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Arrhythmias as Early Post-operative Complications of Cardiac Surgery in Children at Cairo University

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Arrhythmias are a recognized complication of cardiac operations in pediatrics. The aim of the study was to assess the incidence and type of arrhythmias in early post pediatric cardiac surgery patients and to analyze possible risk factors. This is a retrospective study conducted on patients who were followed in post-operative clinic at Cairo University Children's Hospital during the period from September 2007 till January 2009. The following data were collected for each patient; demographic data, pre-operative arrhythmia present, surgical data and post-operative intensive care course. During the study period, 110 patients were enrolled; including 15/110 who had palliative surgery, while 95 out of 110 had corrective surgery. Thirty patients (27.2%) developed post-operative arrhythmias and most of them on day one (60%). Of them 20/30 (66.6%) were cyanotic, while 10/30 (33.3%) were acyanotic. Two (6.6%) had palliative surgery, while 28/30 (93.3%) had corrective surgery. The most common acute post-operative arrhythmias were junctional ectopic tachycardia and Supraventricular tachycardia (33.3%) for each. Out of 95 patients who had corrective surgery, 28 (29.4%) developed arrhythmias most of them (96.4%) within first 48 h post-operatively. they were early after repair of tetralogy of Fallot (18.1%) and (12.1%), respectively. Risk factors for arrhythmias in corrective surgery; such as young age, lower body weight and cyanosis ($p < 0.05$), longer cardiopulmonary bypass time ($p < 0.05$), redooperation ($p < 0.01$), post-operative acidosis, high inotropic support, hypotension and mechanical ventilation ($p < 0.01$), patient with moderate operative risk, post-operative higher doses of inotropic support, longer ventilation time were statistically significance with $p < 0.001$. Younger age, lower body weight, cyanosis, longer cardiopulmonary bypass time, Re-do procedure, acidosis, mechanical ventilation and high inotropic support are the risk factors for post-operative arrhythmias. Junctional ectopic tachycardia and supraventricular tachycardia were the most common post-operative arrhythmias.

Key words: Early post-operative, cardiac arrhythmias, pediatric, risk factors

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INTRODUCTION

Early post-operative arrhythmias occur frequently after cardiac operations in children.

Many reports have been published about arrhythmias as late complication after cardiac operations such as the Mustard or Senning operation for transposition of the great arteries, Fontan procedures, or tetralogy of Fallot repair (Valsangiacomo *et al.*, 2002).

While, data concerning rhythm disturbances in the immediate post-operative period after open heart operation in children are scarce (Jolin *et al.*, 2008). Factors that may cause or increase the risk of post-operative arrhythmias are preexisting myocardial compromise by the cardiac defect, complex operation with extensive scars and suture lines, consequences of myocardial ischemia, post-operative electrolyte disturbances and an increased adrenergic tone or catecholamine stimulation (Buz *et al.*, 2009).

Post-operative cardiac arrhythmias can be of atrial or ventricular origin. Atrial arrhythmias typically arise after Fontan or Senning type operations, whereas ventricular arrhythmias most often occur after total correction of tetralogy of Fallot (Hoffman *et al.*, 2002).

Junctional Ectopic Tachycardia (JET) may develop after surgery for closure of Ventricular Septal Defects (VSD) and complete atrioventricular block (CAVB) can occur after any operation that interferes with the His-Purkinje system (Vaksmann, 2005).

Arrhythmias that may be tolerated in a normal heart can be a major cause of morbidity and mortality after cardiac operation for congenital heart disease (Pfammater *et al.*, 2001).

In the early post-operative period after corrective surgery, arrhythmias may have a major influence on the recovery of the hemodynamically impaired patients and are a prognostic factor for long-term outcome (Rekawek *et al.*, 2007). The aims of study were to assess the incidence of early post-operative arrhythmias after cardiac operation in a pediatric population, to describe their type and to analyze possible risk factors.

MATERIALS AND METHODS

This study was a retrospective study which involved patients who were followed in post-operative clinic at Cairo University Children's Hospital (CUCH) during the period from September 2007 till January 2009; children who had undergone cardiac surgery for correction of congenital or acquired cardiac disease were enrolled in this study. Data was collected retrospectively from the pediatric cardiac intensive care unit surveillance data sheet. Each child was monitored routinely in intensive care during the early post-operative period. Upon

detection of a sustained arrhythmia (≥ 30 sec duration, recurrences and/or effect on hemodynamic parameters), electrocardiography (ECG) (Selman *et al.*, 2008) was performed. All the ECG records were assessed by the same pediatric cardiologist.

For each case, a demographic data and recorded the cardiac diagnosis, operational procedures, perioperative parameters (cardiopulmonary bypass [CPB] time, aorta clamping time, total surgery time) and post-operative parameters (electrolyte levels, oxygen saturation findings, blood pH, serum calcium, sodium, potassium, magnesium levels and doses of inotropic agents required) were collected. Redo-operation referred to the repeated operation at the same midline incision.

Arrhythmias could be defined as sinus bradycardia, frequent premature atrial or ventricular complexes, conduction defects, atrioventricular (AV) blocks and supraventricular and ventricular tachycardias were considered critical arrhythmias. Supraventricular tachycardia was defined as narrow complex tachycardia with one to one atrioventricular conduction and reentry mechanism. Junctional ectopic tachycardia was defined as a narrow complex tachycardia with atrioventricular (AV) dissociation. Frequent premature supraventricular or ventricular beats were diagnosed if their number exceeded 10 per minute. Sinus bradycardia was defined as an inadequate sinus rate for the age and hemodynamic condition of the patient or as a junctional escape rhythm in the absence of AV block or junctional ectopic tachycardia. As estimated normal heart rates are not applicable to children with cardiac dysfunction and in the post-operative state, higher sinus rates than normal were defined as adequate for the post-operative patients (Deal *et al.*, 2008).

The following minimal rates according to age were considered as bradycardia: 120 to 130 beats min^{-1} diurnal rate in neonates, less than 120 beats min^{-1} in children aged less than 1 year, 110 beats min^{-1} in children aged 3 to 4 years, 100 beats min^{-1} in children aged 5 to 7 years, less than 90 beats min^{-1} in children aged 8 to 11 years and 85 beats min^{-1} in children aged 12 to 15 years (Stem, 2008).

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 antiarrhythmic agent (amiodarone) aimed at optimal heart rate for age and hemodynamic conditions.

Amiodarone was our drug of choice for supraventricular. An initial single 5 mg kg^{-1} intravenous dose of amiodarone was then followed by intravenous

infusion of 10 to 15 mg kg⁻¹ per day. No adverse effects of intravenous amiodarone therapy, such as hypotension or proarrhythmic effect, were observed. 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 (Fishberger *et al.*, 2008).

Statistical analysis: Statistical calculations were made using the software SPSS for Windows (version 11.0). Numerical data was expressed as a Mean±SD deviation. Comparison of means for changes in variables was performed using the Paired Student's t-test (Raju, 2005) while, the non-Paired Student's t-test (Hanley, 2008) was used for numeric comparison between two different groups (arrhythmias versus non-arrhythmias in open-heart surgery patients). Nonparametric test for independent samples (the Mann-Whitney Test) (Cassidy, 2005) was used to compare linear variables between groups. For categorical variables the Fisher exact test (Hall, 2007) was used. Multivariate stepwise logistic regression was used to assess the risk factors of post-operative cardiac arrhythmias. A p-value of <0.05 was considered statistically significant.

RESULTS

During the study period, 110 patients were enrolled (70 males, 40 females) their mean age (2.6±1.5 years). The mean body weight (10.7±2.2). 49/110 patients (44.5%) were cyanotic and 61/110 patients were acyanotic (55.5%). Ventricular septal defect was the most common 36/61 (59%) acyanotic congenital heart diseases and Tetralogy of Fallot was the most common 33/49 (67.3%) cyanotic congenital heart diseases. 95/110 (86.3%) of the cardiac surgeries were corrective cardiac surgery and 15/110 (13.7%) were palliative cardiac surgery. 30/110 patients developed arrhythmias in the post-operative period (27.2%). Thirty patients (14 females, 16 males; 27.2% of total studied patients) developed rhythm disturbances most of them were in the first 48 h (90%) while the remaining occur later (Fig. 1).

Supraventricular and junctional tachycardias were the commonest arrhythmias in early post-operative period the details are shown in Fig. 2.

Of the 30 patients who developed arrhythmias; 20(66.6%) patients were cyanotic while 10(33.3%) were acyanotic and 2(6.6%) had a palliative cardiac surgery while 28 (93.3%) had corrective cardiac surgery.

In the two patients who developed arrhythmias and did palliative cardiac surgery; the first patient did pulmonary artery banding and developed (premature atrial beats) on day one that was preceded by hyponatremia, while the second patient did Blalock Tauusing shunt

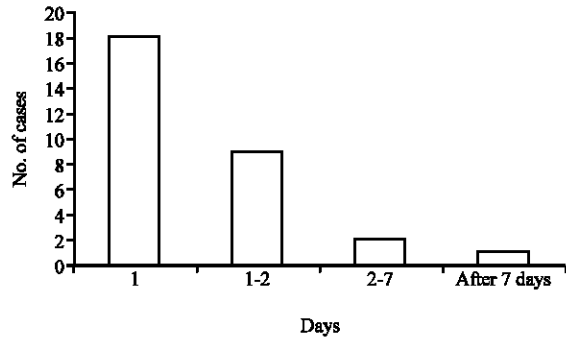


Fig. 1: Onset of post-operative arrhythmias

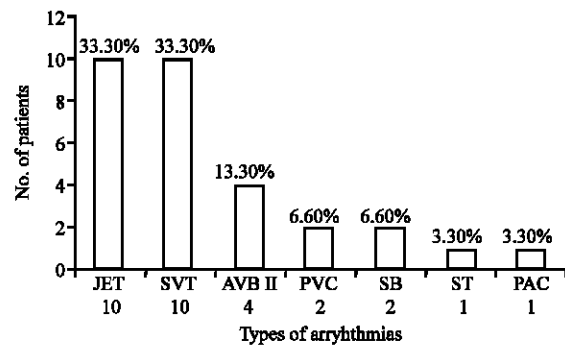


Fig. 2: Type and Frequency of arrhythmias, JET: Junctional ectopic tachycardia; SVT: Supraventricular tachycardia; PVC: Premature ventricular-contraction; AVB: Atrioventricular block; SB: Sinus bradycardia, ST: Sinus tachycardia, PAC: Premature atrial contraction

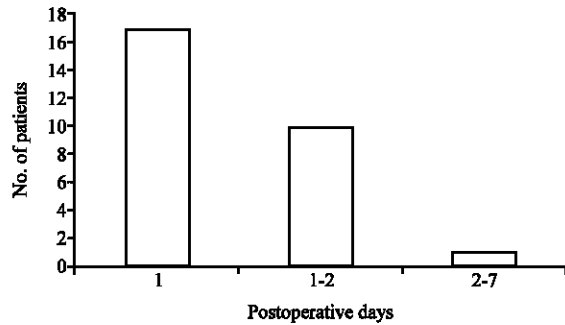


Fig. 3: Onset of Arrhythmias in corrective surgeries patients

(B-T shunt) and developed (sinus tachycardia) on day 3 that was due to anemia. Both patients were excluded from our statistical study.

Within the corrective cardiac surgeries group 95 cases, 28 patients (29.4%) developed arrhythmias most of them during the first 48 h post-operatively 27(96.4%) (Fig. 3).

Table 1: Details of early post-operative arrhythmia in corrective cardiac surgery

Diagnosis (95 Patients)	Type of Arrhythmias				
	JET 10/95 (10.5%)	SVT 10/95 (10.5%)	AVB 4/95 (4.2%)	SB 2/95 (2.1%)	PVC 2/95 (2.1%)
TOF (33 cases)	6	5			
AVC (10 cases)	3		3		
VSD+ASD (10 cases)		3	1	1	
VSD (36 cases)		2			
ASD (2 cases)				1	
D-TGA (3 cases)	1				1
DORV, TGA, PS (one case)					1

JET: Junctional ectopic tachycardia; SVT: Supraventricular tachycardia; PVC: Premature ventricular-contraction; AVB: Atrioventricular block; Sinus bradycardia. TOF: Tetralogy of fallot; AVC: Atrioventricular canal defect; DTGA: Transposition of the great arteries; ASD: Atrial septal defect; VSD: Ventricular septal defect; DORV: Double outlet right ventricle, PS: Pulmonary stenosis

Table 2: The potential risk factors for arrhythmias and perioperative details in corrective cardiac surgery

Parameters	Arrhythmias patients (n = 28)	Non Arrhythmias patients (n = 67)	p-value
Age (months)	11±2.0	16±3.0	<0.05
Body weight (kg)	8±1.5	11.5±1	<0.05
Cyanosis (cases %)	14 (50%)	19 (28.3%)	<0.05*
CPB time (min)	105.4±53.1	80.8±36.3	<0.05
Aortic cross clamp time (min)	50±22.5	47.5±18.6	0.09
Redo-operations (cases %)	4 (14.2%)	1(1.7%)	<0.01*
Post-operative Acidosis (cases %)	7 (25%)	2 (3.5%)	<0.01*
Electrolytes disturbances, cases %)	1 (3.5%)	2 (3.5%)	<0.42
High Inotropic supports (high doses) on leaving operating room (cases %)	9 (32.1%)	3 (5.2%)	< 0.01*
Ventilation Supports days	4±1.5	1 ±0.5	< 0.01
Anemia (cases%)	7 (25%)	15 (26.3%)	0.43
Hypotension on arrival in ICU (cases %)	9 (32.1%)	3 (5.2%)	< 0.01*
ICU stay days	6±2	4±2	0.52

*p<0.05; Data are expressed as Mean±SD

Junctional Ectopic Tachycardia and SVT were the commonest arrhythmias in the post-operative period 10/28(35.7%) for each of them, they were common in early post repaired tetralogy of Fallot (18.1%) and (15.1%), respectively (Table 1).

Although, patients were not classified according to their complexity, arrhythmias were more in patients with (TOF, CAVC, DORV, D-TGA) 20/28 (71.4%) than patients with simple defects (ASD, VSD) 8/28 (28.5%).

Risk factors analysis

Preoperative risk factors: In a univariate analysis independent risk factors for early post-operative arrhythmias were; lower body weight, younger age at time of surgery and cyanosis with (p< 0.05) (Table 2).

Operative risk factors: In a univariate analysis independent risk factors for early post-operative arrhythmias were; Prolonged CPB duration (p<0.05) and a Redo operation (p<0.01) (Table 2).

Post-operative risk factors: In a univariate analysis independent risk factors for early post-operative arrhythmias were; high inotropic support on leaving operating room, hypotension on arrival ICU, ventilation and acidosis (p<0.01) (Table 2).

The multivariate stepwise logistic regression cyanosis, was statistically significance with p<0.005. Longer CPB time, Redo operation were statistically significance with p<0.01. Post-operative higher doses of inotropic support, longer ventilation time were statistically significance with p<0.001.

Treatments of arrhythmias in post corrective cardiac surgery, all cases were successfully treated; Body surface cooling was applied in 5 patients, including 2 with junctional ectopic tachycardia and 3 with supraventricular tachycardia. Antiarrhythmic drug therapy with amiodarone was used in 8 patients, including junctional ectopic tachycardia and 7 with supraventricular tachycardia.

DISCUSSION

Arrhythmias are serious problems because they cause hemodynamic imbalance, often require aggressive treatment and increase mortality risk (Dodge-Hatami *et al.*, 2002). In this study, the incidence of arrhythmia in the 110 cases was 27.2%. It was common after corrective (29.4%) rather than palliative (13.3%) cardiac surgeries. That incidence is close to the rates reported by Pfammater *et al.* (2001) (27%). While, in the study of Valsangiacomo the incidence of arrhythmias were (48%) and this can be

explained by performance of more complex surgical procedures in younger patients in their study (Valsangiacomo *et al.*, 2002). But the incidence in this study was significantly higher than the one reported by Bronzetti who found it (8.9%) as they studied only incidence of Junctional ectopic tachycardia following open cardiac surgery (Bronzetti *et al.*, 2003). Where as in this study, the incidence was quite high because the present study included all kinds of abnormal rhythm with and without hemodynamic effects also we are not focused on specific cardiac lesion to provide broader information about the overall spectrum of rhythm disturbances potentially encountered by the pediatric cardiologist, cardiac surgeon and critical care specialist in the immediate post-operative period.

The lower risk of arrhythmia after palliative heart surgery was due to palliative heart surgical technique does not affect the myocardium or interfere with the conduction system; there were also no negative effects of CPB. In contrast, arrhythmias occur more frequently after corrective heart surgery despite the advances in surgical and CPB techniques as well as myocardial preservation. Most of these disturbances are due to 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 (Kanoknaphat *et al.*, 2008).

Previous studies classified arrhythmias as early and late according to the time of onset, early onset arrhythmias was defined as presence of arrhythmias during the first 48 h post-operatively (Jacobs *et al.*, 2005). In this study within the corrective cardiac surgeries 27 out of 28 (96.4%) developed early onset arrhythmias, the same was reported by other studies this could be expected due to the swelling of the myocardium, unstable hemodynamic status, high doses of inotropes administration and metabolic disturbance were common (Jacobs *et al.*, 2005).

In the present study the most common forms of arrhythmias in early post-operative period following the corrective heart surgeries were JET and SVT, which were common in early post-operative period following repair of tetralogy of Fallot 6/33 (18.1%) and 5/33 (15.1%), respectively. That were supported with other studies (Lan *et al.*, 2003; Gatzoulis *et al.*, 2000). This could be 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. While, in the study of Valsangiacomo *et al.* (2000), the most frequent types of arrhythmia were sinus bradycardia, second and third degree AV block and SVT, this could be related with the difference in complex surgical interventions between different studies.

This study showed that younger age and low body weight at the time of operation were risk factors for early post-operative arrhythmias and they were statistically significant that could be explained by the fact that complex surgical interventions are more frequent early; moreover, the sensitivity to electrolyte and acid-base disorder is higher early in life (Selman *et al.*, 2008). This was reported by earlier study (Valsangiacomo *et al.*, 2002). In the current study the more complex the cardiac defects the more frequent early post-operative arrhythmias (TOF, CAVC, DORV, D-TGA) 20/28 (71.4%) than patients with simple defects (ASD, VSD) 8/28 (28.5%). Also, presence of cyanosis was a risk factor for early post-operative arrhythmias (66.6%) of arrhythmic patients were cyanotic. That was supported by the study of Pfammatter *et al.* (2002) who found that the complexity of the surgical procedure was a strong risk factor of post-operative arrhythmias this can be explained by longer CPB time in complex procedure.

This study mean CPB for the patients who developed arrhythmias was 105.4±53.1 and this was longer than in non arrhythmic patients 80.8±35.3 and this was statistically significant so the longer CPB time is a risk factor for arrhythmias this was reported by Selman *et al.* (2008). This could be explained by the fact that long CPB causes changes in the micro and macro-equilibrium. The arrhythmias might have been increased because of the alterations in the myocardial conduction pathways. Furthermore CPB with ischemia-reperfusion and the related cellular biochemical effects as well as medical interventions such as electrolyte shifts and catecholamine administration may affect the stability of the cellular membrane and result in an increased myocardial irritability and automaticity (Luciano *et al.*, 2002).

As post-operative arrhythmias appeared frequently in the first 24 h, factors belonging to the myocardium, CPB and high inotropic requirement, hypotension, electrolytes disturbances, acidosis and longer ventilation in this period should be researched.

In this study among the arrhythmic patients the need for higher dose on inotropes and hypotension were 9 out of 28 patients for each (32.5%) and the presence of acidosis was in 7 out of 28 patients (25%) showed a statistical significance when compared to non arrhythmic patients that was supported with Rosales *et al.* (2001), Delaney *et al.* (2006) and Duke *et al.* (2004) and this could be explained by the fact that inotropic support, hypotension and acidosis may affect the cellular membrane and result in an increased myocardial irritability and automaticity (Selman *et al.*, 2008).

This study showed that electrolyte disturbances were not statistically significant in developing arrhythmias

which was supported by Dalaney *et al.* (2006). While, others showed that low magnesium level was reported as causative in JET appearance (Batra *et al.*, 2006). This study showed that the Redo-operations, was statistically significant risk factor for early post-operative arrhythmias this could be explained by tissue injury and ionic changes which affected electrical property at cellular level (Kanoknaphat *et al.*, 2008; Canbaz *et al.*, 2008; Karamlou *et al.*, 2006).

Early post-operative arrhythmias influence the long-term outcome of patients with congenital heart diseases, this study showed all reported arrhythmias were transient and their adverse hemodynamic effects could be limited with the therapies used. Thus no life-threatening episodes or deaths were related to post-operative arrhythmias and this can be explained by improved quality of the post-operative intensive care which enables early recognition and immediate treatment of potentially lethal rhythm disturbances. Although, development of early post-operative arrhythmias is associated with a longer post-operative stay at the cardiac intensive care unit, a longer ventilation time and, most importantly, a higher hospital mortality as reported by Rekawek *et al.* (2007). Which could be explained by more cardiac complexity, younger age at intervention (Ono *et al.*, 2006).

Among all treatments, Body surface cooling and drug therapy with amiodarone were the most frequently used. The same was reported by earlier study Haas and Camphausen (2008).

Preventing these arrhythmias will influence the long-term survival of patients with congenital heart diseases. Careful monitoring of these patients especially cyanotic, young patients with lower body weight who are candidate for corrective cardiac surgery with long cardiopulmonary bypass time that might be in need for high inotropic support post-operatively, so medical prevention and early management with appropriate means could improve outcome.

CONCLUSION

Early post-operative period following cardiac surgery is the most critical period during which arrhythmias mostly happened especially in first 48 h. Junctional ectopic tachycardia and supraventricular tachycardia were the most common post-operative arrhythmias. Risk factors for post-operative arrhythmias were preoperative including young age, low body weight at the time of operation and the presence of cyanosis. Predisposing operative factors for arrhythmias included redo procedure and long cardiopulmonary bypass time and post-operative risk factors including Acidosis, mechanical ventilation and high inotropic support.

RECOMMENDATION

Early corrective surgery for congenital heart diseases especially cyanotic group, smooth uncomplicated operative time with early treated any acid base imbalance; minimal effective doses of inotropic drugs in the post-operative time might help in decrease the development of post-operative arrhythmia.

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