

Original Article

Exploring left ventricle dimensions and interventricular septum thickness in the Iranian population: A comparative analysis through ECG gated, CT angiography and echocardiography

Naser Khezerlouy-Aghdam (MD)¹Shahla Meshgi (MD)¹Zahra Hosnavi (MD)¹Haleh Bodagh (MD)¹Mohammadreza Motazedian (MD)²Razieh Parizad (PhD)^{1,3}Asma Yousefzadeh (MD)^{1*}

1. Cardiovascular Research Center, Tabriz University of Medical Sciences, Tabriz, Iran

2. Fassa University of Medical Sciences, Fassa, Iran

3. Tabriz University of Medical Sciences, Tabriz, Iran, Faculty of Nursing and Midwifery, Tabriz, Iran

*** Correspondence:**

Asma Yousefzadeh,
Cardiovascular Research Center,
Tabriz University of Medical
Sciences, Tabriz, Iran

E-mail:

Yousefzadehasma@yahoo.com

Tel: +98 4133352077

Abstract

Background: Cardiovascular diseases (CVDs) are a significant cause of morbidity and mortality worldwide, particularly among the Iranian population. Assessing left ventricular (LV) dimensions and interventricular septum (IVS) thickness is crucial in diagnosing and managing various cardiac conditions. This study aimed to compare LV dimensions and IVS thickness using electrocardiogram (ECG) gated computed tomography angiography (CTA) and echocardiography.

Methods: A cross-sectional study was conducted on 160 Iranian individuals without known CVD from March to September 2023 in Hospital, Tabriz, Iran. Participants underwent both ECG-gated CTA and echocardiography for assessment of LV dimensions and IVS thickness. Measurements were performed by experienced radiologists and cardiologists, respectively. Echocardiography and CTA were analyzed for their correlation using Pearson's correlation coefficient. Statistical analysis was conducted using SPSS V25 software.

Results: The study revealed a significant correlation between various LV dimensions and wall thickness measurements obtained from echocardiography and CTA ($p < 0.000$). Strong and significant correlations were found in measurements taken from different views and regions of the heart, including the parasternal long-axis (PLAX) view, Mid and Base views, and the anteroseptal and inferoseptal regions ($p < 0.000$). Echocardiography measurements also showed significant correlations, with varying strengths.

Conclusion: The comparative analysis of LV dimensions and IVS thickness using ECG-gated CTA and echocardiography demonstrated significant correlations, suggesting the potential clinical utility of both imaging techniques in diagnosing and managing CVD in the Iranian population. The 4-chamber and PSAX methods can be used interchangeably to measure interventricular septum thickness. Further research is required to validate and expand upon these results.

Keywords: Heart ventricles; Ventricular septum; Computed tomography angiography; Echocardiography, Electrocardiography.

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Cardiovascular diseases (CVDs) represent a significant global health challenge, exhibiting various prevalence and impacts across diverse populations (1). Understanding the structural characteristics of the heart, particularly the dimensions of the left ventricle (LV) and interventricular septum (IVS) thickness, is crucial for effective diagnosis and management. Assessing LV function is a fundamental aspect of routine clinical cardiology practice (2).

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Despite the longstanding use of two-dimensional (2D) echocardiography, its limitations in terms of reproducibility and accuracy have led to the exploration of alternative techniques. While echocardiography has been a conventional method due to its portability and lack of contraindications, its limitations, including operator-dependent skills and technical artifacts, have necessitated the exploration of multiple imaging technologies (3). Cardiovascular magnetic resonance (CMR) and cardiac computed tomography angiography (CCTA) have emerged as essential tools for comprehensive and accurate assessment of patients with myocardial diseases. Rapid advancements in CT techniques, offering high temporal and spatial resolution, enable simultaneous evaluation of cardiac injuries alongside coronary vessels (4).

To ensure result accuracy, a comparative study involving dual-source computed tomography (DSCT) and transthoracic echocardiogram (TTE) was conducted and revealed correlations in all measurements except for significant differences in posterior wall thickness and end-diastolic volume/body surface area (EDV/BSA) (5). Similarly, a study comparing transthoracic echocardiogram (TTE and multi-detector computed tomography (MDCT) in heart failure (HF) patients with an ejection fraction (EF) less than 45% showed MDCT tended to overestimate values, though clinical significance remained questionable (6).

The existing discrepancy in studies regarding measurement values in CTA and echocardiography methods, coupled to achieve accurate parameters of size and cardiac function, is crucial for enhancing the accuracy and quality of diagnosis and treatment of CVD. The disparities in results among the different imaging modalities, as well as variations in reference values, underscore the need for clinical studies across populations and using various imaging modalities. This study was designed to investigate the size and thickness of the LV in the Iranian population using both CTA and echocardiography to establish normal values specific to the Iranian population.

Methods

Population: In this cross-sectional study, all individuals without known CAD referred to the CTA department of Madani Hospital, Tabriz, Iran (affiliated with Tabriz University of Medical Sciences) from March to September 2023 were included. The sample size determination was based on the results of the Haneen study, considering a coefficient of correlation parameter alpha equal to 0.01, $p_{wt}=0.21$, a power of 95%, and a 10% error margin, resulting in a sample size of 160 (7). Considering the

inclusion criteria (Iranian patients referred to the CT Angiography Department of Madani Hospital in Tabriz for coronary artery CTA) and exclusion criteria (EF less than 50%, absence of severe coronary stenosis ($>70\%$), uncontrolled hypertension (HTN) (above 130/80 despite medication), diabetes mellitus (DM), body mass index (BMI) ≥ 30 , cases of hypertrophic cardiomyopathy (HCM) and infiltrative diseases, moderate to severe mitral, aortic, or tricuspid valve diseases, inappropriate valve), Iranian population were enrolled in the study.

Image acquisitions: Iranian population in the CT angiography department of Madani Hospital in Tabriz underwent 2D TTE and ECG-gated CCTA.

Transthoracic echocardiography: 2D echocardiography was performed using digital commercial harmonic imaging ultrasound systems equipped with a S3 3 MHz phased-array transducer (Philips IE33, Philips Medical Systems, The Netherlands, or Vivid 7, General Electric's Healthcare Systems, USA) the procedure involved positioning the individual in the left-lateral decubitus position with a raised left arm. Images were adjusted for depth, focus position, and frame rate and sector size for an optimal display of the structure of interest. Images were displayed on the echocardiographic system and measurements were obtained from recordings in the parasternal long-axis (PLAX) acoustic window directly from the 2D images. Using echocardiography in the view PLAX view, the left ventricular end-systolic diameter (LVESD) and left ventricular end-diastolic diameter (LVEDD) were measured from the inner edge to inner edge, perpendicular to the LV axis, just below the tips of the mitral leaflets, at the end of end-systole (ES) and end-diastole (ED). Left ventricular ejection fraction (LVEF) was quantified using a visual assessment method. In the (PLAX view, the LV wall thickness at the end of the diastole was measured at the Mid and Base regions using the outer-edge to outer-edge method. Similarly, in the -chamber view, the LV wall thickness at the end of the diastole was measured at the Mid (outer-edge to outer-edge) and Base regions. In the short-axis view at the papillary muscle level (PSAX), the LV wall thickness at the end of the diastole was measured at the Mid (outer-edge to outer-edge), Base (inferoseptal), and Base (anteroseptal) regions.

Coronary CT angiography: Coronary CTA was performed using a Siemens SOMATOM Sensation 64 multi-detector CT scanner in 133 individuals. Before imaging, study samples received sublingual nitroglycerin and appropriate beta-blockers. Participants in the study were instructed on proper breath-holding techniques. ECG gating was employed for each individual, and imaging was

performed using a retrospective acquisition technique. Imaging parameters included a 0.6 mm slice thickness with a 0.4 mm interval, KVP=120kv, and effective mAs=860 mA. Iodinated contrast material was injected at a dose of 80-100 cc (based on weight) at a rate of 60 cc/s. Multiplanar reconstruction was used for data interpretation and measurement of wall thickness and intracavitary dimensions from standard views and four-chamber, three-chamber, and short-axis views at end-diastole. Using CTA, the LVESD and LVEDD were measured using the leading-edge-to-leading-edge method. These measurements were taken perpendicular to the longitudinal axis of the LV in the 3-chamber view at the ES and ED. It is important to note that the PLAX in echocardiography corresponds to the three-chamber view in CTA. Additionally, individual characteristics including age, gender, height, weight, BMI, smoking status, and other relevant parameters were extracted along with the measured parameters obtained through imaging modalities as mentioned.

Statistical analysis: Measurements of LV size and normal septal thickness between the ventricles were reported using echocardiography and CTA with mean and standard deviation. The comparison of LV wall thickness in the PLAX, parasternal short-axis (PSAX), and four-chamber views, using echocardiography and CTA, was assessed with Pearson correlation. Statistical analysis was performed using SPSS V25 software, and a significance level of $P<0.05$ was considered.

Results

The findings presented in table 1 reveal that the participants' average age was 57.68 ± 11.05 , and their BMI averaged 27.20 ± 3.44 . A predominant 60% of the participants exhibited high blood pressure. LVESD and LVEDD values obtained from echocardiography and CCTA are similar, indicating a consistent measurement of LV diameters between the two imaging modalities (table2). Notable differences in wall thickness values between the two imaging modalities are observed in table3.

Table 1. Anthropometric variables of the study population

	Mean $\pm$ SD*
Age (years)	57.68 $\pm$ 11.05
Weight (kg)	78.76 $\pm$ 11.26
Height (cm)	168.36 $\pm$ 9.26
BMI (kg/m ²)	27.20 $\pm$ 3.44
HTN, n (%)	59 (39.3)
DM, n (%)	17 (11.3)
Smoky, n (%)	16 (10.7)

BMI: Body mass index, HTN: Hypertension, DM: Diabetes mellitus

Table 2. Measurement of LV diameter at end-systole and end-diastole and assessment of LVEF using echocardiography and CT angiography

	Echo	Mean $\pm$ SD*
LVESD (cm)		3.04 $\pm$ 0.39
LVEDD (cm)		4.78 $\pm$ 0.83
LVEF (%)		53.46 $\pm$ 2.31
CCTA		
LVESD (cm)		3.14 $\pm$ 0.42
LVEDD (cm)		4.87 $\pm$ 0.87

LVESD: Diameters at the end of systole, LVEDD: Diameters at the end of diastole, LVEF: Left ventricular ejection fraction, CCTA: Coronary computed tomography angiography

Table 4 demonstrates significant correlations between the measurements of LVEDD and LVESD diameter in the PLAX view ($P<0.001$ and $p<0.000$), as well as LV wall thickness measurements in the PLAX view at Mid and Base ($p<0.000$), using both echocardiography and CTA. Additionally, moderate correlation in LV wall thickness measurements in the Mid four-chamber view, and strong correlation in the Base view using both echocardiography and CTA were observed ($p<0.000$).

Table 3. Measurement of LV wall thickness using echocardiography and CT angiography

	Echo	Mean $\pm$ SD*
PLAX	Mid	9.86 $\pm$ 1.20
	Base	9.74 $\pm$ 1.34
4-chamber	Mid	9.68 $\pm$ 1.22
	Base	9.24 $\pm$ 1.19

	Echo	Mean±SD*
PSAX Base	Anteroseptal	8.94±1.12
	Inferoseptal	9.26±1.08
PSAX Mid	Anteroseptal	9.25±1.09
	Inferoseptal	9.74±1.01
CCTA		
3 chamber	Mid	10.66±2.10
	Base	10.56±2.10
4 chamber	Mid	10.00±2.02
	Base	8.45±1.49
PSAX Base	Anteroseptal	8.48±1.50
	Inferoseptal	8.29±1.34
PSAX Mid	Anteroseptal	9.26±1.66
	Inferoseptal	10.35±5.82

PLAX: Parasternal long-axis, PSAX: Parasternal short-axis

Table 4. Comparison of LV wall thickness and LV diameter measurements using echocardiography and CT angiography

		r	P - value
LVEDD (cm)	Echo CCTA	0.74	<0.001
LVESD (cm)	Echo CCTA	0.88	<0.000
PLAX Mid	Echo CCTA	0.77	<0.000
PLAX Base	Echo CCTA	0.82	<0.000
3-chamber Mid	Echo CCTA	0.56	<0.000
4 chamber Base	Echo CCTA	0.69	<0.000
PSAX Base: Anteroseptal	Echo CCTA	0.77	<0.000
PSAX Base: Inferoseptal	Echo CCTA	0.67	<0.000
PSAX Mid: Anteroseptal	Echo CCTA	0.79	<0.000
PSAX Mid: Inferoseptal	Echo CCTA	0.55	<0.000

*Paired Pearson, Echo: Echocardiography CCTA: Coronary computed tomography angiography, LVEDD: Left ventricular end-diastolic diameter, LVESD: Left ventricular end-systolic diameter, PLAX: Parasternal long-axis, PSAX: Parasternal short-axis

Strong correlation between LV wall thickness measurements in the anteroseptal region of PSAX Base using echocardiography and CTA was found, with moderate and significant correlation identified in the inferoseptal region ($p<0.000$). Furthermore, a strong and significant correlation was found in LV wall thickness measurements in the anteroseptal region of Mid PSAX view using echocardiography and CTA ($p<0.000$), with moderate and significant correlation in the inferoseptal region of PSAX Base ($p<0.000$). Table 5 illustrates that LV thickness measurements using echocardiography in the PLAX Mid view, with PSAX Base, in the inferoseptal region exhibit a relatively weak but significant correlation ($p<0.000$). LV thickness measurements in the PLAX Mid view, with PSAX Base, in the anteroseptal region, and in the -chamber

Mid view, with PSAX Mid, in the inferoseptal region show moderate but significant correlations ($p<0.000$). LV thickness measurements in the 4 chamber Base view, with PSAX Mid, in the inferoseptal region demonstrate a strong and significant correlation ($p<0.000$). Furthermore, LV thickness measurements using CTA in the 3 chamber Mid view with PSAX Base in the inferoseptal region ($P<0.000$), and LV diameter in the 4 chamber Mid view with PSAX Mid in the inferoseptal region ($p<0.036$), exhibit a weak but significant correlation. LV thickness measurements in the 3 chamber Base view with PSAX Mid in the anteroseptal region show a strong and significant correlation ($p<0.000$). Additionally, LV thickness measurements in the Mid 4-chamber view with PSAX Base in the inferoseptal region display a moderate but significant correlation ($p<0.000$).

Table 5. Comparison of LV wall thickness using echocardiography and CT angiography

	r	P-value
ECHO		
PLAX Mid		
PSAX Mid: Anteroseptal	0.49	<0.000
PLAX Base		
PSAX Base: Anteroseptal	0.61	<0.000
4 chamber Mid		
PSAX Mid: Inferoseptal	0.66	<0.000
4 chamber Base		
PSAX Base: Inferoseptal	0.72	<0.000
CCTA		
3 chamber Mid		
PSAX Mid: Anteroseptal	0.69	<0.000
3 chamber Base		
PSAX Base: Anteroseptal	0.23	<.000
4 chamber Mid		
PSAX Mid: Inferoseptal	0.07	<0.36
4 chamber Base		
PSAX Base: Inferoseptal	0.43	<0.000

PLAX: Parasternal long-axis, PSAX: Parasternal short-axis

Discussion

This study aims to compare LV dimensions and IVS thickness in the Iranian population using ECG gated CTA and echocardiography. The results of this study showed that there is a strong correlation between two medical imaging techniques, echocardiography and CTA. Specifically, it implies that both methods are effective for assessing LVEDV and LVESV. The statement further indicates that these measurements can be used interchangeably, meaning

that one can rely on either echocardiography or CTA to obtain similar results for LVEDV and LVESV (8). However, it's noted that there might be slight variations between the two techniques. These differences likely stem from the way certain measurements are taken. In echocardiography, diameters are measured as inner-inner edge, while in CTA, they are measured as leading-leading edge. These distinctions in measurement techniques can lead to minor variations in the calculated volumes, but

overall, both methods are deemed suitable for clinical evaluation. Studies have shown a fair to moderate correlation between LVEDV, LVESV, and LVEF measured using CCTA and echocardiography (9). In addition, MDCT provides comparable results to echocardiography for LVEF and LVV, with a low radiation dose, showing a good correlation between MDCT and 2D-echocardiography for the assessment of LVEDV and LVESV (10). One study showed that there is a good correlation between MDCT and 2D -echocardiography for LVEDV and LVESV assessment, with statistical significance found only between the two modalities for certain parameters (8). The results of this study showed that there is a correlation between echocardiography and CTA in the PSAX view, one may opt to use either of these methods interchangeably. This decision could be influenced by factors such as the suitability of the view and its perpendicularity to the longitudinal axis of the LV in CTA and echocardiography. Precise assessment of LVEF holds significance in the management of patients with diverse cardiac conditions, as it offers prognostic insights and aids in guiding patient care decisions (11-13). Among the array of imaging techniques for assessing LV function, CCTA stands out as a distinctive modality capable of concurrently evaluating LV function and coronary artery anatomy without requiring additional image capture. Nevertheless, one of the constraints associated with CCTA is radiation exposure (14).

The results of this study showed that there is a weak correlation between measurements obtained via echocardiography and CTA in the 4-chamber view, it appears that they are not suitable replacements for each other in this context. One possible reason for this could be the difficulty in obtaining measurements perpendicular to the longitudinal axis of the LV in both imaging modalities. Additionally, distinguishing between the thickness of the septum of the LV and the septum of the right ventricle (RV), as well as identifying the papillary muscles of the mitral valve, may pose challenges in this view. Studies have shown that MDCT-derived LV function parameters, like EF, can be assessed using automated software, showing a good correlation with echocardiography results (15). However, there are differences in measurements between the two methods, with CTA providing more accurate images of heart structures in some aspects compared to echocardiography (16).

The results of this study showed that there is a correlation observed in the PSAX view, specifically in the anteroseptal region at both the base and mid-levels, it suggests that either echocardiography or CTA can serve as suitable alternatives to each other in this context. This correlation implies that

the measurements and findings obtained from echocardiography and CTA in the anteroseptal region at the base and mid-levels are consistent and comparable. Therefore, clinicians or researchers can choose either modality based on factors such as availability, patient preference, or specific clinical requirements without significantly affecting diagnostic accuracy or clinical decision-making. The PSAX view is crucial for assessing LV size and function, and detecting abnormalities like LV hypertrophy. It allows for detailed evaluation of features such as regional and global function, size of ventricles, and characteristics of hypertrophy. The mid-ventricular PSAX view is particularly favored for its reliable portrayal of LV function (17, 18).

The results of this study showed that there is a weak correlation observed in the PSAX view, particularly in the interoseptal region at both the base and mid-levels, it suggests that neither echocardiography nor CTA may serve as good substitutes for each other in this context. The weak correlation implies that measurements and findings obtained from echocardiography and CTA in the interoseptal region at the base and mid-levels may not be consistent or reliably comparable. This inconsistency could be attributed to measurement errors, particularly in individuals with higher blood pressure who are more likely to exhibit hypertrophy in the basal septum. Such hypertrophy can lead to difficulties in accurately measuring and assessing the interoseptal region using either imaging modality.

Therefore, clinicians should be cautious when interpreting results from echocardiography and CTA in the interoseptal region at the base and mid-levels, considering the potential for measurement errors and discrepancies between the two modalities. Additional imaging techniques or clinical assessments may be necessary to confirm findings in this specific region of the heart. Based on the results of this study, a significant correlation was found when comparing septum thickness with both the 4-chamber and PSAX methods. This indicates that these methods can be used interchangeably for each other, especially in patients who do not have good image quality.

Limitations and suggestions: Our study has some limitations. The study included participants from a single hospital in Tabriz, which may not be representative of the entire Iranian population.

Suggestions for future researches: Conducting a multicenter study involving multiple hospitals and diverse geographical regions within Iran would provide a more representative sample and increase the generalizability of the findings.

The findings demonstrated a strong correlation between these imaging techniques, indicating their effectiveness in assessing LVEDV and LVESV. The interchangeability of measurements between echocardiography and CTA suggests that either modality can be used for clinical evaluation. However, caution is advised in interpreting results, particularly in the four-chamber view, where a weak correlation was observed. Despite this, both modalities offer valuable insights into cardiac function and aid in clinical decision-making. Further research and technological advancements in imaging may refine our comprehension of cardiac conditions and enhance patient care. The 4-chamber and PSAX methods can be used interchangeably to measure interventricular septum thickness.

What is current knowledge? The current understanding is that CVDs are a significant cause of morbidity and mortality worldwide, including in the Iranian population. Assessing LV dimensions and IVS thickness is crucial in diagnosing and managing various cardiac conditions. Different imaging modalities, such as ECG gated CTA and echocardiography, have been used individually to assess these parameters.

What is new here? This study contributes to the existing knowledge by comparing LV dimensions and IVS thickness in the Iranian population using both ECG gated CTA and echocardiography. The novelty lies in the direct comparison and correlation analysis between these two imaging techniques for assessing LV dimensions and IVS thickness. The study reveals significant correlations between measurements obtained from both modalities in CCT, including various views and regions of the heart. Additionally, the study identifies specific correlations between measurements taken from different views and regions, providing insights into the associations between LV dimensions and IVS thickness in the Iranian population.

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Yosefzadeh, Shahla Mashky, Mohammadreza Motazedian. Investigation: Naser Khezelouy-Aghdam, Project administration: Haleh Bodagh, Mohammadreza Motazedian. Supervision: Haleh Bodagh, Writing—original draft: Razieh Parizad. Writing—review & editing: Razieh Parizad.

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