Research Article

Establishing Normal Echocardiographic Measurements In Healthy Indian Newborn Infants

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ABSTRACT

Introduction: The echocardiograph is an essential tool for cardiac evaluation and progress in pediatric cardiology has made this investigation more inevitable than before. However, normal values in neonatal cardiology are yet to be established for the Indian subcontinent.

Materials and Methods: We studied 99 healthy term infants, 0 – 7 days old in a tertiary center of Eastern India and documented the mean and standard deviation of 11 basic echocardiographic parameters for future reference.

Conclusions: RVAWd, IVSd, LVEDd and LVEDs have significant correlation with infant body weight.

Keywords: Pediatric, neonates, echocardiography, nomograms

INTRODUCTION

A quantitative assessment of cardiac chambers, valves, and great vessels is often of critical importance in evaluating the severity of any congenital and acquired heart disease and in planning the most appropriate medical, interventional, and/or surgical treatment[1-5]. At present, pediatric echocardiographic nomograms of good quality exist for cardiac valves, pulmonary arteries, the aorta, and the aortic arch[6-8]. Pediatric nomograms for cardiac chamber diameters and areas, however, are still limited or even absent. For the left ventricle, there are sufficient nomograms for M-mode measurements, while normal values for left ventricular diameters and areas evaluated in two- and four-chamber views are almost absent. Furthermore, pediatric echocardiographic nomograms for right ventricular dimensions and atrial dimensions are also extremely limited[9,10].

The primary aim of this work was to establish echocardiographic nomograms for ventricular and atrial dimensions in a population of healthy neonates.

MATERIALS AND METHODS

This cross sectional study was conducted at the Departments of Cardiology, Gynecology & Obstetrics and Pediatric Medicine, at Nil Ratan Sircar Medical College, Kolkata from February 2018 to December 2019. The study included 99 newborn infants who fulfilled the following:

- **Inclusion criteria:** Term infants, healthy on clinical examination
- **Exclusion criteria:** Preterm, low birth weight, restlessness, any obvious illness on clinical examination, and structural heart disease on echocardiography

All the selected infants underwent a single echocardiographic examination within 7 days of birth, by a single examiner with appropriate transducers (7.5, 5.0 Hz) to define the cardiac structures and obtain measurements on the following M mode echocardiographic parameters:

1. Right ventricular anterior wall thickness at end diastole (RVAWd)
2. Right ventricular end diastolic dimension (RVDd) at tricuspid annulus.
3. Thickness of the interventricular septum at end diastole (IVSd)
4. Left ventricular dimension at end diastole (LVEDd)
5. Left ventricular dimension at end systole (LVESd)
6. Left ventricular posterior wall thickness at end diastole (LVPWd)
7. Pulmonary and aortic diameter at the level of semilunar valve (PAD and AOD)
8. Left atrial diameter (LAD)
9. From above dimensions, fractional shortening (FS) and ejection fraction (EF) was calculated

All the newborns underwent echocardiographic examination in the supine position on the mother's lap without any sedation. 2D and M mode echocardiography was performed in the standard precordial positions using a Siemens Accuson CV70 machine. Left ventricle (LV) dimensions were measured by 2D guided M mode echocardiogram of LV at papillary muscle level using parasternal long axis view. Measurements at end diastole were taken at the onset of QRS complex and the systolic internal diameter was measured at maximum excursion of ventricular septum which normally occurs before the maximal excursion of posterior wall. Internal diameter was taken from trailing edge of septum to leading edge of posterior wall (tissue blood interface). Septal thickness and posterior wall thickness was measured at the onset of QRS complex in parasternal long axis. Aortic root dimensions were obtained at the onset of QRS complex from leading age to leading edge of the aortic wall in parasternal long axis view. Left atrium (LA) dimensions were recorded at end-systole as the largest distance between posterior aortic wall and the center of the line denoting the posterior LA wall in parasternal long axis. Right ventricular end diastolic dimension was measured at tricuspid annulus in the apical four chamber view. Diameter of pulmonary artery at the annulus was measured in parasternal short axis view. From the above dimensions, fractional shortening (FS) and ejection fraction (EF) were calculated.
Data was collected in a systematic way and compiled. The cardiac dimensions as obtained from echocardiography were correlated with the body weight of the infant. Keeping in mind that the body surface area changes minimally with body weight in newborns, the former was not taken into separate consideration. Ethical approval was obtained from the Institutional Ethical committee. The unpaired t-test was used to compare the means and establish or refute the statistical significance of these differences, with p values.

RESULTS AND ANALYSIS

We divided our cases into 3 groups based on body weight at the time of performing the echocardiographic assessment as follows:

- Group A: Body weight Body weight : 2 – 2.4 kg
- Group B: Body weight : 2.5-2.9 kg
- Group C: Body weight : 3-3.4 kg

The mean body weight in the study population was 2.87 ± 0.28 kg with Groups A, B and C recording mean body weights of 2.31 ± 0.08, 2.74 ± 0.13 and 3.13 ± 0.14 kg respectively. The genders were equitably distributed with male: female ratio of 1.11 in the study cohort (**Table 1**).

	Total (n = 99)	Group A (n= 8)	Group B (n = 49)	Group C (n = 42)
Male	52	2	22	28
Female	47	6	27	14
M : F	1.11	0.33	0.81	2.0
Mean BW (kg)	2.87 ± 0.28	2.31 ± 0.08	2.74 ± 0.13	3.13 ± 0.14

Table 1: Gender distribution and body weight (BW) (mean ± SD)

Measurement of various wall thicknesses in diastole was comparable across the groups. The mean RVAWd was 3.39 ± 0.67 mm in the study with groups A, B and C having diastolic thickness of 3.64 ± 0.57, 3.58 ± 0.58 and 3.13 ± 0.71 mm respectively. Coming to the IVSd as measured in our study, Groups A, B and C revealed septal thickness of 3.51 ± 0.43, 3.59 ± 0.36 and 3.32 ± 0.55 mm respectively, with the overall mean in the study being 3.47± 0.47 mm. Similarly, the mean LVPWd in the study was 3.12 ± 0.49 mm, with the Groups A, B and C showing post wall thickness of 2.98 ± 0.13, 3.25 ± 0.51 and 3.05 ± 0.49 mm respectively. Statistically significant differences between mean values of RVAWd were observed between groups B and C, while the difference was significant between groups A and B as also between B and C when IVSd was considered (**Table 2, Fig 1**).

		RVAWd (mm)	IVSd (mm)	LVPWd (mm)
Total (n = 99)		3.39 ± 0.67	3.47± 0.47	3.12 ± 0.49
Group A (n= 8)		3.64 ± 0.57	3.51 ± 0.43	2.98 ± 0.13
Group B (n = 49)		3.58 ± 0.58	3.59 ± 0.36	3.25 ± 0.51
Group C (n = 42)		3.13 ± 0.71	3.32 ± 0.55	3.05 ± 0.49
A, B	Unpaired t, df	1.1232, 55	14.7565, 55	1.4791, 55
	p value	0.2662	0.0001	0.1448
B, C	Unpaired t, df	3.3273, 89	2.8069, 89	1.8989, 89
	p value	0.0013	0.0061	0.0608
A, C	Unpaired t, df	1.9278, 55	0.9220, 48	0.3983, 48
	p value	0.0590	0.3611	0.6922

Table 2: Subgroup analysis of RVAWd (right ventricular anterior wall diastole), IVSd (intraventricular septum thickness in diastole) and LVPWd (left ventricular posterior wall thickness in diastole) (mean ± SD)

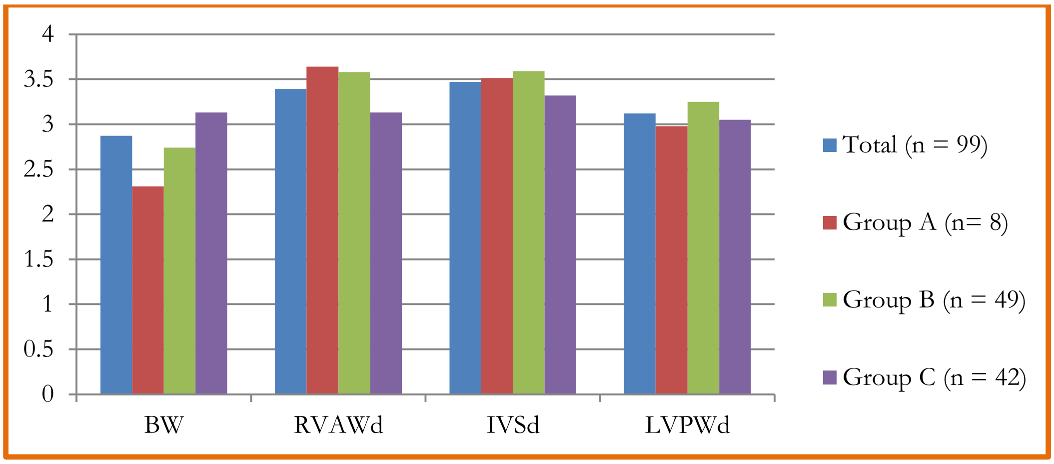

Fig 1: Distribution of mean BW (body weight, in kg), RVAWd (right ventricular anterior wall diastole), IVSd (intraventricular septum thickness in diastole) and LVPWd (left ventricular posterior wall thickness in diastole), in mm.

Subsequently, we analyzed the data for cavity size in our study population. The mean RVDd in the study was 10.96 ± 1.19 mm while this value was 11.04 ± 1.04, 11.12 ± 1.25 and 10.75 ± 1.13 mm in the Groups A, B and C respectively. LVEDd and LVEDs was 14.95 ± 1.68 and 9.76 ± 1.65 mm in the study, 13.06 ± 1.23 and 8.09 ± 1.12 mm in Group A, 14.9 ± 1.83 and 9.53 ± 1.74 mm in Group B, and 15.37 ± 1.3 and 10.34 ± 1.32 mm in Group C. A rising trend with increasing body weight was evident in these LV measurements. However, the analysis of LAD in study population and Groups A, B and C revealed values of 10.09 ± 1.47, 9.5 ± 0.76, 10.38 ± 1.41 and 9.86 ± 1.59 mm respectively, defying any corroboration with body weight. Statistically different mean values were observed for LVEDd between Groups A and B and between A and C. Considering LVESd, the means were statistically different between Groups A and B, B and C and between A and C (**Table 3, Fig 2**).

Further, the pulmonary and aortic valve diameters at the level of the semilunar valves were analyzed. The mean PAD was 8.09 ± 1.31, 8.15 ± 0.57, 8.17 ± 1.37 and 7.99 ± 1.34 mm for the study population and Groups A, B and C respectively. Similarly, the mean AOD was 8.22 ± 1.01, 8.26 ± 0.67, 8.36 ± 1.13 and 8.04 ± 0.90 mm for the study population and Groups A, B and C respectively. Neither of these parameters had any correlation with the body weight. The mean FS was 37.14 ± 4.14%, 38 ± 6.16%, 37.65 ± 4.65% and 36.38 ± 2.84% and the mean EF was 71.21 ± 5.37%, 71.63 ± 7.96%, 71.65 ± 5.92% and 70.62 ± 4.04% for the study population and

		RVDd (mm)	LVEDd (mm)	LVESd (mm)	LAD (mm)
Total (n = 99)		10.96 ± 1.19	14.95 ± 1.68	9.76 ± 1.65	10.09 ± 1.47
Group A (n= 8)		11.04 ± 1.04	13.06 ± 1.23	8.09 ± 1.12	9.5 ± 0.76
Group B (n = 49)		11.12 ± 1.25	14.9 ± 1.83	9.53 ± 1.74	10.38 ± 1.41
Group C (n = 42)		10.75 ± 1.13	15.37 ± 1.3	10.34 ± 1.32	9.86 ± 1.59
A, B	Unpaired t, df	0.1712, 55	2.7339, 55	2.2560, 55	1.7160, 55
	p value	0.8647	0.0084	0.0281	0.0918
B, C	Unpaired t, df	1.4709, 89	1.3903, 89	2.4683, 89	1.6534, 89
	p value	0.1448	0.1679	0.0155	0.1018
A, C	Unpaired t, df	0.6728, 48	4.6419, 48	4.5118, 48	0.6230, 48
	p value	0.5043	0.0001	0.0001	0.5362

Table 3: Subgroup analysis of RVDd (right ventricular diameter in diastole), LVEDd (left ventricular end diastolic diameter), LVESd (left ventricular end systolic diameter) and LAD (left atrial diameter) (mean ± SD)

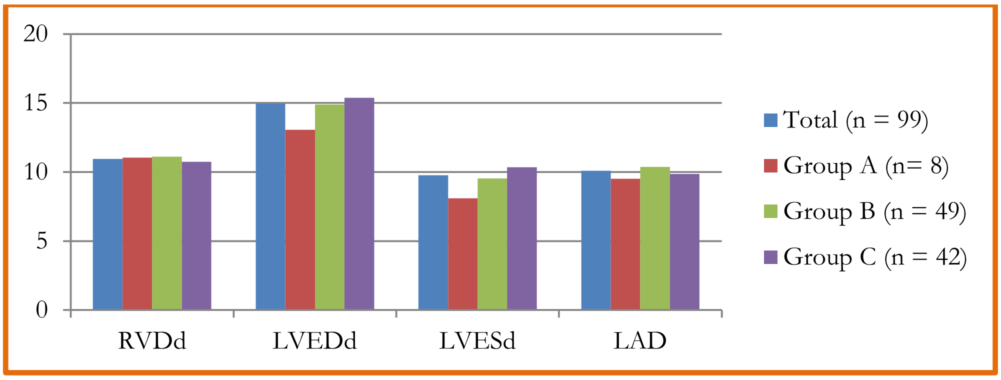

Fig 2: Distribution of mean RVDd (right ventricular diameter in diastole), LVEDd (left ventricular end diastolic diameter), LVESd (left ventricular end systolic diameter) and LAD (left atrial diameter), in mm.

Groups A, B and C respectively (**Table 4, Fig 3 and 4**). The FS appeared to have an inverse correlation with body weight, but no such trend was evident when analyzing the EF. The mean values of PAD, AOD, FS and EF were not statistically different when sub-group analysis was performed with unpaired t test.

		PAD (mm)	AOD (mm)	FS (%)	EF (%)
Total (n = 99)		8.09 ± 1.31	8.22 ± 1.01	37.14 ± 4.14	71.21 ± 5.37
Group A (n= 8)		8.15 ± 0.57	8.26 ± 0.67	38 ± 6.16	71.63 ± 7.96
Group B (n = 49)		8.17 ± 1.37	8.36 ± 1.13	37.65 ± 4.65	71.65 ± 5.92
Group C (n = 42)		7.99 ± 1.34	8.04 ± 0.90	36.38 ± 2.84	70.62 ± 4.04
A, B	Unpaired t, df	0.0405, 55	0.2423, 55	0.1885, 55	0.0084, 55
	p value	0.9679	0.8095	0.8511	0.9933
B, C	Unpaired t, df	0.6311, 89	1.4768, 89	1.5402, 89	0.9529, 89
	p value	0.5296	0.1433	0.1271	0.3432
A, C	Unpaired t, df	0.3299, 48	0.6553, 48	1.1915, 48	0.5438, 48
	p value	0.7429	0.5154	0.2393	0.5891

Table 4: Subgroup analysis of PAD (pulmonary artery diameter), AOD (aortic root diameter), FS (fractional shortening) and EF (ejection fraction) (mean ± SD)

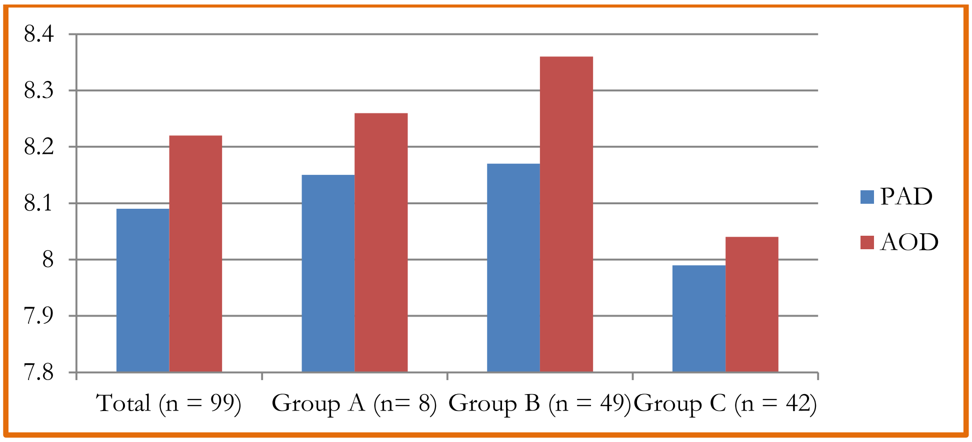

Fig 3: Distribution of mean PAD (pulmonary artery diameter) and AOD (aortic root diameter), in mm.

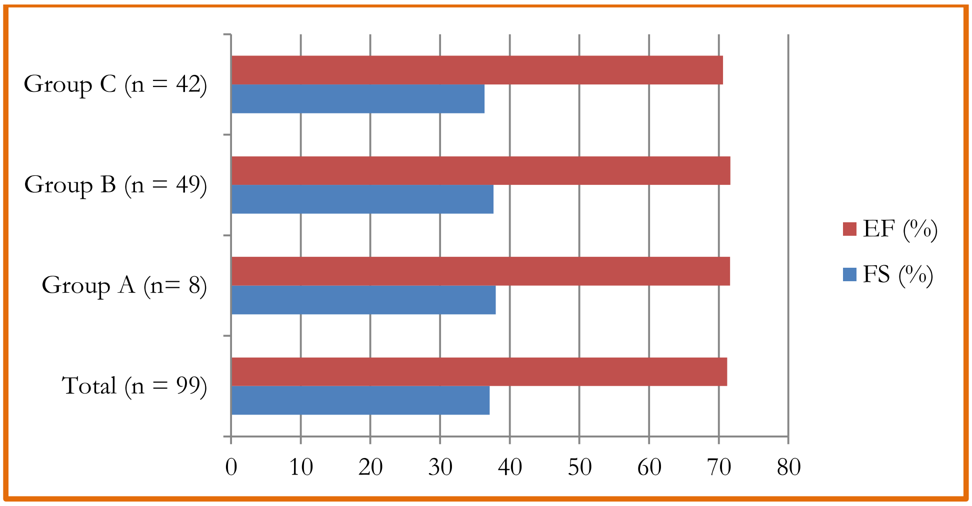

Fig 4: Distribution of mean FS (fractional shortening) and EF (ejection fraction).

The distribution of the study parameters were analyzed as percentiles and tabulated. The percentile values (5th, 10th, 25th, 50th, 75th, 90th, and 95th centiles) for all echocardiographic parameters documented in this study were documented for future reference (**Table 5**).

	Percentiles						
	5th	10th	25th	50th	75th	90th	95th
RVAWd (mm)	2.205	2.410	3.000	3.400	3.800	4.200	4.490
RVDd (mm)	9.000	9.200	9.850	11.200	11.975	12.400	12.700
IVSd (mm)	2.400	3.000	3.225	3.500	3.800	4.100	4.100
LVEDd (mm)	11.310	13.310	14.100	14.850	16.000	17.090	17.785
LVESd (mm)	7.105	7.330	8.500	9.550	11.100	11.790	12.795
LVPWd (mm)	2.40	2.42	2.80	3.00	3.48	3.80	4.10
PAD (mm)	5.820	6.400	7.200	8.000	9.100	9.400	9.690
AOD (mm)	6.500	7.100	7.350	8.200	9.000	9.300	10.295
LAD (mm)	7.330	8.400	9.200	10.100	11.000	11.790	12.000
FS (%)	31.00	32.00	35.00	37.00	39.00	42.00	45.00
EF (%)	64.00	65.00	68.00	71.00	75.00	76.00	80.00

Table 5: Percentile values of the echocardiographic measurements (n = 99)

DISCUSSION

The echocardiogram forms the cornerstone for pediatric cardiac evaluation, an important aspect of which is a quantification of cardiac structure in terms of dimensions. The dimensions of a child's cardiac structure are affected by his or her hemodynamics and somatic growth[11]. Our study observed standard echocardiographic measures in healthy term newborns in Eastern India. There have been several other publications on this subject from across the globe but very little similar documentation from our part of the world.

Eleven parameters such as right ventricular anterior wall thickness at end diastole (RVAWd), right ventricular end diastolic dimension (RVDD) at tricuspid annulus, thickness of the interventricular septum at end diastole (IVSd), left ventricular dimension at end diastole (LVEDD), left ventricular dimension at end systole (LVESD), left ventricular posterior wall thickness at end diastole (LVPWd), pulmonary and aortic diameter at the level of semilunar valve(PAD and AOD), left atrial diameter (LAD), fractional shortening (FS) and ejection fraction (EF) were recorded for each subject.

The measurements of cardiac structures and their comparison with nomograms are essential for preoperative planning for most congenital heart defects[12]. A study comprising 2000 subjects in Europe where newborn babies had larger internal left ventricular diameter both during diastole and systole compared to that of the subjects of present study[13]. The IVS and LVPWd in our study were thinner compared to those of European newborn babies. Dimension of great vessels were smaller in our study than that of the European newborn babies. The mean right ventricular anterior wall thickness was found to be more in our subjects and the right ventricular internal diameter was also found to be more in the present study compared to those in European newborn. Mean left atrial diameter was found to be smaller in our newborn babies than that of European newborns. The mean values of cardiac dimensions in Indian newborns were found to be different from European newborn. These differences indicate that cardiac dimensions have racial differences and Western data cannot be extrapolated to fit the Indian pediatric cardiology nomograms.

Z-Scores are essential to monitor the disease progression for the management of various acquired heart diseases such as Kawasaki disease or rheumatic heart disease[14]. Major pediatric cardiac centers across the world have developed their own nomograms[15]. The Z scores of cardiac structures of the Indian pediatric population remains a challenge. An Indian study from Ajmer, Rajasthan and Mohali, Punjab included the population between 4 and 15 years of age[16]. A study from Maharashtra published in 2018 included individuals aged 0 days to 16 years[17]. Our study is possibly the first publication from this subcontinent with exclusive focus on the first week of life. However, larger data bases and more representation from various social and economic backgrounds will provide more robust data in future.

LIMITATIONS

This study was conducted at Eastern India and failed to include subjects from different ethnic origins. However, this may paradoxically result in a strength of the study, because different racial compositions in a study group may present a bias when interpreting data. Moreover, the use of a homogeneous cohort makes it possible to derive normal values for a specific population and to compare these data with those from populations composed of different races and ethnicity.

CONCLUSIONS

This observational study concludes that Indian pediatric cardiac normative values are different from those established from Western experiences. Few parameters like RVAWd, IVSd, LVEDd and LVEDs have significant correlation with infant body weight. We further establish that all cardiac structural parameters of neonates do not corroborate with their body weight in a linear manner. Moreover, our literature search concludes that data on this subject is virtually non-existent from our part of the world. South East Asian populations differ from those of European descent and separate echocardiographic norms are needed from our part of the world.

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