Open Access

Original Article

Risk Factors for Early Post-Operative Arrhythmias in Children Undergoing Congenital Heart Surgeries

Mujeeb Ur Rehman, Muhammad Asif Khan, Raam Chand*, Shahnawaz Sathio, Abdul Sattar Shaikh, Fatima Amin, Najma Patel**

Department of Pediatric Cardiology, National Institute of Cardiovascular Diseases Karachi Pakistan, *Department of Pediatric Cardiology, National Institute of Cardiovascular Diseases Sukkur Pakistan, **Department of Pediatric Cardiology, National Institute of Cardiovascular Diseases Hyderabad Pakistan

ABSTRACT

Objective: To determine the risk factors for early post-operative arrhythmias in children undergoing congenital heart surgeries at a tertiary care hospital.

Study Design: Prospective longitudinal study.

Place and Duration of Study: National Institute of Cardiovascular Disease, Karachi Pakistan, from Jan to Jul 2020.

Methodology: We included 143 patients of both genders undergoing open heart surgery for congenital heart diseases. We noted all patients' pre-operative, intra-operative, and post-operative clinical characteristics. Patients were monitored in the pediatric cardiac intensive care unit. We analyzed the development of postoperative arrhythmias and the factors associated with them.

Results: In 143 patients, the mean age at the time of surgery was 7.52±6.0 years. There were 83(58.0%) male patients. Tetralogy of Fallot was the most common type of congenital heart disease noted in 57(39.0%) patients. The mean cardiopulmonary bypass time was 83.9±25.5 minutes, while the mean aortic cross-clamp time was 58.1±21.9 minutes. Post-operatively, arrhythmia was observed in 39(27.3%) children. Intra-operative arrhythmias (p<0.001), prolonged cardiopulmonary bypass time (p=0.008), prolonged cross-clamp time (p<0.001), higher inotropic score (p<0.001) and lower post-operative left ventricular ejection fraction (p=0.001) were significantly associated with arrhythmias.

Conclusion: The post-operative arrhythmias among patients undergoing congenital heart surgeries was high. Intra-operative arrhythmias, prolonged cardiopulmonary bypass time, decreased post-operative left ventricular ejection fraction, and high inotropic score were significant risk factors for the development of post-operative arrhythmias.

Keywords: Arrhythmia, Cardiopulmonary bypass, Inotropic score, Left ventricular ejection fraction.

How to Cite This Article: *Rehman MU, Khan MA, Chand R, Sathio S, Shaikh AS, Amin F, Patel N. Risk Factors for Early Post-Operative Arrhythmias in Children Undergoing Congenital Heart Surgeries. Pak Armed Forces Med J 2024; 74(4): 974-978. DOI: https://doi.org/10.51253/pafmj.v74i4.7894*

INTRODUCTION

One of the well-known complications of cardiothoracic surgery throughout the immediate post-operative days is arrhythmias for pediatric and adult groups.[1,2] The incidence of post-operative arrhythmias varies from 7.5-48% among cardiac patients in the pediatric population.[3,4] Iatrogenic injury or manipulation to the cardiac conduction system or myocardial oedema or tenderness next to the conducting system may lead to the majority of these events during the early postoperative period.[5] Hemodynamic variations usually arise throughout this period, increasing instability for the patient and further causing low cardiac output syndrome (LCOS) and cardiac arrest, except arrhythmias are timely managed and resolved. There are multiple reports available in the literature relating to the occurrence in adult patients.[6,7]

Correspondence: Dr Mujeeb Ur Rehman, Department of Pediatric Cardiology, National Institute of Cardiovascular Diseases Karachi Pakistan
Received: 24 Dec 2021; revision received: 15 Jun 2022; accepted: 20 Jun 2022

However, arrhythmias persist for a short duration and are also manageable in most of the bases, but they cause substantial morbidity and mortality.[8] Known risk factors for early postoperative arrhythmias comprise early age and lesser body weight at the time of the procedure, extended length for cardiopulmonary bypass (CPB) and aortic cross-clamp (AXC), electrolyte disproportion, temperature alterations and usage of deep hypothermia and circulatory arrest.[5]

For over an era, researchers have been interested in ascertaining the occurrence of arrhythmias following cardiac procedures in the paediatric group, but most data is predominantly reported by developed nations. This study was planned to determine the risk factors for early post-operative arrhythmias in children undergoing congenital heart surgeries at a tertiary care hospital.

METHODOLOGY

The prospective longitudinal study was conducted from January to July 2020 at the National

Institute of Cardiovascular Disease (NICVD), Karachi Pakistan, after approval from the Institutional Ethical Review Committee (Reference number ERC-06/2020, dated January 18, 2020). The sample size was calculated using a WHO sample size calculator, taking the reported prevalence of early post-operative arrhythmias among children undergoing CHD repair as 15%.[9]

Inclusion Criteria: Patients of either gender who underwent open heart surgery for congenital heart defects were included.

Exclusion Criteria: Patients who underwent surgery without CPB or a history of chronic arrhythmias, were excluded.

Written consent was sought from either patients or their parents/guardians. During the study period, we enrolled a total of 143 patients as per inclusion/ exclusion criteria. The parents were assured that all the patient's data would be kept confidential and that in no situation would the name of the child or the family be used anywhere. The non-probability consecutive sampling technique was used. The data was collected through observation and non-participation of the subjects using a questionnaire filled out by obtaining data from the subjects' medical record files. All patients undergoing congenital heart disease surgeries were monitored for the first 48 hours and reviewed by a paediatric cardiac intensive cardiac unit (PCICU) consultant. The development of arrhythmia was noted, and management was performed per standard protocol.

A rhythm change that would necessitate any interference, like medication adjustment, short-term use of pacing wires, electrical cardioversion/ defibrillation or just observation, was labelled as an arrhythmia. When it occurs in the first 48 hours after the patient comes from the operation theatre, then it is considered as early arrhythmia. A narrow complex tachycardia, with AV dissociation or retrograde atrial capture at least 20% faster than the underlying sinus rate, was considered Junctional Ectopic Tachycardia (JET). All automatic focus and reentrant tachycardia were considered, as they uniformly require interference for correction or limiting the hemodynamic influence of the arrhythmia. The special proforma was designed to record all study data.

Statistical Package for the Social Sciences (SPSS) version 26.00 was used for data analysis. Demographic characteristics along with pre-operative, intra-operative and post-operative clinical characteristics were recorded. Quantitative data were shown as Mean±standard deviation (SD), and qualitative data were represented as frequency and percentages. Quantitative data was compared in the study groups using independent sample student t-test. Qualitative data were compared using the Chi-square test. The *p*-value of ≤0.05 was considered significant.

RESULTS

In 143 patients, the mean age at the time of surgery was 7.52±6.0 years (ranging between 6 months to 30 years), while 54(37.8%) patients were between 2 to 5 years. The mean age at the time of CHD diagnosis was reported to be 3.18±4.7 years. There were 83(58.0%) male patients. Overall, the mean body weight was 18.9±12.7 kg. Tetralogy of Fallot was the most common type of CHD noted in 57(39.0%) patients, followed by VSD in 36(25.2%), as shown in Table-I.

Table-I: Frequency Distribution of Characteristics and Types of Cardiac Lesions (n=143)

Characteristics	n(%)
Age	
6-24 months	15(10.5)
24-60 months	54(37.8)
5-10 years	35(24.5)
10 years and above	39(27.3)
Gender	
Male	83(58.0)
Female	60(42.0)
History of Previous Cardiac Surgery	20(14.0%)
Cardiac lesion	
Tetralogy of Fallot (TOF), Total correction	57(39.9)
Ventricular septal defect (VSD) closure	36(25.2)
Atrial septal defect (ASD) closure	24(16.8)
Atrioventricularseptal defect (AVSD) repair	8(5.6)
Both ASD+VSD Closure	7(4.9)
BD Glenn shunt	6(4.2)
Senning operation	3(2.1)
Fonton operation	2(1.4)

The mean pre-operative LVEF was 69.11±3.0%. The mean CPB time was 83.9±25.5 minutes, while the mean cross-clamp time was 58.1±21.9 minutes. There were 7(4.9%) patients who experienced intra-operative arrhythmia. Post-operatively, arrhythmia was observed in 39(27.3%) children. There were 36(92.3%) patients who were observed to have onset of arrhythmia appearance within 24 hours in the post-operative period. The mean inotropic score was 14.9±8.7. Table-II shows a comparison of the distribution of cardiac lesions with respect to types of

arrhythmias, and no statistically significant difference was noted (p=0.993).

Intra-operative arrhythmias (p<0.001), increased CPB time (p=0.008), increased cross-clamp time (p<0.001), higher inotropic score (p<0.001) and lower post-operative LVEF (p=0.001) were significantly associated with arrhythmias as shown in table-III. Patients with arrhythmias were also found to have significantly more time of ICU stay (p<0.001).

Table-II: Frequency Distribution of Different Type of Arrhythmias Among Cardiac Conditions (n=143)

Types of Arrhythmia	Cardiac Condition								*p*-value
	ASD	ASD+VSD	AVSD	BD GS	Fonton Operation	Senning Operation	TOF	VSD	
Atrial Fibrillation (n=2)	0	0	0	0	0	0	2(100%)	0	0.993
Atrial Flutter (n=2)	0	0	0	0	0	0	2(100%)	0	
Junctional Ectopic Tachycardia (n=14)	1(7.1%)	0	1(7.1%)	1(7.1%)	0	1(7.1%)	6(42.9%)	2(28.6%)	
Supraventricular Tachycardia (n=9)	2(22.2%)	1(11.1%)	0	0	0	1(11.1%)	3(3.3%)	2(22.2%)	
Complete Heart Block (n=7)	1(14.3%)	0	0	0	1(14.3%)	0	2(28.6%)	3(42.9%)	
Ventricular Tachycardia (n=4)	0	0	0	0	1(25.0%)	0	2(50.0%)	1(25.0%)	
Ventricular Fibrillation (n=1)	0	0	0	0	0	0	1(100%)	0	

ASD: Atrial septal defect; VSD: Ventricular septal defect, ASD: Atrial septal defect; AVSD: Atrioventricular septal defect; BD GS: Bidirectional Glenn shunt

Table-III: Association of Different Risk Factor with Arrhythmic and Non-Arrhythmic Patients (n=143)

Risk factors		Arrhythmias (n=39)	No Arrhythmias (n=104)	*p*-value
Age	< 2 years	4(26.7%)	11(73.3%)	0.995
	2-5 years	15(27.8%)	39(72.2%)	
	5-10 years	9(25.7%)	26(74.3%)	
	>10 years	11(28.2%)	28(71.8%)	
Body weight in kg		17.9±11.5	19.2±13.2	0.573
Gender	Male	26(31.3%)	57(68.7%)	0.201
	Female	13(21.7%)	47(78.3%)	
Pre-Operative Cyanosis		21(30.4%)	48(69.6%)	0.412
Pre-operative LVEF		68.6±3.2	69.3±2.9	0.248
History of previous surgery		8(40.0%)	12(60.0%)	0.168
Intra-operative arrhythmias		7(100%)	0	<0.001
CPB time		93.7±28.7	80.6±23.5	0.008
Cross Clamp time		71.5±22.4	53.5±19.9	<0.001
Inotropic score		21.5±10.1	12.5±6.7	<0.001
Post-operative LVEF		47.6±11.5	52.9±7.3	0.001
ICU stay		4.85±2.0	3.04±1.2	<0.001

LVEF: Left ventricular ejection fraction; ICU: Intensive care unit

DISCUSSION

Regardless of advancements in surgical approach, perfusion expertise, and cautious peri-operative care during the previous years, arrhythmias remain an alarming hurdle following congenital cardiac procedures. The documented frequency of arrhythmias is between 7.5% and 48%.4,[10-12] The frequency of arrhythmias in the current study was 27%. Kamel et al. reported the prevalence of post-operative arrhythmias as 27.2%.[13] Our frequency was lower than 31.3% by Chelo *et al*.,[6] and higher than 8.8%, 14.4% and 15% as reported by Yildirim *et al*.,[14] Jain *et al*.,[5] and Delaney *et al*.[9] Valsangiacomo *et al*.[15] demonstrated the prevalence of cardiac arrhythmias during a day after heart surgery to be 48%. Grosse-Wortmann *et al*.[10] reported relatively higher arrhythmias frequency, which was 73.4% for newborns and 79.1%for older children. This higher prevalence was due to the use of Holter monitoring, which is a more sensitive method than bedside ECG monitoring without taking into account the usual benign arrhythmias; this prevalence then dropped to

29.6% and 38.9%, respectively. This variation in the incidence of early post-operative arrhythmias is most likely due to the definition of arrhythmia and the sensitivity of the method used.

We noted JET to be the most frequent type of arrhythmia. At the same time, JET can be a source of significant hemodynamic consequences, which are very difficult to treat in children who have undergone open cardiac surgeries. Although the exact underlying aetiology for the occurrence of JET is not identified, it is understood that it can result from injury to the AV node and the bundle of His.[16] Literature reports the prevalence of JET ranging from 2-11%.[10,17,18]

In the present research, intra-operative arrhythmias (p<0.001), increased CPB time (p=0.008), increased cross-clamp time (p<0.001), higher inotropic score (p<0.001) and lower post-operative LVEF (p= 0.001) were significantly associated with arrhythmias. Patients with arrhythmias were also found to have significantly more time of ICU stay (p<0.001). In this study, we have found a 92.3% early-onset arrhythmia. The mechanism for these post-operative arrhythmias may include direct tissue injury and oedema of the myocardial tissue, altered hemodynamic conditions, high dose inotropic support in the immediate post-operative period and metabolic and electrolytes derangement, as shown in the previous studies.[19] Some studies have also reported that prolonged aortic cross-clamp time is considerably linked with the development of postoperative arrhythmias.[15,20] Among the treatment modalities in our study, amiodarone was the most commonly administered anti-arrhythmic drug, followed by adenosine and temporary pacemaker implantation. In our study, we also used Dexmedetomidine to manage junctional ectopic tachycardia, which is instrumental in managing and inhibiting JET, as shown in a study.

Previous investigations have shown a reduced additional mortality associated with early post-operative arrhythmias ranging from 0 to 1.2%.[9,15] One death which was linked to early post-operative arrhythmia (ventricular fibrillation) was reported in our study; the mortality rate due to post-operative arrhythmias was 0.7% in our study. Delaney et al.[9] demonstrated that electrolyte imbalances have no statistical meaning in developing arrhythmia, while in our study, electrolyte imbalance was meaningfully linked with the occurrence of arrhythmias. This finding was in line with Batra et al.[21], who observed that reduced magnesium levels were accountable for the onset of JET. In our study, children with post-operative arrhythmias have a prolonged ICU stay as compared to those patients whose rhythm was normal; similar findings were reported by Rekawek *et al*.[20]

LIMITATION OF STUDY

We only noted relatively short outcomes in the present study.

ACKNOWLEDGEMENT

The authors thank Muhammad Aamir (Research Consultant, Bahawalpur) for his help with the statistical analysis.

CONCLUSION

The post-operative arrhythmias among patients undergoing congenital heart surgeries was high. Intra-operative arrhythmias, prolonged cardiopulmonary bypass time, decreased post-operative left ventricular ejection fraction, and high inotropic score were significant risk factors for the development of post-operative arrhythmias.

Conflict of Interest: None.

Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

MUR & MAK: Data acquisition, critical review, approval of the final version to be published.

RC & SS: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

ASS, FA & NP: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

REFERENCES

1. Hoque KZ, Sultana AT, Mia M. Early postoperative arrhythmias after paediatric cardiac surgery. Delta Med Coll J 2018; 6(1): 22-28. https://doi.org/10.3329/dmcj.v6i1.35964
2. Sahu MK, Das A, Siddharth B, Talwar S, Singh SP, Abraham A, et al. Arrhythmias in children in early postoperative period after cardiac surgery. World J Pediatr Congenit Heart Surg 2018; 9(1): 38-46. https://doi.org/10.1177/2150135117737687
3. Kabbani MS, Al Taweel H, Kabbani N, Al Ghamdi S. Critical arrhythmia in postoperative cardiac children: Recognition and management. Avicenna J Med 2017; 7(3): 88-95. https://doi.org/10.4103/ajm.AJM_14_17
4. Talwar S, Patel K, Juneja R, Choudhary SK, Airan B. Early postoperative arrhythmias after pediatric cardiac surgery. Asian Cardiovasc Thorac Ann 2015; 23(7): 795-801. https://doi.org/10.1177/0218492315585457
5. Jain A, Alam S, Viralam SK, Sharique T, Kapoor S. Incidence, risk factors, and outcome of cardiac arrhythmia postcardiac surgery in children. Heart Views 2019; 20(2): 47-52. https://doi.org/10.4103/HEARTVIEWS.HEARTVIEWS_88_18

6. Chelo D, Ateba NA, Tchoumi JCT, Nonga BN. Early post-operative arrhythmias after cardiac surgery in children at Shisong Cardiac Center, Cameroon. Health Sci Dis 2015; 16(2): 1-6.
7. Hanash CR, Crosson JE. Emergency diagnosis and management of pediatric arrhythmias. J Emerg Trauma Shock 2010; 3(3): 251-260. https://doi.org/10.4103/0974-2700.66525
8. Peretto G, Durante A, Limite LR, Cianflone D. Postoperative arrhythmias after cardiac surgery: incidence, risk factors, and therapeutic management. Cardiol Res Pract 2014; 2014: 615987. https://doi.org/10.1155/2014/615987
9. Delaney JW, Moltedo JM, Dziura JD, Kopf GS, Snyder CS. Early postoperative arrhythmias after pediatric cardiac surgery. J Thorac Cardiovasc Surg 2006; 131(6): 1296-1300. https://doi.org/10.1016/j.jtcvs.2006.02.010
10. Grosse-Wortmann L, Kreitz S, Grabitz RG, Vazquez-Jimenez JF, Messmer BJ, von Bernuth G, et al. Prevalence of and risk factors for perioperative arrhythmias in neonates and children after cardiopulmonary bypass: continuous holter monitoring before and for three days after surgery. J Cardiothorac Surg 2010; 5(1): 1-8. https://doi.org/10.1186/1749-8090-5-85
11. Satur CM, Stubington SR, Jennings A, Newton K, Martin PG, Gebitekin C, et al. Magnesium flux during and after open heart operations in children. Ann Thorac Surg 1995; 59(4): 921-927. https://doi.org/10.1016/0003-4975(95)00049-q
12. Dorman BH, Sade RM, Burnette JS, Wiles HB, Pinosky ML, Reeves ST, et al. Magnesium supplementation in the prevention of arrhythmias in pediatric patients undergoing surgery for congenital heart defects. Am Heart J 2000; 139(3): 522-528. https://doi.org/10.1016/s0002-8703(00)90097-8
13. Kamel YH, Sewielam M. Arrhythmias as early post operative complications of cardiac surgery in children at cairo university. Pion Egypt Cardiol 2009; 61: 193-199. https://doi.org/10.3923/JMS.2009.126.132
14. Yildirim SV, Tokel K, Saygili B, Varan B. The incidence and risk factors of arrhythmias in the early period after cardiac surgery in pediatric patients. Turk J Pediatr 2008; 50(6): 549-553.
15. Valsangiacomo E, Schmid ER, Schüpbach RW, Schmidlin D, Molinari L, Waldvogel K, et al. Early postoperative arrhythmias after cardiac operation in children. Ann Thorac Surg. 2002; 74(3): 792-796. https://doi.org/10.1016/s0003-4975(02)03786-4
16. Dietl CA, Cazzaniga ME, Dubner SJ, Pérez-Baliño NA, Torres AR, Favaloro RG. Life-threatening arrhythmias and RV dysfunction after surgical repair of tetralogy of Fallot. Comparison between transventricular and transatrial approaches. Circulation 1994; 90(5 Pt 2): II7-II12.
17. Parry AJ, McElhinney DB, Kung GC, Reddy VM, Brook MM, Hanley FL. et al. Elective primary repair of acyanotic tetralogy of Fallot in early infancy: overall outcome and impact on the pulmonary valve. J Am Coll Cardiol 2000; 36(7): 2279-2283. https://doi.org/10.1016/s0735-1097(00)00989-x
18. Cools E, Missant C. Junctional ectopic tachycardia after congenital heart surgery. Acta Anaesthesiol Belg 2014; 65(1): 8.
19. Jacobs JP, Jacobs ML, Maruszewski B, Lacour-Gayet FG, Clarke DR, Tchervenkov CI, et al. Current status of the European Association for Cardio-Thoracic Surgery and the Society of Thoracic Surgeons Congenital Heart Surgery Database. Ann Thorac Surg 2005; 80(6): 2278-2283. https://doi.org/10.1016/j.athoracsur.2005.05.107
20. Rekawek J, Kansy A, Miszczak-Knecht M, Manowska M, Bieganowska K, Brzezinska-Paszke M, et al. Risk factors for cardiac arrhythmias in children with congenital heart disease after surgical intervention in the early postoperative period. J Thorac Cardiovasc Surg 2007; 133(4): 900-904. https://doi.org/10.1016/j.jtcvs.2006.12.011
21. Batra AS, Chun DS, Johnson TR, Maldonado EM, Kashyap BA, Maiers J, et al. A prospective analysis of the incidence and risk factors associated with junctional ectopic tachycardia following surgery for congenital heart disease. Pediatr Cardiol 2006; 27(1): 51-55. https://doi.org/10.1007/s00246-005-0992-6