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Echocardiographic Evaluation of Cardiac Remodeling After Surgical Closure of Ventricular Septal Defect in Different Age Group

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Abstract

Background: Cardiac remodeling is important issue after surgical closure of ventricular septal defect. **Objective:** The purpose of the present study was to evaluate cardiac remodeling by echocardiography by measuring the ejection fraction, fractional shortening, left ventricular internal diameter during diastole (LVIDd) and left ventricular internal diameter during systole (LVIDs) after surgical closure of ventricular septal defect in different age group. **Methodology:** This prospective cohort studies was conducted in the Department of Cardiac Surgery at National Institute of Cardiovascular Disease (NICVD), Dhaka. Patient with surgical closure of VSD were enrolled into this study purposively and were divided into 3 groups according to the age. In group A (n=10), patients were within the age group of 2.0 to 6.0 years; age of group B (n=8) patients were 6.1-18.0 years and the group C (n=6) aged range was 18.1-42.0 years. Echocardiographic variables such as ejection fraction, fractional shortening, LVIDd, LVIDs were taken preoperatively and at 1st and 3rd month of postoperative values. **Result:** A total number of 24 patients was recruited for this study. The mean ages of all groups were 12.60±12.09. After 1 month ejection fraction were decreased by 5.97%, 6.71% and 5.66% in group A, group B and group C respectively. After 3 months ejection fraction were increased by 6.13%, 5.13% and 5.14% in group A, group B and group C respectively. After 1 month fractional shortening were decreased by 13.55%, 9.30% and 9.09% in group A, group B and group C respectively. After 3 months fractional shortening were increased by 7.23%, 7.35% and 4.55% in group A, group B and group C respectively. After 1 month LVIDd were increased by 1.97%, 1.91% and 1.32% in group A, group B and group C respectively. After 3 months LVIDd were decreased by 10.84%, 9.89% and 7.34% in group A, group B and group C respectively. After 1 month LVIDs were increased by 2.19%, 2.86% and 1.98% in group A, group B and group C respectively. After 3 months LVIDs were decreased by 11.68%, 10.97% and 8.87% in group A, group B and group C respectively. **Conclusion:** Cardiac remodeling occurred after surgical closure of ventricular septal defect and remodeling were more significant in younger age group. [Journal of National Institute of Neurosciences Bangladesh, 2016;2(2): 69-74]

Keywords: Cardiac remodeling; ventricular septal defect; surgical closure; echocardiographic evaluation

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Introduction

Ventricular septal defect (VSD) is one of the most frequent congenital cardiac abnormalities[1]. Among infants dying with congenital heart disease in the first month of life, ventricular septal defect is second only to transposition of the great arteries as a cause of death in this age group[2].

Prevalence rate of ventricular septal defects (VSDs) is varied from 0.44 and 0.48 per 1000 in four successive years of study in elementary school children[3]. The traditional treatment of VSD is surgical repair[4]. Since 1954, when the first surgical closure of a PMVSD took place, there have been considerable changes in the surgical strategy for closure in terms of timing, perfusion modalities and approach, making surgical closure a relatively low risk procedure[1]. In the last decade, percutaneous (PC) closure techniques have been developed for all types of ventricular septal defects[5]. Though the surgical approach is considered to be the gold standard; however, it is associated with morbidity and mortality, patient discomfort, sternotomy and skin scar[6-7].

Improvement in cardiac function has been monitored by observing the cardiac remodeling. Cardiac remodeling is the genome expression, molecular, cellular and interstitial changes which are manifested clinically as changes in size, shape and function of the heart after cardiac injury[8]. The process of cardiac remodeling is influenced by hemodynamic load, neuro-hormonal activation and other factors still under investigation. The myocyte is the major cardiac cell involved in the remodeling process[8]. It is very logical to assume that the degree of compensatory changes in the heart depends on the size and flow across the VSD, the relative compliance, pressure and resistance to flow in the ventricles and the greater the duration of this left to right shunt, greater the adaptive changes. Therefore, early intervention is very likely to holt the disease process and thereby the pathological changes and the magnitude of cardiac remodeling is expected to be more compete as a logical consequence. Thus it is very important to focus on echocardiographic evaluation of cardiac remodeling after surgical closure of VSD to evaluate the beneficial effect of early closure. Therefore, this present study was undertaken to evaluate cardiac remodeling by echocardiography by measuring the ejection fraction, fractional shortening, left ventricular internal diameter during systol (LVIDd) and left ventricular internal diameter during systol (LVIDs) after surgical closure of ventricular septal defect in different age group.

Methodology

This study was designed as prospective cohort study and was carried out from January 2014 to May 2014 for a period of five (5) months. This study was conducted in the Department of Cardiac Surgery at National Institute of Cardiovascular Disease (NICVD), Dhaka. All patients presented with isolated VSD who was surgically treated with the age group of 2 to 42 years of both sexes were included as study population. This study population was divided into 3 groups of the basis of preschool going child, school going child and adult which were designated as group A, group B and group C respectively. VSD patients with other associated cardiac diseases and patients with pulmonary artery systolic pressure (PASP) more than 60 mm of Hg was excluded from this study. The sampling technique was purposive sampling method. After getting written informed consent from adult and the guardians of the children, all data regarding demographic variables, echocardiographic variables were collected. M-mode and two-dimensional echocardiography recordings were performed using a phased-array echocardiographic Doppler system (Sonos 5500, Hewlett-Packard [Agilent], Andover, Massachusetts) equipped with a 3-7 MHz transducer. Echocardiography was done in left lateral recumbent position using standard parasternal short- and long-axis and apical views. Left ventricular internal diameter during diastole (LVIDd) and systole (LVIDs), LV ejection indices like ejection fraction and fractional shortening were recorded by echocardiography. All patients were followed up 1 month and 3 months after postoperative days by echocardiography and compared with preoperative echocardiographic findings. Data were collected using a preformed data collection sheet. Baseline information was collected from the patient after exploration of different complaints and sign and symptoms of the cardiovascular diseases. Prior to the commencement of this study, the research protocol was approved by the ethical committee (Institutional Review Board) of BSMMU. Statistical analysis was performed by using window based computer software with Statistical Packages for Social Sciences (SPSS-15) (SPSS Inc, Chicago, IL, USA). Probability values <0.05 was considered as level of significance.

Results

A total number of 24 VSD surgically treated patients was recruited who were divided into three groups. In group A (2.0 to 6.0 years), group B (6.1 to 18.0 years) and group C (18.1 to 42.0 years) the number of patients was 10 patients,

8 patients and 6 patients respectively. The mean age (±SD) of the study population was 12.60 (± 12.09) years with a range of 2 to 42 years. According to echocardiography findings almost all cases were the perimembranous type of VSD which was 22(91.7%) cases and the rest 2(8.3%) cases had sub-aortic (Table 1).

Table 1: Distribution of patients by type of VSD (n=24)

Type of VSD	Group A	Group B	Group C
Perimembranous	10(100.0%)	6 (75.0%)	6(100.0%)
Sub aortic	0 (0.0%)	2 (25.0%)	0(0.0%)
Total	**10 (100.0%)**	**8(100.0%)**	**6(100.0%)**
Mean ± SD	12.60 ± 12.09 (2-42 yrs)		

n = Significant; ns =Not significant; Chi-square test was done to measure the level of significance

In group A the mean (±SD) ejection fraction of heart at the time of preoperative and postoperatively after 1 month and 3 months were 62.00(±4.29), 58.30(±4.13) and 65.80(±3.99) respectively. In group B the mean (±SD) ejection fraction of heart at the time of preoperative and postoperatively after 1 month and 3 months were 63.37(± 3.50), 59.12(±3.68) and 66.62(±3.66) respectively. In group C the mean (±SD) ejection fraction of heart at the time of preoperative and postoperatively after 1 month and 3 months were 64.83(±4.49), 61.16 (± 3.76) and 68.16(±4.57) respectively. After 1 month ejection fraction was decreased by 5.97%, 6.71% and 5.66% in group A, group B and group C respectively but after 3 months it was increased by 6.13%, 5.13% and 5.14% in group A, group B and group C respectively (Table 2).

In group A the mean (±SD) fractional shortening of heart at the time of preoperative and postoperatively after 1 month and 3 month were 33.20(±3.15)%, 28.70(±3.40)% and 35.60(±4.27)% respectively. In group B the mean (±SD) fractional shortening of heart at the time of preoperative and postoperatively after 1 month and 3 month were 32.25(±4.16)%, 29.25(±4.02)% and 34.62(±4.77)% respectively. In group C the mean (±SD) fractional shortening of heart at the time of preoperative and postoperatively after 1 month and 3 month were 33.00(±6.78)%, 30.00(±6.29)% and 34.50(±6.31)% respectively. After 1 month fractional shortening was decreased by 13.55%, 9.30% and 9.09% in group A, group B and group C respectively but after 3 months it was increased by 7.23%, 7.35% and 4.55% in group A, group B and group C respectively (Table 3).

In group A the mean (±SD) left ventricular internal diameter during diastole (LVIDd) of heart at the time of preoperative and postoperatively after 1 month and 3 month were 40.60(±6.85) mm, 41.40(±7.22) mm and 36.20(±5.94) mm respectively. In group B the mean

Table 2: Preoperative and Postoperative Comparison of Ejection Fraction of Heart of the Patients (n=24)

Group	Ejection fraction (%) [Mean±SD]			p-value (A vs C)	Changes (%)	
	Preoperative [A]	Postoperative (after 1 month) [B]	Postoperative (after 3 months) [C]		After 1 month	After 3 months
Group A	62.00 ± 4.29	58.30 ± 4.13	65.80 ± 3.99	0.001	-5.97	+6.13
Group B	63.37 ± 3.50	59.12 ± 3.68	66.62 ± 3.66	0.001	-6.71	+5.13
Group C	64.83 ± 4.49	61.16 ± 3.76	68.16 ± 4.57	0.001	-5.66	+5.14

*Paired t-test was done to measure the level of significance

Table 3: Preoperative and Postoperative Comparison of Fractional Shortening (n=24)

Group	Ejection fraction (%) [Mean±SD]			p-value (A vs C)	Changes (%)	
	Preoperative [A]	Postoperative (after 1 month) [B]	Postoperative (after 3 months) [C]		After 1 month	After 3 months
Group A	33.20 ± 3.15	28.70 ± 3.40	35.60 ± 4.27	0.001	-13.55	+7.23
Group B	32.25 ± 4.16	29.25 ± 4.02	34.62 ± 4.77	0.001	-9.30	+7.35
Group C	33.00 ± 6.78	30.00 ±6.29	34.50 ± 6.31	0.001	-9.09	+4.55

*Paired t-test was done to measure the level of significance

Table 4: Preoperative and postoperative comparison of Left Ventricular Internal Diameter during Diastol (LVIDd) (n=24)

Group	LVIDd (mm) [Mean±SD]			p-value (A vs C)	Changes (%)	
	Preoperative [A]	Postoperative (after 1 month) [B]	Postoperative (after 3 months) [C]		After 1 month	After 3 months
Group A	40.60 ± 6.85	41.40 ± 7.22	36.20 ± 5.94	0.001	+1.97	-10.84
Group B	39.25 ± 11.27	40.00 ± 11.10	35.37 ± 10.45	0.001	+1.91	-9.89
Group C	50.00 ± 3.94	50.66 ± 4.17	46.33 ± 3.88	0.001	+1.32	-7.34

*Paired t-test was done to measure the level of significance

Table 5: Preoperative and postoperative comparison of Left Ventricular Internal Diameter during Systol (LVIDs) (n=24)

Group	LVIDd (mm) [Mean±SD]			p-value (A vs C)	Changes (%)	
	Preoperative [A]	Postoperative (after 1 month) [B]	Postoperative (after 3 months) [C]		After 1 month	After 3 months
Group A	27.40 ± 5.39	28.00 ± 5.84	24.20 ± 4.51	0.001	+2.19	-11.68
Group B	26.25 ± 8.79	27.00 ± 8.38	23.37 ± 7.89	0.001	+2.86	-10.97
Group C	33.83 ± 5.74	34.50 ± 4.96	30.83 ± 5.41	0.001	+1.98	-8.87

*Paired t-test was done to measure the level of significance

(±SD) left ventricular internal diameter during diastole (LVIDd) of heart at the time of preoperative and postoperatively after 1 month and 3 month were 39.25(±11.27) mm, 40.00(±11.10) mm and 35.37(±10.45) mm respectively. In group C the mean (±SD) left ventricular internal diameter during diastole (LVIDd) of heart at the time of preoperative and postoperatively after 1 month and 3 month were 50.00(±3.94) mm, 50.66(±4.17) mm and 46.33(±3.88) mm respectively. After 1 month LVIDd was increased by 1.97%, 1.91% and 1.32% in group A, group B and group C respectively but after 3 months it was decreased by 10.84%, 9.89% and 7.34% in group A, group B and group C respectively (Table 4).

In group A the mean (±SD) left ventricular internal diameter during systole (LVIDs) of heart at the time of preoperative and postoperatively after 1 month and 3 month were 27.40(±5.39) mm, 28.00(±5.84) mm and 24.20(±4.51) mm respectively. In group B the mean (±SD) left ventricular internal diameter during systol (LVIDs) of heart at the time of preoperative and postoperatively after 1 month and 3 month were 26.25(±8.79) mm, 27.00(±8.38) mm and 23.37(±7.89) mm respectively. In group C the mean (±SD) left ventricular internal diameter during systol (LVIDs) of heart at the time of preoperative and postoperatively after 1 month and 3 month were 33.83(±5.74) mm, 34.50(±4.96) mm and 30.83(±5.41) mm respectively. After 1 month LVIDs was increased by 2.19%, 2.86% and 1.98% in group A, group B and group C respectively but after 3 months it was decreased by 11.68%, 10.97% and 8.87% in group A, group B and group C respectively (Table 5).

Discussion

Ventricular septal defect (VSD) is a common congenital anomaly which requires early closure by various methods. In this study 24 patients of different age group who had undergone ventricular septal defect closure by surgery were enrolled. Echocardiographic evaluation was done before operation and 1 month and 3 months after surgical closure of VSD in different age group. Cardiac remodeling was measured by the changes of the ejection fraction, fractional shortening, left ventricular internal diameter during diastole (LVIDd) and left ventricular internal diameter during systole (LVIDs) after surgical closure of ventricular septal defect.

This study was conducted in the Department of Cardiac Surgery at NICVD. The enrolled patients were divided into three groups as 2.0 to 6.0 years (n=10) in group A, other were 6.1-18.0 years (n=8) in group B and 18.1-42.0 years (n=6) in group C, after data collection. The age of the enrolled patients ranged from 2 to 42 years, with a mean age of all group 12.60±12.09 years, majority of patients in the range of 2.0-6.0 years

(41.7%), other were 6.1-18.0 years (33.3%) and 18.1-42.0 years (25%). Twenty two (91.7%) cases had perimembranous VSD. And only 2 (8.3%) had sub aortic. Perimembranous are common type of VSD[9]. According to their location within the septum, defects can be classified as muscular, perimembranous and supracristal[10]. The most common are the perimembranous VSD which is consistent with the present study result[4]. This perimembranous VSD (PMVSD) is the most common hemodynamically significant VSD[1]. Supracristal defects are quite rare in Western countries accounting for 5% of all ventricular septal defect[9].

Ejection fraction was decreased from preoperative to 1st month of postoperative values in all groups. After 1 month it was decreased by 5.97%, 6.71% and 5.66% in group A, group B and group C respectively. Ejection fraction increased significantly from preoperative values to 3rd month of postoperative values of surgical closure of VSD. After 3 months ejection fraction was increased by 6.13%, 5.13% and 5.14% in group A, group B and group C respectively. This study was consistent with the study done by Hwang et al[11] and Yuan et al[12] where Left ventricular ejection fraction increase after surgery[11] and left ventricular ejection fraction improve 1 year after closure of VSD[12].

Fractional shortening was decreased from preoperative to 1st month of postoperative values in all groups. After 1 month fractional shortening was decreased by 13.55%, 9.30% and 0.09% in group A, group B and group C respectively. Fraction shortening significantly increased after 3rd month of postoperative values from preoperative values in each group and the increment was 7.23%, 7.35% and 4.55% in group A, group B and group C respectively.

LVIDd increased from preoperative to 1st month of postoperative values in all groups. After 1 month LVIDd was increased by 1.97%, 1.91% and 1.32% in group A, group B and group C respectively. LVIDd was significantly declined from preoperative values to 3rd month of postoperative values ($p<0.05$). After 3 months LVIDd was decreased by 10.84%, 9.89% and 7.34% in group A, group B and group C respectively. This study was consistent with the study of Yuan et al[12], where LVIDd was reduced 1 year after closure of VSD.

LVIDs increased from preoperative to 1st month of postoperative values in all group. After 1 month LVIDs were increased by 2.19%, 2.86% and 1.98% in group A, group B and group C respectively. LVIDs was significantly declined from preoperative values to 3rd month of postoperative values ($p<0.05$). After 3 months LVIDs were decreased by 11.68%, 10.97% and 8.87% in group A, group B and group C respectively. This study was consistent with other study, where LVIDs were reduced in 1 year after closure of VSD[12]. Remodeling was better in young age group then elder[13]. From this study it is evident that favorable left ventricular morphological changes occur when early surgical closure of VSD is done in relatively younger group of patients.

There are some limitations of this study. The sample size is smaller and it is a short term study. Comparison between different age groups is relatively scanty in the available literature in terms of echocardiographic findings after surgical closure of VSD. Therefore, head to head comparison between other studies could not be done. A large, multicentric long term study can elucidate the optimum age for surgical closure of VSD in term of echocardiographic evidences of cardiac remodeling.

Conclusion

This studies permits to conclude that cardiac remodeling is found better among the young children then older children and adult age group after surgical closure of ventricular septal defect. The ejection fraction, fractional shortening, left ventricular internal diameter during diastole (LVIDd) and left ventricular internal diameter during systole (LVIDs) is significantly improving after three months of surgery.

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