 (80.0%)	0.899
2	23 (20.9%)	18 (21.2%)	5 (20.0%)	
Double density sign				
0	95 (86.4%)	75 (88.2%)	20 (80.0%)	0.325
1	15 (13.6%)	10 (11.8%)	5 (20.0%)	
Subcarinal angle	73.35 ± 11.67	73.41 ± 11.57	73.16 ± 12.27	0.925
≤ 75	63 (57.3%)	50 (58.8%)	13 (52.0%)	0.544
> 75	47 (42.7%)	35 (41.2%)	12 (48.0%)	
≤ 90	101 (91.8%)	78 (91.8%)	23 (92.0%)	1.00
> 90	9 (8.2%)	7 (8.2%)	2 (8.0%)	
Subcarinal angle >75 & Double density sign & 3rd Contour				
0	100 (90.9%)	78 (91.8%)	22 (88.0%)	0.692
1	10 (9.1%)	7 (8.2%)	3 (12.0%)	
Subcarinal angle >90 & Double density sign & 3rd Contour				
0	106 (96.4%)	82 (96.5%)	24 (96.0%)	1.00
1	4 (3.6%)	3 (3.5%)	1 (4.0%)	
Subcarinal angle >75 or Double density sign or 3rd Contour				
0	13 (11.8%)	12 (14.1%)	1 (4.0%)	0.291
1	97 (88.2%)	73 (85.9%)	24 (96.0%)	
Subcarinal angle >90 or Double density sign or 3rd Contour				
0	19 (17.3%)	17 (20.0%)	2 (8.0%)	0.232
1	91 (82.7%)	68 (80.0%)	23 (92.0%)	

Abbreviations: LAVI = left atrial volume index; cm = centimeter; mL = milliliter; mL/m² = milliliter per square meter

TABLE 4. Diagnostic performance of CXR parameters compared with CMR-defined LAE.

Variables	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR- (95% CI)	PPV (%) (95% CI)	NPV (%) (95%CI)	Accuracy (95% CI)
3rd Contour (1 – 2)							
Xxx	78.8%	8.0%	0.9%	2.7%	74.4%	10.0%	62.7%
xxx	(68.6-86.9)	(1.0-26.0)	(0.7-1.0)	(0.7-10.6)	(64.2-83.1)	(1.2-31.7)	(53.7-71.8)
3rd Contour (2)							
Xxx	21.2%	80.0%	1.1%	1.0%	78.3%	23.0%	34.6%
xxx	(13.1-31.4)	(59.3-93.2)	(0.4-2.6)	(0.8-1.2)	(56.3-92.5)	(14.6-33.2)	(25.7-43.4)
Double density sign							
Xxx	11.8%	80.0%	0.6%	1.1%	66.7%	21.1%	27.3%
xxx	(5.8-20.6)	(59.3-93.2)	(0.2-1.6)	(0.9-1.4)	(38.4-88.2)	(13.4-30.6)	(19.0-35.6)
Subcarinal angle							
> 75	41.2%	52.0%	0.9%	1.1%	74.6%	20.6%	43.6%
	(30.6-52.4)	(31.3-72.2)	(0.5-1.4)	(0.8-1.7)	(59.7-86.1)	(11.5-32.7)	(34.4-52.9)
> 90	8.2%	92.0%	1.0%	1.0%	77.8%	22.8%	27.3%
	(3.4-16.2)	(74.0-99.0)	(0.2-4.7)	(0.9-1.1)	(40.0-97.2)	(15.0-32.2)	(19.0-35.6)
Subcarinal angle >75 & Double density sign & 3rd Contour							
Xxx	8.2%	88.0%	0.7%	1.0%	70.0%	22.0%	11.8%
xxx	(3.4-16.2)	(68.8-97.5)	(0.2-2.5)	(0.9-1.2)	(34.8-93.3)	(14.3-31.4)	(5.8-17.9)
Subcarinal angle >90 & Double density sign & 3rd Contour							
Xxx	3.5%	96.0%	0.9%	1.0%	75.0%	22.6%	24.6%
xxx	(0.7-10.0)	(79.6-99.9)	(0.1-8.1)	(0.9-1.1)	(19.4-99.4)	(15.1-31.8)	(16.5-32.6)
Subcarinal angle >75 or Double density sign or 3rd Contour							
Xxx	85.9%	4.0%	0.9%	3.5%	75.3%	7.7%	67.3%
xxx	(76.6-92.5)	(0.1-20.4)	(0.8-1.0)	(0.5-25.8)	(65.5-83.5)	(0.2-36.0)	(58.5-76.0)
Subcarinal angle >90 or Double density sign or 3rd Contour							
Xxx	80.0%	8.0%	0.9%	2.5%	74.7%	10.5%	63.6%
xxx	(69.9-87.9)	(1.0-26.0)	(0.7-1.0)	(0.6-10.1)	(64.5-83.3)	(1.3-33.1)	(54.7-72.6)

Abbreviations: PPV = positive predictive value; NPV = negative predictive value third contour showed the highest sensitivity, 78.8% (95% CI, 68.6–86.9), but very low specificity, 8.0% (95% CI, 1.0–26.0). Conversely, a subcarinal angle > 90° provided the highest specificity, 92.0% (95% CI, 74.0–99.0), but poor sensitivity, 8.2% (95% CI, 3.4–16.2). Using a lower threshold, subcarinal angle > 75° showed moderate sensitivity, 41.2% (95% CI, 30.6–52.4), and specificity, 52.0% (95% CI, 31.3–72.2). The double density sign demonstrated low sensitivity, 11.8% (95% CI, 5.8–20.6), but good specificity, 80.0% (95% CI, 59.3–93.2). Overall diagnostic accuracy was 27.3%–62.7%, indicating poor discriminative ability of CXR markers for CMR-defined LAE.

Combining all 3 criteria (subcarinal angle > 75°, double density sign, and third contour) yielded a sensitivity of 8.2% with specificity of 88.0%. Using a stricter combination with subcarinal angle > 90° further decreased sensitivity to 3.5% while achieving specificity to 96.0%.

Clinical predictors of left atrial enlargement

Patients were stratified by CMR-defined LAE (LAVI > 40 mL/m² in men and > 39 mL/m² in women). Those with LAE were older than those without LAE (70.0 ± 10.1 vs 64.9 ± 9.4 years; *P* = 0.028) and had higher systolic blood pressure (140.0 ± 21.4 vs 127.0 ± 17.9 mm Hg; *P* = 0.007). No significant differences were seen in sex, body mass index, or other cardiovascular risk factors between groups, except for associations between body mass index and the presence of a third contour or subcarinal angle > 90° (Table 5).

DISCUSSION

To our knowledge, this is the first study to evaluate CXR for diagnosing LAE using CMR as the reference standard. The prevalence of LAE was high (77.3%), likely reflecting a high burden of comorbidity, particularly hypertension. Prior studies have demonstrated links between elevated blood pressure and higher LAVI.[16-18] Among CXR signs, the third contour was most prevalent. Prominent left atrial appendage, double density sign, and subcarinal angle > 90° occurred in 20.9%, 13.6%, and 8.2% of patients, respectively. The low prevalence of these findings is explored below.

Prominent left atrial appendage (third contour)

This sign was most prevalent in our cohort. The sensitivity, specificity, and accuracy were 21.2%, 80.0%, and 34.6%, respectively, indicating low overall diagnostic performance. Prior work demonstrated better accuracy in mitral valve disease, particularly rheumatic heart disease.[19,20] No patients in our cohort had rheumatic heart disease. In nonrheumatic LAE, pulmonary artery prominence and ventricular enlargement may obscure the left atrial appendage shadow, rendering the sign undetectable.

Double density sign

The double density sign in the right retrocardiac area showed sensitivity of 11.8%, specificity of 80.0%, and accuracy of 21.3%. Its low prevalence contrasts with prior work; Higgins et al reported universal presence in patients with echocardiographic LAE. Interpretation challenges and variable film quality likely contributed. A curvilinear line over the right cardiac shadow can appear without cardiac disease, while adjacent structures, particularly the right pulmonary vein, can mimic the left atrial border, explaining the interstudy differences.

Widened subcarinal angle

Despite the high prevalence of LAE, only 8.2% of patients had a subcarinal angle > 90°. The sensitivity, specificity, and accuracy were 8.2%, 92.0%, and 27.3%, respectively. This likely reflects that 90° represents the upper limit of normal reported previously[21], so many patients with LAE have angles < 90°. Reported thresholds vary across studies[22,23], likely due to difficulty plotting the left main bronchus axis as it courses beneath the aortic arch. Using a lower cutoff of > 75° increased the proportion of patients meeting the angle criterion to 42.7%, with sensitivity, specificity, and accuracy of 41.2%, 52.0%, and 43.6%, respectively.

When any one of the 3 CXR criteria was considered positive, sensitivity was high but specificity was unacceptably low. Conversely, requiring all 3 criteria yielded high specificity but unacceptably low sensitivity. With all 3 criteria combined, sensitivity was 8.2% using the > 75° angle threshold and 3.5% using the > 90° threshold, while specificity reached 88.0% and 96.0%, respectively.

The study found that the sensitivity and specificity of classical CXR signs for LAE were low. Whether combination of other parameter such as electrocardiogram findings would improve the outcomes is not known.

CONCLUSIONS

This study demonstrated limited diagnostic performance of conventional radiographic signs. Despite its accessibility and routine use, CXR showed low sensitivity and specificity compared with CMR.

Limitations

This study has several limitations. First, the enrolled population had a high prevalence of LAE, which may

TABLE 5. Factors associated with CXR parameters (sex, BMI, age).

Factor	Sex			BMI		Age	
	Male	Female	*p*- value	Mean ± SD	*p* - value	Mean ± SD	*p* - value
X-ray parameter							
3rd Contour							
0	11 (55.0%)	9 (45.0%)	0.306	24.1 ± 3.7*	0.018	68.4 ± 13.0	0.958
1	24 (35.8%)	43 (64.2%)		26.8 ± 5.3**		68.8 ± 9.1	
2	9 (39.1%)	14 (60.9%)		24.5 ± 3.3		69.4 ± 10.8	
3rd Contour							
0	11 (55.0%)	9 (45.0%)	0.130	24.1 ± 3.7	0.074	68.4 ± 13.0	0.866
1 - 2	33 (36.7%)	57 (63.3%)		26.2 ± 4.9		68.9 ± 9.5	
3rd Contour							
0 - 1	35 (40.2%)	52 (59.8%)	0.924	26.1 ± 5.1	0.135	68.7 ± 10.0	0.766
2	9 (39.1%)	14 (60.9%)		24.5 ± 3.3		69.4 ± 10.8	
Double density sign							
0	38 (40.0%)	57 (60.0%)	1.00	25.5 ± 4.3	0.211	68.6 ± 9.9	0.539
1	6(40.0%)	9 (60.0%)		27.9 ± 6.9		70.3 ± 11.9	
Subcarinal angle							
≤ 75	29 (46.0%)	34 (54.0%)	0.135	25.1 ± 4.7	0.058	69.6 ± 10.4	0.336
> 75	15 (31.9%)	32 (68.1%)		26.8 ± 4.7		67.7 ± 9.8	
≤ 90	41 (40.6%)	60 (59.4%)	0.739	25.4 ± 4.5	0.011	68.8 ± 10.2	0.877
> 90	3 (33.3%)	6 (66.7%)		29.6 ± 6.2		69.3 ± 9.9	
Subcarinal angle >75 & Double density sign & 3rd Contour							
0	40 (40.0%)	60 (60.0%)	1.00	25.6 ± 4.6	0.302	68.9 ± 10.1	0.864
1	4 (40.0%)	6 (60.0%)		27.3 ± 6.5		68.3 ± 11.7	
Subcarinal angle >90 & Double density sign & 3rd Contour							
0	42 (39.6%)	64 (60.4%)	1.00	25.6 ± 4.5	0.351	68.8 ± 10.1	0.739
1	2 (50.0%)	2 (50.0%)		30.6 ± 9.1		70.5 ± 11.9	
Carinal Angle >75 or Double Contour or 4th Curve							
0	7 (15.9%)	6 (9.1%)	0.278	23.7 ± 4.4	1.00	71.1 ± 11.7	0.397
1	37 (84.1%)	60 (90.9%)		26.1 ± 4.8		68.5 ± 10.0	
Subcarinal angle >90 or Double density sign or 3rd Contour							
0	10 (22.7%)	9 (13.6%)	0.217	24.2 ± 3.7	0.103	67.6 ± 12.8	0.647
1	34 (77.3%)	57 (86.4%)		26.1 ± 4.9		69.1 ± 9.6	

*p-value < 0.05 of Multiple comparison between 3rd Contour (0) vs 3rd Contour (1).

**p-value < 0.05 of Multiple comparison between 3rd Contour (1) vs 3rd Contour (2).

Abbreviation: BMI = body mass index

have influenced the diagnostic performance of CXR parameters; including more patients with normal left atrial size would improve generalizability. Second, CXRs were performed within 6 months of CMR rather than on the same day; however, only clinically stable patients were included to minimize temporal variation. Third, analysis was restricted to posteroanterior views; adding lateral views might have improved sensitivity. Finally, image interpretation by 2 experienced cardiologists may not capture interobserver variability across a broader range of readers.

Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available due to patient confidentiality but are available from the corresponding author on reasonable request.

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DECLARATIONS

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

Registration Number of Clinical Trial

Not applicable.

Author Contributions

Conceptualization and methodology, S.P, M.M., and T.B. ; Investigation, S.P, M.M., and T.B. ; Formal analysis, S.P, M.M., and T.B. ; Visualization and writing – original draft, S.P. and T.B. ; Writing – review and editing, S.P, M.M., and T.B. ; Funding acquisition, S.P, M.M., and T.B. ; Supervision, S.P, M.M., and T.B. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

The authors did not use any generative artificial intelligence tools in the preparation, writing, or analysis of this manuscript.

Ethics Approval

The study protocol was approved by the Siriraj Institutional Review Board, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand (731/2554 [EC3]).

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