Early outcome of ventricular septal defect closure in infants under five kilograms of body weight

Samy Amin, MD, Hesham Abd El Fattah Shawky MD, Tarek Salah El Din Abd Allah Rezk MD and Ahmed Essam Msc.

Cardiothoracic Surgery Department, Faculty of Medicine, Cairo Univ., Giza-Egypt
email: samymamin@yahoo.com

Abstract: Background: Early primary repair is recommended to interrupt the natural history of the ventricular septal defect (VSD) before the development of severe pulmonary vascular obstructive disease. The pulmonary vascular obstructive disease may begin to develop as early as 6 to 12 months in patients with large VSDs. Meticulous and minute-minute postoperative care is mandatory to achieve a favorable surgical outcome and postoperative results. Size of the patient, which in the past was one of the most frequent reasons for a Palliative surgery as pulmonary artery banding is no longer a contraindication for complete repair in major centers. Mostly all VSDs are closed by a running suture technique. The closure of the VSD is usually done with a patch made of either Gore-Tex or bovine pericardium. **Patients and Methods:** In the period between January 2015 and August 2017, 48 infants under five kilograms of bodyweight with VSD underwent open heart surgery at the Pediatric Cardiothoracic Surgery Unit at Abu El Reesh specialized pediatric Hospital, Cairo University. In our study outcome of surgery was determined by the period of mechanical ventilation time, length of ICU stay, length of ward stay postoperatively, presence of residual VSD, heart rhythm, postoperative chest infection, amount of chest tube drainage, need for blood transfusion, the incidence of re-exploration and mortality. **Results:** The efficacy of VSD closure in low weight infants in our study is demonstrated by the drop of pulmonary artery pressure in the majority of our patients. In our study, there was postoperative pulmonary hypertension in 14.58 % of the cases compared to 87.5% preoperatively. The overall mortality in our study was 4.16%. 89.58% of our cases had normal sinus heart rhythm postoperatively. 89.6% of our cases didn't have residual VSDs. **Conclusion:** The clinical results of operations on VSD infants under five kilograms of bodyweight are satisfactory with attention to the indication and timing of surgery, proper CPB management, rational operations, and perioperative management. Early primary repair is recommended to interrupt the natural history of VSD.

[Samy Amin,, Hesham Abd El Fattah Shawky, Tarek Salah El Din Abd Allah Rezk and Ahmed Essam. **Early outcome of ventricular septal defect closure in infants under five kilograms of body weight.** *J Am Sci* 2019;15(3):92-97]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 14. doi:10.7537/marsjas150119.14.

Keywords: Ventricular Septal Defect (VSD) closure, infants, under five kilograms

1. Introduction:

Ventricular Septal Defect (VSD) repair is the most commonly performed pediatric cardiac operation. Recent reports have indicated a very low incidence of postoperative complications (1,2,3). Early primary repair is recommended to interrupt the natural history of VSD before the development of severe pulmonary vascular obstructive disease (4,5,6). The pulmonary vascular obstructive disease may begin to develop as early as 6 to 12 months of age in patients with large VSDs. Meticulous and minute-minute postoperative care is mandatory to achieve a favorable surgical outcome and postoperative results (7,8,9).

Mostly all VSDs are closed by a running suture technique using a double-armed, half-circle needle of 5-0 or 6-0 Prolene (15,16,18). The closure of the VSD is usually done with a patch made of either Gore-Tex or bovine pericardium (9).

The aim of this study was to evaluate the impact of weight less than 5 kg at operation on mortality and morbidity in the patients with ventricular septal defect undergoing surgical closure.

2. Patients and Methods

This study is an observational retrospective study aimed to cite our experience in surgical VSD closure in infants under five kilograms of bodyweight**.** The study was conducted after obtaining the approval of the local ethical committee and a written formal consent from all the patients' parents is routinely taken in our hospital as a university hospital for research purposes for at the Pediatric cardiothoracic surgery Unit at Abu El Reesh specialized pediatric Hospital (Japanese Hospital), Cairo University in the period between January 2015 and July 2017.

All patients were evaluated thoroughly preoperative, intraoperative and postoperative with special attention to Patients weighing 5 kg or less with either isolated VSD or VSD with other simple cardiac anomalies as ASD or PDA excluding Patients above 5 Kgs and Patients with complex congenital anomalies.

No control group has been added as the policy of our hospital is to operate all the VSDs patients once presented to our unit so we don't have elder patients.

Surgical technique:

The majority of VSDs (Perimembranous, inlet, and the majority of muscular defects) were closed via a right atrial approach; however, some VSDs were closed via a transpulmonary approach. A transverse atriotomy parallel to the atrioventricular groove is made and extended toward the orifice of the inferior vena cava. The edges of the incision were then retracted to provide good exposure of the tricuspid valve and the triangle of Koch. The leaflets of the TV were retracted to expose the defect. All VSDs were closed by a running suture technique using a double-armed, half-circle needle of 5-0 or 6-0 Prolene. The closure of the VSD was done with a patch made of either Gore-Tex or bovine pericardium.

Approach through the PA was reserved for sub pulmonary and doubly committed VSD. The main pulmonary artery was opened transversely just above the commissures. A small vein retractor was placed through the pulmonary valve to expose the ventricular septal defect. Associated simple cardiac anomalies as ASD and PFO were closed either by direct running sutures using 5-0 or 6-0 Prolene.

3. Results

Preoperative Results:

The demographic features of the study group are shown these results are shown in Table (1).

Table (1): Physical characteristics of the study group.

Physical characteristics	Number	Percent
Age (months)		
Range	**3.00-12.00**	
Mean ± SD	**5.91 ± 1.73**	
Weight (kg.)		
Range	**3.40-4.90**	
Mean ± SD	**4.43 ± 0.35**	
Sex		
Female	**32**	**66.67**
Male	**16**	**33.33**
Down syndrome		
No	**42**	**87.50**
Yes	**6**	**12.50**

Data are expressed as mean ± SD or number (%)

Preoperative echocardiographic data included associated cardiac anomalies: 28 cases had isolated VSD with no associated cardiac anomalies (58.33%) and 20 cases had associated simple cardiac anomalies (41.67%) of which 13 cases had associated ASD (27.08% of the study group), 5 cases had associated PDA (10.42% of the study group) and 2 cases had associated ASD and PDA (4.17% of the study group).

Regarding the type of VSD, it was Perimembranous VSD in 38 cases (79.17%), muscular VSD in 7 cases (14.58%) and subpulmonic VSD within 3 cases (6.25%).

Table (2): Preoperative echocardiographic data of the study group.

Preoperative echocardiography	Number	Percent
Pathology		
VSD and ASD	13	27.08
VSD and PDA	5	10.42
VSD, ASD and PDA	2	4.17
Isolated VSD	28	58.33
VSD type		
Muscular VSD	7	14.58
subpulmonic VSD	3	6.25
Perimembranous VSD	38	79.17
VSD size		
Minimum-maximum	6.0-18.0	
Mean ± SD	8.61 ± 2.28	
Pulmonary HTN		

No	6	12.50
yes	42	87.50

Data are expressed as mean ± SD or number (%).

The range of VSD size was 6.0- 18.0 mm with a mean size of 8.61 ± 2.28 mm. PHTN was evident in 42 cases of our study group (87.50**%)** (12 cases 45mmHg, 15 cases 55 mmHg, 15 cases 75mmHg) while 6 cases had normal pulmonary artery pressure (12.50%) (Below 40mmHg)**.** These results are shown in Table (2).

Intraoperative results:

Mean values of aortic cross clamp, bypass and operative times of the study group are reported in Table (3).

Table (3): Mean values of Aortic cross clamp, cardiopulmonary bypass and operative times **(skin to skin)**

Intraoperative results	**Variable**
Aortic cross clamp time (min.)	
Minimum-maximum	36-71
Mean ± SD	45.75 ± 6.24
Bypass time (min.)	
Minimum-maximum	47-120
Mean ± SD	60.19 ± 6.15
Operative time (min.) **(skin to skin)**	
Minimum-maximum	113-175
Mean ± SD	142.02 ±13.44

Data are expressed as mean ± SD.

In our study group VSD was exposed via the transatrial approach in 43 cases (89.58%) while the transpulmonary approach was used in 5 cases (10.42%). (3 of them were subpulmonic VSD with outlet extension and the other 2 were perimembranous VSDs but the upper part of the vid was not apparent so we used a combined atrial and transpulmonic approach).

The results from Table (4) closed that the VSD using a GORE- TEX patch in 38 cases (79.17%), using the bovine pericardial patch in 6 cases (12.50%), while it was closed directly in 4 cases (8.33%). Those 4 cases directly closed were diagnosed preoperatively with a VSD 4mm but intraoperative we found the VSD partially closed with tricuspid tissue and the effective orifice area of the VSD doesn't exceed 1-2mm.

Table (4): Approach to VSD and repair technique of the study group.

	Number	**Percent**
Approach to VSD		
Transatrial approach	43	89.58
Transpulmonary approach	5	10.42
Repair technique		
Direct closure	4	8.33
Closure by bovine precaradiac patch	6	12.50
Closure by gortex patch	38	79.17

Data are expressed as number (%).

Our hospital policy that we don't measure the pulmonary pressure intraoperative and we rely on the pre and postoperative echo assessment in this age group of patients in our study group; 43 cases (89.6%) needed inotropic support while 5 cases (10.4%) didn't need inotropes.

Postoperative results:.

The duration of mechanical ventilation ranged from 0-20 days with a mean duration of 1.6 ± 2.1days. The duration of ICU stay ranged from 2 days to 27 days with a mean duration of 10.50 ± 5.99 days. Ward stay duration ranged from 0 days to 5 days with a mean duration of 0.60 ± 1.36 days.

In our study group 5 cases had temporary heart block postoperatively (10.4%) while 43 cases had sinus rhythm (89.6%).

In our study group chest tube drainage ranged from 10 ml to 60 ml with a mean drainage amount of 22.5 ± 15.8 ml. 21 cases needed a blood transfusion (43.75%) while 27 cases didn't so (56.25%). In our

study group 3 cases needed surgical re-exploration (6.25%) while 45 cases (93.75%) didn't need re-exploration.

The postoperative echocardiographic assessment showed that 43 cases had no residual flow across VSD (89.58%) while 5 cases had residual VSD (10.42%).

Pulmonary hypertension was evident in 7 cases (14.58%) while 41 cases (85.42%) didn't have pulmonary hypertension.5 cases had postoperative chest infection (10%) while 43 cases didn't have pulmonary complications (90%). In our study group there was mortality in 2 cases (4.16%) while there was no mortality in 46 cases (95.84%).

4. Discussion

Given the improvements in neonatal surgical results, surgeons are encouraged to precede with surgery and close symptomatic VSDs in ever smaller patients, hoping to avoid aggressive multidrug and supplemental feeding regimens. Progress in surgical technique has substantially decreased the morbidity and mortality of surgical closure, with the risk of mortality for all patients being <1%. The use of steroids, protease inhibitors, and high-flow, a low-pressure bypass has decreased fluid retention and inflammatory response. There is improved drug treatment for low cardiac output, pulmonary hypertension, and coagulopathy in the postoperative period (10).

In our study we tracked the course of VSD after surgical closure in children weighing less than 5 kilograms. In our study group 33.33 % of the patients were males and 66.67% of them were females. This was different than others who reported 59% males and 41% females resembled finding of others (11,18). However, according to literature VSDs are slightly more common in female patients than in male patients (56% vs 44%). The incidence of abnormalities of ectomesenchymal tissue migration (ie, subarterial outlet VSD) is highest in boys (12).

In our study the mean age was 5.91 ± 1.73 months and the mean weight among our study group was 4.43 ± 0.35kg.12.50% of the patients had Down syndrome. These results were different than other studies in age were they had mean age of 3.9 ± 1.9 months and close to them in which 12.6% of their patients had Down syndrome (10). No control group has been added as the policy of our hospital is to operate all the VSDs patients once presented to our unit.

Congenital heart defect (CHD) is common in infants with Down syndrome (DS), which is the principle cause of mortality. ASD was the most common CHD, occurring in (30.5%) of all infants with Down syndrome, followed by VSD (19.3%), PDA (17.5%), and AVSD (9.4%). (15,16).

Most of our patients were found by echocardiography to have isolated VSD (58.33%), 27.08% of our patients had an associated ASD, 10.42% of them had an associated PDA and 4.17% had both associated ASD and PDA. In contrast to our study others had associated ASD in 21.8% of their patients, 12.3% of them had associated PDA and 7.4% had pulmonary valve stenosis (12).

Regarding the VSD type in our study group; the majority was Perimembranous (79.17%), followed by muscular VSD (14.58%) and finally subpulmonic VSD (6.25%). This resembled finding of others in which VSD type distribution was (82%) perimembranous, (9%) muscular, (1%) Perimembranous and muscular and (8%) subarterial in one and which 80% of VSDs were perimembranous, 13% were outlet VSDs, 3% inlet VSDs and 4% muscular VSDs in the other (17,19).

In our study preoperative PHTN was diagnosed in 87.50% of the patients while PHTN was not present in 12.50% of the patients. This agrees with other studies in which PHTN was diagnosed in 87.6% of the patients while it was not present in 12.4% of the patients (12)**.** Our results are in contrast with others in which only 9.5% of their patients had PHTN preoperatively (20).

In our study, the mean aortic cross-clamp time was 45.75 ± 6.24 minutes, mean bypass time was 60.19 ± 6.15 minutes and the mean operative time was 142.02 ±13.44 minutes. We reported less cross-clamp time than others who reported 53.4±2.69 minutes and their mean bypass time was 77.6±5.47 minutes (1). And longer than others who reported 37 ± 5 minutes cross clamp time and mean cardiopulmonary bypass time was 68 ± 6 minutes. (18).

As regards the surgical approach; VSD was exposed via the transatrial approach in 89.58% of the cases while the transpulmonary approach was used in 10.42% of the cases. This was different from others who used transatrial approach in (87.7%), transatrial-transventricular in (2.3%), transventricular in (2.7%), transaortic in (1.9%), and transpulmonary in (5.4%) of cases. (18, 21).

Regarding technique for VSD closure in our study; VSD was closed using a patch in 91.67% of the cases, while it was closed directly in 8.33% of the cases. This was different than others that had 87.3% of VSDs closed by patch and 12.7% were closed directly (10).

VSD in our study was closed using a GORE-TEX patch in 79.17% of the cases, using the bovine pericardial patch in 12.50% of the cases, while it was closed directly in 8.33% of cases. The handling characteristics of bovine pericardium are better than other materials. The elastic bovine pericardium is also more in harmony with septal movements than

synthetic prosthetic materials, such as PTFE and Dacron. Bovine pericardium, carry a lower risk of endocarditis. This was different than others who 100% of VSDs were closed by a synthetic patch (24).

The mean duration of postoperative mechanical ventilation in our study was 1.6 ± 2.1 days. These results are close to the results of others which was 1.8±0.96 (11).

In our study the mean time of postoperative ICU stay was 10.50 ± 5.99 days. This contrasts the results of others where the mean ICU stay was 3±1.24 days (18**).** The prolonged ICU stays time is due to that our hospital policy is that the patient stay in the ICU till home discharge except for few cases (3 cases with mild wound discharge for frequent dressing) went down to the word to free space for new cases and they were from far away governments.

In our study the mean duration of postoperative hospital stay was 0.60 ± 1.36 days while in the study conducted by other it was 5.4±3.6 days (5).

In our study 10.4% of the cases had temporary heart block postoperatively while 89.6% of the cases had sinus rhythm. This resembled finding of others who had postoperative temporary heart block in 10.5% of their cases (1).

In our study 6.25% of the patients needed reoperation. This was less than others who reported 14% (10) and more than some else who reported 2.8% (1,22).

In our study Postoperative echocardiographic assessment showed that 89.58% of our cases had no residual flow across VSD while 10.42% had residual VSD around 2-3mm. This was more than the finding of others who reported residual VSD in 5% of cases. May be this is due to different echocardiography machine technology and different operators. (11).

As regards postoperative pulmonary hypertension detected by postoperative echocardiography 14.58% of our cases had postoperative pulmonary hypertension while 85.42% didn't have pulmonary hypertension. This resembled finding of others who didn't have pulmonary hypertension 86.4% of their cases (15,23).

In our study 10% of the cases had postoperative chest infection this is close to the results of the study conducted by others which was around 13% (7).

In our study group there was mortality in 4.16% of the patients. In spite this percent is higher than others who reported no mortalities among their study group (15) and close to others who reported 2.5% (18) yet the mortalities were only 2 cases out of the 48 cases and unrelated to their age and weight but due to prolonged hospital stay (first case 4 weeks and 2nd case 6 weeks) and complicated with a chest infection in the ICU.

Conclusion

The clinical results of operations on VSD infants under five kilograms of bodyweight are satisfactory with attention to the indication and timing of surgery, proper CPB management, rational operations and perioperative management. Early primary repair is recommended to interrupt the natural history of VSD before the development of the severe pulmonary vascular obstructive disease.

Several limitations have been faced in the study as the limited number of the studied cases and unavailability of a comparative study group with elder age and bigger weights as the policy in our department is that all the VSDs are operated once presented to our hospital, an ICU policy should be adopted to avoid unnecessary prolonged postoperative mechanical ventilation. And the availability of a postoperative ward to avoid unnecessary postoperative ICU stay.

References

1. Scully BB, Morales DL, Zafar F, McKenzie ED, Fraser CD Jr, Heinle JS, Current expectations for surgical repair of isolated ventricular septal defects, Ann Thorac Surg. 2010 Feb;89(2):544-9; discussion 550-1. doi: 10.1016/j.athoracsur.2009.10.057
2. Akhter Mehmooda, Sameh R. Ismaila, Mohamed S. Kabbania, Riyadh M. Abu-Sulaimana, Hani K. Najm. (2014), Outcome of low body weight (<2.2 kg) infants undergoing cardiac surgery, jsha.2014.03.002.
3. Doaa Abdullah M. Shahbah, Amr Megahed Abo-Elnaga, Eman Mahmoud El-Moghazy and Wael Mohammad Lotfi. Perioperative Risk factors for Prolonged Mechanical Ventilation Following Cardiac Surgery for Congenital heart Disease in Pediatric Patients., J Egypt Soc Cardiothorac Surg 2012; 20 (1-2): 13-20.
4. Roguin N, Du ZD, Barak M, Nasser N, Hershkowitz S, Milgram E. High prevalence of muscular ventricular septal defect in neonates. J Am Coll Cardiol. 1995;26(6):1545–1548. doi: 10.1016/0735-1097(95)00358-4.
5. Bacha EA, Cao QL, Starr JP. Perventricular device closureof m uscular ventricular septal defect. 1 Thorac Cardia vase Surg2003; 126: 1 7 1 8.
6. Christopher L. Curzon, DO, Sarah Milford-Beland,, Jennifer S. Li, MHS, Sean M. O'Brien,, Jeffrey Phillip Jacobs, Marshall Lewis Jacobs, Karl F. Welke, Andrew J. Lodge, Eric D. Peterson,, MPH, James Jaggers, Cardiac surgery in infants with low birth weight is associated with increased mortality: Analysis of the Society of Thoracic Surgeons Congenital Heart Database,

March 2008Volume 135, Issue 3, Pages 546–551, DOI: 2007.09.068.
7. Curzon CL1, Milford-Beland S, Li JS, O'Brien SM, Jacobs JP, Jacobs ML, Welke KF, Lodge AJ, Peterson ED, Jaggers J. (2008), Cardiac surgery in infants with low birth weight is associated with increased mortality: analysis of the Society of Thoracic Surgeons Congenital Heart Database, J Thorac Cardiovasc Surg. 2008 Mar;135(3):546-.
8. Jacobs ML, O'Brien SM, Jacobs JP. An empirically based tool for analyzing morbidity associated with operations for congenital heart disease. J Thorac Cardiovasc Surg. 2013;145(4):1046–1057. doi: 10.1016/j.jtcvs.2012.06.029
9. Kogon B, Butler H, Kirshbom P, Kanter K, McConnell M. Closure of symptomatic ventricular septal defects: how early is too early? Pediatr Cardiol. 2008;29(1):36–39.
10. Anderson BR, Stevens KN, Nicolson SC. Contemporary outcomes of surgical ventricular septal defect closure. J Thorac Cardiovasc Surg. 2013;145(3):641–647.
11. AE Topal, MD, MN Eren, MD, Risk factors for the development of pneumonia post cardiac surgery, Cardiovasc J Afr. 2012 May; 23(4): 212–215., doi: 10.5830/CVJA-2012-005
12. Maartje Schipper Martijn G. Slieker Paul H. Schoof Johannes M. P. J. Breur (2017), Surgical Repair of Ventricular Septal Defect; Contemporary Results and Risk Factors for a Complicated Course, Pediatr Cardiol (2017) 38: 264. https://doi.org/10.1007/s00246-016-1508-2
13. Mavroudis C, Backer CL, Jacobs JP. (2003) Ventricular septal defect. In: Mavroudis C, Backer CL, eds. Pediatric Cardiac Surgery, 3rd ed. Philadelphia, PA: Mosby Inc.
14. Prema Ramaswamy, MD, Kuruchi Srinivasan, MD, Ventricular Septal Defects, medscape.com/article/892980, 10.12.2015
15. Maneesh Kumar, Rajesh Sharma, Sidharth Kumar Sethi,1 Subeeta Bazaz, Prerna Sharma, Anil Bhan, and Vijay Kher, Vasoactive Inotrope Score as a tool for clinical care in children post cardiac surgery, Indian J Crit Care Med. 2014 Oct; 18(10): 653–658., doi: 10.4103/0972-5229.142174.
16. Min-A Kim, You Sun Lee, Nan Hee Yee, Jeong Soo Choi, Jung Yun Choi, and Kyung Seocorresponding, (2015), Prevalence of Congenital Heart Defects Associated with Down Syndrome in Korea, J Korean Med Sci. 2014 Nov; 29(11): 1544–1549. Published online 2014 Nov 4. doi: 10.3346/jkms.2014.29.11.1544
17. Numan Ali Aydemir, Bugra Harmandar M.D., Ali Riza Karaci M.D., Ahmet Sasmazel, Ahmet Bolukcu M.D., Turkay Saritas M.D., Ilker Kemal Yucel M.D., Filiz Izgi Coskun M.D., Mehmet Salih Bilal, Ibrahim Yekeler; Results for Surgical Closure of Isolated Ventricular Septal Defects in Patients Under One Year of Age, Journal of Cardiac surgery, First published: 15 March 2013, DOI: 10.1111/jocs.12073
18. Sherif Azab, Hossam El-Shahawy, Ahmed Samy, Waleed Mahdy, (2000), Permanent complete heart block following surgical closure of isolated ventricular septal defect, doi.org/10.1016/j.ejcdt.2013.03.007
19. Stevens KNAnderson BR, Nicolson SC, Gruber SB, Spray TL, Wernovsky G, Gruber PJ, Contemporary outcomes of surgical ventricular septal defect closure, J Thorac Cardiovasc Surg. 2013 Mar;145(3):641-7.
20. Shi Z, Shu Q, Zhang ZW, Surgical treatment for ventricular septal defect in infants under 5 kg of body weight, Zhejiang Da Xue Xue Bao Yi Xue Ban. 2007 Nov;36(6):610-3.
21. Seddio F, Reddy VM, McElhinney DB. (1999) Multipleventricular septal defects: how and when should they be repaired? J Thorac Cardiovasc Surg 117, 134–139; discussion139–140.
22. Valerie A. Schroeder, Jeffery M. Pearl, Steven M. Schwartz, Thomas P. Shanley, Peter B. Manning, David P. Nelson, Circulation. 2003;107:2823-2828, Originally published June 10, 2003, Volume 107, Issue 22.
23. Ziae Totonchi, Farah Baazm, Mitra Chitsazan, Somayeh Seifi, and Mandana Chitsazan; Predictors of Prolonged Mechanical Ventilation after Open Heart Surgery, J Cardiovasc Thorac Res. 2014; 6(4): 211–216, Published online 2014 Dec 30. doi: 10.15171/jcvtr.2014.014
24. Mohamed Aboul-Ezz and Ahmed El-Minshawy., Ventricular Septal defects with Severe Pulmonary Hypertension: Preoperative, Operative and Postoperative analysis., J Egypt Soc Cardiothorac Surg 1996; 4 (4): 23-38.