Documenting Junctional Ectopic Tachycardia Following Pediatric Open Heart Surgery

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Objective: *To determine appropriated documentations for diagnosis junctional ectopic tachycardia (JET) before treatment in post-operative open heart surgery and identify risk factors for post-operative cardiac arrhythmias in children.*

Material and Method: *The authors performed a retrospective chart review in 277 patients who underwent surgical corrections at British Columbia's Children Hospital from January 1st, 2000 to December 31st , 2001. History, clinical symptoms, complication of surgery and post-operative cardiac arrhythmias were reviewed from medical records. The authors investigated whether JET was being diagnosed accurately and whether it was being adequately documented prior to the initiation of therapy. The authors also identified risk factors that were associated with JET. All documentations before treatment were reviewed by Pediatric cardiologists to confirm diagnosis.*

Results: *Although the diagnostic accuracy (84%), sensitivity (87%), and specificity (84%) are high, a significant number of patients with post-operative arrhythmias were treated without adequate documentation of the arrhythmia. The documentation of arrhythmias in the Intensive Care Unit was largely limited to rhythm strips, with very few 12-lead ECGs and wire studies performed to assist with the diagnosis.*

Conclusion: *The presented data indicates that, in this critically-ill population, there was an unacceptable number of patients with post-operative arrhythmias who may have been treated inappropriately. It is very important to emphasize the interpretation of wire studies, an investigation normally done in a critical care setting and whose interpretation is very important to the accurate diagnosis of pediatric arrhythmias*

Keywords: *Post-operative arrhythmia, Junctional ectopic tachycardia, Congenital heart disease, Atrial wire study, ECG, Diagnosis*

J Med Assoc Thai 2005; 88(Suppl 3): S214-22
Full text. e-Journal: *http://www.medassocthai.org/journal*

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Transient arrhythmias are common complication following surgery for congenital heart defects (CHD). Arrhythmias are associated with an increased morbidity and mortality in the post-operative period, occurring in over one-half of patients with certain lesions[1-7]. Junctional ectopic tachycardia (JET) is the most common arrhythmia following surgery for CHD. JET is a life-threatening arrhythmia characterized as an incessant narrow complex tachycardia in the absence of a pre-existing bundle branch block. There is usually atrioventricular dissociation, although retrograde conduction to the atria is possible[8,9]. Post-operative JET has been reported to be self-limited, subsiding within 72 to 96 hours[10]. The incidence of JET in the post-operative period ranges from 5-16% and occurs more commonly following repair of tetralogy of Fallot, ventricular septal defects, atrioventricular septal defects and the Fontan procedure[11-16]. Although the diagnosis can be made from a single lead on a monitor rhythm strip, the diagnosis is best made from the post-operative 12-lead electrocardiogram (ECG). Due to post-operative conduction abnormalities, such as bundle branch block, an atrial wire study is often necessary to confirm the diagnosis[13,17]. Previous studies have used a variety of methods to diagnose JET, but have not commented on how the arrhythmia was documented nor the diagnostic accuracy.

The etiology of JET is not well understood but it is thought to be the result of injury to the conduction system during surgery[18-20]. The mechanisms underlying JET are not known, but have been attributed to enhanced automaticity in the His bundle due to the observation of a "warm up" and "cool down" effect, as well as the failure to terminate the arrhythmia with atrial or ventricular overdrive pacing[8,9]. Treatment is generally aimed at rate control and a number of approaches have been tried with most centers adopting a tiered approach[10,16]. The principles of treatment include addressing significant hemodynamic residua, eliminating electrolyte imbalance, minimizing inotrope use, applying hypothermia, overdrive pacing, followed by escalation of therapy with anti-arrhythmic agents. Amiodarone has replaced most other medications used to treat post-operative JET[21-23]. Although post-operative JET can be managed successfully in most patients, morbidity and mortality are still seen in the current era, including the adverse effects associated with the treatment itself[10,11,16,24].

Given that there are potential adverse outcomes associated with JET and its treatment, it is crucial to confirm the diagnosis before treatment. The purpose of the present was to determine whether JET was being diagnosed accurately in our institution. The authors also wanted to determine whether JET was being sufficiently documented prior to the initiation of therapy and identify risk factors associated with JET at our institution.

Material and Method

A retrospective review was conducted of all pediatric open-heart surgeries that were performed at the British Columbia Women's and Children's Hospital between January 1st, 2000 and December 31st, 2001. The data was collected from medical records, clinical and surgical databases and included demographic data, information about underlying heart disease, pre-operative status, previous surgeries and complications, pre-existing arrhythmias, operative techniques and peri- and post-operative course. Particular attention was paid to diagnosis, documentation, and treatment of the arrhythmia.

The diagnosis of JET was made if the patient had retrievable documentation of a normal QRS tachycardia with a QRS rate between 160-230 bpm or greater than the 98th percentile for age with either: (1) atrioventricular dissociation with a ventricular rate exceeding the atrial rate; or (2) retrograde ventriculo-atrial conduction

demonstrated not to be anterograde conduction of an atrial or sinus tachycardia (Fig. 1). All available arrhythmia documentation were reviewed. To assess the accuracy of the diagnosis of JET, all recordings were reviewed by at least two investigators, with one (SS) blinded to the clinical diagnosis. The post-operative course was evaluated in terms of complications which included cardiac arrest, pericardial effusion, low cardiac output syndrome, recurrent pleural effusion, neurologic complications, renal or hepatic failure. The need for extracorporeal life support (ECLS), duration of intubation, length of stay in the Intensive Care Unit (ICU) and hospital were also recorded. The patient's status at last follow-up was noted. Mortality was defined as occurring early (died $\leq$ 30 days after surgery) or late (died > 30 days after surgery).

Statistical Analysis

Frequency tables were calculated for all categorical data. Chi-square statistics were used to test for associations between categorical data and the risk for post-operative arrhythmias. Relative risk (RR) and 95% confidence limits (CI) are reported. Univariate analyses were performed on all continuous data. Median values (range of values) were reported. A Wilcoxon Rank Sum test was used to test the equality of median values between groups of patients.

Because multiple comparisons were made the authors adopted the following convention for interpreting statistical significance: p-values <0.005 were considered statistically significant; p-values between 0.005 and 0.05 were considered to be of marginal statistical significances and worthy of

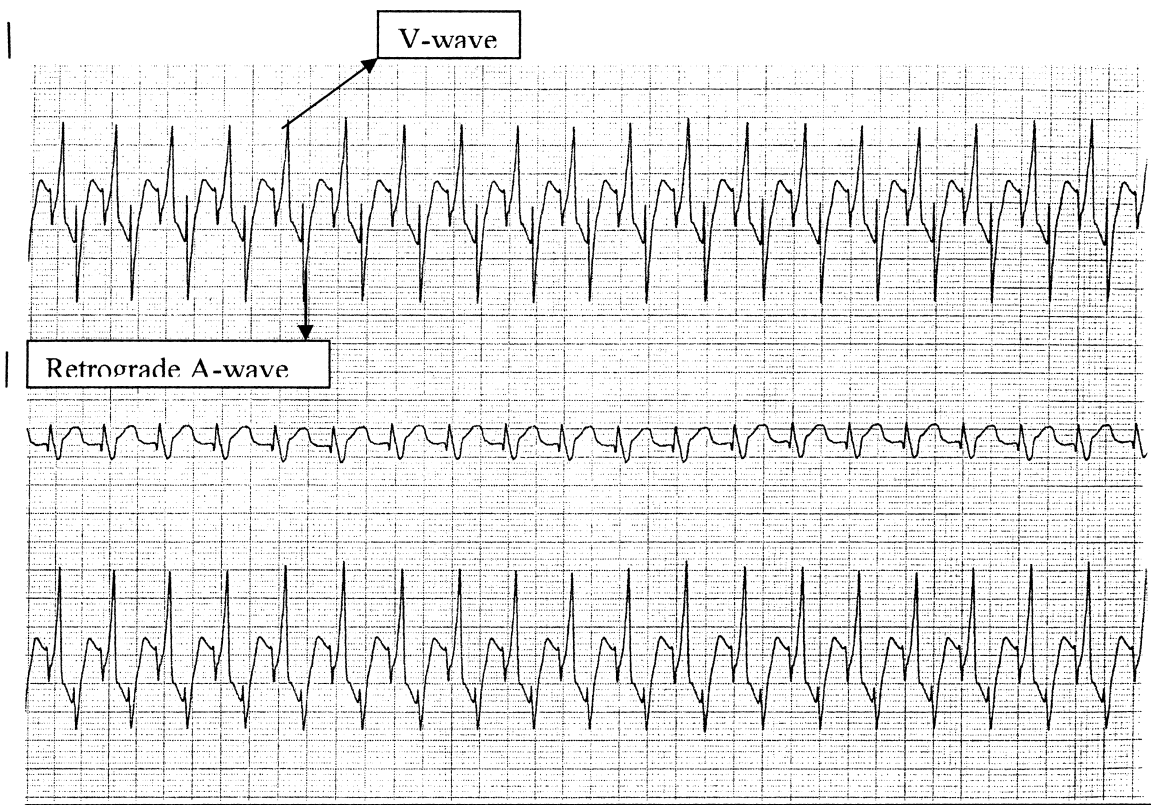

Fig. 1 Wire study demonstrating the importance of differentiating anterograde from retrograde atrial activation

further investigation; and p-values greater than 0.05 were considered to be not statistically significant. All statistical analyses were completed using SAS Statistical Software, SAS Institute, Cary, NC.

Definitions

Sensitivity was defined as the proportion of patients with JET who were treated as if they had JET. Specificity was defined as the proportion of patients who did not have JET who were treated as if they didn't have JET. Diagnostic accuracy was defined as the proportion of patients who were correctly diagnosed (those patients diagnosed and treated as having JET who actually had JET [true positives] and those patients diagnosed and treated as not having JET who actually didn't have JET [true negatives]).

Results

Demographics

A total of 277 patients (149 males) with a diagnosis of CHD underwent 278 open-heart surgical procedures during the study period. One patient underwent both a cavo-pulmonary connection and the Fontan completion during the study period. There were no arrhythmias following either procedure and only the Fontan completion was included to simplify our analysis. The patients' median age and body weight at the time of surgery were 18.5 months (3 days - 279 months) and 11.2 kg (2.3-99 kg), respectively.

Arrhythmia Documentation

Post-operative arrhythmias were diagnosed in 66 patients (24%), with JET being the most common. When the authors reviewed all of the arrhythmia documentation, 57/66 patients (86%) had retrievable documentation of their arrhythmia

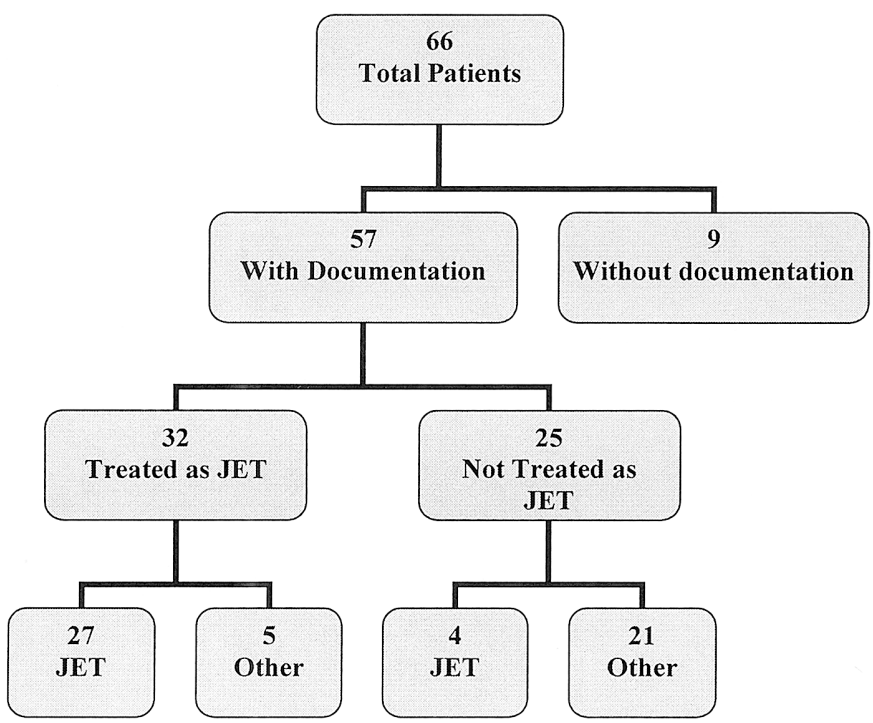

Fig. 2 Schematic diagram illustrating the treatment given to the cohort of patients identified with post-operative arrhythmias

(see Fig. 2). The 9 patients without retrievable documentation were excluded from further analyses. There were 32 patients who were diagnosed and treated for JET in the clinical setting. Documentation consisted of 29 single lead rhythm strips, 2 atrial wire studies, and 1 twelve lead electrocardiogram (ECG). Our secondary review confirmed the diagnosis of JET in 27/32 (84%) patients with retrievable documentation. Among the 5 documented cases with altered diagnoses on retrospective review, one was found to have sinus tachycardia, one had frequent atrial ectopic beats with an underlying sinus rhythm, two had bradycardia with junctional escape beats, and one had atrial flutter. In the remaining 25 cases with arrhythmia documentation, the authors identified 4 additional cases of JET that were originally diagnosed as a supraventricular tachycardia other than JET. When the authors only consider the 57 patients with retrievable documentation in these calculations, the sensitivity is 87% (27/31), the specificity is 84% (21/25) and an overall diagnostic accuracy is 84% (48/57). In the remaining patients with post-operative arrhythmias (non-JET), the diagnoses after secondary review are listed in Table 1. Nearly 6.5% of patients had either no retrievable documentation or the available documentation did not support the original diagnosis.

Risk Factors and Outcomes in Patients with JET

Thirty-one of 268 patients (11.6%) fulfilled the authors' criteria for a diagnosis of JET. The median time to onset of JET post-operatively was 6 hours (intraoperatively-21 days) with a median duration of 38 hours (1-168 hours). In the patients with JET, no significant hemodynamic residua requiring re-intervention were identified. A tiered approach to treatment was used (Table 2) and JET was eventually controlled in all patients.

Patients with JET were younger (7.7 vs 26.9 months; $p<0.03$), and smaller (6.5 vs 12.1 kg; $p<0.004$) at the time of surgery. JET was most

Table 1. Types of arrhythmias among the group of patients with retrievable documentation who had other arrhythmias

Total other arrhythmia N= 26	Treated as JET N (%)	Not Treated as JET N (%)	Total N
Congenital Heart Block	----	7(100)	7
Sinus Bradycardia with Junctional Escape	2 (25)	6 (75)	8
Sinus Tachycardia	1(100)	----	1
Ventricular Tachycardia	----	4(100)	4
Ectopy	1(33)	2(67)	3
Re-Entrant Supraventricular Tachycardia	----	1(100)	1
Atrial Ectopic Tachycardia	----	1(100)	1
Atrial Flutter	1(100)	----	1

Table 2. Number of patients with JET who responded to different treatment strategies

Total	Treated JET							
Documented	N = 25	C	P	A	C, P	C, A	P, A	C, P, A
JET	(81%)	0	0	1(4%)	6(24%)	2(8%)	2(8%)	14(56%)
	No treatment							
N = 31	as JET							
	N = 6							
	(19%)							

C=Cooling; P=Pacing; A=Amiodarone; C, P=Cooling, Pacing; C, A=Cooling, Amiodarone; P, A=Pacing, Amiodarone; C, P, A= Cooling, Pacing, Amiodarone

commonly observed following surgery for atrioventricular septal defect repair (33%), tetralogy of Fallot/double outlet right ventricle repair (30%), total anomalous pulmonary venous return (25%), and transposition of the great arteries (23%). An interval between cardioplegia infusions of greater than 27 minutes was associated with an increased risk for JET (RR=3.4; CI=1.6-7.2). Predictably, the use of hypothermia (≤ 25 °C) during surgery was associated with an increased risk of post-operative JET (RR=3.1; CI=1.31-7.3). Neither anaesthetic factors, intra-operative steroids, surgical approach, or warm reperfusion cardioplegia were associated with JET. JET was associated with longer bypass time (188 vs 122 minutes; p<0.0003) and aortic cross-clamp time (94 vs 65 minutes; p<0.0002); however, there was no difference in circulatory arrest time between the groups.

JET was associated with a longer duration of intubation (6 vs 1 days; p<0.0001); chest tube drainage (5 vs 2 days; p<0.002); ICU stay (7 vs 2 days; p<0.0001); post-operative organ failure (RR=5.1; CI=2.5-10.5); and hospital stay (21 vs 8 days; p<0.0001). Fifteen patients in the study cohort died (5%) at a median of 30.6 days (intraoperatively-8 months) after surgery. JET was present in 7 of these patients and was associated with an increased risk for death (RR=6.9; CI=2.7-17.8). Hemorrhage, necrosis, or sutures within or closely applied to the regions of the atrioventricular node, bundle of His, or main bundle branches were found by gross and/or microscopic examination in 4/5 of the patients with JET who had autopsies.

Discussion

The true incidence of postoperative JET is estimated to be between 1 and 22% after repair of CHD[13,23]. Although JET has been recognized as a serious and potentially lethal post-operative complication, relatively little is known about its etiology. At least two factors appear to be necessary for its occurrence. The first factor is "activation" of the nodal focus. The second is the neuro-humoral environment, including factors such as the patient's age and inotrope use. In the present series, a number of previously identified risk factors were shown to be associated with JET[4,11,16,19,25]. Despite advances in surgical techniques and knowledge of the disposition of the conduction system[26], JET continues to be a significant contributor to post-operative morbidity and mortality[4,11,19,25]. Medical therapies associated with JET can also increase morbidity. Therefore, it is crucial to document this arrhythmia prior to initiating therapy.

Previous series do not comment specifically about documentation of the arrhythmia and diagnostic accuracy. The ECG remains the modality of choice for diagnosing arrhythmias. The use of a single rhythm strip has been popularized by the use of sophisticated, multi-purpose monitoring systems in the ICU. In the present series, the authors were unable to retrieve 12-lead ECGs in the vast majority of patients. Predictably, there was a discrepancy between the clinical diagnosis and retrievable documentation in a significant number of patients (15.8% or 9/57 patients) treated for arrhythmias. Failure to make an accurate diagnosis may negate the opportunity of using an alternate treatment strategy, such as in the patient with atrial flutter who might have had overdrive pacing to terminate the arrhythmia.

With sophisticated imaging modalities, the importance of the ECG is easily overlooked. The emphasis in training programs is now on radiofrequency ablation and device implantation. As post-operative patients are typically the most crticially ill patients the authors manage, there is no room for diagnostic or treatment errors. Therefore, it is important to continue to uphold the importance of arrhythmia diagnosis, and the use of wire and esophageal electrophysiology studies.

Since reviewing the present results the authors have adopted a more stringent protocol for both the diagnosis and management of JET. To ensure an accurate diagnosis a twelve lead ECG and wire study are now performed. Additional maneuvers such as atrial or ventricular pacing examining atrioventricular nodal conduction may be necessary to render the wire study diagnostic.

Conclusion

The documentation of arrhythmias in the ICU was largely limited to rhythm strips, with very few 12-lead ECGs and wire studies performed to assist the diagnosis. Although the diagnostic accuracy, sensitivity, and specificity are high, our data indicates that, in this critically-ill population, there was an unacceptable number of patients with post-operative arrhythmias may have been treated inappropriately. When developing training standards for pediatric cardiology and electrophysiology it will be very important for those developing the curriculum to emphasize the interpretation of wire studies, an investigation normally done in a critical care setting and whose interpretation is very important to the accurate diagnosis of pediatric arrhythmias

Limitations

The authors recognize that a retrospective review does not take into account the discussions that may have been part of the clinical management. Some of the arrhythmia documentation done at the bedside may not become part of the permanent medical record. In the present review, the majority of cases did not have sufficient retrievable documentation. As well, the "gold standard" for diagnosing an arrhythmia is an electrophysiology study, however, this is neither feasible nor practical for all post-operative pediatric patients with arrhythmias.

Acknowledgements

The authors wish to thank Dr. Shubhayan Sanatani, Dr. Walter Duncan, Dr. George Sandor, and Dr. Marion Tipple for their thoughtful contributions to this manuscript.

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หลักฐานการวินิจฉัยภาวะหัวใจเต้นผิดจังหวะ (Junctional Ectopic Tachycardia) ภายหลังการผ่าตัดหัวใจชนิดเปิดในเด็ก

อังคณา เก่งสกุล, เจมส์ พอทส์, อมรพีท แซนดรู, ไมเคิล แพทเตอร์สัน, ซูโร เซ็ต, เกรน เทเลอร์, สัพบาร์ยัน ซานนาทานี

วัตถุประสงค์: เพื่อศึกษาถึงหลักฐาน (documentation) ทางการแพทย์ที่เหมาะสมของการวินิจฉัยภาวะหัวใจเต้นผิดจังหวะ (Junctional ectopic tachycardia, JET) และค้นหาปัจจัยเสี่ยงต่อการเกิดภาวะหัวใจเต้นผิดจังหวะ ภายหลังการผ่าตัดหัวใจชนิดเปิดในเด็ก (open heart surgery)

วัสดุและวิธีการ: การศึกษาแบบย้อนหลัง (retrospective study) ในผู้ป่วยเด็กทั้งหมดจำนวน 277 รายที่ได้รับการผ่าตัดหัวใจชนิดเปิด (Open heart surgery) ในโรงพยาบาลแม่และเด็กที่ British Columbia ในระหว่างวันที่ 1 มกราคม พ.ศ. 2543 - 31 ธันวาคม พ.ศ. 2544 โดยการศึกษาและรวบรวมข้อมูลจากแฟ้มบันทึกประวัติผู้ป่วยในแผนกเวชระเบียน ในด้านอาการทางคลินิก ประวัติและภาวะแทรกซ้อนของการผ่าตัด โดยมุ่งเน้นและให้ความสำคัญต่อความถูกต้องของการวินิจฉัยก่อนการรักษา และปัจจัยเสี่ยงต่อการเกิดภาวะ JET ภายหลังการผ่าตัด โดยมีการทบทวนหลักฐานการวินิจฉัยโดยผู้เชี่ยวชาญเพื่อรับรองความถูกต้องของการวินิจฉัย

ผลการศึกษา: ถึงแม้ว่าการวินิจฉัยโรค JET ที่เกิดภายหลังการผ่าตัดหัวใจในเด็กมีความแม่นยำ (accuracy, 84%), ความไว (sensitivity, 87%) และความเฉพาะเจาะจง (specificity, 84%) ที่สูง แต่การวินิจฉัยส่วนใหญ่ยังขาดการบันทึกหลักฐานการวินิจฉัยก่อนให้การรักษาที่ถูกต้อง เนื่องมาจากความเร่งด่วนที่จะต้องทำการรักษาให้ทันท่วงที หลักฐานส่วนใหญ่จึงเป็นการบันทึกการวินิจฉัยด้วย rhythm strips, มีจำนวนน้อยที่จะมีการบันทึกที่สมบูรณ์ด้วย 12-leads electrocardiogram หรือ wire study electrocardiogram ก่อนที่จะได้รับการรักษา

สรุป: จากการศึกษานี้พบว่ายังมีผู้ป่วยอาการหนักจำนวนหนึ่งที่ได้รับการรักษาภาวะหัวใจเต้นผิดจังหวะภายหลังการผ่าตัดหัวใจโดยไม่มีการบันทึกหลักฐานของการวินิจฉัยที่ถูกต้อง ดังนั้น การตระหนักถึงความสำคัญของการมีหลักฐานบันทึกและการแปลผลอย่างถูกต้องจากการตรวจ wire study และ 12-leads electrocardiogram ในหอผู้ป่วยวิกฤติซึ่งจะนำไปสู่การวินิจฉัยที่ถูกต้องในภาวะหัวใจเต้นผิดจังหวะภายหลังการผ่าตัดหัวใจในเด็ก