Incidence of Conductive Disorder After Surgical Closure of VSD

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ABSTRACT

Background: Ventricular septal defect (VSD), accounts for up to 40% of all cardiac malformations. Defects that are present alone or in conjunction with other congenital cardiac abnormalities can be diagnosed. The conduction system, particularly the bundle of his and its branches, is susceptible to harm when the individual sutures are inserted. A permanent pacemaker is typically needed if a heart block occurs during or after therapy.

Objective: we aimed to evaluate the incidence of conductive disorders after surgical VSD closure.

Patients and Methods: A prospective observational study was conducted on 100 patients < 18 years with VSD from 2019 to 2021 at the Cardiothoracic Surgery Department of Cairo University Hospitals and Atfal Masr children's hospital. They had a clinical diagnosis of VSD and are referred for elective surgical VSD closure either including isolated VSD or combined with other intracardiac lesions.

Results: The peri-membranous defect was the most common type and most VSD lesions were of moderate diameter. The mean ICU stay was 2.91 days. Abnormal rhythm occurred in 12 patients (12%). The most common conductive disturbance that occurred was incomplete right bundle branch block (RBBB) (6%), but complete heart block (CHB) occur in 1% which need a permanent pacemaker, bleeding happened in 2 (2%) patients and one patient died. Regarding the comparison between populations with post-operative normal rhythm and conductive disturbance, there was a significant difference in VSD types and diameter. Conductive disorder in surgical VSD closure was mostly associated with a larger diameter, Peri-membranous, and doubly committed VSD.

Conclusion: VSD repair is considered to be a safe procedure with a very low mortality rate. In this study, we found out that large VSD was the most associated risk factor for conductive disturbance occurrence in VSD patients.

Keywords: Conductive disorder, VSD, Surgical closure.

INTRODUCTION

One of the most frequent congenital heart defects, accounting for up to 40% of all cardiac anomalies, is the ventricular septal defect. Since many tiny defects present at birth close soon after birth, the frequency of this abnormality varies with age during the examination. It also depends on how sensitive the examination technology is [(1)].

A highly sensitive color doppler echocardiogram was used to screen newborn infants, and a prevalence of up to 5% has been recorded [(2)]. The majority are minor muscle flaws that go away within the first year of life. Because many individuals can be asymptomatic and many faults can close over time, the precise prevalence of ventricular septal defects in communities differs between studies based on the technique of diagnosis and the age of the community [(3)].

The diagnosis covers a broad range of defects, both those that are unrelated to other congenital cardiac deformities and those that are connected to them [(4)]. The presentation, symptoms, natural history, and management of ventricular septal defects are all influenced by the size and anatomical correlates of the lesion, the patient's age, and the local diagnostic and interventional skills [(5)].

The conduction system, in particular the bundle of His and its branches, is frequently connected to a portion of the defect's border and is vulnerable to damage during the placement of the individual stitches [(6)]. Heart block that develops during or following the procedure is typically a sign that a permanent pacemaker should be inserted [(7)].

This study aimed to evaluate the incidence of conductive disorders after surgical VSD closure.

PATIENTS AND METHODS

This is a prospective observational study carried out at the Cardiothoracic Surgery Department of Cairo University Hospitals and Atfal Masr children hospital Between January 2019 and October 2021 on 100 patients.

Inclusion criteria: All patients aged less than 18 years of age with a clinical diagnosis of VSD who are referred for elective surgical closure of VSD were included in the study. It included isolated VSD and patients with coexisting atrial septal defects, patent ductus arteriosus, patent foramen ovale, vascular rings, coarctation of the aorta, or stenotic/regurgitant semilunar valves. This study included patients who had already had pulmonary artery banding.

Exclusion criteria: Atrioventricular canal, right ventricle with double outlet, and tetralogy of Fallot. The patient's past medical and surgical history, intracardiac hemodynamics, ventricular function, and any concomitant cardiac abnormalities. Patient outcomes, postoperative complications, and surgical indications were noted.

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Clinical symptoms and signs: congestive heart failure, recurrent chest infection, failure to thrive, tachypnea, recession.
Chest X-ray: increase vascular marking.
Echocardiography: location and size of the defect. The extent of hemodynamic consequences and associated anomalies.

Procedure: A median sternotomy was performed on all patients. For all patients, cardiopulmonary bypass was used. Closure of a Gortex or Dacron patch utilizing interrupted (5 cases) or ongoing methods (92 cases). Three patients had pledget direct VSD closure. When necessary, tricuspid septal leaflets were detached. When necessary, concurrent valvuloplasty, atrial septal defect repair, vascular ring repair, patent foramen ovale closure, patent ductus arteriosus ligation, and/or division, were also carried out. When necessary, modified ultrafiltration was applied to some individuals. Every patient had transthoracic echocardiography performed before surgery as well as an intraoperative transesophageal echocardiogram or a postoperative transthoracic echocardiogram.

Ethical consent:
The study was approved by the academic and ethical committees of the Atfal Masr Children's Hospital and Cairo University Hospitals. Informed consent was obtained from written informed consent was taken from parents for participation in the study. The Declaration of Helsinki, the World Medical Association's code of ethics for studies involving humans, guided the conduct of this work.

Statistical analysis:
Statistical Package for Social Sciences (SPSS) version 25 for Windows was used to code, process, and analyze the obtained data (IBM SPSS Inc, Chicago, IL, USA). Using the Shapiro Walk test, the distribution of the data was examined for normality. Frequencies and relative percentages were used to depict qualitative data. To determine differences between two or more sets of qualitative variables, use the chi-square test (2). Two independent groups of normally distributed variables were compared using the independent samples t-test (parametric data). In the regression model, using the Enter method, significant predictors from the Univariate analysis were included. Calculated odds ratios with a 95% confidence interval were adjusted odds ratios. A p-value less than 0.05 was regarded as significant.

RESULTS
As shown in **Table (1)**, the mean age was 51.53 months, the mean height was 99.2 cm, and the mean weight was 15.6 kg. Males were more than females. Atrial septal defect (ASD) was in 25% of cases. Peri-membranous was the most common type and most VSD lesions were of large diameter **(Table 2).**

Table (1): Patient's basal characteristics.

Variable	Results (N = 100)
Age (month)	51.53 (37.49)
Height (cm)	99.2 (22.5)
Weight (Kg)	15.6 (11.2)
Gender -Male -Female	 56 (56%) 44 (44%)
Preoperative medical treatment	77 (77%)
ASD	25 (25%)
Other congenital Anomalies	40 (40%)
PR interval (cm)	0.11 (0.06)
QRS duration (cm)	0.13 (0.06)
Preoperative LVEF (%)	58.1 (5.7)

Table (2): VSD characteristics

Variable	Results (N = 100)
Type of VSD Peri-membranous Muscular Inlet Doubly committed	 80 (80%) 10 (10%) 6 (6%) 4 (4%)
VSD Diameter Small (less than 1/3 of the aortic annulus) Moderate (from 1/3 to 2/3 of the aortic annulus) Large (more than 2/3 of the aortic annulus)	 9 (9%) 15 (15%) 76 (76%)

The mean ICU stay was 2.91 days. Abnormal rhythm occurrence happened in 12 (12%) patients. The most common conductive disturbance that occurred was Incomplete RBBB, Complete RBBB, and CHB occur in 1 patient 1% of which need a pacemaker, Residual VSD happened in 3 patients (3%), bleeding happened in 2 (2%) patients and one patient died (down syndrome isolated hypertensive VSD) **(Table 3).**

Table (3): Follow-up results during the hospital stay

Variable	Results (N = 100)
ICU stay (Days)	2.91 (1.31)
Rhythm (Follow-up) -Sinus -Abnormal rhythm	 88 (88%) 12 (12%)
Conductive disturbance Incomplete RBBB Complete RBBB CHB Other	 6 (6%) 3 (3%) 1 (1%) 2 (2%)
Complication Residual VSD -Bleeding -PH crisis	 3(3%) 2 (2%) 1(1%)
Death	1 (1%)

Regarding the comparison between the population with post-operative normal rhythm and conductive disturbance, there was a significant difference in VSD type, diameter, and shunt. Conductive disorder in surgical VSD closure was mostly associated with ASD, larger diameter, Peri-membranous, and Doubly committed VSD **(Table 4)**

Table (4): Comparison between populations with post-operative normal rhythm and conductive disturbance.

Variable	Normal Rhythm N = 88	Conductive Disturbance N = 12	P-value
Age (month)	48.62 (34.52)	54.24 (37.32)	0.6
Height (cm)	98.19 (21.3)	102.5 (22.8)	0.52
Weight (Kg)	14.7 (10.3)	16.1 (11.1)	0.66
Gender Male Female	 45 (51.14%) 43 (48.86%)	 7 (58.33%) 5 (41.57%)	0.64
Preoperative medical treatment	70 (79.55%)	7 (58.33%)	0.1
ASD	21 (23.86%)	4 (33.33%)	0.48
Other congenital Anomalies	40 (45.45%)	4 (33.33%)	0.43
PR interval (cm)	0.11 (0.03)	0.11 (0.09)	0.97
QRS duration (cm)	0.14 (0.06)	0.12 (0.03)	0.26
Preoperative LVEF	57.8 (5.3)	58.9 (5.8)	0.5
Type of VSD Peri-membranous Muscular Inlet Doubly committed	 76 (86.3%) 9 (10%) 2 (2.2%) 1 (1.1%)	 4 (33.3%) 1 (8%) 4 (33%) 3 (8.33%)	<0.001
VSD Diameter Small Moderate Large	 8 (9.09%) 14 (15.91%) 66 (75%)	 1 (8.33%) 1 (8.33%) 10 (83.33%)	0.078
VSD Shunt Left to right Both	 83 (90.36%) 5 (5.68%)	 7 (55%%) 5 (41.67%)	<0.001
ICU stay (Days)	2.6 (1.21)	3.2 (1.52)	0.12
Complication Bleeding PH crisis	 0 0	 2 (16.67%) 1 (8.33%)	-
Death	0	1 (8.33%)	-

In univariate regression analysis, muscular VSD and large ones were the most significant association with conductive disorders occurrence after VSD repair **(Table 5).**

Table (5): Univariate regression analysis.

Variable	95% CI	P-Value
Age	0.95 – 1.00	0.067
Male gender	0.067 - 1.02	0.07
Height (cm)	0.7 - 1.15	0.32
Weight (Kg)	0.073 - 0.1.26	0.36
Pre-operative medical treatment	0.52 – 2.21	0.22
ASD	1.54 – 4.55	0.02
PR interval (cm)	0.66 – 1.5	0.81
QRS duration (cm)	0.59 – 1.3	0.059
Preoperative LVEF	0.31 – 2.2	0.31
Peri-membranous VSD	1.32 – 6.78	0.03
Muscular VSD	1.15 – 8.35	0.06
Inlet VSD	1.12 – 1.56	0.3
Doubly committed VSD	1.55 – 7.7	0.02
VSD Diameter (Large)	2.63 – 9.92	0.002
Direct closure with a pledget	0.5 – 3.68	0.043
Septal leaflet detachment	1.15_ 8.35	0.05

DISCUSSION

One of the most typical lesions requiring surgical repair is a ventricular septal defect (VSD)8. The first surgical closure of the VSD was carried out by **Lillehei and associates in 1955** [9].

Operative mortality has been significantly decreased as a result of numerous later advancements in surgical repair, including better methods for cardiopulmonary bypass, myocardial preservation, anesthetic, and postoperative care. Although they are uncommon, complications can include death, residual VSD, conduction problems, emergency reoperation, cerebral damage, and residual VSD [10]. Long-term outcomes for infants who have isolated VSD surgically closed are also favorable.

An old study by **Meijboom *et al.*** [11] found that after more than 10 years postoperatively, all survivors were still growing normally and had a satisfactory quality of life. Another recent study, by **Rex *et al.*** [12], found that surgically closing a ventricular septal defect in an infant or toddler had good long-term outcomes. There is no pulmonary hypertension. Even though many individuals have morphological, hemodynamic, or electrophysiologic consequences, personal health evaluation and exercise capacity are equivalent to those of the general community.

Similar results have been reported by other recent investigations, with a 1% chance of mortality, substantial morbidity, urgent reoperation, and significant residual VSD [7, 13, 14].

Conduction system damage is still the main contributor to long-term postoperative cardiac morbidity, especially as more surgical procedures are performed on younger and younger patients [(13)]. Complete heart block has been a major side effect of VSD closure that is linked to a higher chance of dying later [(14)].

As a result of the atrioventricular nodes and the bundle of His' tight anatomical proximity to the inferoposterior wall, the conduction system is particularly vulnerable during the closure of perimembranous VSDs. The frequency of intraoperative damage has been decreased thanks to a greater understanding of the anatomy of the conduction system. There is no longer a full heart block after VSD repair, according to numerous studies.

Complete heart block in the perimembranous ventricular septal defect after surgical closure was 10 (9.71%) in **Shah *et al.*** [(15)] study. The majority of complete heart blocks (12.8%) were detected in people who were younger than or equal to 10 years old, according to the complete heart blockage distribution. The study concluded that while VSD closure is less frequently linked to CHB, there should still be plans in place for a pacemaker to timely pace the patient in the event of an emergency.

The outcomes of numerous individuals who underwent VSD surgery at the Great Ormond Street Hospital for Children for 26 years were recently examined by **Andersen *et al.*** [(16)]. Their study's findings lead them to hypothesize that the probability of iatrogenic total heart block with VSD closure should be less than 1% and that these patients should expect mortality rates that are close to 0%. Complete heart block occurrence during our investigation was only 1%.

Incomplete RBBB (6%) and Complete RBBB (3%) were the two most typical disturbances in perimembranous VSD. According to a recent study by **Gholampour-Dehaki *et al.*** [(7)], 2% of patients had CHB complications. Following VSD closure, the right bundle branch block is a recognized finding in 84 (36.4%) partial, 42 (18.2%) full, and 29 (12.6%) cases with left anterior hemiblock.

It has been debatable how a long-lasting right bundle branch block affects left ventricular performance after surgically closing a VSD. A recent article by **Pederson *et al.*** [(17)] looked at how long-lasting right bundle branch block affects left ventricular function. In long-term follow-up, they observed that the right bundle branch block remained a frequent finding even after surgical correction, which may be related to diastolic dysfunction but does not appear to impair systolic ventricular performance. Following surgical VSD closure, the right bundle branch block is still a frequent finding that requires ongoing assessment.

In the univariate regression analysis of our study, muscular VSD and large ones were the most significant association with conductive disorders occurrence after VSD repair.

In our study cases with larger VSD were more reliable for conductive disturbance occurrence most probably due to the larger needed intervention. Also, Peri-membranous and doubly committed were all risk factors for a conductive disturbance occurrence. Perimembranous VSD was the most potent associated risk for a conductive disturbance occurrence.

CONCLUSION

Surgical VSD repair is considered to be a safe procedure with a very low mortality rate. In this study, we found out that large VSD was an independent risk factor for conductive disorder occurring after VSD closure.

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REFERENCES

1. **Penny D, Vick W (2011):** Ventricular septal defect. The Lancet, 377(9771): 1103-1112.
2. **Cresti A, Giordano R, Koestenberger M *et al.* (2018):** Incidence and natural history of neonatal isolated ventricular septal defects: do we know everything? A 6-year single-center Italian experience follow-up. Congenital Heart Disease, 13(1): 105-112.
3. **Fulton D, Saleeb S, Triedman J *et al.* (2022):** Isolated ventricular septal defects in infants and children: Anatomy, clinical features, and diagnosis. UpToDate, 2(3): 26. https://www.medilib.ir/uptodate/show/5787
4. **Ahmed M, Sethna S, Krueger L *et al.* (2022):** Variable Anterior Segment Dysgenesis and Cardiac Anomalies Caused by a Novel Truncating Variant of FOXC1. Genes, 13(3): 411. doi: 10.3390/genes13030411
5. **Tobler D, Greutmann M (2020):** Simple cardiac shunts in adults: atrial septal defects, ventricular septal defects, patent ductus arteriosus. Heart, 106(4): 307-314.
6. **Karki R, Raina A, Ezzeddine F *et al.* (2021):** Anatomy and Pathology of the Cardiac Conduction System. Cardiac Electrophysiology Clinics, 13(4): 569-584.
7. **Gholampour-Dehaki M, Zareh A, Babaki S *et al.* (2016):** Conduction disorders in continuous versus interrupted suturing technique in ventricular septal defect surgical repair. Research in Cardiovascular Medicine, 5(1): e28735. doi: 10.5812/cardiovascmed.28735
8. **Cox K, Algaze-Yojay C, Punn R *et al.* (2020):** The natural and unnatural history of ventricular septal defects presenting in infancy: an echocardiography-based review. Journal of the

American Society of Echocardiography, 33(6): 763-770.

9. **Lillehei C (1955):** The results of direct vision closure of ventricular septal defects in eight patients using controlled cross circulation. Surg Gynecol Obstet., 101: 446-466.
10. **Houeijeh A, Godart F, Jalal Z *et al.* (2020):** Transcatheter closure of a perimembranous ventricular septal defect with Nit-Occlud Lê VSD Coil: a French multicentre study. Archives of Cardiovascular Diseases, 113(2): 104-112.
11. **Meijboom F, Szatmari A, Utens E *et al.* (1994):** Long-term follow-up after surgical closure of the ventricular septal defect in infancy and childhood. Journal of the American College of Cardiology, 24(5): 1358-1364.
12. **Rex C, Eckerström F, Heiberg J *et al.* (2019):** Surgical closure of a ventricular septal defect in early childhood leads to altered pulmonary function in adulthood: a long-term follow-up. International Journal of Cardiology, 274: 100-105.
13. **Hernandez-Madrid A, Paul T, Abrams D *et al.* (2018):** Arrhythmias in congenital heart disease: a position paper of the European Heart Rhythm Association (EHRA): Association for European Paediatric and Congenital Cardiology (AEPC): and the European Society of Cardiology (ESC) Working Group on Grown-up Congenital heart disease, endorsed by HRS, PACES, APHRS, and SOLACE. EP Europace, 20(11): 1719-1753.
14. **Bai Y, Xu X, Li C *et al.* (2015):** Complete atrioventricular block after percutaneous device closure of perimembranous ventricular septal defect: a single-center experience on 1046 cases. Heart Rhythm, 12(10): 2132-2140.
15. **Shah S, Ullah I, Khan M *et al.* (2015):** Frequency of Complete Heart Block After Surgical Closure of Perimembranous Ventricular Septal Defect. Journal of Postgraduate Medical Institute, 29(4): 213-214. https://www.jpmi.org.pk/index.php/jpmi/article/view/1759
16. **Andersen H, de Leval M, Tsang V *et al.* (2006):** Is complete heart block after surgical closure of ventricular septum defects still an issue? The Annals of Thoracic Surgery, 82(3): 948-956.
17. **Pedersen T, Andersen N, Knudsen M *et al.* (2008):** The effects of surgically induced right bundle branch block on left ventricular function after the closure of the ventricular septal defect. Cardiology in the Young, 18(4): 430-436.