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Junctional Ectopic Tachycardia in The Postoperative of Cardiovascular Surgery: A Cohort Study

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ABSTRACT

Introduction: Arrhythmias in the postoperative of cardiovascular surgery are an important cause of morbidity and mortality. Junctional ectopic tachycardia (JET) is among the most frequent types of arrhythmias. The purpose of this study is to describe the prevalence of JET in a certain population and to find predisposing factors for its development.

Population and Methods: Analysis of a retrospective observational cohort study of 0–16-year-old patients admitted to an intensive care unit in the postoperative period following cardiovascular surgery between January 1, 2013 and December 31, 2018.

Results: Of 2247 admitted patients, 268 underwent recovery from cardiovascular surgery. Fifty-nine percent (n=157) were males. Mean age was 32 months (r: 0-187 months) and mortality rate was 5% (n=14). The prevalence of arrhythmias was 21% (n=56) and 9 out of 14 deceased patients had arrhythmias. The most frequent type of arrhythmia was junctional ectopic tachycardia in 18 patients (6.7%). Extracorporeal circulation time >110 (OR 4.74, 95% CI 1.28-6.36) and septal defect repairs (OR 8.03, 95% CI 1.79-11.05) were associated with the development of junctional ectopic tachycardia.

Conclusion: Junctional ectopic tachycardia was the most frequent arrhythmia and its development was associated with extracorporeal circulation time longer than 110 minutes and septal repair surgery.

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Introduction

Arrhythmias in patients in the postoperative period following cardiovascular surgery are an important cause of morbidity and mortality and determine longer than expected hospitalization. Most of these arrhythmias occur at an early stage and may lead to hemodynamic compromise so treatment is of utmost importance. Different publications describe a wide range (8-48%) of incidence of arrhythmias but there is little evidence of their development [1-4].

Postoperative arrhythmias are known to be related to events during surgery or to the underlying disease and the surgical substrate. For identification and treatment, it is essential to have a team trained in cardiovascular recovery. Junctional ectopic tachycardia (JET) is among the most frequent arrhythmias.

The aim of this study is to contribute information on the prevalence of arrhythmias and to assess risk factors for developing JET in postoperative patients of cardiovascular surgery in the Pediatric Intensive Care Unit (PICU).

Population and Methods

A retrospective observational cohort study was conducted in patients aged 0-16 years who had been admitted to a PICU after cardiovascular surgery between January 1, 2013 and December 31, 2018. There were no exclusion criteria. The following variables were included among others: sex, age, heart disease diagnosis, type of surgery, cross-clamp and extracorporeal circulation time, vasoactive support, days on mechanical ventilation assistance (MVA), hospital stay (all variables are described and definitions specified in Annex I). The diagnosis of arrhythmia was reached with a 12-lead electrocardiogram.

Statistical Analysis

For the analysis of data, patients with arrhythmias versus patients with no arrhythmias were compared. Detailed univariate and multivariate analyses were conducted on the development of JET. A multiple linear regression to analyze risk factors influencing the duration of arrhythmia was performed.

Continuous data were expressed as mean + standard deviation (SD) or median and interquartile range (IQR). After verifying the assumptions of normality of the population, samples were compared using the student's t-test or Wilcoxon's test. Categorical data were expressed in proportions and compared using the X2 test or Fisher's exact test. A p-value below 0.05 was considered

statistically significant. For the initial comparison of both groups the Chi-Square test and univariate analysis were used. Then a multivariate logistic regression was conducted to predict the prevalence of arrhythmias and evaluate the association of each regression variable with the outcome variable (JET). By using logistic regression, the effects of confounding variables and the interactions among them could be controlled. Risk measurements with their corresponding 95% confidence intervals were used. A JET predictive model was made which was tested for performance analyzing its calibration and discrimination power. The Hosmer-Lemeshow test was applied analyzing deciles of risk and influencing patterns and/or outliers.
The STATA 8.0 statistical software (California, USA) was used.

The study was approved by the Institutional Assessment Committee (CIE, Spanish acronym). The informed consent requirement was exempted (Approval number: CIE No. 19-003).

Results

The pediatric intensive care unit admitted 2247 patients between January 1, 2013 and December 31, 2018, with an average PIM2 score of 3.43 and a Standardized Mortality Ratio of 1.

During this period, 268 patients in the postoperative period following cardiovascular surgery were included. Fifty-nine percent (n=157) of patients were males and 41% (n=111) were females. Mean age was 32 months (r: 0-187 months). Mortality rate was 5% (n=14). Table 1 describes the characteristics of patients with arrhythmia and patients who did not develop this condition.

Heart rate alterations were documented in 56 of the 268 patients, accounting for a prevalence of 21%. Nine of the 14 deceased patients had arrhythmia (3 JET and 6 ventricular fibrillation). The most frequent arrhythmia was JET in 18 patients (32.1%), followed by AV block in 14 patients (25%), extrasystoles in 13 (23.2%), ventricular fibrillation in 6 (10.7%) and lastly paroxysmal supraventricular tachycardia in 5 patients (8.9%).

Initially, a univariate analysis was performed between each covariate and the outcome variable, which was JET; variables that showed a statistically significant association were incorporated into the model (Table 3). Then a multivariate analysis was performed among all interacting variables to see the confounding effect and interactions among all covariates and their final association with the outcome variable.

The multivariate analysis (Table 4) was performed by applying a multiple logistic regression relating the final event (JET) and the following covariates: dexmedetomidine, extracorporeal circulation (ECC) time, adrenaline and/or noradrenaline >0.2 mcg/kg/min and septal defect. This detailed analysis served to establish the impact or risk factor that each one has in relation to the outcome variable.

Extracorporeal circulation time >110 and septal defect repair were strongly associated with the development of JET, while the use of dexmedetomidine was a protective factor. During the multivariate analysis, some variables changed their effect so a confounding effect could be inferred. For example, the use of adrenaline or noradrenaline >0.2 mcg/kg/min, which in the univariate analysis was associated with JET (OR 1.91, 95% CI 1.27-2.10), in the multivariate analysis OR 2.57 had 95% CI 0.85-4.16, with a non-significant p. This can be observed with all the variables in the final model.

We also analyzed the correlation between JET duration and pump time. In the multiple linear regression analysis, we saw that the risk ratio for developing arrhythmias with ECC times over 100 minutes increased by 0.39 days, while when working on this variable and dividing it into <100 minutes, 100-110 minutes and >110 minutes the risk had a different magnitude, observing after the multivariate logistic regression that >110 minutes was associated with OR 4.74 (95% CI 1.28-6.3) with a relevant statistical significance.

The predictive model for the JET outcome variable reveals that pump time and septum repair are predisposing factors for this arrhythmia, while dexmedetomidine would be protective (Table 2). To test the sensitivity and specificity of the model, a Hosemer-Lemeshow test was performed and a ROC curve was drawn where the model performance (relationship between sensitivity and specificity) shows an area under the curve of 0.78 (Figure 1), which reveals good calibration and discrimination power.

Table 1: Patient demographics

Gender	
Male	157 (58.6%)
Female	111 (41.4%)
Age, month, median	32
Age, month	
< 6	104 (38.8%)
6-24	67 (25)
> 24	97 (36.2%)
Pediatric Index of Mortality 2, %, median	3.43
Congenital heart disease	
Ventricular Septal Defect	41 (15.3%)
Atrial Septal Defect	30 (11.2%)
Tetralogy of Fallot	29 (10.8%)
Atrioventricular Canal Defect	22 (8.2%)
Pulmonary Atresia with Ventricular Septal Defect	17 (6.3%)
Hypoplastic Left Heart Syndrome	17 (6.3%)
Pulmonary Atesia with Intact Ventricular Septum	12 (4.5%)
Transposition of the Great Ventricule	10 (3.7%)
Truncus Arteriosus	5 (1.9%)
Anomalous Left Coronary Artery from the Pulmonary Artery	4 (1.5%)
Double-Outlet Right Ventricule	4 (1.5%)
Arrhythmia	56 (20.9%)
Junctional ectopic tachycardia	18 (32.1%)
AV block	14 (25%)
Extrasystoles	13 (23.2%)
Ventricular fibrillation	6 (10.7%)
Paroxysmal supraventricular tachycardia	5 (8.9%)
Extracorporeal circulation time, median, minutes (IQR)	65 (9-240)

Cross-clamp time, median, minutes (IQR)	35 (3-150)
Mechanical ventilation assistance, median, days (IQR)	1 (0-74)
Dexmedetomidine	117 (43%)
PICU stay, median, days (IQR)	6 (0-90)
Hospital stay, median, days (IQR)	7 (0-102)
Mortality	14 (5.2%)

Table 2: Univariate analyses

Variables	JET		
	OR	IC 95%	*p*
Age < 6 months	3.24	2.79 - 5.34	0.01
Age 6-24 months	2.13	0.81 - 9.33	0.75
Age > 24 months	1.24	0.42 - 5.98	0.46
Mael	1.75	0.29 - 2.67	0.54
Dexmedetomidine	0.67	0.32 - 0.79	0.00
Septal Defect correction	5.52	2.37 - 11.73	0.00
Amiodarone	0.89	0.6 - 0.12	0.05
Hypomagnesemia	2.01	1.07 - 4.70	0.03
Hypocalcemia	2.03	1.90 - 4.54	0.02
Right Ventricule Disease	1.03	0.75 – 3.06	0.72
Left Ventricule Disease	2.21	0.32 - 8.91	0.83
Extracorporeal circulation<100	1.47	0.48 - 4.78	0.07
Extracorporeal circulation 100-110	2.34	1.17 – 5.23	0.01
Extracorporeal circulation >110	6.56	2.32 - 12.05	0.00
Adrenaline >0.2 y/o Noradrenaline >0.2	1.95	1.27 - 2.10	0.02
Mechanical ventilation assistance	1.71	0.78 - 1.99	0.31

OR= odds ratio

Table 3: Multivariate analysis

	Odds ratio	Standard error	Z	p	IC 95%
Dexmedetomidine	0.47	0.16	-2.15	0.01	0.23 - 0.93
Extracorporeal circulation >110	4.74	0.27	3.59	0.00	1.28 – 6.36
Extracorporeal circulation 100-110	1.52	0.09	-3.74	0.10	0.37 – 2.73
Adrenaline >0.2 Noradrenaline >0.2	2.57	0.63	3.83	0.26	0.85 – 4.16
Septal Defect correction	8.03	0.01	5.76	0.00	1.79 – 11.05

Table 4: Multiple logistic regression

	Coeficiente	Std error	t	p	IC 95%
Extracorporeal circulation >100	0.3916	0.0051	-10.09	0.000	0.06-0.81
Dexmedetomidine	-1.4454	0.4165	-3.47	0.001	-2.26 - -0.62
Adrenaline	8.9857	1.8690	4.79	0.000	5.26 – 12.65
Septal Defect correction	6.3340	1.9525	3.24	0.031	2.47 – 10.19
Age	-0.2365	0.1089	-2.17	0.031	- 0.45 – 0.02

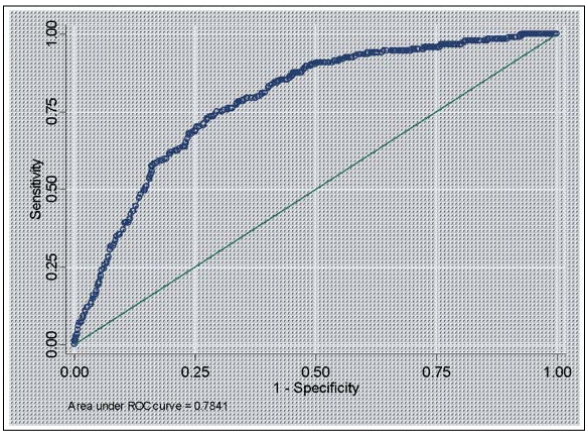

Figure 1: ROC curve

Discussion

In this study, the prevalence of arrhythmias was 21%, coinciding with other publications, although we should emphasize the frequency and importance of the hemodynamic impact of junctional ectopic tachycardia [1-4].

The strength of the study lies in the strong association between septal defect repair and ECC time in the development of JET. The weaknesses of the study are that the sample size of the arrhythmia events was below 100 and the population belongs to a single cardiovascular recovery center with its corresponding surgical group. Although this is a weakness, it allows reducing the biases from the dispersion of other centers' work protocols, thus mitigating the verification bias.

As regards the type of arrhythmias, tachyarrhythmia was the most frequent one, JET among them. We were able to observe that septal defect repair surgery is an important independent risk factor. This was in agreement with other lines of research [1-7]. ECC time is also an independent variable that increases the risk of JET significantly. Here we have also observed that the longer the ECC time, the longer the duration of JET. Numerous hypotheses support the fact that ECC artificially increases the endothelium, and this causes greater associated systemic inflammatory response; therefore, it could be speculated that the inflammatory response would be greater, which would in turn lead to greater development of arrhythmias [1,3,4,7].

In most studies, age at the time of surgery has been shown to be an important factor; the younger the patient, the greater the risk of developing arrhythmias [1,3,7]. This association was not observed in our study.

The use of adrenaline and/or noradrenaline at doses higher than 0.2 mcg/kg/min was associated with the development of JET in the initial univariate analysis. Later, when the multivariate analysis was performed, this association was no longer significant, probably due to the confounding effect of the other variables.

One of the variables included in this study was the use of dexmedetomidine. In recent years, the administration of this drug as a sedative-analgesic agent in the postoperative period following cardiovascular surgery has become more frequent since it has good sedative properties with no hemodynamic impact. According to publications, the use of dexmedetomidine substantially decreases the frequency of tachyarrhythmias [8-11]. The reason for the protective effect of dexmedetomidine is controversial; however, there is speculation about the administered dose, the start of the infusion or the length of time it is used. In addition, we observed that patients receiving dexmedetomidine had lower doses of inotropic drugs, but this finding was not statistically significant.

It is necessary to train the treating team for an early recognition and treatment of JET since inadequate management conspires against the optimal evolution of the child in the postoperative period following cardiovascular surgery.

Conclusion

Extracorporeal circulation time longer than 110 minutes and ventricular septal defect repair surgery were statistically significantly associated with the development of junctional ectopic tachycardia.

Appendix I – Variables Analyzed and Definitions of Variables Evaluated variables

-Sex
-Age
-Diagnosis of pre-surgical heart disease
- Right, left or mixed ventricular pathology
-Surgery performed
-Time of extracorporeal circulation (ECC)
-Time of aortic clamping
-Lactic acid value in mEq/l: at admission, 6 hours, 24 hours and 48 hours after surgery
-Calcium value in mg/dl on admission to the intensive care unit
-Magnesium value in mg/dl on admission to the intensive care unit
-Value of ionic calcium upon admission to the intensive care unit in mmol/l
-Days in invasive mechanical ventilation
-Requirement of non-invasive ventilation
-Requirement of adrenaline greater than 0.2mcg/kg/min
-Requirement of norepinephrine greater than 0.2mcg/kg/min
-Sedoanalgesia with dexmedetomidine
-Development of post-surgical arrhythmias
-Type of arrhythmia
-Arrhythmia duration
-Use of temporary pacemaker
-Time of pacemaker use
-Loading with amiodarone at 5mg/kg or 10mg/k
-Amiodarone drip
-Cardioversion/defibrillation
-Adenosine
-definitive pacemaker
-Stay in PICU
-Hospital stay
-Mortality

Variable definition:

-Arrhythmias: Arrhythmia is defined as any alteration in the normal heart rhythm that is reflected in the electrocardiogram (ECG).
-Type of arrhythmias:
Bradyarrhythmias:

- Sinus bradyarrhythmia: ECG shows the P wave preceding the QRS complex with a lower frequency than expected for age. The PQ complexes are constant and equal.
- First degree AV block: It is evidenced on ECG by a P wave followed by a prolonged PR interval and then the QRS complex. Normal PR interval values are based on age and rhythm.
- Type I second degree AV block: It is evidenced by a PR interval that progressively lengthens until a P wave is not conducted.
- Type II second degree AV block: It is evidenced by a constant PR interval and with one or more P waves that are not conducted to the ventricle.
- Third degree AV block: Complete heart block. P waves are not preceded by QRS complexes.

Tachyarrhythmias:

- Sinus tachyarrhythmia: P wave followed by very close QRS complex, in a 1:1 ratio. The morphology of the P wave should be similar to the pre-surgical one.
- Junctional ectopic tachycardia: Tachycardia with a QRS complex similar to the baseline with the presence of atrioventricular dissociation with an atrial rate lower than the ventricular rate.
- Atrial ectopic tachycardia: P wave with different morphology and abnormally high atrial rhythm.

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