

ORIGINAL ARTICLE

ECHOCARDIOGRAPHIC PARAMETERS OF PAKISTANI ADULTS WITH NORMAL ECHOCARDIOGRAM

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Objectives: The objective of this study was to determine the ranges of normal 2D and Doppler echocardiographic parameters in Pakistani population.

Methodology: In this cross-sectional study a total of 108 adults with normal echocardiogram were included. Comprehensive transthoracic echocardiogram was done and right and left sided chambers and mitral inflow velocities were measured. Normal ranges were computed as mean $\pm 2 \times$ SD (standard deviation) and normal ranges were compared with the American Society of Echocardiography (ASE) recommended normal ranges.

Results: A total of 108 healthy individuals were included in this study, a majority, 64.8% (70) were male and mean age was 32.48 ± 7.7 years with 58.3% (63) ≤ 32 years of age. Local normal reference ranges for most of the parameters are relatively narrower than the ASE reference ranges. Both the minimum and maximum reference values for most of the parameters are smaller in our population as compared to the ASE reference ranges. When comparing mitral inflow velocities, E wave in our population has higher velocities and small deceleration time while A wave has lower velocities than in the western population. Local normal reference range for the LVEF was observed to be mostly similar to the ASE reference ranges for both genders.

Conclusion: Comparing our results with internationally recognized ASE recommended values, it becomes evident that our population especially males have small LV dimensions and volumes. LV dimensions are important when decisions are taken about surgeries in valvular heart diseases like aortic regurgitation and mitral regurgitation.

Keywords: Echocardiography, reference values, Pakistani adults, ASE (American Society of Echocardiography)

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INTRODUCTION

The foundation of producing cardiac images lies in the ability to quantify the size of cardiac chambers and assess its functional capacity.¹ Echocardiography is the most frequently employed technique in this regard due to its distinctive capacity to produce moving images of the pounding heart along with its easy accessibility and mobility.² There are official recommendations that are created and disseminated for standardizing the various techniques used in the quantification of cardiac chambers.¹ Therefore, upon use by the physicians, it ensures that the standards are uniform and help in the overall communication process.^{3,4}

With the advancements in technology and alterations in echocardiographic practice over the past few years, there is a growing need for updating recommendations which were originally established for quantifying cardiac chambers, this was the aim of the group collected together from the American Society of

Echocardiography and the Association of Cardiovascular Imaging in Europe.^{1,5,6}

Measurements of the cardiac chambers, great arteries along with measurement of spectral Doppler and tissue Doppler are essential for comprehensive echocardiographic evaluation. Current echocardiographic guidelines recommend that for comprehensive echocardiographic study physicians should measure and provide detailed information on both right and left sided cardiac chambers when evaluating patients.⁶⁻⁹ There are guidelines available for standard technical performance and interpretation of data generated by comprehensive examination.⁶ Although there are reports on normal echocardiographic data, reference values for cardiac structure and function may be influenced by physical characteristics of the target population.¹⁰ Therefore, reference values from one population cannot be extrapolated to other populations.

All the echocardiographic parameters that are used to compare during echocardiographic studies are derived

from those defined in the western world. We till date do not have a proper reference range based on studies conducted in Pakistan and some other countries of South Asia.¹¹ It is a well-known fact that the population in South Asia has a very much different genetic and physical makeup as compared to the population in the west. The difference in the body size in itself brings into the question the reference range that we quote as normal values derived from studies conducted in the west.^{2,11,12}

The aim of this study is to establish reference values for echocardiographic measurements of cardiac chambers, great arteries, and Doppler and tissue Doppler studies in adult Pakistanis that can be applied in epidemiologic studies, clinical trials and clinical practice. Since most of the parameters vary with gender and age, reference values should be stratified for gender and age.

METHODOLOGY

Our study was cross-sectional study conducted in a single hospital evaluating normal Pakistani adult subjects using comprehensive transthoracic echocardiography (TTE). We included adult subjects with normal echocardiography, between 18 to 75 years of age, and who had no significant cardiac disorders or clinical illnesses that might affect cardiac structure and function, such as hypertension and diabetes. We also excluded subjects if a structural or functional abnormality on the cardiac valve or cardiac chamber was evident during echocardiographic examination. All study patients agreed to provide their information for research purposes and the study protocol was approved by the institutional review board. Verbal informed consent was taken from the subjects.

Echocardiographic images were acquired and measured using GE Vivid s60 echocardiography machine. TTE measurements were performed according to the American Society of Echocardiography guidelines.^{4,13,14} All TTE variables were measured in three cardiac cycles and average values were taken. Left ventricular (LV) end diastolic dimension (LVEDD), interventricular septal wall thickness (IVST), LV posterior wall thickness (LVPWT), and the dimension of the aortic root were measured at end-diastole. LV dimensions (LVEDD and LVESD) and LV wall thickness (IVST and LVPWT) were also measured on 2D images using parasternal views. LV volumes and ejection fraction were measured using the biplane Simpson's method on apical 4-chamber and 2-chamber views. LV end-diastolic and end-systolic volume (LVEDV and LVESV) were measured and indexed to BSA. The basal RV dimension was measured in the RV-focused

apical 4-chamber view at end- diastole. Proximal RV outflow tract dimension was measured in parasternal long axis view. The LV end-systolic dimension (LVESD) and left atrial (LA) anteroposterior dimension were measured at end-systole. LVEDD and LVESD were indexed to body surface area (BSA). LA volume was calculated using both the ellipsoid method and the area-length method and indexed to BSA. Right atrial (RA) transverse dimension was measured on an apical 4-chamber view. Images for aortic root measurement were acquired on a zoomed parasternal long-axis view and dimension of the sinus of Valsalva was measured at end-diastole using leading edge to leading edge techniques. Briefly, on the apical 4-chamber view, mitral inflow velocities were obtained using pulsed-wave (PW) Doppler imaging with a 1–3 mm sample volume placed between the mitral leaflet tips during diastole. Early diastolic (E) velocity, late diastolic (A) velocity and mitral E wave deceleration time (DT). Mitral annular velocities were obtained at the septal mitral annulus from the apical 4-chamber view using TDI. Early diastolic annular (e') velocity of septal annulus was measured.

All the parameters and collected information were recorded using a predefined structural proforma. After quality assessment of the data, IBM SPSS Statistics for Windows, Version 21.0. (IBM Corp., Armonk, NY, US) was used for the analysis of data. Each of the TTE parameter were assessed for the outlier values. Lower bound (LB) for the detection outlier values as computed as $LB = \text{interquartile range (IQR)} - 2.2 \times Q1$ (first quartile) and upper bound (UB) was calculated as $UB = \text{interquartile range (IQR)} + 2.2 \times Q3$ (3rd quartile). Any value beyond these limits were labeled as outlier and were removed from the analysis. Normal reference rage was computed mean $\pm 2 \times SD$ with lower limit of reference range as mean - $2 \times SD$ and upper limit of reference range was computed as mean + $2 \times SD$.

RESULTS

A total of 108 healthy individuals were included in this study, a majority, 64.8% (70) were male and mean age was 32.48 ± 7.7 years with 58.3% (63) ≤ 32 years of age. Mean body surface area was observed to be 1.9 ± 1.5 m². Our estimated normal reference ranges for the local population for various parameters are presented in the Table 1 and 2 below.

Gender stratified comparison of local reference ranges with ASE reference ranges for various echocardiographic parameters are presented in Figure 1. Local normal reference ranges for most of the parameters are relatively narrower to the ASE reference ranges. Both the minimum and maximum

reference values for most of the parameters are smaller in our population as compared to the ASE reference ranges. When comparing mitral inflow velocities, E wave in our population has higher velocities and small deceleration time while A wave has lower velocities than those in ASE references. The local normal

reference range for the LVEF was observed to be mostly similar to the ASE reference ranges with the range of 51-71% vs. 52-72% for male and 50-73% vs. 54-74% for the female patients respectively, as presented in Figure 2.

Table 1: Estimated normal reference ranges for the Pakistani population for various left ventricular parameters

Parameter	Male		Female		Local Reference [2-SD range]	
	N	Mean ± SD	N	Mean ± SD	Male	Female
LV internal dimension						
Diastolic dimension (cm)	69	4.4±0.3	38	4.1±0.4	3.7-5	3.4-4.9
Systolic dimension (cm)	70	2.6±0.3	38	2.5±0.4	2-3.3	1.7-3.2
LV diastolic diameter/BSA (cm/m ²)	70	2.4±0.2	38	2.6±0.2	2-2.8	2.2-3
LV systolic diameter/BSA (cm/m ²)	70	1.5±0.2	36	1.5±0.2	1.1-1.8	1.1-1.9
LV volumes (biplane)						
LV EDV (mL)	70	69.3±15.8	38	60.3±17.8	38-101	25-96
LV ESV (mL)	69	26.5±7.5	37	24.3±8.9	11-42	7-42
LV EF % (biplane)	70	61.3±5.1	38	61.6±5.7	51-71	50-73
LV volumes normalized by BSA						
LV EDV (mL/m ²)	67	38.9±6.8	38	37.9±9.1	25-52	20-56
LV ESV (mL/m ²)	69	15±3.3	36	14.9±3.8	8-22	7-22
LV wall indices						
Septal thickness (cm)	70	0.8±0.1	38	0.7±0.1	0.6-1	0.5-0.9
Posterior wall thickness (cm)	70	0.8±0.1	38	0.7±0.1	0.6-1	0.5-0.9

Table 2: Estimated normal reference ranges for the Pakistani population for various other parameters

Parameter	Male		Female		Local Reference [2-SD range]	
	N	Mean ± SD	N	Mean ± SD	Male	Female
LA and RA size						
AP dimension index (cm/m ²)	70	1.6±0.2	37	1.7±0.2	1.2-2	1.2-2.2
AP dimension (cm)	70	3±0.4	38	2.8±0.4	2.2-3.7	2-3.6
Maximum LA volume/BSA (mL/m ²)	70	17.3±4.6	38	18.6±4.8	8.2-26.4	9-28.3
Aortic root dimensions						
Sinuses of Valsalva	69	2.7±0.3	38	2.6±0.4	2.2-3.3	1.8-3.4
RA and RV chamber size (both gender combined)						
RA minor diameter (mm)	108	30.81±4.19			22.42-39.2	
RV basal diameter (mm)	107	30.79±3.47			23.86-37.73	
RVOT PLAX diameter (mm)	108	21.63±3.12			15.4-27.86	
RV function Parameters (both gender combined)						
TAPSE (mm)	108	20.63±2.33			15.98-25.28	
Doppler and Tissue Doppler measurements (both gender combined)						
DTE	105	159.3±30.22			98.87-219.74	
Mitral E	108	81.46±16.6			48.27-114.66	
Mitral A	106	57.18±12.52			32.13-82.23	
E'	98	10.43±2.49			5.45-15.41	
Mitral E/E'	105	8.1±2.05			4-12.21	

DISCUSSION

In this study, standard 2D measurements along with Doppler study were taken. Most of the patients were young males. Regarding echocardiographic parameters in our study males as compared to females have large LV dimensions and volumes. This difference becomes negligible if the values are indexed. The septal and posterior wall thickness is same in both genders. But our overall results show that our population has comparatively small chamber sizes and volumes with respect to the western population.

There has been similar studies done in different countries like the one done by Choi J-O et al.¹⁵ and Yao G-H et al.¹⁶ for the Korean and Chinese population respectively. Another study carried out by Prajapati D et al.¹² documented the standard echocardiographic values for a small sample size of the population in Nepal. Various other studies are carried out in different countries assessing cardiac chambers in their population.^{10,11,16-19} A very popular study the NORRE study was conducted in European population to provide 2D echocardiographic reference ranges for cardiac chamber quantification.¹⁴

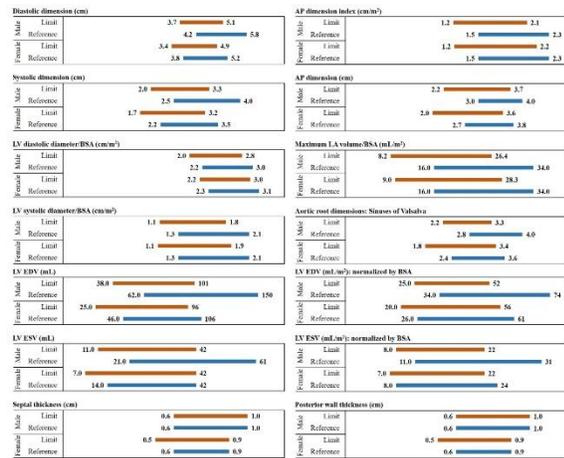


Figure 1: Comparison of local references ranges with ASE reference ranges for various echocardiographic parameters stratified by gender

Finally, the World Alliance Societies of Echocardiography (WASE) Normal Values Study evaluates individuals from multiple countries and races with the aim of describing normative values that could be applied to global community worldwide and to determine differences and similarities among people from different countries and races.³ It states that the current guideline-recommended normal ranges for LV volumes and LVEF should be adjusted. Inter-country variability is significant for LV volumes, and therefore nationality should be considered for defining ranges of normality.²⁰

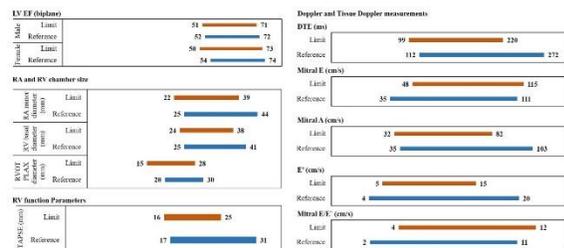


Figure 2: Comparison of local references ranges with ASE reference ranges for various echocardiographic parameters

Therefore, it becomes imperative to do study for establishing standard reference values for the Pakistani population since no such work has been done in the past. This study is the first one to be carried out in our setup involving the sufficient sample size to this date. Even for a single country, the wide range of information collected using these studies illustrates the impact of lifestyle, race, ethnicity and BSA on echocardiographic parameters. Therefore, in order to achieve standard reference values for the Pakistani population, there is a need for carrying out a nationwide database that is sizeable enough to generalize the findings across the whole country.

The main limitation of this study was small sample size and the relative younger age of the chosen population, in our study we only used 2D methods for reporting standard echocardiogram. In future for the purposes of clinical research, 3D echo might provide great use as it measures ventricular volume, mass and geometry without having the need to use mathematical equations and formulae which may be not suitable for the present anatomy of the human heart. Moreover, although the study was carried out at a center with a high volume of patients still the sample size was not quite large, and the study was carried out at single center, therefore the results from this study may not be used for generalization purposes across the whole population of Pakistan. Last but not least is inter observer variability which is seen throughout while reporting echocardiogram.

CONCLUSION

Our male population has larger cardiac chambers as compared to females. While comparing our results with internationally recognized ASE recommended values, we come to conclude that our population especially males have small LV dimensions and volumes. So our severely dilated left ventricles could only be moderate enlargements in their population. LV dimensions are important when decisions are taken about surgeries in valvular heart diseases like aortic regurgitation and mitral regurgitation. Therefore, we need further studies to be carried out on larger scale throughout the country with large sample size to set our own references that will surely influence our clinical practice and decision making.

AUTHORS' CONTRIBUTION

SG, MN, LB and IJB: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. SR and FH: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

Conflict of interest: Authors declared no conflict of interest.

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