The Reliability of Automated Three-Dimensional Echocardiography-HeartModel\textsuperscript{A,1} Versus 2D Echocardiography Simpson Methods in Evaluation of Left Ventricle Volumes and Ejection Fraction in Patients With Left Ventricular Dysfunction

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ABSTRACT

Background: Two-dimensional echocardiography (2DE) Simpson methods is the most frequently used imaging modality to assess left ventricular ejection fraction (LVEF). LVEF is an important predictor of morbidity and mortality in a wide range of patients and clinical scenarios. Despite its importance in prognosis and clinical decision making, most echocardiography laboratories currently determine EF primarily by visual estimation, which is highly experience-dependent and sensitive to intra- and inter-observer variability and suboptimal accuracy and repeatability. Over the last decade, 3-dimensional echocardiography (3DE) has become increasingly implemented in clinical practice. The automated 3D HeartModel\textsuperscript{A,1} tracks every frame over the cardiac cycle using 3D speckle technology. HeartModel\textsuperscript{A,1} is a fully automated program that simultaneously detects LA and LV endocardial surfaces using an adaptive analytics algorithm that consists of knowledge-based identification of initial global shape and orientation followed by patient-specific adaptation. Objective: The objective of the study was to compare the automated 3D HeartModel\textsuperscript{A,1} echocardiography and 2D Simpson methods echocardiography in evaluation of the left ventricular ejection fraction and left ventricular volumes in patients with left heart dysfunction. Methods: The study prospectively enrolled 165 patients with symptoms of LV dysfunction (ischemic or nonischemic) and New York Heart Association (NYHA) functional class I-III, referred for an echocardiographic study to evaluate the LV volumes and LV ejection fraction (LVEF) during the period from March 2020 to March 2022. Echocardiographic images were acquired by experienced echocardiographers using a commercially available Philips EPIQ machine (Koninklijke Philips Ultrasound, USA) equipped with X5-1 Matrix probe for 2DE and DHM 3DE acquisitions, respectively. Results: 2D Simpson methods echocardiography results for estimated LVEF were 38.43 ± 1.70 in patients with NYHA class I-II, 30.53 ± 1.60 in patients with NYHA class III. Using 3D Heart Model, LVEF were 38.23 ± 1.71 in patients with NYHA class I-II and 30.27 ± 1.50 in patients with NYHA class III. The results of 2D Simpson methods echocardiography for estimated LVESV in NYHA class I-II and NYHA class III were 99.06 ± 6.36 ml/m², 121.96 ± 2.93 ml/m² respectively, LVESV were 60.91 ± 3.91 ml/m², 84.74 ± 2.70 ml/m² respectively, for 3D Heart Model, LVESV in NYHA class I-II and NYHA class III were 100.07 ± 6.72, 121.38 ± 3.01 ml/m² respectively, LVESV were 61.75 ± 3.94 ml/m², 84.73 ± 2.33 ml/m² respectively. 2DE measurement of LV volumes and EF was completed in 6.1 ± 0.8 min. per patient. 3D HeartModel\textsuperscript{A,1} acquisition and analysis in most patients was completed in <3.2 min., an average time of 2.9 ± 1.3 min. per patient. The result of our study shows that the 3D HeartModel\textsuperscript{A,1} is a reliable and robust method for LVEF and LV volume analysis, which has similar results to 2D echocardiography performed by experienced sonographers. In this study, we found that 3DE DHM fully automated tool is also significantly faster than 2DE analysis and can help overcome the time-consuming nature and its present a strong argument for its incorporation into the clinical workflow. Conclusion: 3D DHM provides fast and accurate LV volumes and LVEF quantification, as it avoids geometric assumptions and left ventricular foreshortening, has better reproducibility and has incremental value to predict adverse outcomes in comparison with conventional 2DE. In the future major benefit of AI in echocardiography is expected from improvements in automated analysis and interpretation to reduce workload and improve clinical outcome.

Keywords: 2D Simpson methods echocardiography, 3D HeartModel, A.I echocardiography, Left ventricle ejection fraction (LVEF), Left ventricular dysfunction.
The Reliability of Automated Three-Dimensional Echocardiography-HeartModel

1. BACKGROUND

Two-dimensional echocardiography (2DE) has been pivotal in the surveillance and management of a number of cardiovascular conditions including heart failure, coronary artery disease and valvular heart disease. The accuracy of left ventricular (LV) function assessment using 2D TTE has been questioned due to a number of limitations including geometrical assumptions, apical foreshortening, operator subjectivity and poor endocardial definition. Chamber quantification is a critical component of transthoracic echocardiography (TTE), including left ventricular (LV) end-diastolic and end-systolic volumes (LVED, LVES), end-systolic left atrial (LA) maximal volume and LV ejection fraction (LVEF). LVEF is mainly affected by preload, afterload, and contractility, and absolute LV volumes reflect these factors differently: end-systolic volume (ESV) is mainly affected by afterload and contractility, and end-diastolic volume (EDV) by preload and contractility. Two-dimensional echocardiography (2DE) is the most frequently used imaging modality to assess LVEF, but it has been shown to have substantial intrasubject and intersubject variability and suboptimal accuracy and repeatability. Indeed, the recently published guidelines on chamber quantification recommend that two- or three-dimensional echocardiographic (2DE, 3DE) measurements of LV and LA volumes should be routinely performed as part of all clinical studies. The availability of 3D TTE equipment and the ability to visualize real-time data have made it more accessible to the clinic. However, despite the advantages of this technology, many of the department’s echocardiograms still remain 2D.

The automated 3D HeartModel A.I. uses 3D speckle technology to visualize the movements of the LA and LV over the course of a cardiac cycle. This method allows the cardiologist to perform accurate and comprehensive analysis of the left heart function. It also provides a comprehensive view of the wall motion and volume change of the LV over the heart cycle. The results of 2D echocardiography can be compared with those of single-beat procedures in assessing the heart function of patients with arrhythmia. According to researchers, 3D echocardiography is more accurate and reproducible than 2DE when it comes to assessing the left ventricular ejection fraction. Compared to 2DE, 3D echocardiography provides a more accurate and reproducible method for assessing the left ventricular ejection fraction. It also has the potential to improve the accuracy of the procedure and predict adverse outcomes.

The development of fully sampled matrix array transducers, the ability to visualize real-time datasets and accessible post-processing packages has resulted in 3D TTE being more easily accessible and usable in the clinic. Over the past decade, the use of 3D echocardiography has become more prevalent in clinical practice. The automated 3D HeartModel A.I. uses speckle technology to visualize every frame of the cardiac cycle. It allows the cardiologist to visualize the left heart function and its associated wall motion. It also allows the patient to get a holistic view of the volume change over the heart cycle. The accuracy of 3D echocardiography was also improved by the multi-beat selection process. This method was more accurate and reliable compared to 2DE in assessing the left ventricular ejection fraction (LVEF).

2. OBJECTIVE

The objective of the study was to compare the automated 3DE HeartModel A.I. echocardiography and 2DE Simpson methods in evaluation of left ventricular ejection fraction and left ventricular volumes in patients with symptoms of left heart dysfunction.

3. PATIENTS AND METHODS

The study prospectively enrolled 166 patients with symptoms of LV dysfunction (ischemic or nonischemic) and New York Heart Association (NYHA) functional class I to III, referred for an echocardiographic study to evaluate the LV volumes and LV ejection fraction (LVEF) during the period from March 2020 to March 2022. Both 2DE and 3DE HeartModel A.I. LVEF, LVEDVi and LVESVi were obtained during the same study.

Ischemic cause of LV dysfunction symptoms was defined as stenosis >50% of the left main coronary artery or >70% of 1 or more major coronary arteries at angiography, previous myocardial infarction, or coronary revascularization. Patients without an ischemic cause were classified as having nonischemic LV dysfunction. Exclusion criteria at enrolment were unwillingness to be part of the study, history of unexplained syncope, insufficient acoustic window to allow the quantitation of 2DE LVEF without the infusion of contrast agents (i.e., more than 2 LV segments not adequately visualized), myocardial infarction in the 40 days or revascularization in the 90 days preceding the enrollment, and more than moderate stenosis orregurgitation of any valve.

Echocardiographic images were acquired by experienced echocardiographers using a commercially available Philips EPIQ machine (Koninklijke Philips Ultrasound, USA) equipped with X5-1 Matrix probe for 2DE and DHM 3DE acquisitions, respectively. Most recently, machine learning techniques, commonly known as artificial intelligence (AI), have been employed to automatically identify LV endocardial boundaries and calculate LVEF. 2DE and 3DE imaging was performed in 165 patients using an X5-1 matrix array transducer (Philips, Andover, MA). The acquisition of the 2DE LV apical 4-chamber (A4C) and 2-chamber (A2C) views and a 3D HeartModel A.I. data set of the LV were recorded. In addition, the LV (end-diastolic and end-systolic) volume measurement using the biplane method of disks from the 2DE images was recorded. The modified biplane Simpson’s method of discs was used to determine LV volumes and function. End-diastolic and end-systolic endocardial borders were traced manually on frozen 2D images obtained from the A4C and A2C views to derive end-diastolic volume (EDV) and end-systolic volume (ESV). End-diastole was defined as the peak of the electrocardiographic R wave and/or one frame before mitral valve closure. End-systole was defined as one frame before mitral valve opening or when end-systolic volume
was deemed smallest by the operator. Finally, the time required to complete the data analysis to obtain LV and LA volumes from 3DE data sets using the new Heart-Model A.I. software was recorded. The first step of Heart Model’s automated analysis is knowledge-based identification, which is trained to use approximately 1000 echo images from a wide variety of heart shapes and sizes. The software screens the cardiac chamber shapes, including the overall morphological size, shape, curvature, and volume of the 3DE data, to select the best “matching” shapes. The automated 3D HeartModel A.I analysis was performed both on a standard personal computer and in the EPIQ imaging system with and without global and regional adjustments. Image contrast, frequency, depth, and sector size were adjusted for adequate frame rate and optimal LV border visualization.

Datasets were stored digitally. Calculation of 2D volumes and LVEF was performed using the biplane disk summation algorithm (modified Simpson’s rule). Manual tracing of the endocardial border was performed at both end-diastole and end-systole, paying attention to include LV wall trabeculations and papillary muscles within the cavity. Measurements of 3DE LV volumes and LVEF were performed using a commercially available software package (automated 3D Heart Model, Philips Ultrasound, Koninklijke, USA). 3D HeartModel A.I. is a fully automated program that simultaneously detects LA and LV endocardial surfaces using an adaptive analytics algorithm that consists of knowledge-based identification of initial global shape and orientation followed by patient-specific adaptation.

Statistical analysis was performed using statistical software (IBM Statistics, SPSS version 23.0, Inc, Chicago, IL). All data are expressed as mean ± SD. Since the tested variables does not meet the criteria for normal distribution, a nonparametric Mann-Whitney U test was used. All volumes and EF measurements, both 2DE and 3DE were feasible in all 166 patients. Linear regression was performed for correlation analysis. Hodgges-Lehman Median Difference was used for additional comment.

The inter- and intrabserver variability was measured according to the following formula: (SDdiff × 100%)/total mean × √2, where SDdiff is the SD of difference between measurements. The significance level was set as P < 0.05.

4. RESULTS

The total initial cohort were 198 patients, we excluded 33 patients with poor 2DE acoustic window, 4 patients...
with 3DE datasets unsuitable for quantitative analysis despite an acceptable 2DE acoustic window. Thus, we included in our final study cohort 166 patients (76 males, 90 females, age: 63 ± 16 years) were evaluated at our outpatient cardiology polyclinic in whom LVEF could be measured with both 2DE and 3D DHM echocardiography.

The enrolled patients were divided into 2 groups according to the NYHA functional class, the first group was including the patients with NYHA class I and II (81 patients), the second group was including the patients with NYHA class III (85 patients). The image quality was excellent in 69%, good or fair in 31% of enrolled patients.

Table 1 shows baseline demographic and clinical characteristics of the enrolled patients. A complete 2D echo was performed in both NYHA class group. 3D echo examination was obtained in all 166 patients (feasibility = 100%). 2D echo measurement of LV volumes and EF was completed in 6.1 ± 0.8 min. per patient. 3D HeartModel A.I. acquisition and analysis in most patients was completed in <3.2 min., an average time of 2.9 ± 1.3 min. per patient. All volumes and EF measurements, both 2DE and 3DE were feasible in all 166 patients.

Using 2D echocardiography the results of estimated LVEF were 38.43 ± 1.70 in patients with NYHA class I-II, 30.53 ± 1.60 in patients with NYHA class III. Using 3D Heart Model, LVEF were 38.23 ± 1.71 in patients with NYHA class I-II and 30.27 ± 1.50 in patients with NYHA class III. Statistical analysis showed significant differences in LVEF between the NYHA class I-II and NYHA class III P< 0.0001 (Table 2, Figure 1).

The results of 2D and 3D HeartModelA.I. echocardiographic parameters analysis in the overall study population. 2DE = 2-dimensional echocardiography, 3DE = 3-dimensional echocardiography, DHM = Dynamic Heart Model. LVEDVi = left ventricle end-diastolic volume index, LVESVi = left ventricle end-systolic volume index, LVEF = left ventricle ejection fraction. Values are mean ± SD.

| Item                        | All Patients (N = 166) | Patients With NYHA class I-II (n = 81) | Patients with NYHA Class III (n = 85) | p Value |
|-----------------------------|------------------------|---------------------------------------|---------------------------------------|---------|
| 2D Echocardiography         |                        |                                       |                                       |         |
| 2DE LVEDVi, ml/m²           | 110.79 ± 12.48         | 99.06 ± 6.36                          | 121.96 ± 2.93                        | < 0.0001|
| 2DE LVESVi, ml/m²           | 73.11 ± 12.40          | 60.91 ± 3.91                          | 84.74 ± 2.70                         | < 0.0001|
| 2DE LVEF, %                 | 34.38 ± 4.29           | 38.43 ± 1.70                          | 30.53 ± 1.60                         | < 0.0001|

DHM 3D Echocardiography

| Item                        | All Patients (N = 166) | Patients With NYHA class I-II (n = 81) | Patients with NYHA Class III (n = 85) | p Value |
|-----------------------------|------------------------|---------------------------------------|---------------------------------------|---------|
| 3DE LVEDVi, ml/m²           | 110.98 ± 11.98         | 100.07 ± 6.72                         | 121.38 ± 3.01                         | < 0.0001|
| 3DE LVESVi, ml/m²           | 73.52 ± 11.96          | 61.75 ± 3.94                          | 84.73 ± 2.33                         | < 0.0001|
| 3DE LVEF, %                 | 34.16 ± 4.30           | 38.23 ± 1.71                          | 30.27 ± 1.50                         | < 0.0001|

Figure 1. Comparison of left ventricle volumes and EF between 2D Simpson methods and 3D HeartModelA.I. Echocardiography in both groups. Linear regression analysis comparing ventricular volumes (LVEDVi and LVESVi) and LV EF obtained from 2DE and automated HeartModelA.I. 3DE in patients with NYHA class I-II and NYHA class III for all patients. Upper panel, linear regression analysis of left ventricular volumes and ejection fraction between 2D and automated 3D HeartModelA.I. in NYHA class I-II patients. Lower panel, linear regression analysis of left ventricular volumes and ejection fraction between 2D and automated 3D HeartModelA.I. in NYHA class III patients. LVEDVi = Left ventricle end-diastolic volume index, LVESVi = Left ventricle end-systolic volume index, LVEF = Left ventricle ejection fraction.
There was no significant difference between 3D and 2D in the estimation of LVEF (P > 0.05; median pairwise difference, 1.0% [95% PIs, -0.5% to 0.0%]). 3D HeartModelA.I indexed end-diastolic volumes (iEDVs) and end-systolic volumes (iESVs) were somewhat larger than 2D LVEDVi (P > 0.05; median pairwise difference, 1.0 mL/m2 [95% PIs, 0.5 to 2.0 mL/m2]) and LVESVi: P < 0.05; median pairwise difference, 0.5 mL/m2 [95% PIs, 0.5 to 1.0 mL/m2]). In the vast majority of cases (98.8% of cases for LVEDVi and 92.8% of cases for LVESVi).

The results of statistical analysis showed that the 3D HeartModel A.I is a reliable and robust method for LVEF and LV volume analysis, which has similar results to 2D echocardiography performed by experienced sonographers.

The assessment of cardiac chambers by 2D echocardiography relies on the use of geometric models which assume that the geometry of the LV or the LA is the same in all the individuals. It has been demonstrated that as a result of different pathophysiological conditions, global or regional modifications of cardiac chamber shape may occur leading to worsened accuracy in volumetric measurements (7). The HeartModel A.I. tracks every frame over the cardiac cycle using 3D speckle technology. The moving contours of LA and LV borders and waveforms, additional LV, LA indexes, LV Mass measurements provide a holistic view of the left heart function, LV wall motion and linkage between the LV and LA volume change over the heart cycle to increase the diagnostic confidence. The multi-beat selection and results average made the heart function evaluation more reliable than single beat in arrhythmia patients such as Atrial fibrillation. Automated 3D HeartModelA.I has been reported to support the importance of LVEF to predict patient outcome and its impact on patient selection for novel therapies. In the last decade, 3DE LVEF has been validated using CMR as a reference modality, and normative values for 3DE LV volumes and EF have been established (6, 16, 25).

This study showed that the use of the 3D HeartModelA.I method was accurate as 2D echocardiography in the evaluation of the left ventricular volumes and ejection fraction. This study showed that 3D HeartModel A.I. method is a reliable and robust method for LVEF and LV volume analysis, which has similar results to 2D echocardiography performed by experienced sonographers (1, 2, 14-17).

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5. DISCUSSION

It is widely accepted that the calculation of LVEF is pivotal in clinical decision-making. Many clinical trials investigating medical therapies for cardiology patients are based on LVEF estimation. More recent data continu
be more reproducible and accurate than 2DE to measure LVEF. 3DE provides a more accurate LVEF quantitation, as it avoids geometric assumptions and left ventricular (LV) foreshortening, has better reproducibility (including test-retest evaluations), and has incremental value to predict adverse outcomes in comparison with conventional 2DE (13, 24, 26).

Compared with 2DE, 3DE HeartModel\textsuperscript{A.I.} is free of the issues related to the foreshortening of LV apical views, does not rely on any geometric assumptions about LV shape to measure LV volumes, and includes the functional contribution of all 18 LV myocardial segments into the calculation of LVEF (13). Moreover, 3DE LVEF has been reported to have higher accuracy, better reproducibility, and lower test–retest variability than 2DE LVEF (5, 12, 26). Accordingly, 3DE seems better suited than 2DE for accurate LVEF quantitation particularly in ischemic patients with abnormal LV geometry or extensive wall motion abnormalities (27). Although previous studies have shown that 3DE LV volumes and LVEF provide increasing predictive power to predict outcomes over their 2DE equivalents (7, 8).

The new fully automated software has been recently validated and found to be reasonably accurate compared to manual 3D measurements using QLAB (3DQ) in a group of over 150 patients at The University of Chicago. This promising software has the potential to enable the integration of 3DE volumetric LV and LA measurements into routine clinical workflows around the globe (7, 8).

Volume assessment by three-dimensional echocardiography relies on the endocardial border tracing through a virtually infinite number of rotational planes, remarkably increasing its accuracy and reproducibility as demonstrated by the numerous studies (9-13). In our study, reproducibility of three-dimensional as opposed to two-dimensional echocardiography derived parameters was confirmed by lower intra- and inter-observer variability. 3D DHM transthoracic echocardiography has advantages and disadvantages. The advantages are:

- Provides easily recognizable images,
- A comprehensive and time-volume analysis of LV function can be obtained from a single 3D TTE dataset,
- Avoids foreshortening associated with 2D TTE, Measurements do not require geometric assumptions about shape, LVEF assessment is accurate and reproducible compared to CMR, Better reproducibility and precision compared with 2D TTE.

The disadvantages can be summarized in the following:
- Requires specific training to acquire and analyses, Arrhythmias makes 3D (multi-beat) acquisition challenging. Limited by poor acoustic windows, Good image quality is required for accurate LV ejection fraction quantification, Lower spatial and temporal resolution compared to 2D TTE, LV volumes underestimated compared to CMR (1, 3, 4, 6).

The reproducibility of the echocardiography techniques showed a marked improvement with the introduction of 3DE in both intra-observer and inter-observer methods and comes close to CMR. The intrabserver standard measurement error of 3DE LVEF has been reported to be 1.7%, whereas the same parameter for 2DE LVEF was twice higher (3.3%) (18, 19). This difference may be clinically relevant for patients undergoing echocardiography to be evaluated for ICD implantation. 3DE LVEF might help to identify patients misclassified using 2DE LVEF, which might account for over 20% of cases of SCD in the community (27, 28, 30).

Visual assessment of LV function on 2D echocardiograms has been used in many hospitals; for example, by estimating the LVEF in 5% steps such as 30-35% or just classifying the LV function as normal, mildly, moderately, or severely impaired. The reason for using a visual rather than a quantitative assessment is the extra time needed to calculate LV volumes and difficulties to trace the endocardial borders on still frames (3). In the past, three-dimensional (3D) echocardiography was cumbersome and time consuming, limiting its application to research or studies outside the operating room. Recent technical improvements have allowed real-time assessments with faster and easier use of 3D echocardiography. In this setting, several studies using transthoracic echocardiography (TTE) have definitely demonstrated the superiority of 3D over 2D echocardiography, because fully automated detection of the LV endocardial borders allows rapid, accurate, and reproducible measurements of LV volumes, showing higher correlation with the reference standards of magnetic resonance imaging (MRI) and ventriculography. 3D echocardiography eliminates the need for cognitive reconstruction of LV shape by the clinician operator and use of geometric assumptions for LV quantification (12, 15).

3DE HeartModel\textsuperscript{A.I.} LVEF and volumes assessment has been reported to be accurate and reproducible when compared with cardiovascular magnetic resonance (CMR) in a myriad of pathologies and in healthy volunteers or quantitative gated single photon emission computed tomography in patients with coronary artery disease and superior to 2D TTE (15). A meta-analysis of 23 studies, including 1638 TTE datasets, confirmed that 3D TTE is superior to 2D TTE but underestimated volumes when compared with CMR (15). Chukwu et al. (2008) report this phenomenon to be more likely in patients with larger end-diastolic volumes, possibly due to the fact that large ventricles may not fit within the probe’s scanning sector and issues with accurate endocardial border detection. Despite this caveat, 3D TTE is superior to 2D TTE in providing better reproducibility and precision (20).

An interesting point is that whilst chemotherapy related cardiac dysfunction is defined as a decrease in the LVEF of 10% from baseline to a value below the lower limit of normal; Thavendiranathan et al. (2013) reported that the minimal identifiable difference by 2D TTE (biplane method of LVEF estimation) is 9%, contrast use did not significantly alter this difference (9.8%) whilst 3D TTE LVEF was reported to have a minimal identifiable difference of 4.8%. This has important implications for echocardiography departments involved in following up oncology patients (18, 20).

Besides being an accurate modality for LV ejection fraction (LVEF) estimation, 3D TTE derived LVEF has
superior prognostic utility when compared with 2D LVEF according to two single center studies. The first study reported that in 455 patient’s 3D LVEF had superior incremental value when compared with 2D LVEF in stepwise Cox regression analyses to predict all-cause death or cardiac hospitalization at 6.6±3.4 years follow-up. The second study reported similar findings in 724 patients at 3.7±1.1 years follow-up (16, 17, 18).

In a common busy echocardiography laboratory, a representative number of 40-50 studies with acquisition and analysis in 2DE take almost 3 hours (176 minutes) with HeartModelAl (66 minutes with minor editing and 31 minutes without editing). With 2DE as the actual reference, a decrease in acquisition and analysis times of 63% for HeartModelAl, with minor editing and 82% without editing were noted. To allow the 3DE technology to be used routinely in clinical laboratories there is a need to implement automated methods that overcome the time-consuming workflow dictated by 3DE today (24, 25).

Current medical guidelines recommend 3DE chamber quantification for patients undergoing an echocardiography exam, but adoption in clinical practice has lagged due to time-consuming analysis that has traditionally been associated with the process. By showing that experienced readers in different parts of the world can obtain accurate and reproducible automated measurements of LVEDV, LVESV and LVEF with clinically non-significant differences, this research demonstrates that HeartModelAl is a time-saving option that yields consistent, reproducible results across laboratories (6, 24-26).

In this study we have shown that it is feasible and to obtain more accurate LV volumes and LVEF by using 3DE HeartModelAl. It provided highly reproducible results, with low intra-observer, inter-observer and inter-examination variability. These accurate and reproducible results were achieved rapidly, with data analysis being performed online. Importantly, we see the greatest virtue of this new technique that is poised to become part of the routine clinical evaluation of LV function in its speed, ease of use, reproducibility and accuracy (8, 13, 19).

6. CONCLUSION

This study showed that the use of the 3D HeartModelAl method was accurate as 2D echocardiography in the evaluation of the left ventricular volumes and ejection fraction. HeartModelAl, 3DE provides a more accurate LVEF quantitation, as it avoids geometric assumptions and left ventricular (LV) foreshortening, has better reproducibility (including test-retest evaluations), and has incremental value to predict adverse outcomes in comparison with conventional 2DE. LVEF by 3DE was superior and more accurate in evaluation LVEF in patients with LV dysfunction. In this study, we found that 3DE DHM fully automated tool is also significantly faster than 2DE analysis and thus can help overcome the time-consuming nature and its present a strong argument for its incorporation into the clinical workflow. These findings could contribute to fuller integration of 3DE quantification into clinical routine. Automated 3DE provides a comprehensive picture of heart function with real-time results, which can help clinicians assess and diagnose patients quickly and confidently.

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