RESIDUAL DEFECTS AFTER SURGICAL REPAIR OF VENTRICULAR SEPTAL DEFECTS IN CHILDREN: INCIDENCE, RISK FACTORS AND FOLLOW-UP

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Abstract- Residual ventricular septal defects (VSD) are major complications after cardiac surgery. We studied the incidence of this complication, risk factors for its occurrence and short-term follow-up in 179 pediatric patients that underwent surgical closure of VSD from April 2003 until May 2004. All data were gathered retrospectively except measurements of shunt ratio. Studied risk factors included age, sex, weight, height, ejection fraction, VSD size, presence of pulmonary stenosis (PS), responsible surgeon, use of patch material for closing VSD, mean degree of hypothermia, cardiopulmonary bypass and aortic cross-clamp times, hemorrhage, documented infection, and surgical approach for defect closure. The incidence of all residual VSDs was 56% and significant ones (*i.e.* with Qp/Qs > 1.5) 22%. The only statistically significant risk factors were higher age, weigh and height of the patients. There was notable but statistically insignificant differences in residual shunt incidence among the patients of different surgeons and with the use of different patch materials. During the median follow-up period of 9.5 months, 35% of the residual defects were closed spontaneously. Six patients underwent catheterization, three of which were candidates of residual VSD closure. As residual VSD is a hemodynamically and psychologically important complication, we recommend VSD closure at lower age and the use of intraoperative epicardial or transesophageal echocardiography to minimize its occurrence.

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Key words: Ventricular septal defect, echocardiography, children, congenital heart diseases, corrective surgery

INTRODUCTION

Approximately 20% of patients with congenital heart diseases (CHD) have ventricular septal defect (VSD) as a solitary lesion (1). A VSD also constitutes part of a large proportion of other congenitally abnormal hearts. After a corrective cardiac surgery, there may remain residual VSDs. These defects may have hemodynamic, financial and psychological impacts on the patients and their parents. They may need re-operation or device closure, drug therapy and antibiotic prophylaxis against endocarditis. So recognition of the risk factors and natural history of residual VSDs can be helpful to decrease the incidence of this complication and to reassure the parents. Fortunately with the advent of intraoperative echocardiography methods, especially transesophageal echocardiography (TEE), most of the residual shunts are now discovered and closed in the operating

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room. So far, we have not used these facilities for our pediatric patients, therefore residual VSDs are a major concern for us.

In this study, we reviewed patients who had total correction of all CHDs including a VSD and searched for possible risk factors by comparing the patients with a residual shunt with those without it. We also represent short-term follow-up of our patients.

MATERIALS AND METHODS

Patients

Inclusion criteria were total corrective surgery from 20th April of 2003 till 3rd May of 2004 (12.5 months), admission in pediatric department, a VSD being part of the abnormalities and its closure during the surgery. Exclusion criteria include death of the patient at or during intensive care unit (ICU) stay before complete evaluation for residual defects, and multiple defects that some of them were not closed (due to possible confusion between a residual defect and one left open).

Most of the data gathered retrospectively from the hospital files, except measuring Qp/Qs that was done for approximately half of the patients with a residual VSD before hospital discharge. Ethics committee of our institution approved the study protocol. We obtained informed consent from parents of all participants.

Echocardiography

Only those abnormalities were accepted as residual defects that were confirmed by both Doppler and Color Doppler echocardiography. Measurements of shunts ratio were done using modified continuity equation for mitral and aortic valves as follows:

$Qp/Qs = MV\ diameter^2 \times MV\ mean\ VTI / AV\ diameter^2 \times AV\ mean\ VTI$ (MV, mitral valve; VTI, velocity time integral; AV, aortic valve).

Mitral valve was selected instead of pulmonary valve to avoid effects of turbulent flow in the latter assuming that without an atrial level shunt, mitral valve flow is equal to pulmonary flow. Mean VTI was measured by averaging five consequent VTIs to avoid the effects of respiration on this variable. Mitral valve measurements were done in apical view and aortic valve ones in suprasternal view (2-4).

Risk factors

The patients were divided into two groups based on the presence of a residual VSD after the surgery. We compared two groups for several factors to search for possible risk factor(s) of residual shunt. These factors consisted of the age, sex, weight, height, ejection fraction (EF) and VSD size (both by echocardiography), presence of valvar or subvalvar PS, responsible surgeon, use of patch material for closing VSD (direct suturing or use of Gore-Tex, pericardial, and Dacron patches), mean degree of hypothermia during the surgery, cardiopulmonary bypass (CPB) and aortic cross-clamp (ACC) times, more than mild hemorrhage from surgery sites, documented infection(s) after the surgery (culture positive; blood, tracheal aspirate, urine, or other sites), and surgical approach to close VSD (from the right atrium, right ventricle or aorta). In accordance with medical ethics, we assigned four letters (A, B, C and D) by chance to the surgeons that were responsible for most of the operations. The other surgeons operated one or two patients during the study period, so their data were not presented.

Statistics

All data were gathered and analyzed by SPSS for Windows release 11.0.0 standard version. Paired *t* and Pearson Chi-square tests were used and *P* values lower than 0.05 was considered significant. Otherwise specified, data are presented as mean ± standard deviation.

RESULTS

General

A total of 179 patients met our criteria and included in the study. There were 96 male patients (54%) and 83 female ones (46%). Mean age of them was 5.43 ± 4.08 years. There were 72 cases of tetralogy of Fallot (40%), 70 of perimembranous VSD (39%), 9 cases of VSD and pulmonary stenosis (not of tetralogy type), 6 cases of residual VSD after previous surgeries, 6 cases of double-outlet right ventricle and VSD, 5 cases of double-chamber right ventricle and VSD, 4 cases of pulmonary atresia and VSD, 2 cases

of complete atrioventricular septal defect, 2 cases of corrected transposition and VSD, and one case of each of muscular VSD, complete transposition and VSD, and double-outlet left ventricle and VSD. A previous pulmonary artery banding was done for 24 patients (13.5%). There were 101 cases with residual VSDs (56%).

Risk factors

The only statistically significant differences between the patients with residual shunt and those without it were in the age, weight and height at operation (Table 1). Those with a residual VSD were on average 16.5 months older, 3 kilograms heavier and 7 centimeters taller than the others. There were other factors with notable differences. The incidence of residual VSD ranged from 69.7% in the patients operated by the surgeon C to 43.1% in the patients of the surgeon B, but this difference was also not statistically significant. In addition, there was a large but non-significant difference in residual VSD incidences after using different patch materials. The defects closed by Gore-Tex, Dacron and pericardial patches had 50, 56 and 70% incidences of residues, respectively, but those closed by direct suturing had a 68% incidence. The other studied factors have yielded almost the same results in the two groups.

Shunt measurements

Qp/Qs were estimated by echocardiography for 50 patients with residual VSD (almost half of the patients). 39 cases (78%) had a value <1.5, 8 cases (16%) had 1.5 ≤ Qp/Qs < 2 and 3 cases (6%) had Qp/Qs of 2 or larger.

Table 1. Comparison of probable risk factors between the patients with and without residual VSD*

Factor	+ Residual VSD	- Residual VSD	*P* value
Age (years)	6.03 ± 4.53	4.66 ± 3.27	0.025†
Sex (F/M ratio)	0.91	0.81	0.724
Weight (Kg)	18.3 ± 10.6	15.3 ± 8.96	0.048†
Height (cm)	107 ± 25	100 ± 20.5	0.048†
Hemoglobin (mg/dL)	13.2 ± 2.52	13.3 ± 2.38	0.673
Hematocrit (%)	42.2 ± 8.19	42.8 ± 8.01	0.664
Ejection Fraction (%)	76.7 ± 9.73	74.9 ± 9.3	0.217
VSD size (mm)	11.2 ± 4.74	11 ± 4.6	0.851
+PS/-PS ratio	1.39	1.7	0.443
Surgeon (%)			
A	65.2	34.8	0.103
B	43.1	56.9	
C	69.7	30.3	
D	45	55	
Patch (%)			
Gore-Tex	50	50	0.237
Pericardial	70	30	
Dacron	56.2	43.8	
No patch	68.2	31.8	
Degree of Hypothermia (ºC)	30.2 ± 1.86	30.2 ± 1.79	0.892
CPB time (minutes)	79.3 ± 24.5	81.4 ± 22.3	0.560
ACC time (minutes)	48 ± 20.2	46.4 ± 18.2	0.585
Hemorrhage (%)	9	5.19	0.336
Infection (%)	2	0	0.212
Approach (RA/RV ratio)	0.333	0.375	0.927

Abbreviation: F, female; M, male; CPB, cardiopulmonary bypass; ACC, aortic cross-clamp.
* Data are given as mean ± SD or as percent.
† Significant difference.

Follow-up

Of 145 patients (81%) who had follow-up from 1 to 18.5 months (median 9.5 months), 83 cases (57%) had residual VSD. The other patients lost to follow up. Twenty nine residual shunts of the total 83 followed up cases (35%) were closed during the follow-up period. The mean duration between the surgery and estimated time of closure (midway between the last echocardiography with VSD and the first one without it) was 3.94 ± 2.93 months. The other 54 cases (65%) did not show closure of their residual VSDs during follow-up period of 7.53 ± 5.12 months. Catheterization for approval of significant shunt was offered to the 11 cases who had estimated Qp/Qs ≥ 1.5 by echocardiography, but the parents of only six patients accepted it. The recommendations after the catheterization were clinical follow-up for 3 and re-operation for the other 3 ones. Only one of those patients underwent re-operation and the parents of the other two patients did not accept re-operation.

DISCUSSION

Residual shunts after closure of VSD have great impacts on the patient and their parents. We have showed that without intra-operative echocardiography, 56% of patients in our series had residues and 22% of those with measurement of Qp/Qs had a significant shunt needing re-operation.

Comparing the rate of residual VSD in our study with the other ones is a difficult task. The studies vary in their target age group, underlying CHD and severity of residual VSDs reported. There is general agreement that residual VSDs with pulmonary to systemic flow ratios larger than 1.5 are significant and require re-operation (5). The accuracy of echocardiographic estimation of that ratio is well established (2-4). But not all studies have used this definition for significant residual VSD, although they solely reported the incidence of significant shunts. The reported incidence of residual VSD ranges from around 73% (6, 7) to 5-6% (8, 9) in different reports. Von Segesser *et al.* used fibrin sealant to decrease the incidence of residual VSD (6). In their control group, 16 of 22 patients (73%) had residual defects. Wienecke *et al.* found residual VSD in 12 of 18 patients after the surgery (7). Three of 12 patients (25%) with VSD and different types of PS required reoperation for residual VSD in the report of Kitagawa *et al.* (10). On the other hand, Demirag *et al.* reported only 4 cases of residual defects after 78 VSD closures (5%) (8). Two of 36 patients (6%) after total correction of tetralogy of Fallot (TOF) had a residual VSD in the series of Abd El-Karim *et al.* (9). Most of the other reports found values between these two tails of the spectrum. It is evident that in our study, both significant and minor residues have incidence rates in the higher side of the reported spectrum. Whether this is due to more meticulous search for residual defects or a true higher incidence is not known.

The psychological impacts of a residual VSD are not showed directly. In our experience, acceptance of a residual defect after open heart surgery and eventual requirement of catheterization and re-operation can be very difficult for the patients and their family. This led to the acceptance of catheterization in only 6 patients and re-operation in only 1 of 3 patients in whom re-operation was indicated.

Intra-operative echocardiographies (transesophageal, epicardial or epiaortic, and substernal approaches) are well established modalities to reduce the incidence of surgical residues (11-13). They can greatly decrease the incidence of residual VSDs, specially the significant ones. We hope that we can benefit from this facility at our operating room in near future.

The only factors that coincide with lower incidence of residual VSD in our study were the age, height and weight of our patient. Evidently these factors are dependant on each others. So we can conclude that closure of VSD at a younger age, besides other well known benefits, can lower the incidence of residual shunt. So the current trend toward operation at a lower age can also minimize the incidence of this serious complication. Direct visualization of peri-patch areas in beating heart, double patches sandwiching the septum and the use of fibrin sealant are other proposed methods to decrease the incidence of postoperative residual VSDs (6, 14, 15).

We have showed that the patients with residual VSD are older, taller and heavier. It seems that higher age can be a risk factor for postoperative residual VSD. There was notable but statistically insignificant difference in the incidence of residual VSD among the patients of our four cardiac surgeons. It is possible that with increasing number of cases, this difference become significant. If so, choice of the responsible surgeon can also lower the incidence of residual VSD. Another insignificant but notable difference is found in the incidences of residual VSD after using different patch material for closing VSD. The use of synthetic materials (Gore-Tex and Dacron) has a lower risk than the use of pericardial patches or direct suturing of the defect.

Fortunately a relatively large number of residual VSDs (35%) were closed spontaneously during a median short-term follow-up of less than 4 months. Bol-Raap *et al.* reported spontaneous closure of residual VSDs in 37 of their 73 patients (51%) during follow-up period of 3.9 years (16).

Our study has some limitations. First, we do not perform shunt measurements for all patients. It was due to the fact that we preferred one echocardiographer do all measurements for more precise results and due to professional limitations, he could not perform it for all patients. The second limitation of our study was its short intervals of follow-up, although we have showed spontaneous closure of more than one third of residual VSDs during these short times.

In conclusion, based on the results of our study, we recommend total correction of CHD at younger age, by more experienced surgeons and with the use of synthetic patches to prevent residual VSD. Also based on the other studies, we recommend use of intra-operative echocardiography (transesophageal or epicardial) to lessen the incidence of this important complication. Fortunately a relatively large percentage of residual VSDs were closed during a short follow-up period and there is hope for closure of more during a longer period.

Conflict of interests

The authors declare that they have no competing interests.

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