Study of Echocardiographic Measurements to Estimate the Physiological Cardiac Efficiency in Apparently Healthy Patients Visiting University Hospital for Cardiac Evaluation

Nepal O,[1] Humagain S,[2] Koju RP[2]

[1]Department of Physiology

[2]Department of Internal Medicine/Cardiology

Kathmandu University School of Medical Sciences,

Dhulikhel, Kavre, Nepal.

Corresponding Author

Ojashwi Nepal

Department of Physiology,

Kathmandu University School of Medical Sciences,

Dhulikhel, Kavre, Nepal.

E-mail: ojan2nep@gmail.com

Citation

Nepal O, Humagain S, Koju RP. Study of Echocardiographic Measurements to Estimate the Physiological Cardiac Efficiency in Apparently Healthy Patients Visiting University Hospital for Cardiac Evaluation. *Kathmandu Univ Med J.* 2021; 76(4): 424-8.

ABSTRACT

Background

Healthy cardiac function is evaluated by echocardiography in the non-invasive cardiology department. Cardiac functional and structural evaluation is assessed by cardiologists based on a physiologically defined normal range. We want to compute the physiological value of variables in the healthy population.

Objective

To compute and compare the recorded echocardiographic parameters among apparently healthy patients.

Method

This is a retrospective study and a total of 544 subjects whose standard reference range was within the normal limit are included for computational study. 268 males (52.8%) and 240 females (47.2%) were studied for the size of the aortic root, size of the left atrium, left ventricular internal diameter during diastole (LVIDd) and systole (LVIDs), interventricular septum during diastole and systole (IVSd and IVSs), left ventricular posterior wall during diastole (LVPWd) and systole (LVPWs) and ejection fraction (EF).

Result

Ejection fraction (EF) is not significantly different (p=0.14) between genders, Mean±SD; 70.45±6.7 for females and Mean±SD; 68.34±7.18 for males. The mean age of examined female patients is Mean±SD; 36.88±12.6 which is not significantly different with male patients age Mean±SD; 38.28±12.5. Males have larger left ventricular internal diameter in diastole, Mean±SD; 43.90±6.4 than females Mean±SD; 41.37±8.08. Ejection fraction for females is Mean±SD; 70.45±6.7, for males is Mean±SD; 68.34±7.18 with p=0.14.

Conclusion

Absolute echocardiographic measurements vary physiologically between apparently healthy genders yet the ejection fraction is not significantly different between both the genders in the examined Nepali population.

KEY WORDS

Diastole, Echocardiography, Ejection fraction, Systole, Ventricular

INTRODUCTION

Cardiac function is well studied by the utilization of echocardiographic ultrasound systems. Echocardiographic examination of patients visiting the non-invasive cardiology department has become a routine investigation to assess the anatomy and physiology of the heart. Heart functions and anatomical adjustments during systole and diastole are identified with a well-defined range for clinical purposes.[1] Normal values have been studied for the native population of different countries.[2] Differences in recorded parameters from defined standard values for echocardiographic examinations have been documented.[3] Here, we compute the recorded parameters among patients whose echocardiographic findings are within the normal range and compare them to the defined standard reference range.

METHODS

This is a retrospective study of echocardiography findings of patients visiting the cardiac outpatient department in Dhulikhel Hospital from the year of September 2016 to March 2021. Out of recorded 4969 patients, 544 of them had normal echocardiography findings. The age range of patients with normal echo findings in OPD including both genders was from 4 years to 77 years old. Patients 18 years and above are included in the study. A total of 544 subjects whose standard reference range was within the normal limit are included for computational study. The data set of 28 subjects were excluded due to a minimum age limit of 18 years and a maximum of 77 years, for inclusion in the analysis. Now, out of 516 subjects, age values for 8 subjects were not available, as obtained from the record, thus were not included in the study. The remaining 508 subjects i.e., 268 males (52.8%) and 240 females (47.2%) were studied for the size of the aortic root, size of the left atrium, left ventricular internal diameter during diastole (LVIDd) and systole (LVIDs), interventricular septum during diastole and systole (IVSd and IVSs), left ventricular posterior wall during diastole (LVPWd) and systole (LVPWs) and ejection fraction (EF). Amongst available measurements, LVIDd, LVIDs, IVSd, LVPWd, and EF were parameters in 503, 502, 504, 504, and 503 subjects respectively, of the obtained data sheet, from the record. The availability of data is not uniform for recordings made in the studied population. However, LVIDs, IVSd, LVPWd, and ejection fraction (EF) are major echocardiographic parameters evaluated for normal heart function by cardiologists as per locally established clinical practice, thereby data is available for maximum individuals of the studied population for those parameters. Mean and SD for age in females was 36.8±12.6 and in males was 38.2±12.5. Procedure for examination was performed by cardiologists on duty at the noninvasive cardiology unit utilizing Philips EPIQ 7 echocardiography machine for two-dimensional (2D) guided M-mode measurements of the patients. Obtained records for mentioned parameters are described as mean and standard deviation. P-value less than 0.05 is deemed significant for performed analyses in the entire and gender-specific population. The reference range for each parameter was calculated by a 95% confidence interval for the mean. Three subjects with an age range above 67 years were excluded by SPSS due to less number of subjects in the group range. Mean and SD obtained for evaluated parameters were compared with reference values of two different populations by utilization independent sample t-test. Computation of left ventricular blood volume is performed by Teichholz formula.[4]

[7/(2.4+LVIDd)] (LVIDd)^3

Computation of ejection fraction by the echocardiographic software is made by subtraction of the end-systolic volume from the end-diastolic volume over end-diastolic volume;

(EDV-ESV)/EDV

Measured echocardiography variables were studied with 95% CI for six age range starting from 18 years till 77 years. Since the sample size for the sixth age range was the smallest i.e. 3 subjects (0.6%), the software could not compute values for the group. Five age range with computed normative values has been mentioned in the result.

RESULTS

A total of 508 healthy subjects, echocardiographic measurements as mentioned in table 1, has mean and standard deviation along with 95% confidence interval for normal range of examined variables. The number of patients varies for variables examined due to the unavailability of entries in the record sheet of the department. However, clinically important seven echocardiographic variables are close to the total numbers of included patients in the study.

Table 1. Descriptive echocardiographic measurement values in the examined population

	Frequency (N)	Mean±SD	95% CI (LB/UB)
Age	508	37.5±12.5	34.7,40.3
Aortic root(mm)	497	29.3±3.8	28.4,30.1
Left atrium (mm)	497	32.9±3.7	32.1,33.7
LVIDd (mm)	503	42.6±7.3	40.9,44.2
LVIDs (mm)	502	26.0±5.1	24.9,27.2
IVSd (mm)	504	9.6±1.8	9.2,10.0
IVSs (mm)	86	12.2±2.0	11.8,12.7
LVPWd (mm)	504	11.0±3.1	10.3,11.7
LVPWs (mm)	150	13.4±2.7	12.8,14.0
EF (%)	503	69.4±6.9	67.8,70.9

Left ventricular internal diameter during diastole (LVIDd), Left ventricular internal diameter during systole (LVIDs), Interventricular septum during diastole (IVSd) and interventricular septum during systole (IVSs), left ventricular posterior wall during diastole (LVPWd), left ventricular posterior wall during systole (LVPWs) and ejection fraction (EF), Confidence interval (CI), Lower bound (LB), Upper bound (UB).

Means and standard deviation obtained for echocardiographic variables are compared gender-wise. The range for variables with a 95% confidence interval for the mean is mentioned for both genders in table 2. Left ventricular posterior wall thickness in diastole (LVPWd) and ejection fraction (EF) is not significantly different between genders. The age of examined patients is not significantly different for gender comparison and the rest of the variables are significantly different when compared for obtained means. Males have larger left heart dimensions than females yet the ejection fraction is not different significantly between genders.

Table 2. Means and 95% CI of normative values for both gender of all measured echocardiographic variables

	Frequency (N)	Mean±SD	95% confidence interval for Mean (LB/UB)
Age			
Female	240	36.88±12.6	32.89, 40.87
Male	268	38.28±12.5	34.23, 42.34
Aortic root			
Female	234	27.63±3.63	26.49, 28.78
Male	263	31.05±3.17	30.02, 32.08
Left Atrium (LA)			
Female	234	32.10±4.3	30.71, 33.49
Male	263	33.82±2.6	32.97, 34.67
LVIDd			
Female	239	41.37±8.08	38.81, 43.92
Male	264	43.90±6.4	41.82, 45.97
LVIDs			
Female	238	25.07±5.19	23.43, 26.71
Male	264	27.13±4.9	25.53, 28.73
IVSd			
Female	239	9.2±1.86	8.61, 9.78
Male	265	10.08±1.67	9.53, 10.62
IVSs			
Female	46	11.71±2.2	10.99, 12.43
Male	40	12.85±1.69	12.30, 13.40
LVPWd			
Female	239	11.02±4.07	9.74, 12.31
Male	265	11.13±1.79	10.55, 11.71
LVPWs			
Female	75	13.12±3.1	12.14, 14.10
Male	75	13.72±5.2	12.98, 14.46
Ejection Fraction (EF)			
Female	239	70.45±6.7	68.34, 72.57
Male	264	68.34±7.18	66.01, 70.67

Variables recorded as absolute measurements of apparently healthy patients when compared to Egyptian adults and eastern Indian adults, ejection fraction was the only parameter not to differ, significantly.[5] And, remaining variables were significantly different when compared between Nepali to either Egyptians or eastern Indians as depicted in table 3.

Table 3. Means of absolute echocardiographic measurements of native Nepali patients compared to two different populations in Africa and Asia.

	Means of DH values (Total from 508)	Means of Egyptian adults (Total = 1364)	p-value	Means of Eastern Indian adults (Total = 1377)	p-value
Aortic root	29.3±3.8	24.59±2.9	0.000	28±2.5	0.000
Left atrium	32.9±3.7	26.61±3.21	0.000	24.5±3.7	0.000
LVIDd	42.6±7.3	47.86±4.3	0.000	43.6±1.9	0.000
LVIDs	26.0±5.1	30.42±4.3	0.000	27.7±3.1	0.000
IVSd	9.6±1.8	8.71±1.25	0.000	9.0±0.7	0.000
LVPWd	11.0±3.1	8.62±1.28	0.000	8.2±1.0	0.000
EF	69.4±6.9	69.14±6.83	0.467	68.9±5.1	0.089

DH: Dhulikhel Hospital

Gender-based comparisons for echocardiography variables are shown in table 4. Values for aortic root dimension and left ventricular internal diameter during systole are not available in a study by Sullere et al.[6] Between Nepali adults and Indian adults for study performed by Sullere et al. compared all parameters were significantly different wherein ejection fraction was lesser in Indians than Nepali population, but was within the normal standard physiological range (EF=55-80%).[6] In a study of younger eastern Indian adults, LVIDd and EF were found to be equal in means and were not different from Nepali adults.[7] Indian female adults had significantly less ejection fraction in a study performed by Sullere et al. when compared to the Nepali female population.[6] Healthy female eastern Indian adults have significantly larger left ventricular dimensions during diastole and systole than healthy Nepali adult females yet the ejection fraction is significantly lesser in eastern Indian females but was well within the standard normal range for the measured parameters.

Mean, SD, and 95% CI is calculated for five age groups. Patients of 18 years of age to 67 years are divided into five age groups with ten years interval in each group as expressed in table 5.

DISCUSSION

As per the reference values of the clinical lab at the site of echocardiographic imaging measurements of the aortic root, left atrium, and LVIDd are < 40 mm, < 40 mm, and < 55 mm respectively. LVIDs, IVSd, and ejection fraction are < 45 mm, up to 12 mm, and 55-80% respectively. Values of measured parameters either in a total of means or as discreet to respective genders are within the normal limit. However, measured values do differ significantly while comparing to populations of Egypt and India.

Table 4. Means of absolute echocardiography variables for Nepali males and females are compared with respective gender with two different Indian populations

	Nepali (DH)		Sullere et al.[6]				Eastern Indian adults[7]			
	Male	Female	Male (444)	P-value	Female (263)	P-value	Male (773)	P-value	Female (604)	P-value
Aortic root	31.05±3.1	27.6±3.6	NA	NA	NA	NA	27.9±2.5	0.000	28.1±2.5	0.033
Left atrium	33.82±2.6	32.1±4.3	33.10±3.2	0.002	30.80±3.6	0.000	24.5±3.6	0.000	24.5±3.7	0.000
LVIDd	43.9±6.4	41.37±8.08	47.2±4.0	0.000	44.4±4.3	0.000	43.6±2.0	0.250	43.6±1.9	0.000
LVIDs	27.13±4.9	25.07±5.19	NA	NA	NA	NA	27.7±3.1	0.028	27.70±3.1	0.000
IVSd	10.08±1.6	9.20±1.86	11.00±1.00	0.000	10.20±1.2	0.000	9.00±0.70	0.000	9.00±0.70	0.024
LVPWd	11.13±1.79	11.02±4.07	10.80±0.80	0.001	10.20±1.00	0.002	8.30±1.00	0.000	8.20±1.00	0.000
EF	68.34±7.18	70.45±6.7	60.60±4.9	0.000	62.20±5.1	0.000	68.70±4.80	0.359	69.10±5.5	0.003

Table 5. Means of normative values ofclinicallymeasured echocardiographic variables in five different age groups of examined population

	Age group in years	Frequency (N)	Percent (%)	Mean±SD	95% confidence interval for Mean (LB/UB)
Aortic root					
1	18-27	103	20.3	27.94±3.71	25.96, 29.92
2	28-37	179	35.2	28.54±3.44	27.20, 29.87
3	38-47	131	25.8	31.73±3.49	29.80, 33.67
4	48-57	74	14.6	29.38±4.12	27.17, 31.58
5	58-67	18	3.5	30.40±3.50	26.05, 34.75
Left Atrium (LA)					
1	18-27	103	20.3	30.56±4.24	28.30, 32.82
2	28-37	179	35.2	33.96±3.08	32.77, 35.16
3	38-47	131	25.8	33.07±3.71	31.01, 35.12
4	48-57	74	14.6	33.13±3.94	31.02, 35.23
5	58-67	18	3.5	33.80±2.16	31.11, 36.49
LVIDd					
1	18-27	103	20.3	43.06±5.60	40.08, 46.05
2	28-37	179	35.2	43.21±7.19	40.43, 46.00
3	38-47	131	25.8	40.93±11.71	34.45, 47.42
4	48-57	74	14.6	42.69±4.68	40.19, 45.18
5	58-67	18	3.5	42.40±5.72	35.29, 49.51
LVIDs					
1	18-27	103	20.3	26.13±4.01	23.99, 28.26
2	28-37	179	35.2	26.14±4.75	24.30, 27.99
3	38-47	131	25.8	26.07±6.94	22.22, 29.91
4	48-57	74	14.6	26.19±5.52	23.24, 29.13
5	58-67	18	3.5	25.20±4.91	19.09, 31.31
IVSd					
1	18-27	103	20.3	8.69±2.52	7.34, 10.03
2	28-37	179	35.2	9.54±1.45	8.97, 10.10
3	38-47	131	25.8	10.07± 1.43	9.27, 10.86
4	48-57	74	14.6	10.13±1.70	9.21, 11.04
5	58-67	18	3.5	10.20±1.78	7.98, 12.42
LVPWd					
1	18-27	103	20.3	10.00±1.93	8.97, 11.03
2	28-37	179	35.2	11.00±1.82	10.29, 11.71
3	38-47	131	25.8	12.80±6.08	9.43, 16.17
4	48-57	74	14.6	10.50±1.75	9.57, 11.43
5	58-67	18	3.5	11.60±1.14	10.18, 13.02
Ejection Fraction (EF)					
1	18-27	103	20.3	68.94±4.47	66.55, 71.32
2	28-37	179	35.2	69.59±8.01	66.48, 72.70
3	38-47	131	25.8	68.15±7.43	64.04, 72.27
4	48-57	74	14.6	70.00±7.32	66.10, 73.90
5	58-67	18	3.5	72.00±41.50	64.00, 80.00

Though studies have mentioned many variables examined during the routine echocardiographic examination, by practice in local clinical setup, cardiologists assess aortic root dimension, left atrial anteroposterior dimension, left ventricular internal diameter during diastole, left ventricular diameter during systole, interventricular septum thickness during diastole, left ventricular posterior wall thickness in diastole and ejection fraction for heart functions and structure.

Echocardiographic measurements remain a standard non-invasive imaging tool for the evaluation of heart functions and their structure. Interestingly, differences in echocardiographic measurements for genders, ethnicity, and race have been reported in various studies.[8-10] These physiological variations for measured parameters are evident between genders in apparently healthy patients of this study for compared means. Absolute measurements of LVPWs and EF are not significantly different between genders in our findings of the study. Previous measurements in the Nepali population performed by Prajapati et al. have reported significant gender differences in many of the variables but the ejection fraction.[11] The finding is consistent with the report in this study.

Dimensions of the heart may vary among different populations yet the percentage of blood ejected is not

significantly different. This is evident from table 3. The gender-based comparison shows the normal mean value of ejection fraction to be on the upper side of the limit in Nepali males and females than Indian population healthy subjects but, means of ejection fraction of Nepali adults are closer to eastern Indian adults. Examined cardiac dimensions differ among adult populations of different countries and the contractile function of the heart as designated by ejection fraction also varies significantly.

Since the general characteristics of patients were not documented in the database, body mass index could not be calculated and compared for indexed values. Absolute measurements expressed are limited to essential variables as provided in the database and standard reference range for all echocardiographic parameters are not discussed in this study. Indexed echocardiographic measurements of the native Nepali population are a requirement to express healthy cardiac functions in patients for better clinical assessment by cardiologists and further study is warranted in the Nepali population for the purpose.

CONCLUSION

Absolute echocardiographic measurements vary physiologically between apparently healthy genders yet the ejection fraction is not significantly different between both the genders in apparently healthy Nepali populations visiting hospitals for cardiac care and assessment.

ACKNOWLEDGEMENT

We are thankful to Dr. Abha Shrestha of the Department of Community Medicine at KUSMS for the support extended in statistical analysis.

REFERENCES

1. The American Society of Echocardiography recommendations for cardiac chamber quantification in adults: A quick reference guide from the ASE workflow and lab management task force. Available from; https://asecho.org /wp-content/ uploads/2018 /08/ WFTF-Chamber-Quantification-Summary-Doc-Final-July-18.pdf
2. Asch FM, Banchs J, Price R, Rigolin V, Thomas JD, Weissman NJ, et al. Need for a Global Definition of Normative Echo Values—Rationale and Design of the World Alliance of Societies of Echocardiography Normal Values Study (WASE). Establishing normal echocardiographic values, Editorial Comment. *Journal of the American Society of Echocardiography*. Jan 2019.
3. Schvartzman PR, Fuchs DF, Mello AG, Coli M, Schvartzman M, Moreira LB. Normal Values of Echocardiographic Measurements. A Population-Based Study. *Arq. Bras. Cardiol.* Aug 2000; 75 (2) https://doi.org/10.1590/S0066-782X2000000800003.
4. Scott D. Solomon. Essential Echocardiography. A Practical Handbook with DVD (Contemporary Cardiology). 2007 Humana Press Inc. The United States.
5. Missiri AME, Meniawy KALE, Sakr SAS, Mohamed ASEd. Normal reference values of echocardiographic measurements in young Egyptian adults. *The Egyptian Heart Journal.* 2016;68, 209-15.
6. Sullere V, Jain D, Sullere S, Anthony C. Global longitudinal strain, ejection fraction, effort tolerance and normal echocardiography measurements in healthy Indians. *Indian Heart J*. 2018; 70(5): 637-641. doi: 10.1016/j.ihj.2018.05.018
7. Mukherjee A, Halder SK, Nandi S, Mandal M, Khanra D, Biswas K. A study on normal reference values of echocardiographic chamber dimensions in young eastern Indian adults. *Indian Heart J*. 2021; 73: 77-84. https://doi.org/10.1016/j.ihj.2020.12.010
8. Lancellotti P. Normal reference ranges for echocardiography: do we really need more? *Eur Heart J Cardiovasc Imaging*. 2014;15:253–4.
9. Daimon M, Watanabe H, Abe Y, Hirata K, Hozumi T, Ishii K, et al. Normal values of echocardiographic parameters in relation to age in a healthy Japanese population: the JAMP study. *Circ J.* 2008;72:1859–66.
10. Ilercil A, O'Grady MJ, Roman MJ, Paranicas M, Lee ET, Welty TK, et al. Reference values for echocardiographic measurements in urban and rural populations of differing ethnicity: the strong heart study. *J Am Soc Echocardiogr.* 2001;14(6):601–11.
11. Prajapati D, Sharma D, Baidya SG, Shakya U, Shrestha N. Normal Echocardiographic Parameters of Healthy Adult Individuals working in National Heart Centre. *Nepalese Heart Journal*. 2012; 9 (1).