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ORIGINAL ARTICLE

Supraventricular tachycardia in children from the perspective of a specialised between-hospital transport team☆

Anna Sabaté Rotés[a], Marc Figueras Coll[a,b], Ferran Gran Ipiña[a], Alba Gallardo-Calero[a,b,c,d,e], Luis Renter Valdovinos[c,d], Pedro Domínguez-Sampedro[d], Ferran Rosés-Noguer[a,e,*]

[a] *Servicio de Cardiología Pediátrica, Hospital Universitari Vall d'Hebron, Universitat Autònoma de Barcelona, Barcelona, Spain*
[b] *Unidad de Cardiología Pediátrica, Hospital Universitari Josep Trueta, Girona, Spain*
[c] *Unidad de Cuidados Intensivos Pediátricos, Servicio de Pediatría, Hospital Parc Taulí, Sabadell, Barcelona, Spain*
[d] *Unidad de Trasporte Pediátrico, Hospital Universitario Vall d'Hebron, Sistema de Emergencias Médicas de Catalunya, Barcelona, Spain*
[e] *Paediatric Cardiology Department, Royal Brompton and HarefieldNHS Foundation Trust, Chelsea, Londres, United Kingdom*

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KEYWORDS
Supraventricular tachycardia;
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Abstract
Aims: The aim of this study is to establish the incidence of supraventricular tachycardia (SVT) as a main reason for between-hospital transfer in children, as well as to describe the clinical presentation, prognosis and treatment, risk factors presenting with haemodynamic compromise, and to propose a specific management protocol for the transport.
Methods: A retrospective observational study was conducted on all patients with supraventricular tachycardia transferred by the Hospital Vall d'Hebron *Sistema de Emergencias Médicas Pediátricas* (SEM-P) between January 2005 and June 2017.
Results: During the study period, 67 (0.9%) patients (out of a total number of 7348 transfers) suffered from SVT. The median age was 57 days (2 h-18 years old). There was clinical evidence of cardiogenic shock on admission in 14 (20.9%) patients. Age ≤1 year was the only independent risk factor associated with presenting with cardiogenic shock on admission, with an OR of 10.2 (95% CI: 1.2–89.9; $p = 0.004$). The majority of patients could be treated appropriately by the local hospital team, except for oral intubation and cardioversion that were performed mainly by the transport team on arrival at the local hospital. Median stabilisation time was 35 min (9–169), and median total transport time was 30 min (9–165).

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* Corresponding author.
E-mail address: froses@vhebron.net (F. Rosés-Noguer).

Conclusions: Only 0.9% of transport cases are due to SVT, but this can be highly demanding as patients can be critically ill. Age ≤1 year was the only independent risk factor associated with presenting with cardiogenic shock on admission. Coordination between the local and the transport teams is crucial for a good clinical outcome.

PALABRAS CLAVE
Taquicardia paroxística supraventricular;
Emergencias;
Transporte;
Pediátrico

Taquicardia paroxística supraventricular desde la perspectiva del transporte interhospitalario

Resumen
Objetivo: Determinar la frecuencia de taquicardia paroxística supraventricular (TPSV) como motivo de traslado interhospitalario en la edad pediátrica, describir la forma de presentación clínica, evolución y tratamiento, y factores de riesgo de presentar compromiso hemodinámico y proponer un protocolo de manejo específico para el transporte.
Método: Estudio retrospectivo observacional de los pacientes atendidos en el Sistema de Emergencias Médicas Pediátricas (SEM-P) del Hospital Vall d'Hebron entre enero 2005 y junio 2017.
Resultados: De un total de 7.348 traslados, 67 fueron pacientes con TPSV (0,9%). Edad mediana de 57 días de vida (2 h a 18 años). Catorce pacientes (20,9%), presentaban signos de compromiso hemodinámico en el momento del diagnóstico. La edad ≤1 año fue el único factor de riesgo independiente para presentar compromiso hemodinámico al diagnóstico con un OR de 10,2 (IC 95%: 1,2–89,9; p: 0,004). La mayoría de pacientes revirtieron con las intervenciones del hospital emisor, exceptuando la intubación y la cardioversión eléctrica, realizadas más frecuentemente por el equipo de trasporte (ET). El tiempo mediano de estabilización fue de 35 min (9–169), con un tiempo mediano de traslado de 30 min (9–165).
Conclusiones: El transporte de pacientes pediátricos con TPSV es poco frecuente, pero puede requerir un manejo altamente especializado. La edad ≤1 año es el único factor de riesgo independiente para presentar compromiso hemodinámico. La coordinación entre el equipo del hospital emisor y el ET es de gran importancia para un buen resultado asistencial.

Introduction

Paroxysmal supraventricular tachycardia (PSVT) is the most frequent form of arrhythmia in the paediatric age group following sinus tachycardia.[1] The underlying mechanisms of PSVT involve a pattern of reentry or the presence of arrhythmias due to enhanced abnormal automaticity, which are referred to as ectopic or focal tachycardias. In young children, tachycardias due to accessory pathways are most frequent (80%), but in adolescence the proportion is reversed, and nodal reentrant tachycardias become more frequent.[2,3] In the group of reentrant tachycardias, we ought to specifically mention permanent junctional reciprocating tachycardia (PJRT), also known as Coumel's tachycardia, because while it is a reentrant tachycardia it is caused by an occult accessory pathway typically located in the posterior septal portion of the tricuspid ring with properties of decremental conduction that produce a characteristic electrocardiographic pattern with a prolonged RP interval and negative P waves in the inferior leads. This form of tachycardia is relevant because it is particularly frequent in infants and usually has onset with tachycardiomyopathy.[4] Ectopic atrial tachycardias (ATs) are relatively infrequent in children,[2] amounting to approximately 10% of the total cases of PSVT according to some authors.[5] Due to its abrupt onset, older patients usually can identify the exact time of onset of the tachycardia, but it may go undetected in younger patients, especially in newborns and infants, and eventually present as severe acute heart failure secondary to tachymyocardiopathy.[3,6] Acute care of the episode varies depending on the level of haemodynamic instability of the patient and focuses on terminating the tachycardia and initiating supportive care to revert the haemodynamic effects of the episode, which may require mechanical ventilation, use of inotropic/diuretic agents and administration of antiarrhythmic drugs to stabilize the patient, and in some cases even cardiopulmonary resuscitation (CPR) manoeuvres. The interventions used to terminate PSVT may include vagal manoeuvres, treatment with antiarrhythmic drugs and electrical cardioversion based on the severity and mechanism of the tachycardia.[7,8]

The aetiology, presentation, treatment and outcomes of PSVT in paediatric patients are thoroughly described in books on paediatrics and paediatric cardiology.[9,10] In the current scientific literature, there are articles on the subject of the prehospital care of PSVT in adults,[11] but none specifically

focused on the paediatric population. The available literature includes some prospective studies that report outcomes of PSVT management in the emergency department[1,12] and others that describe the outcomes of using adenosine for its management.[13,14] The Paediatric Medical Emergency System (P-MES) of Catalonia is responsible for paediatric and neonatal interhospital transport and covers the entire regions of Catalonia and Andorra, with a maximum range of action of 4 h and a radius of 300 km. It comprises 3 units: 2 land units and 1 air unit (helicopter). All units are based off the city of Barcelona. Each transport team (TT) consists of a paediatrician, a paediatric nurse and a medical transport technician.

The objectives of our study were to establish the frequency of PSVT as a reason for interhospital transport, describe the clinical presentation of PSVT, its outcomes, and its management, and analyse the risk factors associated with haemodynamic instability, with the purpose of proposing a specific protocol for the management of these patients during interhospital transport.

Patients and methods

We conducted a retrospective observational study of all patients given a final diagnosis of PSVT between January 2005 and June 2017. We retrieved data from the database of the P-MES of the Hospital Universitari Vall d'Hebron, which stores data collected prospectively in a structured and systematic fashion, collecting information for the following variables: age (newborn, ≤30 days, or child >30 days), weight, sex, previous history of tachycardia, current ongoing treatment, presence of congenital heart defects, symptoms and haemodynamic instability, mechanism of the tachycardia, type and effectiveness of treatment used to terminate the episode, severity of episode based on need for mechanical ventilation, administration of volume expanders or inotropic agents, type of vascular access, performance of CPR, time to stabilization, duration of transport and complications during transport. We did not include patients with other types of arrhythmia.

We defined haemodynamic instability as the presence of poor general condition, respiratory distress, decreased peripheral perfusion, systemic hypotension and metabolic acidosis (pH <7.35 and base excess <−5). We defined the time to stabilization as the time elapsed from the departure of the P-MES team from the referring hospital to arrival to the receiving hospital.

The descriptive analysis of the data was performed with the software SPSS® version 18.0. We expressed continuous data as mean ± standard deviation (SD) or median and range depending on whether or not they followed a normal distribution, and compared proportions with the Fisher exact test, considering differences corresponding to *p*-values of less than 0.05 statistically significant. To assess potential risk factors for haemodynamic instability, we performed a multivariate logistic regression with backward stepwise removal based on likelihood ratios (LRs) by applying the BSTEP-LR method.

Results

Of a total of 7348 transports, 67 corresponded to patients with PSVT (0.9%). Table 1 summarises the demographic, clinical and aetiological characteristics of included cases. Most patients were aged 1 year or less (42; 62.7%), the male-to-female ratio was 1:1.16, and the median weight of patients was 4.8 kg (2.2–80). For most patients, this was the first episode of PSVT (64.2%).

The main presenting symptom that led to diagnosis of tachycardia varied by age group. In the group of 51 patients aged less than 5 years, the most frequent symptoms were irritability with poor general health (25, 49.0%), followed by chest pain (4, 7.8%) and syncope (1, 1.9%). In the remaining 21, the diagnosis was made following incidental finding of

Table 1 Demographic, clinical and aetiological characteristics.

Variables	*n* or value	Percentage or range
Sex		
Female	36	53.7
Male	31	46.7
Median age	57 days	2 h–18 years
Age ≤1 year	42	62.7
Age ≤5 years	51	76.1
Median weight, kg	4.8	2.2–80
History of heart disease	6	9.0
Previous PSVT	24	35.8
Previous antiarrhythmic treatment	13	54.1
Tachycardia when TT arrived to RH	22	32.8
Mechanism of tachycardia		
Reentry tachycardia with short RP interval	56	83.6
Coumel's reentry tachycardia with long RP interval	3	4.5
Automatic atrial tachycardia	7	10.4
Atrial fibrillation	1	1.5
Haemodynamic instability	14	20.9

PSVT, paroxysmal supraventricular tachycardia; RH, referring hospital; TT, transport team.

Table 2 Summary of treatments performed.

Variables	n or value	Percentage or range
Spontaneous resolution of tachycardia	7	10.4
Performance of vagal manoeuvres	37	55.2
Effective	11	29.7
Ineffective	26	70.3
Who performed the vagal manoeuvres?		
Referring hospital	33	89.2
Transport team	3	8.1
Both	1	2.7
Administration of adenosine	45	67.2
Effective	24	53.3
Ineffective	21	46.7
Who performed the adenosine stress test?		
Referring hospital	36	80.0
Transport team	6	13.3
Ambos	3	6.7
Administration of antiarrhythmic drugs	15	22.4
Effective	9	60.0
Ineffective	6	40.0
Who administered antiarrhythmic drugs?		
Referring hospital	11	73.3
Transport team	4	26.7
Synchronized cardioversion	6	7.5
Effective	4	66.7
Ineffective	2	33.3
Who performed cardioversion?		
Referring hospital	2	33.3
Transport team	4	66.7
Cardiopulmonary resuscitation	1	1.5
Condition during transport		
Sinus rhythm without recurrences	54	80.6
Multiple recurrences	4	6.0
Transport with tachycardia	9	13.4

a high heart rate (HR) in absence of any other symptoms, and in 4 cases the diagnosis was made after detection of an increased HR during a bronchitis episode. In the group of 16 patients aged more than 5 years, the symptoms that led to diagnosis were palpitation in 13 cases (81.2%), abdominal pain in 1 (6.2%), and incidental finding of increased HR in 2 (12.5%). Of all 67 patients, 14 (20.9%) presented with haemodynamic instability at the time of diagnosis. Only 6 patients (8.9%) had an underlying congenital heart defect. The underlying mechanism of PSVT was a reentrant pattern with a short RP interval in 56 (83.6%), PJRT in 3 (4.5%) and ectopic/automatic AT in 7 (10.4%). One patient had atrial fibrillation (1.5%).

Acute treatment of tachycardia

Table 2 summarises the treatments used in these patients. Of the 67 patients, 45 (67.2%) already had a sinus rhythm when the TT arrived to the referring hospital (RH), and 22 (32.8%) still had tachycardia. When it came to the treatment used to terminate tachycardia, in 7 patients (10.4%) it resolved spontaneously without intervention of the medical team. Vagal manoeuvres were performed in 37 patients (55.2%) and were only effective in 11 (16.4%). Adenosine was given to 45 patients (67.1%) and was effective in 24 (35.8%). The mean effective dose was 179 ± 75 μg/kg, with a median of 3 attempts per patient (1–4). The mean initial dose of adenosine was of 101 ± 48 μg/kg. The mean second dose of adenosine was of 145 ± 56 μg/kg. The mean third dose of adenosine was of 207 ± 87 μg/kg. None of the patients developed significant side effects. Fifteen patients (22.4%) received other antiarrhythmic drugs, which were effective in 9 (60%). Synchronised electric cardioversion was performed in 6 patients (7.5%) and effective in 4 (66.7%). After stabilization, 54 patients (80.6%) underwent transport with a sustained sinus rhythm without recurrence of tachycardia, 9 (13.4%) underwent transport with tachycardia without establishment of a sinus rhythm during the transfer, and 4 (6.0%) had multiple episodes of PSVT during transport.

Analysis of supportive care during transport

Of the 67 patients, 58 (86.6%) underwent placement of a peripheral catheter, inserted in the RH in 52 cases (89.7%) and by the P-MES in 1 (1.7%), and in 5 cases (8.6%) they had to insert a new peripheral catheter due to extravasation

Table 3 Analysis of risk factors for haemodynamic instability.

Variable	Univariate				Multivariate			
	OR	LB of 95% CI	UB of 95% CI	*P*	OR	LB of 95% CI	UB of 95% CI	*P*
Age ≤1 year	10.8	1.3	88.3	.004	10.2	1.2	89.9	.004
Mechanism of tachycardia								
Reentry tachycardia with short RP interval								
Coumel's type reentry tachycardia with long RP interval	1.8	0.2	22.0	.588	1.1	0.1	18.3	.926
Automatic atrial tachycardia or fibrillation	0.5	0.1	4.7	.534	0.3	0.0	3.6	.513
History of heart disease	0.7	0.1	6.9	.784	1.4	0.1	16.8	.954
Previous episodes of PSVT	0.4	0.1	1.4	.134	0.6	0.1	2.8	.293
Tachycardia when TT arrived to RH	2.5	0.8	8.5	.124	3.1	0.7	13.0	.114
Male sex	1.2	0.4	3.9	.753	1.3	0.3	5.3	.949

CI, confidence interval; LB, lower bound; OR, odds ratio; PSVT, paroxysmal supraventricular tachycardia; RH, referring hospital; TT, transport team; UB, upper bound.

of the previous catheter. Seven (10.4%) patients required mechanical ventilation, with staff in the RH performing the intubation in 3 of the patients (42.9%) and the TT in 4 (57.1%). An umbilical catheter was placed in 4 patients (6%), 3 at the RH and 1 by the TT. Five patients (7.5%) required placement of a central venous catheter, in 4 cases inserted at the RH and in only 1 case by the TT. Only 1 patient required intraosseous cannulation, which was performed by the TT. Four patients (6%) required volume expanders, administered at the RH in 2 cases and by the TT in 2. Six patients (9%) received inotropic drugs to ensure correct tissue perfusion, with inotropic support initiated at the RH in 3 cases and by the TT in the rest. Only 1 patient (1.5%) went into cardiac arrest, with CPR delivered by staff from both the RH and the TT.

In the study sample, the median time to stabilization was 35 min (9–169), and the median duration of transport 30 min (9–165). In comparison, in the total of patients transported by the P-MES in the same period, the median time to stabilization was of 35 min (14–220) and the median duration of transport 35 min (10–190).

Analysis of risk factors for haemodynamic instability

Of the 67 patients, 14 (20.9%) had haemodynamic instability at the time of diagnosis. Table 3 presents the results of the univariate and multivariate analyses of risk factors. The only significant risk factor in the multivariate analysis was age 1 year or less, with the probability of having haemodynamic instability being 10-fold in this group compared to patients aged more than 1 year. In the multivariate analysis, male sex, a previous history of tachycardia and the presence of tachycardia at the time the transport team arrived to the referring hospital were not significant risk factors for haemodynamic instability. The mechanism of the tachycardia and the presence of Coumel's tachycardia were not risk factors for haemodynamic instability either.

Discussion

This article is the first to present the experience of a paediatric transport team in the management of PSVT in the paediatric age group. There are articles in the literature on the prehospital management of adults with PSVT by paramedics,[11] which is a different situation from the one analysed in our study.

Our findings show that PSVT corresponds to a small percentage of the total transports (about 1% of all interhospital transports). The predominant age groups were newborns, infants and toddlers, with no differences based on sex. Previous studies have reported an incidence of PSVT in children of 0.1%–0.4%,[15] with a predominance of boys and onset before age 4 months.[10] A relevant finding of our study is that 19.4% of patients had haemodynamic instability at the time of transport, with age equal or less than 1 year being the sole independent risk factor for this condition, with an OR of 10.2 (95% confidence interval, 1.2–89.9; $p = 0.004$), which demonstrates that adequate management of these patients may involve advanced life support throughout transport. Other possible risk factors like sex, pre-existing heart disease, a history of previous episodes, an electrical mechanism of tachycardia and whether the patient still had tachycardia when the TT arrived to the referring hospital were not statistically significant in our analysis.

The high percentage of patients with haemodynamic instability in our cohort may result from selection bias in our sample, as we only included patients that the RH decided to transfer to a specialised hospital, and it would be logical to assume that these were the most severely ill patients. The treatment patients received at the RH in transport did not deviate from published guidelines,[15] and the transport team was able to maintain a sinus rhythm without recurrence of tachycardia in most patients, with no relevant complications and no deaths occurring during transport. Although previous studies have reported that the time elapsed from onset of tachycardia to reversion to sinus rhythm is associated with the risk of haemodynamic instability, the time of onset of tachycardia is often not known in children.

We ought to highlight that both the clinical diagnosis and treatment of the patients were mostly established by RHs. Decision-making by the TT predominated only in patients with haemodynamic instability in relation to the use of advanced life support measures like intubation or cardioversion. The time to stabilization and the duration of transport did not differ significantly from the corresponding median times recorded for the overall population served by our transport team.

As concerns the treatments used to terminate the tachycardia, we ought to highlight that only 29.7% of vagal manoeuvres were effective. In contrast, administration of adenosine was successful in 53% of cases. Patients received a median of 3 doses of adenosine. The mean initial dose of 100 μg/kg, but the mean effective dose was nearly twice as high. Guidelines on the management of PSVT in the neonatal period recommend initial doses of 50 μg/kg,[16] but data from our study suggest that doses of less than 100 μg/kg are ineffective, so it seems appropriate to recommend an initial dose of 100 μg/kg and escalating to 200 and 300 μg/kg if the initial dose is not effective.

There is sufficient evidence in the literature,[2] further supported by our findings, to recommend transport of all patients aged less than 1 year with a first episode of PSVT to a paediatric cardiology specialty centre for monitoring, assessment and treatment given the high percentage of patients in this age group that develop haemodynamic instability. Only in case of older children with tachycardia that reverts with basic measures it would be appropriate to refer the patient to an outpatient paediatric cardiology clinic with indications on when to seek attention at the RH and education on how to perform vagal manoeuvres,[1,10] as is done with adult patients.[8] None of the patients in our study met these criteria, and therefore the transfer was justified in every case.

Some of the limitations of our study are the selection bias implied in including patients requiring intrahospital transport by a specialised team and the difficulty in making a comprehensive evaluation of the outcomes of all transported patients due to the large number of receiving hospitals.

Conclusions

Transport of paediatric patients with PSVT to a tertiary care hospital is infrequent and may require highly specialised care, especially in infants aged 1 year or less. In our case series, 20% of patients had haemodynamic instability at the time of transport, the probability of which was 10.2 times greater in the group aged 1 year or less. Adequate management and treatment of these patients allows transport with maintenance of a sinus rhythm, which is associated with a lower morbidity and mortality.

Conflicts of interest

The authors have no conflicts of interest to declare.

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