Arrhythmia in Early Post Cardiac Surgery in Pediatrics: Siriraj Experience

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Objectives: To determine the incidence, risk factors and outcome of early postoperative arrhythmias in pediatric patients with congenital heart disease.

Material and Method: A prospective study was conducted in every pediatric patient who consecutively underwent open-heart surgery at Siriraj Hospital from January 1st to December 31st, 2006. The collected data were demographic data, diagnosis, pre-operative arrhythmia, cardiac surgical data and continuous electro-cardiographic monitoring data throughout the post operative intensive care period.

Results: A total of 191 pediatric patients underwent cardiac surgery Forty-five cases (23.5%) developed early post operative cardiac arrhythmias i.e. junctional ectopic tachycardia 18 cases (40%), heart block 7 cases (15.6%), supraventricular tachycardia 2 cases (4.4%). Cardiac arrhythmia occurred mostly within 24 hours after the operation. Patients with single ventricle physiology repaired developed the highest incidence of acute post operative arrhythmia (36.4%). Longer, cardiopulmonary bypass time; and redo-operation were the risk factors. Thirty-nine cases were treated with medications, 7 cases with temporary pacing, and 1 case with electrical cardioversion. Four patients needed long-term anti-arrhythmic agents. Cardiac arrhythmia played role in the causes of death in 2 cases (1.1% of total cases).

Conclusions: Post operative arrhythmias remained common and important complications of pediatric open-heart surgery. Long cardiopulmonary bypass time and redo-operation were risk factors for early post operative arrhythmia.

Keywords: Post operative arrhythmia, Congenital heart diseases, Junctional ectopic tachycardia

Postoperative arrhythmia has been a major cause of morbidity and mortality in patients who underwent cardiac surgery. The incidence of post operative cardiac arrhythmias in pediatrics ranged from 14.2% to 48%[1-5]. Junctional ectopic tachycardia

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is common in early post operative congenital heart disease[6]; and the main cause of prolongation of ventilation, CICU, stay with 3% mortality[7]. Reports from various institutes demonstrated the difference in factors that were associated with arrhythmias i.e. longer cardiopulmonary bypass time, longer aortic cross-clamp time, longer ischemic time, younger age at operation, lower body weight, higher surgical complexity, metabolic abnormalities, pulmonary hypertension, myocardial infarction, and left ventricular ejection fraction of

less than 40% [1-3,6-10]. However, there is little information regarding the incidence and risk factors for arrhythmias in acute post open-heart surgery in Thailand.

The aim of the present study was to examine the incidence of each type of post operative arrhythmia together with risk factors in relation to the incidence, management and outcome in order to improve the outcome of open-heart surgery.

Material and Method

Every pediatric patient who consecutively underwent open-heart surgery at the Division of Cardiothoracic Surgery, Department of Surgery, Siriraj Hospital and was subsequently admitted to the Intensive Care Unit between January 1st and December 31st, 2006, were prospectively enrolled. Collected data included demographic data, cardiac diagnosis, types of surgery, cardiopulmonary bypass time, aortic cross-clamp time, circulatory arrest time, previous cardiac arrhythmia, pulmonary arterial pressure, and review of continuous electrocardiographic monitoring data during the intensive care period as well as electrocardiogram.

In the present study, arrhythmias were classified as junctional ectopic tachycardia, frequent (> 10 beats per minute) premature ventricular contraction, ventricular tachycardia, heart block, and other miscellaneous arrhythmias including slow junctional rhythm, and ventricular fibrillation. Supraventricular tachycardia was defined as narrow complex tachycardia with one to one atrioventricular conduction and reentry mechanism. Redo-operation referred to the repeated operation at the same midline incision.

Patients were put on continuous electrocardiographic equipment connected to a central monitoring station with memory function during acute post operative period in the Intensive Care Unit. Onset, duration, types of arrhythmia, management, and result of management data were collected.

The options of treatment were decided for each individual case at the discretion of the management team according to the standard recommendation by the American Heart Association. Junctional ectopic tachycardia was treated by avoidance of hyperthermia, optimizing sedation, pain control, limitation of exogenous catecholamine and administration of anti-arrhythmic agent (amiodarone) aimed at optimal heart rate for age and hemodynamic conditions. Supraventricular tachycardia was treated with adenosine, electrical cardioversion and/or amiodarone infusion. Post operative heart block was treated with temporary pacing and observation for recovery was done for 7-14 days before the decision to implant a permanent pacemaker.

Statistical analysis

Data were analyzed with SPSS for Windows (Version 11.5). Continuous data were expressed as frequency or mean $\pm$ the standard deviation (SD) or median with range. Comparisons between groups were analyzed with unpaired T-test or Mann-Whitney U-test when appropriate. The chi-square was used to assess the association between the risk factors and outcome variable. A multivariable logistic regression model was used to identify the independent risk factors of post operative arrhythmias and junctional ectopic tachycardia. Two-tailed value of $p < 0.05$ was taken as evidence of differences not attributable to chance.

Results

Patient population

During the study period, 191 patients were enrolled. Male to female ratio was 1:0.94. The median age at operation was 39.53 (0.03-191.23) months.

Types of diagnosis are demonstrated in Fig. 1. Common surgical procedures in our institute were repair of septal defect (included ventricular septal defect, atrial septal defect, and truncus arteriosus), tetralogy of Fallot physiology (included tetralogy of Fallot, double outlet right ventricle and ventricular septal defect with pulmonic stenosis, d-transposition of great arteries and ventricular septal defect with pulmonic stenosis) and single ventricle physiology, respectively. Other types of diagnosis were 3 with total
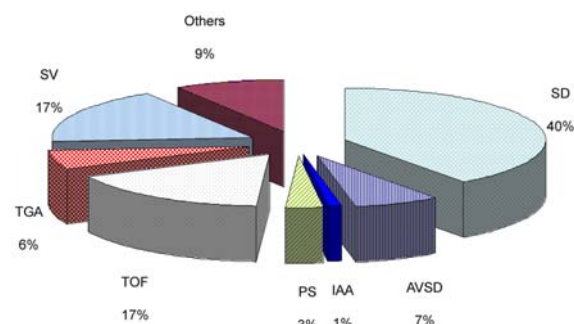
SD, Septal defect; AVSD, Atrioventricular septal defect; TOF, tetralogy of Fallot; TGA,transposition of great arteries; IAA, Interrupted aortic arch; PS, pulmonic stenosis; SV, single ventricle physiology

Fig. 1 Types of cardiac diagnosis

anomalous pulmonary venous return, 2 with valvular aortic stenosis, 2 with subaortic stenosis, 2 with corrected transposition of the great arteries, 2 with hypertrophic cardiomyopathy, 2 with mitral valve disease, 1 with anomalous left coronary artery from pulmonary artery, 1 with coronary artery disease (Progeria), 1 with Ebstein's anomaly, 1 with aortic valve disease, and 1 with metastatic Wilms' tumor.

Demographic data, cardiac condition, pulmonary artery pressures, and operative data are demonstrated in Table 1. The median cardiopulmonary bypass

time was 74 (20-251) minutes, aortic cross-clamp time was 37 (0-147) minutes, and the circulatory arrest time was 0 (0 to 45) minute, respectively.

Details of early postoperative arrhythmia in open-heart surgery are shown in Table 2.

The median onset and duration of arrhythmias were 9 (intra-operative period -240) hours after surgery and 20 (1-480) hours respectively. The details are shown in Fig. 2.

The most common acute post-operative arrhythmia was junctional ectopic tachycardia. It

Table 1. Patients' characteristic (n = 191)

Characteristics	Arrhythmia (n = 45)	Non-arrhythmia (n = 146)	p-value
Gender (Male : Female)	1:0.74	1:1.02	0.33
Age (months)	48.03 (0.03-181.07)	38.33 (1.37-191.23)	0.30
Weight (kilogram)	12.5 (1.99-42.5)	12.0 (2.5-54.5)	0.78
Univentricular repair, cases (%)	12 (25.5)	20 (13.9)	0.06
Cyanosis, cases (%)	28 (59.6)	58 (40.3)	0.02*
Preoperative arrhythmia, cases (%)	3 (6.4)	1 (0.7)	1.07
Pulmonary artery pressure $\geq$ 50% of systemic, cases (%)	16 (34)	43 (29.8)	0.59
Cardiopulmonary bypass time, median range (minute)	96 (30-251)	65 (20-240)	<0.001*
Aortic cross-clamp time, median range (minutes)	48 (0-147)	36 (0-147)	0.08
Circulatory arrest time, median range (minutes)	0 (0-45)	0 (0-27)	0.59
Redo-operation, cases (%)	11 (23.4)	5 (3.5)	<0.001*
Procedure with ventricular septal defect closure, cases (%)	23 (48.9)	85 (59)	0.23
Extensive atriotomy, cases (%)	4 (8.5)	9 (6.3)	0.59
Ventriculotomy, cases (%)	3 (6.4)	5 (3.5)	0.39

* $p < 0.05$

Table 2. Cardiac diagnosis and types of arrhythmia

Group of disease (cases) (n = 191, 100%)	Type of arrhythmia (n)							
	VT (1, 0.5%)	JR (10, 5.23%)	JET (18, 9.42%)	VF (1, 0.5%)	SVT (2, 1%)	PVC (4, 2.1%)	AVB (7, 3.7%)	SB (2, 1%)
SD (77)	0	0	2	0	0	1	5	0
AVSD (13)	0	2	1	0	0	0	0	0
IAA (1)	0	0	1	0	0	0	0	0
PS (5)	0	0	1	0	0	1	0	0
TOF (33)	0	2	4	0	0	1	1	0
TGA (11)	0	1	2	1	0	0	0	0
SV (33)	0	2	6	0	2	1	0	1
Others (18)	1	2	1	0	0	0	1	1
% of arrhythmia cases	2.2	22.2	40	2.2	4.4	8.8	15.6	4.4

VT, ventricular tacgycardia; JR,junctional rhythm; JET, junctional ectopic tachycardia; VF,ventricular fibrillation; SVT, supraventricular tachycardia; PVC, premature ventricular-contraction; AVB, atrioventricular block; SB, sinus bradycardia; SD, septal defect; AVSD,atrioventricular septal defect; IAA, interrupted aortic arch; PS, pulmonic stenosis; SV, single ventricle physiology
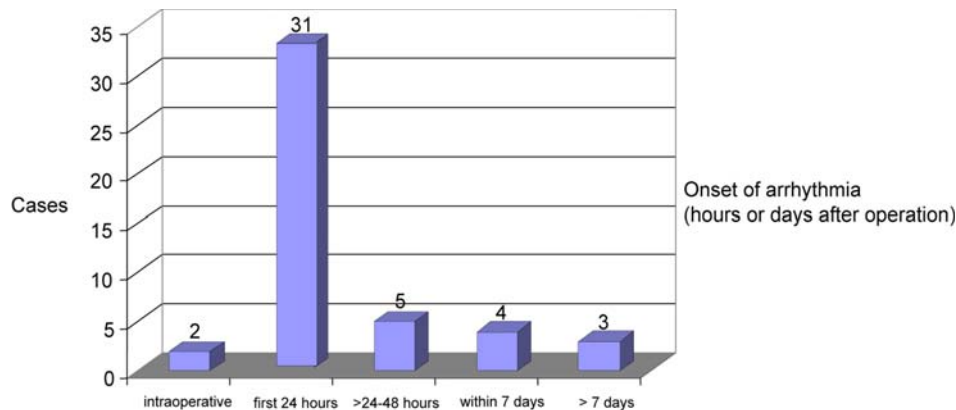
Fig. 2 Onset of postoperative arrhythmia

was common in early post repaired single ventricle physiology and tetralogy of Fallot physiology, 18% and 11.7% respectively. Heart block (2nd, and 3rd degree atrioventricular block) occurred in early post septal defect repair in 5 cases (6.5%). The comparisons of the demographic data and cardiac condition between the arrhythmic and non-arrhythmic groups are illustrated in Table 1.

The incidence of arrhythmia in patients who underwent ventricular septal defect closure (including isolated ventricular septal defect, and ventricular septal defect in tetralogy of Fallot, pulmonary atresia, coarctation of aorta and interrupted aortic arch) was 23 cases (21.3%), who underwent atriotomy was 4 cases (30.8%), and 3 cases (37.5%) in patients who underwent ventriculotomy. No statistical significant association between these factors and incidence of post operative arrhythmia was found as shown in Table 1.

With multivariable logistic regression: Forward Likelihood Ratio method, redo-operation and cardiopulmonary bypass time were the risk factors of acute postoperative arrhythmia (Odds ratio = 6.78, 95% CI = 2.16-21.33; p 0.001 and Odds ratio = 1.009, 95% CI = 1.002-1.016; p 0.014, respectively).

Junctional ectopic tachycardia

Junctional ectopic tachycardia was common in acute postoperative repair of patients with single ventricle physiology (Table 2). The median onset and duration of junctional ectopic tachycardia was 12.5 (1-103) hours after open-heart surgery and 36 (1-264) hours respectively. By univariate analysis, cardiopulmonary bypass time, redo-operation and cyanosis were risk factors for junctional ectopic tachycardia as shown in Table 3. Once, these factors were analyzed by logistic

regression: Forward Likelihood Ratio method and the results showed redo-operation and cardiopulmonary bypass time were the risk factors associated of junctional ectopic tachycardia (Odds ratio = 8.72, 95% CI = 2.58-29.39; p < 0.001 and Odds ratio = 1.012, 95% CI = 1.002-1.0122; p 0.014, respectively).

The analysis of cardiopulmonary bypass time with estimation of Receiver Operating Characteristic curve showed that the cardiopulmonary bypass time of more than 85 minutes increased the likelihood of having acute postoperative arrhythmia and junctional ectopic tachycardia (Odds ratio = 4.87, 95% CI = 2.34-10.12; p < 0.001 with sensitivity 70.2%, specificity 67.4% and Odds ratio = 6.79, 95% CI = 2.03-22.68; p = 0.001 with sensitivity 83.3% and specificity 62.4%).

Atrioventricular block

The incidence of transient second and third degree atrioventricular block in the present study was 7 cases (3.7%). Five cases were patients with septal defect repaired. Median duration of atrioventricular block was 3 (1-12) days, post operation. No permanent pacemaker implantation was required.

Other cardiac arrhythmias

Premature ventricular tachycardia occurred in 4 patients, but it did not compromise the hemodynamic status and all responded to medical treatment *i.e.* correction of metabolic problems, prevention and correction of hypoxia.

The incidence of ventricular tachycardia and ventricular fibrillation were very low (2 cases, 1%). Both of them died in the acute post operative period. One patient had ventricular fibrillation with cardiac arrest before surgery and died post operatively from

Table 3. Characteristics of patients with and without junctional ectopic tachycardia

Characteristics	Junctional ectopic tachycardia (n = 18)	No-junctional ectopic tachycardia (n = 173)	p-value
Gender (Male : Female)	1:0.4	1:1	0.06
Age (months)	40.58 (1.53-174.43)	39.53 (0.03-191.23)	0.97
Weight range (kilogram)	1.3 (2.9-30.0)	12 (1.99-54.50)	0.94
Univentricular repair, cases (%)	6 (33.3)	26 (15)	0.10
Cyanosis, cases (%)	13 (72)	73 (42)	0.02*
Preoperative arrhythmia, cases (%)	1 (5.6)	3 (1.73)	0.83
Pulmonary artery pressure $\geq$ 50% of systemic, cases (%)	6 (33.3)	53 (30.6)	0.81
Cardiopulmonary bypass time, median range (minute)	105 (30-251)	71 (20-240)	0.003*
Aortic cross-clamp time, median range (minutes)	42.5 (0-147)	37 (0-147)	0.98
Circulatory arrest time, median range (minutes)	0 (0-34)	0 (0-45)	0.52
Redo-operation, cases (%)	7 (38.9)	9 (5.2)	<0.001*
Procedure with ventricular septal defect closure, cases (%)	9 (50)	99 (57.2)	0.56
Extensive atriotomy, cases (%)	1 (5.6)	12 (6.9)	0.83
Ventriculotomy, cases (%)	2 (11.1)	6 (3.5)	0.12

* $p < 0.05$

hemodynamic instability. The other who had hypertrophic obstructive cardiomyopathy treated with long-term anti-arrhythmic agent had pre-operative arrhythmia and died from intractable ventricular tachycardia 48 hours after surgery.

Most of the patients (39 cases, 83%) with arrhythmias were treated with medications, 7 with temporary pacemaker implantations, and 1 with electrical cardioversion. Only 4 patients needed longterm treatment with anti-arrhythmic agents. No patient required permanent pacemaker implantation. Overall mortality was 9 cases (4.7%). Ventricular fibrillation, ventricular tachycardia played an important role in the causes of death in 2 cases (4.4%). The causes of death of others included severe cardiac lesions with low cardiac output and deep cyanosis, pulmonary hypertensive crisis, and/or serious infection.

Discussion

The incidence of acute post cardiac surgery arrhythmia in open-heart surgery was 24.6% which was similar to the previous studies[1,3]. The number was quite high because the present study included all kinds of abnormal rhythm with and without hemodynamic effects. The causes of arrhythmia could be explained by direct injury to cardiac tissue from myocardial incision, cannulation, suture affecting atrioventricular conduction, and rapid change of intracardiac pressure caused by volume and pressure fluctuation.

The most common type of arrhythmia encountered in the present study was junctional ectopic tachycardia (9.4% of total cases) which is similar to the previous study[5]. Junctional ectopic tachycardia was common in surgical repair of single ventricle physiology (6/33, 18%), arterial switch operation (2/11, 18.2%) followed by tetralogy of Fallot repaired (4/33, 12%) which were comparable to the previous studies[4,5]. In tetralogy of Fallot repaired, junctional ectopic tachycardia was explained by direct trauma or infiltrative hemorrhage of the His bundle secondary to increasing traction through the right atrium for resection of right ventricular outflow tract obstruction. However, this explanation could not be used with d-transposition of the great arteries repaired which has had very little risk of direct trauma to the conduction system. A high incidence of junctional ectopic tachycardia in surgical repair of single ventricle physiology could be claimed by a high incidence of abnormal conducting system in these patients. Long cardiopulmonary bypass time and redo-operation were risk factors for junctional ectopic tachycardia, these could be from tissue injury and ionic changes which affected electrical property at cellular level. These findings might reflect increasing complexity of cardiac diseases. The fact that there was no mortality from junctional ectopic tachycardia in the present study suggested an advance in the authors' therapeutic regimen and standard of care in this group of patients which was different from the previous study[11].

The incidence of transient second and third degree atrioventricular block in previous studies were 0.7-5%[18], 81% regained normal sinus rhythm by postoperative day 7, and 97% by postoperative day 9, respectively[2,4,17-20]. In the present study, the incidence was comparable (3.7%) and all of the presented patients returned to normal sinus rhythm in 1-12 days. Heart block was mostly found in patients with septal defect repair (6.5% of patients of septal defect repaired). The previous study demonstrated complete heart blockage that required a permanent pacemaker in less than 1%[18]. Post operative cardiac arrhythmia frequently occurred within 24 hours postoperatively, which could be explained by swelling of the myocardium, unstable hemodynamic status, high doses of inotropes administration and metabolic disturbance.

To the best of the authors' knowledge, there was no previous report which demonstrated that the length of cardiopulmonary bypass time was associated with postoperative cardiac arrhythmia. In the present study, cardiopulmonary bypass time > 85 minutes increased the likelihood of having both postoperative arrhythmia and junctional ectopic tachycardia. The patients who underwent open-heart surgery with long cardiopulmonary bypass time should be monitored carefully in the early post operative period.

The mortality rate attributed mainly from arrhythmia was 1.1% (2 cases), which was similar to the previous studies[3,11]. The main causes of the mortality were ventricular tachycardia and ventricular fibrillation, which were life threatening cardiac arrhythmia and were accepted as an important cause of death within 30 days post operation[7].

Conclusion

Post operative arrhythmias remained a frequent complication of post cardiac surgery in pediatric patients, especially junctional ectopic tachycardia. Hemodynamically significant arrhythmia could be lethal in patients with severe underlying heart diseases. Long cardiopulmonary bypass time (> 85 minutes), and redo-operation were risk factors for acute post operative arrhythmias as well as junctional ectopic tachycardia. Careful monitoring, medical prevention and early management with appropriate means could improve outcome.

Limitation of the study

A larger number of patients might reveal more precise information regarding the risk factors of post operative arrhythmia. Temporary atrial and ventricular pacing wires are not routinely placed in post open-heart surgery in our institute, so the authors cannot evaluate the impact of pacing to optimize atrioventricular synchrony in patients with junctional ectopic tachycardia.

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การศึกษาภาวะหัวใจเต้นผิดจังหวะหลังผ่าตัดหัวใจระยะแรกในเด็กโรคหัวใจพิการแต่กำเนิด

กนกนภัส ไชยรักษ์, จารุพิมพ์ สูงสว่าง, กฤตย์วิกรม ดุรงค์พิศิษฏ์กุล, ดวงมณี เลาหประสิทธิพร, ประคัลภ์ จันทร์ทอง, อภิชาติ นานา, สมชาย ศรียศชาติ, ถาวร ทรัพย์ทวีสิน, อังกาบ ปราการรัตน์

วัตถุประสงค์: เพื่อหาอุบัติการณ์ ปัจจัยเสี่ยง และผลของการเกิดภาวะหัวใจเต้นผิดจังหวะหลังผ่าตัดหัวใจ ในผู้ป่วยเด็กโรคหัวใจ

วิธีการศึกษา: เป็นการศึกษาแบบไปข้างหน้าในผู้ป่วยเด็กโรคหัวใจที่เข้ารับการผ่าตัดหัวใจแบบ *open-heart surgery* ในโรงพยาบาลศิริราช ตั้งแต่วันที่ 1 มกราคมถึง 31 ธันวาคม พ.ศ. 2549 โดยมีการเก็บข้อมูลพื้นฐานของผู้ป่วย, การวินิจฉัยโรค, ภาวะหัวใจเต้นผิดจังหวะก่อนเข้ารับการผ่าตัด ข้อมูลเกี่ยวกับการผ่าตัด และมีการติดตามสัญญาณชีพ รวมถึงคลื่นไฟฟ้าหัวใจของผู้ป่วยในหอผู้ป่วยวิกฤติ

ผลการศึกษา: จากผู้ป่วยเด็กที่เข้ารับการผ่าตัดหัวใจทั้งสิ้น 191 คน พบว่า 45 คน (23.5%) มีภาวะหัวใจเต้นผิดจังหวะ ในจำนวนนี้เป็น *junctional ectopic tachycardia* 18 ราย (40%), *heart block* 7 ราย (15.6%), *supraventricular tachycardia* 2 ราย (4.4%). โดยมีอุบัติการณ์สูงสุดในผู้ป่วยกลุ่ม *single ventricle physiology* (29.7%) และพบหัวใจเต้นผิดจังหวะได้บ่อยภายใน 24 ชั่วโมงแรกหลังการผ่าตัด สำหรับการรักษาประกอบด้วยการใช้ยาจำนวน 39 คน, ใช้เครื่องกระตุ้นการเต้นของหัวใจชนิดชั่วคราว 7 คนและการช็อกด้วยไฟฟ้าอีก 1 คน โดยมีผู้ป่วย 4 คนต้องรับการรักษาต่อเนื่องด้วยยาควบคุมจังหวะการเต้นของหัวใจ มีผู้ป่วยเสียชีวิตจำนวน 2 คน และพบว่าการผ่าตัดที่มีระยะเวลาใช้เครื่องปอดและหัวใจเทียมนาน รวมถึงการผ่าตัด *Redo-operation* เป็นปัจจัยเสี่ยงต่อการเกิดภาวะหัวใจเต้นผิดจังหวะหลังผ่าตัดหัวใจ

สรุป: ภาวะหัวใจเต้นผิดจังหวะหลังผ่าตัดหัวใจยังคงเป็นภาวะแทรกซ้อนที่สำคัญสำหรับการผ่าตัดหัวใจในผู้ป่วยเด็ก ระยะเวลา *cardiopulmonary bypass* ที่ยาว และการผ่าตัดเปิดหัวใจครั้งต่อมาเป็นปัจจัยเสี่ยงที่สำคัญของการเกิดภาวะหัวใจเต้นผิดจังหวะระยะต้น