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The Prevalence and Risk Factors of Early Arrhythmias Following Pediatric Open Heart Surgery in Egyptian Children

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Abstract

AIM: This study aimed to assess the prevalence of early postoperative arrhythmias after cardiac operation in the pediatric population, and to analyse possible risk factors.

MATERIAL AND METHODS: Cross-sectional study included 30 postoperative patients, with age range four up to 144 months. They were selected from those admitted to the Cardiology Unit in the Pediatric department of Ain Shams University hospitals, after undergoing cardiopulmonary bypass (CPB) surgery for correction of congenital cardiac defects. All patients had preoperative sinus rhythm and normal preoperative electrolytes levels. All patients' records about age, weight, type of surgery, intraoperative arrhythmias, cardiopulmonary bypass time, ischemic time and use of inotropic drugs were taken before they were admitted to the specialised pediatric post-surgery intensive care unit (ICU).

RESULTS: Arrhythmia was documented in 15 out of 30 patients (50%). Statistically significant difference between the arrhythmic and non-arrhythmic group were recorded in relation to the age of operation (23 vs 33 months), weight (12 vs. 17 kg), ischemic time (74.5 vs. 54 min), cardiopulmonary bypass time (125.5 vs. 93.5min), inotrope use (1.6 vs. 1.16) and postoperative ICU stay (5.8 vs. 2.7 days), P<0.05.

CONCLUSION: Early postoperative arrhythmias following surgery for congenital heart disease are relatively frequent in children (50%).Younger age, lower body weight, longer ischemic time and bypass time, and more inotrope use are all risk factors for postoperative arrhythmias and lead to increase the hospital stay.

Introduction

Immediate postoperative arrhythmias are a widely recognised complication of cardiothoracic surgery in both the adult and pediatric populations [1]. Although they are transient and manageable, they are considered a major cause of morbidity and mortality after cardiac surgery for congenital heart disease during the phase of postoperative hemodynamic instability [2-4].

There are many factors known to increase the risk of post congenital heart repair surgeries. Cardiopulmonary bypass (CPB), intraoperative injury to the conduction system and myocardium, postoperative metabolic abnormalities and electrolyte disturbances are known factors associated with increased risk of arrhythmias following surgery [4, 5]. The incidence and types of arrhythmia after cardiac surgery vary with age, the underlying lesion, the type of surgery, and local practice patterns. The overall incidence of early postoperative arrhythmia has been reported to be as high as 48% in children. [6]

After frequent premature ventricular contractions (PVCs), ectopic junctional tachycardia (JET) is the most common arrhythmia in patients undergoing congenital heart surgery. The operative and perioperative factors that may contribute to postoperative JET remain ill-defined [1]

This study aimed to assess the prevalence of early postoperative arrhythmias after cardiac operation in the pediatric population and to analyse possible risk factors.

Material and Methods

Following approval by the "Ethical Committee" of Ain-Shams University and the parents' consent, 30 patients of both sexes; who undergoing CPB for corrective surgery of congenital cardiac defects; were selected from the Cardiology Unit in the Pediatric department of Ain-Shams University hospitals. The females represented 60% (18 patients) while males were 40% (12 patients) of the study population. Their ages ranged from 4 to 144 months with an average of 51.11 (± 45.12) months. They had mean weights of 17 kg (± 10.61 kg) ranging from 3 to 33 kg.

This cross-sectional study was carried out between March 2013 and March 2014. All patients had preoperative sinus rhythm and normal preoperative magnesium and other electrolytes levels. All patients' records about type of surgery, intraoperative arrhythmias, cardiopulmonary bypass time, ischemic time, type of used inotropic drugs and the dose were taken before they were admitted to our specialised pediatric post-surgery intensive care unit (ICU)

Arrhythmias assessment

Arrhythmias were classified as supraventricular tachycardia (SVT), ectopic junctional tachycardia (JET), premature ventricular contractions (PVCs), complete heart block (CHB), junctional rhythm (JR) and ventricular tachycardia (VT). SVT was defined as retrograde P wave (AV reentrant) or 1:1 AV conduction. JET was defined as a narrow complex tachycardia with atrioventricular (AV) dissociation [7].

PVCs was diagnosed if there was premature QRS complex and prolongation of its duration for age with premature ventricular complex not preceded by premature atrial activity [8, 9]. CHB occurs when none of the atrial impulses is conducted to the ventricles. There is a complete loss of rhythm conduction from a working atrial pacemaker, thereby allowing the ventricular pacemaker to take over [10].

JR characterized by normal QRS morphology at a rate not exceeding the maximum junction escape rate for age (up to 3 years it is 50 to 80 beats/min and 40 to 60 beats/min over 3 years) and slower than the atrial escape rhythm (up to 3 years it is 80 to 100 beats/min up and 50 to 60 beats/min over 3 years) [7, 11]. VT was defined as series of 3 or more repetitive excitations originating from one of both ventricles. The QRS complexes are different from the usual QRS morphology with a prolonged duration of corresponding age [7].

Standard electrocardiograms (ECGs) were registered in all patients at the time of ICU admission, using (Cardiofax ECG-9620L) a real-time electrocardiograph with three channel recorder. Continuous ECG monitoring was performed during the entire ICU stay with (Drager Infinity Vista XL monitors). Before hospital discharge, a 12-lead ECG was routinely done. In case of arrhythmia in the postoperative course, the patient also had a 24 hr Holter recording before discharge.

A Vision™ Holter analysis system, manufactured by Spacelabs Burdick was used in this study. During analysis, the vision™ Holter analysis system uses a technique known as feature extraction to group the individual QRS complexes into forms based on their features. After the individual QRS complexes have been consolidated into forms, the forms are classified into one of the following categories: Normal (N), Ventricular (V), Paced (P), or Artifact (x). Identification of ventricular and supraventricular arrhythmia takes place. These are then classified as runs, couplets or isolated episodes. The interpretation of the Holter monitoring was then finalized after the cumulative analysis of the edited forms, arrhythmias and full disclosure of the recording

Operative details and inotropic drugs use

After recording the basic details like age and weight, a history of arrhythmia and related drugs was taken. Preoperative electrolytes levels were measured. Preoperative 12 leads electrocardiogram, and Preoperative echocardiography was done. General anaesthesia was performed in all patients. During the operation, the bypass and ischemic time were recorded. When necessary, the following inotropic drugs were used: Milrinone (0.3-0.75mcg\kg\min), Adrenaline (0.1- 0.5 mcg \kg\min), Dobutamine (5-20 mcg\kg\min), while weaning them from CPB. Post-operative stay in the intensive care unit (ICU stay) was also recorded.

Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS/Windows Version 16, SPSS Inc., and Chicago, IL, USA). Statistical significance was set at $P < 0.05$. The patients under study were classified into two groups according to the occurrence of postoperative arrhythmia: arrhythmic group (who get postoperative arrhythmia, and non-arrhythmic group (who did not get postoperative arrhythmia). The non-parametric data (qualitative) were expressed as frequency distribution: numbers and percentage of the total. Comparisons between the different non-parametric variables were analyzed using Chi-square test. While the parametric data (quantitative) were expressed as mean + SD. Student independent t-test was used to compare two parametric data.

Results

The current study documented that arrhythmias were found in 15 out of 30 patients who represented an overall incidence of 50%. Those were grouped as follow: 5 patients (33.33%) with Junctional ectopic tachycardia (JET), 4 patients (26.67%) with Junctional rhythm (JR), 2 patients (13.33%) with complete heart block (CHB), 2 patients (13.33%) with premature ventricular contractions (PVCs), 1patient (6.67%) got attack of ventricular tachycardia (VT) and another one (6.67%) got supraventricular tachycardia (SVT) (Table 1).

Table 1: Percentage of different types of early postoperative arrhythmias among study population

Type of arrhythmia	No.	%
Junctional ectopic tachycardia	5	33.33%
Junctional rhythm	4	26.67%
Complete heart block	2	13.33%
Premature ventricular contractions	2	13.33%
Ventricular tachycardia	1	6.67%
Supraventricular tachycardia	1	6.67%
Total	15	100.00%

Statistically significant differences between the arrhythmic and non-arrhythmic groups were found in relation to the age of operation (23 vs 33 months), weight (12 vs. 17 kg), ischemic time (74.5 vs. 54 min), cardiopulmonary bypass time (125.5 vs. 93.5 min), number of inotropic drugs used (1.6 vs. 1.16) and postoperative ICU stay (5.8 vs. 2.7 days), P < 0.05 (Table 2). It was noticed that younger the age, lower body weight, longer ischemic time and bypass time, and the more inotrope use, are all risk factors for the arrhythmic group and lead to increase the hospital stay. These risk factors lead to the increased possibility of postoperative arrhythmias.

Table 2: Comparison between the arrhythmic and non-arrhythmic groups

Variable	No arrhythmia		Arrhythmia		Independent t-test	
	Mean	SD	Mean	SD	t	P-value
AGE (months)	33.66	13.656	23.84	9.089	2.318	0.027
WEIGHT (kg)	17.00	12.21	12.13	6.44	2.768	0.010
ISCHEMIC TIME (min)	53.99	32.741	74.6	35.36	3.212	0.003
BYPASS TIME (min)	93.57	28.77	125.65	24.697	3.277	0.003
Inotrope no.	1.56	0.64	1.16	0.325	2.158	0.039
ICU stay (day)	2.7	0.9	5.8	1.2	4.648	0.000

Table 3 showed a significant relationship between the absence of inotropic support and absence of early postoperative arrhythmias. Inotropic support was not used in 5 patients, only one of them had arrhythmias (20%) while the other four patients (80%) did not experience any form of early postoperative arrhythmias (P-value 0.039). Adrenaline also was not used in 15 patients, of those four patients (26.6%) had arrhythmias while the other 11 patients (73.3%) did have any form of arrhythmia (P-value 0.028). However, the insignificant effect of the use of milrinone or dobutamine on the occurrence of early postoperative arrhythmias was detected (P value > 0.05), as nearly half the patients who used/did not use one of these drugs had arrhythmias.

Table 3: Comparison between arrhythmic and non-arrhythmic group as regard inotropic drugs use

		No arrhythmia		Arrhythmia		Chi-square test	
		No.	%	No.	%	X^2	P-value
Inotropic support	Used = 25	11	73.33%	14	93.33%	0.960	0.039
	Not used = 5	4	26.67%	1	6.67%		
Milrinon	Used = 4	2	12.50%	2	14.29%	0.156	0.693
	Not used = 26	14	87.50%	12	85.71%		
Adrenaline	Used = 15	4	26.67%	11	73.33%	4.800	0.028
	Not used = 15	11	73.33%	4	26.67%		
Dobutamine	Used = 19	9	60.0%	10	66.7%	0.000	1.000
	Not used = 11	6	40.0%	5	33.3%		

Moreover, adrenaline at doses below 0.1 mcg/kg/min was already running in 4 patients, three patients of them had no arrhythmias. Adrenaline at doses between 0.1-0.2 mcg/kg/min was used in 7 patients, six patients of them also had no arrhythmias. While adrenaline at doses > 0.2 mcg was used in 4 patients, all of them had arrhythmias (P-value 0.033). This means that there was a significant effect of increasing the dose of adrenaline more than 0.2 mcg/kg/min on increasing the risk of occurrence of arrhythmias. However, the insignificant effect of increasing the dose of dobutamine infusion on the increased occurrence of arrhythmias was found (P value > 0.05).

Table 4: Comparison between arrhythmic and non-arrhythmic group as regards dosage of inotropes used

		Arrhythmia		No arrhythmia		Total		P-value
		No.	%	No.	%	No.	%	
Dobutamine grade	5 < 10 ug	1	6.7%	4	26.67%	5	16.67%	
	10 < 20 ug	6	40.0%	5	33.33%	11	36.67%	0.235
	> 20 ug	3	20.0%	0	0.0%	3	10.00%	
Adrenaline grade	0.05 - < 0.1 ug	1	6.7%	3	20.00%	4	13.33%	
	0.1 - 0.2 ug	6	40.0%	1	6.67%	7	23.33%	0.033
	> 0.2	4	26.7%	0	0.0%	4	13.33%	

Discussion

Studies have been conducted on rhythm complications related to surgical repair of congenital heart disease, most have focused on rhythm disturbances as a late complication of a single diagnosis or procedure, whereas others have evaluated the risk of a single rhythm disturbance [12]

Current results demonstrated that arrhythmias were a frequent early complication after an open heart operation for congenital heart disease, despite the advances in surgical and CPB techniques as well as myocardial preservation. This high incidence, occurring in spite of all surgical technical improvements, can be explained by the performance of more complex surgical procedures in increasingly younger patients.

The current study found a peak prevalence of arrhythmias of 50 % which is near to previously

reported studies like Alp et al. (2014) 43.5%. Delaney et al. reported the prevalence of arrhythmias in their patients that necessitated intervention, 15% of their cohort. However, Grosse-Wortmann et al. (2010) reported peak prevalence of arrhythmias 79.1%, which was higher than all other reported studies. They explained this difference as being a result of Holter monitoring, which may reflect a more sensitive method of detection, especially of extrasystoles, instead of bedside monitoring [13-15].

Pathophysiologic causes for early postoperative arrhythmias are various, including direct surgical injuries like myocardial incision, results of cannulation, sutures close to the conduction system, and acute changes of the intracardiac pressure caused by volume and pressure overload [16].

Junctional ectopic tachycardia was the most frequent arrhythmia in the current study including 33.3% of the arrhythmic population, then Junctional rhythm 26.67%, complete heart block and premature ventricular contractions 13.3 % and ventricular tachycardia and supraventricular tachycardia 6.67% while in Alp et al. 2014 supraventricular extra-systole was the most common arrhythmia with 65%, ventricular extra-systole 24%, atrial fibrillation and supraventricular tachycardia 2.9% each, atrial flutter 1.9 % and Junctional rhythm 1%. After frequent PVCs, JET was the most common arrhythmia in patients undergoing congenital heart surgery [13].

The precise aetiology of JET is unknown, but it is believed to be the result of enhanced automaticity in the bundle of His, either in its right atrial or right ventricular portion, promoted by haemorrhage into the conduction tissues. It is postulated that disruption of conduction tissue, either by direct trauma or penetrating blood and interstitial inflammatory cells, may result in an irritable focus leading to JET [14].

In the present study, comparison between the arrhythmic and non-arrhythmic group of patients revealed a statistically significant difference as regard age at operation (23 vs. 33 months), ischemic time (74.5 vs. 54 min), cardiopulmonary bypass time (125.5 vs. 93.5 min), number of use of inotropic drugs (1.6 vs. 1.16) and postoperative ICU stay (5.8 vs. 2.7 days), $P < 0.05$. This came in agreement with Delaney et al. who showed a statistically significant difference between the mean values for the arrhythmic and non-arrhythmic groups about age at operation (22 vs 45 months), ischemic time (105 vs 44 min), cardiopulmonary bypass time (189 vs 109 min). Alp et al. reported that there was no association in their cohort to these risk factors, they explained that because they include neonates with simple procedures like PDA ligation and division [12, 13].

Pfammatter et al. reported that the incidence of early postoperative arrhythmia after cardiac operation in children was 11% of children with bypass time of < 50 minutes. This proportion rose to 33% for bypass time between 50 and 100 minutes and to 50% for bypass time > 100 minutes. They stated that the association between higher occurrence rate of arrhythmias and longer cardiopulmonary time might just reflect increasing complexity of the surgery [17].

Inotropic support is the mainstay of treatment of patients with low cardiac output that resulted either from a surgical intervention that included cardiopulmonary bypass or as a component of the underlying heart disease.

In this study, a strong relationship between the absence of inotropic support and absence of early postoperative arrhythmias was found. Inotropic support was not used in 5 patients, only one of them had arrhythmia (20%). This is consistent with what was mentioned by Smith et al. that patients, in whom inotropic support was not used, the experienced low incidence of early postoperative arrhythmias [18].

Statistically significant effect of the use of adrenaline; particularly if its dose was more than 0.2 ug/kg/min; on the occurrence of early postoperative arrhythmias was found. While the statistically insignificant effect of the use of either milrinone or dobutamine on the occurrence of early postoperative arrhythmias was found.

Milrinone acts independently of the adrenergic receptor through phosphodiesterase inhibition and therefore does not cause increased myocardial oxygen consumption or catecholamine stimulation to the heart [18].

In conclusion, early postoperative arrhythmias following surgery for congenital heart disease are relatively frequent in children: 50%. Junctional ectopic tachycardia and junctional rhythm were common types of arrhythmias. Lower age, lower body weight, longer CPB time, longer cross-clamp time, use of inotropic support; particularly adrenaline at a dose more than 0.2 mcg/kg/min, all are risk factors for postoperative arrhythmias.

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