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Original Article

Challenges and Complications in Percutaneous Closure of Postoperative Residual Ventricular Septal Defects

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Abstract

Objectives: Surgical intervention has historically been the primary approach for closing ventricular septal defects (VSDs) in patients with congenital heart disease. However, the emergence of minimally invasive techniques, such as percutaneous device closure, offers alternative treatment modalities. This retrospective descriptive cross-sectional study aims to assess the challenges and complications associated with percutaneous closure of postoperative residual VSDs.

Methodology: The study retrospectively analyzed medical records of patients who underwent percutaneous closure of postoperative residual VSDs between April 2016 and September 2019 at the Pediatric and Congenital Heart Disease department of Mashhad University of Medical Sciences. Data collected included patient demographics, echocardiographic findings before, during, and after surgery, as well as follow-up results. Transthoracic echocardiography (TTE) was utilized to assess residual VSD size, position, hemodynamic consequences, and associated lesions pre-procedure.

Results: Twelve patients with postoperative residual VSDs underwent percutaneous device closure, resulting in immediate closure in six cases, while minimal residual VSDs persisted in others. Follow-up duration averaged 23.50 ± 39.73 months, with no mortality reported during this period. Two adverse events, namely fever with chills and intravascular hemolysis, occurred in separate patients. Atrial and right ventricular dilatation was observed in three patients, while others exhibited normal heart chamber dimensions. Left ventricular ejection fraction (LVEF) remained within normal limits across all patients.

Conclusion: Percutaneous closure of postoperative residual VSDs represents a minimally invasive, effective, and safe alternative to traditional surgical approaches. Despite challenges, such as adverse events and residual shunting, percutaneous closure offers favorable outcomes, supporting its adoption as a viable treatment option.

Keywords: Complications, Percutaneous Device Closure, Postoperative Residual Ventricular Septal Defects

INTRODUCTION

Ventricular Septal Defect (VSD) stands as one of the most prevalent congenital heart malformations [1-4], representing approximately 20% of all isolated congenital heart defects. The condition poses a significant health burden globally, with its occurrence varying across different populations [5,6]. Traditionally, surgical intervention has been the cornerstone in managing VSDs, aiming to mitigate potential complications and restore cardiac function. However, despite its effectiveness, surgical closure of VSDs in pediatric patients may entail considerable morbidity, ranging from sternotomy scars to prolonged hospital stays, heightened infection risks, and even organ dysfunction [7,8]. These challenges underscore the pressing need for alternative, less invasive treatment modalities to address VSDs, particularly in the pediatric population.

In response to the limitations of conventional surgical approaches, minimally invasive techniques such as percutaneous device closure have emerged as promising alternatives. Percutaneous closure offers several advantages over traditional surgical methods, including reduced morbidity, shorter recovery times, and enhanced patient comfort [9-16]. This approach has been increasingly adopted in various clinical settings worldwide, demonstrating efficacy in closing different types of VSDs arising from congenital causes, myocardial infarction, trauma, or postoperative residual defects [17]. The growing utilization of percutaneous closure underscores its potential to revolutionize the management of VSDs, especially in young patients, by offering a less invasive yet effective treatment option.

Against this backdrop, the present study seeks to contribute to the expanding body of evidence on percutaneous closure techniques for postoperative VSDs in pediatric patients. By assessing both the efficacy and complications associated with this approach, the study aims to provide valuable insights into the feasibility and safety of percutaneous closure in this specific patient population. Understanding the outcomes and challenges of percutaneous closure procedures for postoperative VSDs is crucial for informing clinical decision-making and optimizing patient care in the evolving landscape of congenital heart defect management.

METHODOLOGY

Study Design: This study employed a descriptive cross-sectional retrospective design spanning from April 2016 to September 2019. It aimed to investigate the outcomes of percutaneous closure procedures for residual isolated ventricular septal defects in pediatric patients.

Setting: The research was conducted at the Pediatric and Congenital Heart Disease Department of Mashhad University of Medical Sciences, located in Mashhad, Iran. This department served as the primary site for patient recruitment and data collection.

Participants: The study included patients meeting specific inclusion criteria: those with postoperative residual isolated ventricular septal defects weighing over 10 kg, with defect sizes ranging from 3 mm to 15 mm, situated in the perimembranous or upper-muscular region, and with a distance to the aortic valve exceeding 3 mm. Patients with specific exclusion criteria, such as certain types of septal defects, comorbidities, or pulmonary vascular obstructive disease, were excluded.

Variables: Key variables included demographic characteristics (e.g., age, gender), clinical parameters (e.g., size and location of residual VSD, echocardiographic findings), procedural details (e.g., choice of closure device, anesthesia protocol), and follow-up outcomes (e.g., immediate post-procedure results, complications, long-term follow-up).

Data Sources/Measurement: Data were collected from medical records, encompassing patient demographics, preoperative evaluations, procedural details, and post-procedure follow-up assessments. Transthoracic echocardiography (TTE) was utilized to evaluate residual VSD characteristics before closure, during the intervention, and throughout the follow-up period.

Bias: Efforts were made to minimize bias through standardized procedures, such as obtaining informed consent from patients or legal representatives, adherence to ethical guidelines, and consistent data collection methods. Additionally, the retrospective nature of the study may have introduced certain

biases, which were mitigated through meticulous data retrieval and analysis.

Study Size: The study encompassed a cohort of 12 patients, comprising both males and females, with a mean age of 8.17 ± 3.8 years. These patients were selected from the pool of eligible candidates who underwent treatment within the defined timeframe and met the specified inclusion criteria. The final sample size was determined by the availability of suitable cases meeting the study criteria, ensuring that all eligible patients within the designated timeframe were included in the analysis.

Quantitative Variables: Quantitative variables such as age at initial catheterization, size of residual VSD, and duration of follow-up were analyzed to assess procedural outcomes and long-term efficacy of closure interventions.

Statistical Methods: Descriptive statistical analysis was performed using SPSS software version 20, utilizing measures such as mean, and standard deviation to summarize continuous data while frequency and percentages for categorical data.

RESULTS

Participants: The study involved 12 patients, comprising 5 males and 7 females, with a mean age of 8.17 ± 3.8 years. These patients were selected based on specific inclusion criteria, including postoperative residual isolated ventricular septal defects (VSDs) with sizes ranging from 3 mm to 15 mm.

Table 1: Distribution of Ventricular Septal Defect (VSD

VSD Types	N (%)
Aneurysmal PM	3 (25%)
PM	4 (33.3%)
Sub aortic	3 (25%)
Multi fenestrated Aneurysmal PM	1 (8.3%)
Mid-muscular	1 (8.3%)

Descriptive Data: Before cardiac surgery, echocardiographic assessments revealed VSDs with sizes ranging from 0.30 mm to 1.62 mm, with a mean size of 0.69 ± 0.38 mm. Among these cases, 75% (9 patients) exhibited left-to-right shunts, while 16.7% (2 patients) and 8.3% (1 patient) demonstrated predominantly right-to-left and bi-directional shunts, respectively. Pulmonary artery pressures were within the normal range in three-fourths of the cases, while half presented with systemic pulmonary hypertension. All patients exhibited normal ejection fraction.

Table 2: Distribution of Primary Surgical or Percutaneous Closure Types in the Study Cohort

Primary surgery/intervention Types	N (%)
Isolated VSD Closure	2 (16.7%)
VSD Repair &PA De-banding	3 (25%)
Percutaneous VSD Closure by coil	2 (16.7%)
TOF/TC	3 (25%)
VSD Closure & PS repair	1 (8.3%)
VSD Closure & PDA ligation	1 (8.3%)

Outcome Data: Following primary surgery, patients underwent either surgical or percutaneous closure procedures for residual VSDs. The average follow-up duration post-intervention was 23.50 ± 39.73 months. Mitral valve insufficiency (MI) developed in two patients post-surgery, while in one patient, it improved. Tricuspid regurgitation improved in two out of three patients with pre-existing conditions but occurred as a surgical complication in six cases post-surgery.

Table 3: Distribution of Closure Devices Utilized in the Study Cohort

Type of Device	N (%)
Occlutech duct occluder	6 (50%)
PFM VSD Le Coil	2 (16.7%)
Occlutech PmVSD + PFM VSD Le Coil	1 (8.3%)
LifeTech Muscular VSD Occluder	1 (8.3%)
Amplatzer Duct Occluder II (ADO II)	1 (8.3%)
PFM PDA Occluder coil	1 (8.3%)

After surgery, some patients experienced normalization of previously dilated left atrial and ventricular chambers, while others exhibited progression to dilation in all four chambers. Additionally, atrial and right ventricular dilation occurred as surgical complications associated with Right Ventricular Outflow Tract (RVOT) and Right Ventricular Hypertrophy (RVH), primarily in patients with tetralogy of Fallot.

Main pulmonary artery dilation occurred post-surgery in three patients with tetralogy of Fallot, with improvements in two cases. Pulmonary valve stenosis improved in two out of three patients, while pulmonary valve insufficiency improved in three patients but emerged as a new complication in four

others. No cases of aortic valve stenosis, patent ductus arteriosus (PDA), or coarctation of the aorta (CoA) were detected, with aortic valve insufficiency observed in only one case.

Main Results: Following percutaneous residual VSD closure, patients were followed up for an average of 14.6 ± 16.7 months. No deaths occurred during this period, although two adverse events were reported, including fever and chills in one patient and intravascular hemolysis in another. Mitral valve insufficiency persisted in three cases, with two cases pre-existing before the intervention and one emerging post-procedure. Tricuspid valve insufficiency was observed in ten cases post-procedure, with three cases considered new complications. Residual VSD closure was achieved in six patients, while minimal residual shunts remained in the other six. Pulmonary valve insufficiency improved in one patient but persisted in others, with no new complications post-procedure. Post-procedure echocardiography confirmed the satisfactory position of all occluder devices (Further detailed outcomes are provided in Table 4).

Table 4: Comparison of Selected Features before and After Primary Surgery, and Post Residual VSD Closure

	Before	After Primary Surgery	Post Residual VSD Closure
Mitral valve Insufficiency			
Up to Mild	1	2	3
Tricuspid valve Insufficiency			
Up to Moderate	3	7	10
Chamber Size Feature			
LA+LV Dilation	8	3	0
RA+RV Dilation	3	5	4
All Four Chambers Dilation	1	1	0

DISCUSSION

The present study focused on evaluating the feasibility of percutaneous closure for residual ventricular septal defects (VSDs) occurring after surgery or interventional procedures in twelve patients. Among these cases, successful complete closure was achieved percutaneously for six residual VSDs, while in the remaining six cases, only a very small residual VSD persisted. Notably, the occurrence of complications such as mitral and tricuspid valve regurgitation post-surgery underscores the importance of vigilant monitoring and management strategies. While most postoperative residual VSDs are attributed to patch leakage, there is a noteworthy mention of iatrogenic Gerbode defects, including Gerbode-like shunts, which require careful consideration in clinical management. The study also sheds light on the clinical significance of residual VSD closure, particularly in cases presenting symptoms of increased pulmonary blood flow and left ventricular volume overload, with successful closure observed in a majority of such cases.

Comparative analysis with previous studies, such as Kouakou et al.'s 2019 research, reveals similarities in findings related to residual VSDs and associated left ventricular volume overload [18]. However, our study highlights a higher incidence of residual iatrogenic Gerbode-like defects, necessitating tailored intervention strategies. Despite the persistence of tricuspid valve insufficiency post-intervention in all cases, our study aligns with previous research, like Knop et al.'s 2018 study, which underscores the efficacy of percutaneous closure techniques [19]. Furthermore, the absence of major complications in our study, despite the reported occurrence of minor adverse events, reinforces the safety profile of percutaneous closure procedures in managing residual VSDs.

The broader context of research in this field, as illustrated by studies such as those by Dua et al., Walsh et al., and Walavalkar et al., further substantiates the efficacy and safety of percutaneous closure techniques for residual VSDs [20-22]. These studies not only validate our findings but also emphasize the importance of long-term follow-up to assess the sustained effectiveness of such interventions [17,20,21].

Limitations: Despite the promising results, our study has several limitations, including the small sample size and constraints related to device availability and patient selection. Moreover, the absence of long-term follow-up data limits our ability to assess the durability and sustained efficacy of percutaneous closure. Future research endeavors should aim to address these limitations by conducting larger-scale studies with extended follow-up periods, encompassing diverse patient cohorts and employing advanced imaging modalities to enhance procedural precision and outcomes assessment.

CONCLUSION

In light of the findings from our study, transcatheter closure emerges as a promising and safe alternative for managing postoperative residual ventricular septal defects (VSDs) in pediatric patients. The successful closure achieved in the majority of cases underscores the efficacy of this minimally invasive approach, offering notable advantages over traditional surgical interventions. While further analysis is warranted to comprehensively evaluate the safety and long-term efficacy of transcatheter closure, our findings provide compelling evidence of its feasibility and favorable outcomes. Minimally invasive procedures, such as transcatheter closure, offer distinct advantages over conventional surgery, including reduced morbidity, shorter recovery times, and enhanced patient satisfaction. The preference for such interventions among families underscores the growing recognition of their benefits and potential to optimize patient care.

AUTHORS' CONTRIBUTION

BA, MN, SAQ, and SSG: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work.

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REFERENCES

1. Zhang J, Ko JM, Guileyardo JM, Roberts WC. A review of spontaneous closure of ventricular septal defect. Proc (Bayl Univ Med Cent). 2015;28(4):516-20.
2. Golboie SH, Zanguoie M, Salehi S, Rabiee N, Salehi F. Prevalence of congenital heart disease among newborns with respiratory distress and cyanosis in a tertiary care hospital in Birjand, Iran, during 2016. J Surg Trauma. 2019;7(1):21-5.
3. van Nisselrooij AEL, Lugthart MA, Clur SA, Linskens IH, Pajkrt E, Rammeloo LA, et al. The prevalence of genetic diagnoses in fetuses with severe congenital heart defects. Genet Med. 2020;22(7):1206-14.
4. Diab KA, Cao QL, Hijazi ZM. Device closure of congenital ventricular septal defects. Congenit Heart Dis. 2007;2(2):92-103.
5. Rudolph AM. Ventricular Septal Defect. In: Rudolph AM. (editor). Congenital Diseases of the heart: clinical-physiological considerations. 3rd ed. New York: Wiley-Blackwell; 2009: 197-244.
6. Moeinipour A, Lotfalizadeh M, Sepehri Shamloo A, Esfahanizadeh J, Mottahedi B, Alizadeh B, et al. Evaluation of Pregnancy risk factors in Women with Tetralogy of Fallot and cyanotic congenital heart disease (narrative review). Iran J Obstet Gynecol Infertil. 2015;18:19-24.
7. Minette MS, Sahn DJ. Ventricular septal defects. Circulation. 2006 Nov 14;114(20):2190-7. Erratum in: Circulation. 2007;115(7):e205.
8. Saurav A, Kaushik M, Mahesh Alla V, White MD, Satpathy R, Lanspa T, et al. Comparison of percutaneous device closure versus surgical closure of peri-membranous ventricular septal defects: A systematic review and meta-analysis. Catheter Cardiovasc Interv. 2015;86(6):1048-56.
9. Zhao Y, Wang N, Wen P, Ouyang WB, Zhang FW, Qiu X, et al. Safety and efficacy of percutaneous intervention for children with combined congenital heart abnormality solely guided by transthoracic echocardiography. Zhonghua Xin Xue Guan Bing Za Zhi. 2018;46(10):804-9.
10. Liu H, Wang Z, Xia J, Hu R, Wu Z, Hu X, et al. Evaluation of Different Minimally Invasive Techniques in Surgical Treatment for Ventricular Septal Defect. Heart Lung Circ. 2018;27(3):365-70.
11. Omelchenko A, Gorbatykh Y, Voitov A, Zaitsev G, Bogachev-Prokophiev A, Karaskov A. Perventricular device closure of ventricular septal defects: results in patients less than 1 year of age. Interact Cardiovasc Thorac Surg. 2016;22(1):53-6.
12. Bu H, Yang Y, Wu Q, Jin W, Zhao T. Echocardiography-guided percutaneous closure of perimembranous ventricular septal defects without arterial access and fluoroscopy. BMC Pediatrics. 2019;19:302.
13. Odemis E, Saygi M, Guzeltas A, Tanidir IC, Ergul Y, Ozyilmaz I, et al. Transcatheter closure of perimembranous ventricular septal defects using Nit-Occlud(®) Lê VSD coil: early and mid-term results. Pediatric Cardiology. 2014;35(5):817-23.
14. Zhao LJ, Han B, Zhang JJ, Yi YC, Jiang DD, Lyu JL. Postprocedural Outcomes and Risk Factors for Arrhythmias Following Transcatheter Closure of Congenital Perimembranous Ventricular Septal Defect: A Single-center Retrospective Study. Chin Med J (Engl). 2017;130(5):516-21.
15. Baldasare MD, Polyakov M, Laub GW, Costic JT, McCormick DJ, Goldberg S. Percutaneous repair of post-myocardial infarction ventricular septal defect: current approaches and future perspectives. Tex Heart Inst J. 2014;41(6):613-9.
16. Glovaci D, Naqvi A, Yu K, Patel P, Krishnam M. Utility of cardiac MRI in determining percutaneous versus surgical post-infarction ventricular septal defect repair. Future Cardiol. 2018;14(2):125-30.
17. Bu H, Yang Y, Wu Q, Zhao T. Percutaneous puncture closure of postoperative residual ventricular septal defects without radiation. Ann Thorac Surg. 2020;109(6):e457-9.
18. Kouakou NYN, Song J, Huh J, Kang IS. The experience of transcatheter closure of postoperative ventricular septal defect after total correction. J Thorac Cardiovasc Surg. 2019;14:104.
19. Knop MT, Litwin L, Szkutnik M, Białkowski J, Galeczka M, Fiszer R. Percutaneous closure of perimembranous and postsurgical ventricular septal defects with Amplatzer Duct Occluder II Additional Sizes in paediatric patients –case series. Adv Interv Cardiol. 2018;14(4):429-32.
20. Dua JS, Carminati M, Lucente M, Piazza L, Chessa M, Negura D, et al. Transcatheter Closure of Postsurgical Residual Ventricular Septal Defects: Early and Mid-Term Results. Catheter Cardiovasc Interv. 2010;75:246-55.
21. Walsh MA, Coleman DM, Oslizlok P, Walsh KP. Percutaneous Closure of Postoperative Ventricular Septal Defects with the Amplatzer device. Catheter Cardiovasc Interv. 2006;67:445-51.
22. Walavalkar V, Maiya S, Pujar S, Ramachandra P, Siddaiah S, Spronck B, et al. Percutaneous device closure of congenital isolated ventricular septal defects: A single-center retrospective database study amongst 412 cases. Pediatric Cardiol. 2020;41:591-8.