

ACCURACY OF POSTERIORANTERIOR THORACIC PHOTOGRAPHY IN DETERMINING CARDIOMEGALY AND CHAMBER ENLARGEMENT COMPARED TO ECHOCARDIOGRAPHY AT THE HAJI ADAM MALIK CENTRAL GENERAL HOSPITAL MEDAN YEAR 2023

Tri Widi Wibowo¹, Henny Maisara Sipahutar², Hilfan Ade Putra Lubis³

¹Department of Radiology, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia

²Department of Heart and Vascular Disease, Faculty of Medicine, Universitas Sumatera Utara,

Abstract

Background: The main modality for identifying cardiac chamber enlargement is echocardiography examination, but due to its limitations, posteroanterior (PA) chest X-ray is often used as an alternative method. **Methods:** This study is an observational study with a cross-sectional design conducted at Radiology Installation and Polyclinic of Integrated Heart Center of The Haji Adam Malik Central General Hospital in patients who came to cardiac polyclinic or emergency room of Integrated Heart Center of The Haji Adam Malik Central General Hospital and underwent posteroanterior chest X-ray and echocardiography who met the inclusion and exclusion criteria. Data were analyzed descriptively to determine the frequency distribution of each demographic variable and risk factor. In addition, the level of sensitivity, specificity, positive predictive value, negative predictive value, of PA chest X-ray to echocardiography in patients with heart problems was calculated. **Results:** The sensitivity of PA chest X-ray for LVH examination was 91.8% with a specificity of 84.6% and accuracy of 89%; for RVH examination was 90.9% with a specificity of 68.2% and accuracy of 85%; for LAH examination was 89.2% with a specificity of 74.3% and accuracy of 84%; and for RAH examination was 70.4% with a specificity of 86.3% and accuracy of 82%. **Conclusion:** PA chest X-ray examination showed good accuracy for identifying cardiomegaly and cardiac chamber enlargement, therefore can be used as an alternative method besides echocardiography examination.

Keywords: Cardiomegaly, cardiac chambers, chest X-ray, echocardiography

INTRODUCTION

Radiologic modalities that can be used for the diagnosis of heart enlargement include posteroanterior (PA) thoracic photographs and echocardiography, better known as ECHO.^{1,2} Heart size is an important and useful diagnostic parameter in chest x-ray (CXR). Cardiomegaly is caused by a variety of diseases, including valvular heart disease, coronary heart disease, and cardiomyopathies as well as pericardial disease.³ Hypertension, diabetes and obesity also cause increased circulatory burden which can lead to cardiomegaly.¹ Increased cardio thoracic ratio (CTR) on CXR is associated with poor patient prognosis.³

ECHO is a noninvasive modality with visualization of the size of the heart chambers and function in real time.^{1,2} The 2-dimensional (2D) ECHO examination is the gold standard for diagnosing heart enlargement with a sensitivity of 100%.^{1,2,4} However, the ECHO examination is highly dependent on the operator's ability, limiting the use of this tool.⁵ Therefore, PA thoracic photographs can be used as an alternative method with lower costs and easier availability and accessibility.⁶

RESEARCH METHODS

This study was an observational study with a cross-sectional design conducted at the Radiology Installation and Integrated Heart Center Poly (PJT) of The Haji Adam Malik Central General Hospital. The research time was carried out in the period April - September 2024 until the total number of samples was met. The samples of this study were patients who came to the cardiac clinic and emergency room of the Integrated Heart Center of The Haji Adam Malik Central General Hospital and performed posteroanterior thoracic photographs and echocardiography and who met the inclusion and exclusion criteria. Sampling technique with consecutive sampling technique.

The inclusion criteria in this study were patients aged > 18 years who had undergone a thoracic photo examination in the posteroanterior position and echocardiography at The Haji Adam Malik Central General Hospital with maximum inspiration (Costae 6 anterior intersects the right mid hemidiaphragm / costae 9 posterior aligns the top of the right hemidiaphragm). Patients who had a history of malignancy in the lung or mediastinum, history of pericardial effusion, skeletal abnormalities (scoliosis), deformities of the heart organ, PA thoracic photographs, with insufficient inspiration and incomplete patient medical record data were excluded from this study.

RESEARCH PROCEDURS

Examination of posteroanterior thoracic photographs using the PHILIPS DigitalDiagnost C90 HP device then reading the CTR by two readers (by 1 Radiology Specialist and the researcher). Measurement of the ratio of the transverse diameter of the heart to the thoracic tranverse diameter in a blinded manner. Echocardiography examination was then performed using GE Vivid E95 equipment by a heart and blood vessel specialist.

STATISTICAL ANALYSIS

Data were presented descriptively as number (n) and percentage (%) of several variables namely age, gender, CTR results of thoracic photographs and echocardiography. A concordance test was performed to assess the concordance between cardiac CTR results from PA thoracic photographs and echocardiography. Data were analyzed descriptively to determine the frequency distribution of each demographic variable and risk factor. In addition, the sensitivity, specificity, positive predictive value (NDP), negative predictive value (NDN), of PA thoracic photographs against echocardiography in patients with cardiac problems were calculated. Analysis was performed using SPSS 26 (Statistical Product and for Social Sciences) computer program.

RESULTS

This study followed 100 patients who were examined by posteroanterior thoracic photographs and echocardiography in the period January 2023 - December 2023. The mean age of the patients was 49.84 + 14.29 years with the majority being female (51%). Cardiomegaly was found in 75 patients (75%) with the main etiology being Valvular Heart Disease and the main risk factor being Hypertension (57%). (Table 1)

Table 1. Demographic Characteristics of Research Subjects

| Demographic Characteristics | n = 100 |
|-----------------------------|---------|
| Gender, n (%) | |
| Man | 49 (49) |
| Woman | 51 (51) |
| Age, year | |

| | |
|----------------------------|---------------|
| Average (SD) | 49,84 (14,29) |
| Median (Min – Mak) | 52 (18 – 77) |
| Cardiomegaly, n (%) | |
| Yes | 75 (75) |
| No | 25 (25) |
| Etiology, n (%) | |
| Valvular Heart Disease | 52 (52) |
| Non Valvular Heart Disease | 48 (48) |
| Risk Factors, n (%) | |
| Hipertensi | 57 (57) |
| Diabetes melitus | 21 (21) |
| Dislipidemia | 22 (22) |

Posteroanterior thoracic photograph examination found 62 people (62%) with left ventricular hypertrophy (LVH) compared to 61 people (61%) on echocardiographic examination; 22 people (22%) with right ventricular hypertrophy (RVH) compared to 23 people (61%) on echocardiographic examination; 67 people (67%) with left atrial enlargement (LAH) compared to 65 people (65%) on echocardiographic examination; and 29 people (29%) with right atrial enlargement (RAH) compared to 27 people (27%) on echocardiographic examination. (Table 2)

Table 2. Results of Cardiomegaly Examination Based on Posteroanterior Thoracic Examination and Echocardiography

| Parameter | Thorax PA | Echocardiography |
|------------|-----------|------------------|
| LVH, n (%) | | |
| Yes | 62 (62) | 61 (61) |
| No | 38 (38) | 39 (39) |
| RVH, n (%) | | |
| Yes | 22 (22) | 23 (23) |
| No | 78 (78) | 77 (77) |
| LAH, n (%) | | |
| Yes | 67 (67) | 65 (65) |
| No | 33 (33) | 33 (33) |
| RAH, n (%) | | |
| Yes | 29 (29) | 27 (27) |
| No | 71 (71) | 73 (73) |

The sensitivity of PA thoracic photographs for LVH examination was 91.8% with specificity of 84.6% and accuracy of 89%; for RVH examination was 90.9% with specificity of 68.2% and accuracy of 85%; for LAH examination was 89.2% with specificity of 74.3% and accuracy of 84%; and for RAH examination was 70.4% with specificity of 86.3% and accuracy of 82%. (Table 3)

Table 3. Accuracy of Cardiomegaly Screening Results Based on Posteroanterior Thoracic Photograph Examination to Echocardiography Examination Results

| Parameter | LVH (Echo) | | Sensi- tivity | Speci- ficity | NDP | NDN | Accuracy |
|--------------------|------------|----|------------------|------------------|-------|-------|----------|
| | Yes | No | | | | | |
| LVH (Thorax PA) | | | | | | | |
| Yes | 56 | 6 | 91,8% | 84,6% | 90,3% | 86,8% | 89% |
| No | 5 | 33 | | | | | |

| | | | | | | | |
|-----------------|----|----|-------|-------|-------|-------|-----|
| RVH (Thorax PA) | | | | | | | |
| Yes | 15 | 7 | 65,2% | 90,9% | 68,2% | 89,7% | 85% |
| No | 8 | 70 | | | | | |
| LAH (Thorax PA) | | | | | | | |
| Yes | 58 | 9 | 89,2% | 74,3% | 86,6% | 78,8% | 84% |
| No | 7 | 26 | | | | | |
| RAH (Thorax PA) | | | | | | | |
| Yes | 19 | 10 | 70,4% | 86,3% | 65,5% | 88,7% | 82% |
| No | 8 | 63 | | | | | |

DISCUSSION

The size of the heart is very important for the identification of heart enlargement due to left ventricular enlargement or right ventricular enlargement.⁷ In the initial examination, cardiomegaly can be detected first with a posteroanterior (PA) chest X-Ray (CXR) examination. For further accurate examination, cardiac echocardiography (ECHO), cardiac computed tomography (CCT), and cardiac magnetic resonance imaging (CMRI) can be evaluated.⁸

2D echocardiography is the gold standard for the diagnosis of cardiomegaly. The advantages of echocardiography are real-time visualization of cardiac chambers and function, non-invasive, unaffected by thoracic deformity and patient inspiration/expiration, but has several disadvantages such as cost, limited availability and highly dependent on operator expertise which causes limited use of this tool. With several drawbacks to echocardiography, there is a need for an alternative radiologic modality that is reliable for cardiomegaly screening. Posteroanterior (PA) CXR is an alternative option due to its availability and economical cost.⁷

The right heart side on CXR depicts the right atrium and the left heart side depicts the left ventricle and a portion of the right ventricle. The posteroanterior view on CXR is commonly used to determine the CTR.³ Cardiomegaly is determined when the CTR is greater than 0.5.⁷ The advantages of CXR are cost-effective, non-invasive, and easily accessible to patients. Some factors that affect the estimation of heart size on CXR method are age, gender, height, weight, breathing depth at the time of CXR, thoracic cavity deformity, and the CXR technique used.⁹

The results of this study are in contrast to the study of McKee et al where 55 children who were reported to have cardiomegaly on ECHO examination, 33 (60%) of them showed results without cardiomegaly on CXR. The sensitivity of CXR to identify cardiomegaly was 40% with specificity of 91%, NDP was 56% and NDN was 84%.¹⁰

The results of this study are similar to Shirani et al who found CTR in patients with ECHO cardiomegaly was $57.7 \pm 5.7\%$ and in patients without ECHO cardiomegaly was $46.9 \pm 7\%$. When $CTR \leq 50\%$ of the thoracic cavity width is considered normal, CTR shows a false positive cardiomegaly classification of 28.2% and a false negative of 9.2%.¹¹ Torres et al showed that on PA CXR, a CTR cut off of 0.50 has a sensitivity and specificity of 72%, a positive likelihood ratio of 2.6, and a negative likelihood ratio of 0.38. However, in CXR AP, a CTR cut off of 0.50 had a sensitivity of 89%, specificity of 38%, positive likelihood ratio of 1.40, and negative likelihood ratio of 0.31. When evaluated, CTR should be assessed as the ratio of maximum cardiac diameter to

maximum thoracic diameter, as this technique has the best diagnostic performance and reproducibility.¹²

The results of this study are similar to the study of Truszkiewicz et al found a statistically significant positive linear relationship between left ventricular end-diastolic diameter (LVEDd) on echocardiographic examination and CTR ($r = 0.38$, $p < 0.05$), left ventricular mass (LVM) and CTR ($r = 0.42$, $p < 0.05$), and left ventricular mass index (LVMI) and CTR ($r = 0.50$, $p < 0.05$). The criterion of “CTR > 0.49” in determining LVH showed a sensitivity of 93.3% and specificity of 82.7% with an accuracy of 84.4%. By analyzing the type of left ventricular geometry, the highest accuracy of 80.2% for concentric hypertrophy (CH) was obtained using the “CTR > 0.49” criterion (with a sensitivity of 84.0% and specificity of 60.0%) and the highest accuracy of 71, 9% for eccentric hypertrophy (EH) was obtained using the “CTR > 0.52” criteria (with a sensitivity of 80.5% and specificity of 36.8%), and an accuracy of 57.3% for concentric remodeling (CR) (with a sensitivity of 36.7% and specificity of 78.7%). CTR can be used as a marker of left ventricular hypertrophy assessed by standard echocardiographic criteria.⁹

The results of this study are similar to Hammermeister KE et al., showing the sensitivity and specificity of CTR ≥ 0.5 to detect left ventricular enlargement of 88% and 41%, while to detect a reduced ejection fraction of 86% and 35%, respectively.¹³

Different research results obtained in the study of Jung et al. showed the accuracy of CTR on pathological End Diastolic Volume Index and Ejection Fraction values showed sensitivity of 77.3% and 57.4%, specificity of 79.3% and 80.8%, and accuracy of 78.9% and 72.5%, respectively. They concluded that CTR on standard CXR plays an important role in the screening and follow-up of patients with heart disease.³

The results of this study are similar to Gwaba et al showing 88% of patients with cardiomegaly had abnormal echocardiographic findings while 12% showed normal echocardiographic findings. This means that 88% of patients with cardiomegaly diagnosed on CXR had one or more cardiovascular diseases accompanying the cardiomegaly. This study has shown that there is a strong association between cardiomegaly diagnosed on CXR and echocardiographic findings.¹⁴

Rahayu et al showed Left ventricular internal dimension (LVID) on echocardiography also showed a very strong positive correlation with CTR on CXR PA ($p < 0.0001$, $r = 0.680$). The left ventricular chamber forms the lower left part of the acoustic shadow of the heart. Therefore, any dilatation of the left ventricular cavity will always manifest in the form of enlargement of the acoustic shadow of the heart where any increase in heart size abnormality will be reflected in CXR PA. Thoracic X-ray is a reliable alternative examination method to diagnose cardiomegaly/heart enlargement without echocardiographic examination.⁷

The enlargement of each heart chamber is positively related to the CTR and maximum heart diameter. The right atrium forms the right heart border and the left ventricle forms the left heart border on anterior CXR. Right atrial enlargement is the largest contributor to the increase in CTR and maximum heart diameter on CXR. The slightly lower contribution of the left ventricle to heart diameter may be related to the rotation of the heart as it enlarges. Left ventricular dilatation is associated with counterclockwise rotation of the heart within the thorax, which may result in a normal CTR. In addition, right ventricular enlargement is associated with clockwise rotation of the heart, thereby increasing the transverse diameter of the heart even though the right ventricle generally does not form one of the borders of the heart on anterior CXR.¹²

The sensitivity and specificity rates of CXR in the Monfared et al study for the diagnosis of cardiomegaly were 34% and 84.5% respectively, which can be used as a

screening test for cardiomegaly. When the posteroanterior view on CXR shows the absence of cardiomegaly, most of the same results are found on echocardiographic examination. Although CXR may not have the same level of diagnostic accuracy as echocardiography, its easy accessibility and high specificity for the diagnosis of cardiomegaly are helpful and play an important cost-benefit role, especially for cardiomegaly screening.³

CONCLUSION

The accuracy of Posteroanterior thoracic photography in determining cardiomegaly and chamber enlargement compared to echocardiography in LVH is 89%, for RVH is 85%, for LAH is 84% and for RAH is 82%. In addition to echocardiographic examination, PA thoracic photo examination can be an accurate alternative method for the identification of cardiomegaly and heart chamber enlargement.

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