ORIGINAL ARTICLE

COMPARATIVE ANALYSIS OF LEFT VENTRICULAR EJECTION FRACTION ASSESSMENT: VISUAL ESTIMATION VIA ECHOCARDIOGRAPHY VERSUS QUANTITATIVE MEASUREMENT THROUGH CARDIOVASCULAR MAGNETIC RESONANCE IMAGING

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Objectives: This retrospective observational study aimed to evaluate the correlation between visually estimated left ventricular ejection fraction (LVEF) via 2D echocardiography (ECHO) and quantitatively measured LVEF via cardiovascular magnetic resonance imaging (CMR).

Methodology: The study was conducted at Aga Khan University Hospital, involving patients who underwent both 2D ECHO and CMR within a maximum interval of three months between the two studies. LVEF was visually estimated by experienced cardiologists on 2D ECHO and quantitatively calculated on CMR.

Results: Among 127 patients meeting inclusion criteria, comparisons between visually estimated LVEF ranges on ECHO and LVEF on CMR consistently showed highly significant differences ($p < 0.0001$), with ECHO underestimating LVEF. The mean difference between visually estimated average LVEF by ECHO and calculated LVEF by CMR was 4.9 ± 7.0. Subgroup analysis revealed consistent findings across patients with coronary artery disease (CAD) and those with dilated or hypertrophic cardiomyopathy.

Conclusion: Despite a significant difference, the observed discrepancy in LVEF values between visually estimated ECHO and quantitatively measured CMR remains small. Thus, visually estimated LVEF by experienced readers retains its reliability as a method for diagnosing and managing patients in routine clinical practice.

Keywords: Cardiovascular magnetic resonance (CMR), left ventricular ejection fraction (LVEF), coronary artery disease (CAD), dilated cardiomyopathy (DCM), hypertrophic cardiomyopathy (HCM)

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INTRODUCTION

Left ventricular ejection fraction (LVEF) serves as a crucial metric in the diagnosis and management of cardiac patients, providing critical insights into the heart's pumping function. Transthoracic echocardiography has emerged as a cornerstone in assessing LVEF, offering a non-invasive and widely accessible means of evaluating left ventricular systolic function in clinical practice.[1-3] Despite its widespread use, concerns persist regarding the accuracy and reliability of visually estimating LVEF via 2D echocardiography.[4] Variability between observers and limitations of quantitative methods underscore the need for further investigation into the comparative efficacy of echocardiographic assessment methods.[5]

In contrast, cardiovascular magnetic resonance (CMR) imaging stands out as the gold standard for precisely quantifying LVEF, offering superior accuracy and reproducibility compared to echocardiography. However, despite its recognized advantages, there remains a paucity of comparative data between visually estimated LVEF on echocardiography and quantitatively measured LVEF on CMR, particularly in our region.[6] This knowledge gap underscores the importance of conducting a comprehensive study to elucidate the correlation between these two modalities and assess the reliability of visual estimation against the gold standard of CMR.

Therefore, this study aims to address this gap by investigating the correlation between visually estimated LVEF on echocardiography and quantitatively measured LVEF on CMR in a cohort of cardiac patients. By quantifying any observed differences between the two modalities, this research endeavors to provide valuable insights into the accuracy and reliability of visual estimation of LVEF in routine clinical practice. Ultimately, the findings of this study have the potential to inform clinical decision-making, enhance patient management strategies, and optimize the utilization of echocardiography and CMR in the assessment of LVEF across diverse cardiac conditions.

METHODOLOGY

Study Design: This retrospective observational study aimed to investigate the correlation between visually estimated left ventricular ejection fraction (LVEF) obtained through transthoracic echocardiography (ECHO) and quantitatively measured LVEF acquired via cardiac magnetic resonance imaging (CMR).

Setting: The study was conducted within the Cardiology section of Aga Khan University Hospital (AKUH) in Karachi, Pakistan. Utilizing the hospital's extensive medical records, patients spanning from 2011 to 2021 were included, reflecting a diverse and comprehensive dataset.

Participants: The study included patients diagnosed with coronary artery disease (CAD) or any form of cardiomyopathy (CMP), who underwent both ECHO and CMR at AKUH within a maximum interval of three months between the two studies. Patients were excluded if either ECHO or CMR was not conducted at AKUH, or if the time interval between the two studies exceeded three months.

Variables: The primary variables of interest were the visually estimated LVEF from ECHO and the quantitatively measured LVEF from CMR. Additionally, demographic data such as age, gender, clinical features, and co-morbid conditions were collected to provide comprehensive context for the study.

Data Sources / Measurement: Data collection was conducted following approval from the ethical review committee of AKUH, ensuring adherence to ethical guidelines. Information was retrieved from the hospital's electronic record system and recorded in a structured data entry form for each patient. Visual estimation of LVEF from ECHO was performed by experienced cardiologists, while CMR data acquisition and analysis were conducted using standardized protocols and software.

Bias: Efforts were made to minimize bias by employing strict inclusion and exclusion criteria, as well as ensuring consistency in data collection and analysis methodologies. Additionally, the retrospective nature of the study mitigated the risk of selection bias.

Study Size: The study encompassed a sizable cohort of patients spanning a decade (2011-2021), contributing to the robustness and generalizability of the findings.

Quantitative Variables: Continuous variables were summarized using mean ± standard deviation or median, while categorical variables were presented as counts with proportions.

Statistical Methods: Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 23.0.0, employing appropriate statistical tests including the paired t-test for comparison of continuous variables and the Pearson $\chi 2$ test for categorical variables. This rigorous statistical approach ensured the validity and reliability of the study findings.

Ethical Considerations: Stringent ethical considerations were upheld throughout the study, with patient confidentiality maintained at all times. Patient data was anonymized and securely stored, with access restricted to authorized researchers only. As an observational study, no direct risks were posed to the patients, and ethical approval was obtained prior to data collection.

RESULTS

Participants: The study included 127 patients with cardiac disease who underwent CMR at Aga Khan University Hospital from 2011 to 2021. The majority of the participants were male (83.46%), with ages ranging from 19 to 86 years and a mean age of 55.23 ± 14.34 years. Diabetes (50.39%) and hypertension (48.03%) were the most prevalent co-morbid conditions, while only a small proportion of patients were current smokers (14%) or had dyslipidemia (14.17%). Coronary artery disease (55.12%) was the most common cardiac diagnosis among the participants, followed by dilated cardiomyopathy (24.41%) and hypertrophic cardiomyopathy (18.11%).

Descriptive Data: Table 1 presents the baseline characteristics of the participants, detailing the distribution of demographic variables and co-morbid conditions within the study cohort.

Table 1: Baseline characteristics

Characteristics	Summary
Total (N)	**127**
Mean age (years)	55.23 ± 14.3
Female	21 (16.5%)
Male	105 (83.5%)
Diabetes	64 (50.4%)
Hypertension	61 (48%)
Smoking	19 (15%)
Dyslipidemia	18 (14.2%)
Peripheral arterial disease	2 (1.6%)
Chronic kidney disease	10 (7.9%)
ARVC	2 (1.6%)
Coronary artery disease	70 (55.1%)
Dilated cardiomyopathy	31 (24.4%)
Hypertrophic Cardiomyopathy	23 (18.1%)
Myocarditis	1 (0.8%)

Outcome Data: In Table 2, the study compared LVEF values obtained from CMR and ECHO for the same participants. The visually estimated LVEF from ECHO was compared to the quantitatively measured LVEF from CMR, revealing a consistent pattern across all comparisons. The results indicated that LVEF values were significantly lower when estimated via ECHO compared to CMR, with highly significant p-values (<0.0001) for all comparisons.

Table: 2 Comparison of LVEF by CMR and ECHO

Modality	LVEF	95% CI	P-Value
CMR	35.76 ± 16.5	32.85-38.63	<0.0001
ECHO (U)	31.81 ± 14.2	29.30-34.32	
CMR	35.76 ± 16.5	32.85-38.67	<0.0001
ECHO (A)	30.84 ± 14.2	28.34-33.35	
CMR	35.76 ± 16.5	32.85-38.67	<0.0001
ECHO (L)	29.80 ± 14.3	27.36-32.40	

Main Results: The main findings of the study demonstrate a significant difference between LVEF values obtained from ECHO and CMR, with ECHO consistently underestimating LVEF compared to CMR. The mean difference between visually estimated average LVEF by ECHO and quantitatively measured LVEF by CMR was 4.9 ± 7.0. Furthermore, when analyzing subgroups based on cardiac diagnosis (dilated cardiomyopathy, hypertrophic cardiomyopathy, and coronary artery disease), the difference in LVEF values between ECHO and CMR remained significant across all groups (p-value <0.0001), indicating the robustness of the findings across different cardiac pathologies.

Table 3: Comparison between LVEF by CMR and by ECHO in different cardiac disease patients

LVEF By	LVEF	95% CI	P-Value
Dilated Cardiomyopathy			
CMR	29.3 ± 13	24-34.37	0.003
ECHO (A)	25.4 ± 11	21-29.62	
Hypertrophic Cardiomyopathy			
CMR	59.04 ± 19.2	50.74-67.34	<0.0001
ECHO (A)	49.67 ± 14.94	43.2-56.13	
Coronary Artery Disease			
CMR	30.7 ± 8.37	28.7-32.69	<0.0001
ECHO (A)	26.78 ± 9.14	24.6-28.96	

DISCUSSION

This pioneering study represents the first comprehensive comparison in our region between visually estimated left ventricular ejection fraction (LVEF) by echocardiography (ECHO) and quantitatively measured LVEF by cardiac magnetic resonance imaging (CMR). Our findings illuminate a significant disparity between the two modalities, with ECHO consistently underestimating LVEF in comparison to CMR. Notably, this underestimation is particularly pronounced in the lower range values of LVEF.

Contrary to a study by Lei Zhao et al., which reported 2D ECHO overestimating LVEF compared to CMR, especially in patients with LVEF <35%, our results align more closely with studies by Ponikowski P & Rupert Simpson et al., which concluded that 2D ECHO consistently underestimates LVEF compared to CMR, irrespective of the technique employed.[4-7] Importantly, while Simpson's and 3D LVEF methods were utilized in those studies,[8] our study uniquely focused on visual estimation of LVEF on ECHO, a widely practiced method known to yield reliable results when performed by experienced readers, as demonstrated by Rana S et al.[8]

Our investigation extends beyond the general cardiac population to patients with specific cardiac pathologies, namely hypertrophic cardiomyopathy (HCM), dilated cardiomyopathy (DCM), and coronary artery disease (CAD). The uniformity of our findings across these diverse patient groups underscores the robustness of the observed discrepancy between ECHO and CMR in LVEF estimation. Notably, the magnitude of underestimation in LVEF was more pronounced in HCM patients compared to DCM and

CAD patients, highlighting potential implications for clinical decision-making in this subset of patients.

Our study's findings are corroborated by prior research, including studies by Schwaiger J, Gardner BI et al., and Goud S et al., which similarly concluded that 2D ECHO underestimates LVEF when compared to CMR, particularly in patients with acute coronary syndrome.[3,9-11] The mean difference of 4.9 ± 7.0 between visually estimated average LVEF by ECHO and quantitatively measured LVEF by CMR underscores the small yet clinically significant discrepancy between the two modalities. While this difference may not substantially impact routine clinical decision-making, it assumes greater importance in scenarios such as device implantation or management of valvular heart disease, where precise LVEF assessment is pivotal.

Valvular heart disease patients, though not included in our study, represent a cohort where even minor discrepancies in LVEF assessment can have profound implications for surgical intervention decisions. In such cases, CMR may offer superior accuracy and should be considered the preferred modality, especially when decision-making is challenging.

LIMITATION

Limitations of our study include its retrospective, single-center design. Despite these limitations, our study provides valuable insights into the comparative accuracy of ECHO and CMR in LVEF assessment, underscoring the importance of selecting the appropriate imaging modality based on clinical context. Future prospective multicenter studies are warranted to further validate our findings and explore their implications across diverse patient populations.

CONCLUSION

This study reveals a consistent underestimation of LVEF by 2D echocardiography (ECHO) compared to quantitatively measured LVEF via CMR across patients with cardiac disease. Despite this difference, the minor magnitude suggests that visually estimated LVEF by experienced readers remains reliable for routine clinical practice. While CMR offers superior accuracy, particularly in critical decision-making scenarios, the smaller discrepancy supports the continued utility of ECHO in everyday clinical assessments. Further research is needed to elucidate the clinical implications and guide optimal imaging modality selection in cardiac disease management.

AUTHORS' CONTRIBUTION

MAT, RAK, FATS, and AR: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. MAT, RAK, FATS, and AR: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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