Birjand University of Medical Sciences

Journal of Surgery and Trauma

Original Article

Clinical outcomes of pulmonary valve replacement surgery in pediatrics: a single-center experience long-term study

Hassan Mottaghi Moghaddam Shahri[1], Mohsen Yaghubi[2], Reza Ghasemi[3], Milad Chambari[4], Mahmood Hosseinzadeh Maleki[5]

[1] Associate Professor, Department of Pediatrics, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

[2] MSc in Extra-Corporeal Technology, Department of Extra-Corporeal Circulation, Razavi Hospital, Imam Reza International University, Mashhad, Iran

[3] Assistant Professor, Department of Cardiology, 9-Day Hospital, TorbatHeydariyeh University of Medical Sciences, Torbat Heydariyeh, Iran

[4] Department of Pediatrics, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

[5] Associate Professor, Department of Cardiac Surgery, Imam Reza Hospital, Mashhad University of Medical Sciences, Mashhad, Iran

Corresponding Author:
Tel: +989155127487
Email: hoseinzadehmalekim@mums.ac.ir

Abstract

Introduction: Heart valve disease in pediatricsis an increasing global concern, especially in developing countries. This study aims to determine the clinical outcomes of pulmonary valve replacement (PVR) surgery in pediatrics.

Methods: The authors retrospectively identified all pediatrics undergoing PVR surgery at Imam Reza hospital (Mashhad, Iran) between 2000 and 2020. Their medical records were reviewed for demographic characteristics, clinical data (intra-operative and postoperative), and follow-up results. Echocardiography and electrocardiography were performedonall patients before the surgery and periodically after the surgery.

Results: Among 50 pediatrics undergoing surgical PVR, 38 (76%) were female and others were male (14%), with a mean age of 10.39±5.31 years. The leading cause of PVR was the Tetralogy of Fallot. There was a significant relationship between age at the time of surgery and the size of the pulmonary valve(P=0.02).There were also statistically significant differences between QTc intervals before and after surgery (P=0.001). Further more, there was a significant correlation between QTc intervals before and after surgery and the ageof pediatrics at the time of surgery (P=0.01, r=-0.6).There was also a statistically significant relationship between the ICU stay (P=0.01) and the weaning time of the mechanical ventilation (P=0.03).

Conclusion: It is recommended that this procedure ispostponed as much as possible to decrease postoperative life-threatening events in pediatrics.In addition, if this surgery is conducted with good surgical and nursing management, it can be safe with low complications among other cardiac valve procedures.

Keywords: Congenital Heart Disease, Pulmonary Valve Atresia, Pulmonary Valve Insufficiency, Pulmonary Valve Stenosis, Tetralogy of Fallot

Citation: Mottaghi Moghaddam Shahri H, Yaghubi M, Ghasemi R, Chambari M, Hosseinzadeh Maleki M.Clinical outcomes of pulmonary valve replacement surgery in pediatrics: a single-center experience long-term study.J Surg Trauma.2022;10(2):71-76.

Received: October 17, 2021 ***Revised: December 11, 2021*** ***Accepted: May 23, 2022***

[DOI: 10.32592/jsurgery.2022.10.2.103]

Introduction

Despite the increasing life expectancy due to improvements in the diagnosis and treatment of cardiovascular disease, congenital heart defect repair is stilla challengedue to its high morbidity and mortality rates(1-2).

Patients with congenital heart disease (CHD) are a fast-growing population, and valvular heart defects are the leading cause of many congenital lesions(3). Surgical innovation has provided new treatments that have improved survival in this population. Nevertheless, there are many challenges in treating patients with complicated anatomic and rare physiologic patterns(4).

Among valvular heart diseases, pulmonary valve (PV) defects have a high morbidity and mortality rate, especially when combined with other structural heart defects(5).

The major structural defects of the PV that need surgical intervention include congenital pulmonary stenosis (PS) and pulmonary regurgitation (PR) in CHD(6).

Congenital PS is the most frequent entity within CHD that may occur in 5 per 10,000 live births(7). While PS is mostly found as an isolated defect, valvular PS is often associated with other congenital life-threatening co-morbidities. Additionally, in some cases, this defect is combined with genetic syndromes(8-9). despite the introduction of novel approaches to PS correction, such as balloon pulmonary valvuloplasty(10-11).

Since surgical valvoplasty is an alternative procedure, it is considered for pediatrics with the main pathologic patterns, such as hypoplastic pulmonary annuli or severe pulmonary regurgitation(12). On the other hand, a mild type of PR is relatively common in normal individuals; however, if it is combined with CHD, it needs special considerations(13).

Isolated congenital PR is rare and most often associated with congenital pulmonary valve atresia(14). For patients with PR, Pulmonary Valve Replacement (PVR) surgery is the most studied therapeutic and wised approach(15).

There is no evaluation of the clinical outcomes of surgical PVR in pediatrics in Iran. Therefore, the present study aimed to determine this issue as the first attempt to investigate the clinical situation in pediatrics undergoing surgical PVR.

Materials and Methods

After the study protocol was approved (Approval code: IR.MUMS.MEDICAL.REC.1397.234), a retrospective cohort study was conducted on all pediatrics undergoing PVR surgery between 2000 and 2020 in Imam Reza hospital (Mashhad, Iran). The inclusion criteria were being below 18 and requiring surgery of the congenital (structured) valvular defects. On the other hand, the exclusion criteria wereas follows: 1) other cardiac operations and simultaneous repair of complex congenital heart defects, 2) the incidence of general complications, such as re-exploration, due to massive bleeding, as well as tamponade, and 3) all deaths less than six months after surgery.

All data were collected from the pediatrics cardiac surgery portal and included demographic variables, the findings of clinical and para-clinical examinations (echocardiographic findings) before and after the cardiac surgery, as well asthe intra-operative findings. Moreover, the electrocardiographic study was conducted after the PVR surgery. The incidence of intraoperative andearlypostoperative complications was evaluated for all cases, which included valve-related events (paravalvular leakage, endocarditis, and thrombosis), the mal-function of the simultaneously replaced valve, and arrhythmia.

Continuous variables were reported as mean±SD. In analyticalstatistics, the normality of quantitative variables was firstly assessed using the Kolmogorov-Smirnov test. The student T-test and Mann-Whitney Utest were used to assess and compare the two groupsin terms of parametric and non-parametric variables, respectively. Additionally, an analysis of variance (ANOVA) test was runto evaluate more than two quantitative feature variables.

The extracted features from the electrocardiogram were compared before and after the measurement using the Wilcoxonsigned-rank test. A significance level of $P<0.05$ was considered. All statisticalanalyses were performed using the SPSS

[DOI: 10.32592/jsurgery.2022.10.2.103]

software (version 22.0, SPSS Inc., Chicago, IL, USA).

Results

Among 50 pediatrics undergoing surgical PVR, 38 (76%) were female and others were male (14%), with a mean age of 10.39±5.31 years, ranging from 18 months to 17 years. Among these patients, 48 patients onlyhad PVR surgerybuttwo of them experienced PVR surgery combined with aortic valve replacement; therefore, these two were excluded from the study. Fortunately, there was no death among all patientsafter six months of follow-up. The mean percentile weight of the pediatrics based on their age was 27.95±24.58 kg at birth time and 36.73±30.65 kg atthe time of surgery.

All valves used in these pediatrics were biological and most of them (80.68%) were manufactured bySt.Jude® medical cardiac valves (Minnesota, USA).

After evaluatingthe collected data, two patients had a redo PVR surgery nine years aftertheir primary surgery. The mean size of the PVs in these patients was in group sizes of 15-19 mm and 20-25 mm. The mean size of the PVs used in all patients was 23.80±2.64.

There was no significant relationship between the mean age of the patients and the need for reintervention in the follow-up period (P=0.09).

Furthermore, the age of the pediatrics was not significantly related to the aortic cross-clamp time (P=0.53) and cardiopulmonary bypass time (P=0.63). There were also no statistically significant differences amongaortic cross-clamp time (P=0.51), cardiopulmonary bypass time (P=0.59), and the gender of the patients. Nevertheless, the Pearson correlation test revealed that the time of the aortic cross-clamp and the cardiopulmonary bypass increased with an increase of age (r=0.7).

On the other hand, there was a significant relationship between the age at the time of surgery and the PV size (P=0.02). The linear regression analysis revealed that concurrent with the increase of age, the size of the valve increased by 0.13 mm in size.

The transpulmonary pressure gradient was measured after surgery, andthe data were categorized into three levels: mild form (0-29 mmHg), moderate form (30-59 mmHg), and severe form (more than 60 mmHg).

Among 28 patients with the last transpulmonary pressure gradient in pulmonary stenosis, 15 were in the mild, 11 in the moderate, and 2in the severe form. On the other hand, among 4 pediatrics with the last transpulmonary pressure gradient in pulmonary insufficiency, 1was in the mild and 3 were in the moderate form. The mean pressure gradient was 33.33±18.32 mmHg in the pulmonary stenosis group and 20.75±6.39in the pulmonary insufficiency group.

The most common cardiac anomalies in patients were the Tetralogy of Fallotin 32 (66.6%), isolated pulmonary stenosis in 7(14.5%), pulmonary atresia in 5 (10.4%), PV insufficiency-stenosis in 2 (4.1%), and trancusatreriousus in 2 (4.1%) patients.

The frequency of the postoperative complications showed that one patient had post-surgery excessive hemorrhage (2%), and one had a complete atrioventricular block (2%). The postoperative complications are illustrated in (Table 1).

Table 1. Postoperative complication in patients after pulmonary valve replacement

Postoperative complication	N (%)
Post-surgery excessive hemorrhage	1 (2)
Complete atrioventricular block	1 (2)
Permanent pulmonary stenosis	3 (6)
Pericardial effusion	4 (8)
Post-surgery fever	1 (2)

[DOI: 10.32592/jsurgery.2022.10.2.103]

The electrocardiography after cardiac surgery showed that except for one of the pediatrics with a complete atrioventricular block, the common conduction abnormality in the others was long QTc intervals (32%). There werealso statistically significant differences between QTc intervals before and after surgery (P=0.001). Moreover, there was a significant correlation between QTc intervals before and after surgery and the pediatrics' age at the time of surgery (P=0.01, r=-0.6).

Pediatrics had no life-threatening dysrhythmias (ventricular tachycardia and ventricular fibrillation), and the mean QRS duration in all of them was 138±65 msec before surgery, which decreased to 124±32 after the PVR surgery. However, this reduction was not statistically different before and after surgery (P=0.08).

There was a statistically significant relationship between the ICU stay (P=0.01) and the weaning time of the mechanical ventilation (P=0.03) with age. These findings show that with an increase in patients' age, the need for ICU stay and the weaning time dramatically decrease.

Discussion

This study was conducted to determine the clinical outcomes of surgical PVR in pediatrics. Unfortunately, very few studies have been carried out on pediatrics with PVR.

The redoPVR in this study was reported in two cases, which showed the good management of pediatrics after surgery. Albeit, the findings cannot demonstrate the leading cause of re-operation after the first surgery due to the limited number of patients experiencing this conduction. However, other studies reported some factors that can cause are do PVR surgery(16-19).

In the present study, the need for a redo PVR was observed nine years after the primary surgery. However, other studies reported having above five cases needing re-operation corrective PV-related surgeriesat least in the first five years of the follow-up(18, 20).

This study noted that pediatrics who needed are do PVR had smaller valves than others, which was parallel with the findings of McKenzie et al. that showed a significant correlation between the use of smaller size valves and the risk of valve reintervention. On the other hand, the mean age of patients was 10.39±5.31 years in this study, and there was no significant relationship between the age of patients and the need for a reintervention strategy. Nevertheless, other studies showed that the intervention in the primary stages could significantly increase the risk of reinterventions(20-21).

In the present study, the most prevalent cause of PVR was the Tetralogy of Fallot, which was in line with the findings of similar previous studies(20-22). In addition, Cesnjevar et al. revealed that the later planning ofthe PV intervention, due to the Tetralogy of Fallot,can decrease the chance of reintervention if the primary defects aresuccessfully corrected. Mean while, the successful management of theTetralogy of Fallot correction was reported in previous studies(2).

The ICU stay and the weaning time was dramatically higher in younger patients, compared tothose inothers. This result was similar to McKenzie et al. findings(20). On the other hand, there were no statistically significant differences between the age of the patients and the ICU stay, as well as weaning time, in other similar studies(21-22).

These differences in the results may be due to the diversity of ageranges in this study, compared to other studies. The differences in age ranges were remarkably lower in other studies and they approximately evaluated patients between 5 to 12 years old.

According to the present study findings, the transpulmonary pressure gradient in pulmonary stenosis after surgery was reported in the mild and moderate categories. Therefore, it is expected that this item increases many years after the surgical procedure. It is thus recommended that long-term follow-up studies consider this issue.

The unique finding of this study was the electrocardiographic analysis before and after surgery. These findings revealed statistically significant differences between QTc intervals before and after surgery. Furthermore, there was a significant correlation between this item and the

[DOI: 10.32592/jsurgery.2022.10.2.103]

pediatrics' age at the time of surgery. Therefore, based on these findings, the incidence of life-threatening dysrhythmias with longer QTc intervals seems imminentin younger pediatrics after PVR. Additionally, it seems crucial to perform close electrocardiographic monitoring and implement protective strategies after PVR surgery in ICU and even after the patients' discharge from the hospital.

It is suggested that future studies consider the effect of other predisposing risk factors, such as consanguineous marriages, on long-term postoperative patients' characteristics(23).

Conclusion

The findings of this study suggested that the PVR surgery in pediatrics was postponed as much as possible, and after the surgery, electrocardiographic studies included other critical care and intervention more than ever. Moreover, the surgical approach of PVR with a high quality of surgery, post-surgery care, and a long-term follow-up can be the safest procedure with a low complication rate.

Acknowledgments

None.

Funding

This study has no source of funding.

Conflict of interest

The authors declare no Conflict of interest.

References

1. YounessiHeravi MA, Mojdekanlu M, SeyedSharifi SH, Yaghubi M. The role of cardiovascular risk factors in involvement of coronary arteries; A predictive model in angiographic study. JNorth Khorasan University Med Sci. 2014; 6(1): 199-205.

2. F Ghanei-Motlagh, R Ghasemi, S Nazari, M Yaghubi. Successful outcome of pregnancy in a 31 years old woman with uncorrected Tetralogy of Fallot; A case report. JNorth Khorasan University Med Sci. 2016; 8(3): 541-547.

3. Saef JM, Ghobrial J. Valvular heart disease in congenital heart disease: a narrative review. CardiovascDiagnTher. 2021;11(3):818-839.

4. R Ghasemi, R Gharaee, S Nazari, S Sadri, F Tehrani Zadeh, M Yaghubi. Apical Hypertrophic Cardiomyopathy Presenting as Peripheral Cyanosis on Exertion and Paroxysmal Nocturnal Dyspnea: An Atypical Case Report. JKMU. 2021; 28(3): 306-310.

5. Milos NC, Nordstrom DB, Ongaro I, Chow AK. Variations in structure of the outflow tract of the human embryonic heart: A new hypothesis for generating bicuspid aortic semilunar valves. Ann Anat. 2017;211:88-103.

6. Lin CJ, Lin CY, Chen CH, Zhou B, Chang C. Partitioning the heart: mechanisms of cardiac septation and valve development. Development. 2012;139:3277-3299.

7. Hoffman JI, Kaplan S. The incidence of congenital heart disease. J Am CollCardiol. 2002;39(12):1890-1900.

8. Bashore TM. Adult congenital heart disease: right ventricular outflow tract lesions. Circulation. 2007;115(14):1933-1947.

9. Colquitt JL, Noonan JA. Cardiac findings in Noonan syndrome on long-term follow-up. Congenit Heart Dis. 2014;9(2):144-150.

10. Taggart NW, Cetta F, Cabalka AK, Hagler DJ. Outcomes for balloon pulmonary valvuloplasty in adults: comparison with a concurrent pediatric cohort. Catheter Cardiovasc Interv. 2013;82(5):811-815.

11. Wang SZ, Ou-Yang WB, Hu SS, Pang KJ, Liu Y, Zhang FW, et al. First-in-Human Percutaneous Balloon Pulmonary Valvuloplasty Under Echocardiographic Guidance Only. Congenit Heart Dis. 2016;11(6):716-720.

12. Fathallah M, Krasuski RA. Pulmonic Valve Disease: Review of Pathology and Current Treatment Options. Curr Cardiol Rep. 2017;19(11):108.

13. Yoshida K, Yoshikawa J, Shakudo M, Akasaka T, Jyo Y, Takao S, et al. Color Doppler evaluation of valvular regurgitation in normal subjects. Circulation. 1988;78(4):840-847.

14. Earing MG, Connolly HM, Dearani JA, Ammash NM, Grogan M, Warnes CA. Long-term follow-up of patients after surgical treatment for

[DOI: 10.32592/jsurgery.2022.10.2.103]

isolated pulmonary valve stenosis. Mayo Clin Proc. 2005;80(7):871-876.
15. Khanna AD, Hill KD, Pasquali SK, Wallace AS, Masoudi FA, Jacobs ML, et al. Benchmark Outcomes for Pulmonary Valve Replacement Using The Society of Thoracic Surgeons Databases. Ann Thorac Surg. 2015;100(1):138-145.
16. Batlivala SP, Emani S, Mayer JE, McElhinney DB. Pulmonary valve replacement function in adolescents: a comparison of bioprosthetic valves and homograft conduits. Ann Thorac Surg. 2012;93(6):2007-2016.
17. Chen PC, Sager MS, Zurakowski D, Pigula FA, Baird CW, Mayer JE Jr, et al. Younger age and valve oversizing are predictors of structural valve deterioration after pulmonary valve replacement in patients with tetralogy of Fallot. J Thorac Cardiovasc Surg.2012;143(2):352-360.
18. Zubairi R, Malik S, Jaquiss RD, Imamura M, Gossett J, Morrow WR. Risk factors for prosthesis failure in pulmonary valve replacement. Ann Thorac Surg. 2011;91(2):561-565.
19. Shinkawa T, Anagnostopoulos PV, Johnson NC, Watanabe N, Sapru A, Azakie A. Performance of bovine pericardial valves in the pulmonary position. Ann Thorac Surg. 2010;90(4):1295-1300.
20. McKenzie ED, Khan MS, Dietzman TW, Guzmán-Pruneda FA, Samayoa AX, Liou A, et al. Surgical pulmonary valve replacement: a benchmark for outcomes comparisons. J Thorac Cardiovasc Surg. 2014;148(4):1450-1453.
21. Cesnjevar R, Harig F, Raber A, Strecker T, Fischlein T, Koch A, et al. Late pulmonary valve replacement after correction of Fallot's tetralogy. Thorac Cardiovasc Surg. 2004;52(1):23-28.
22. Warner KG, O'Brien PK, Rhodes J, Kaur A, Robinson DA, Payne DD. Expanding the indications for pulmonary valve replacement after repair of tetralogy of fallot. Ann Thorac Surg. 2003;76(4):1066-1071.
23. Daliri G.AM, MotaghiH, EslahiA, JafariZ, ShahidiS, KeyvanlouM and et al. The Frequency of Congenital Heart Disorders among Children Issued from Consanguineous Marriages in Khorasan Province, Northeast of Iran. Int Biol Biomed J.2015;1(3): 98-102.

[DOI: 10.32592/jsurgery.2022.10.2.103]