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Retrospective study showed that palpitations with tachycardia on admission to a paediatric emergency department were related to cardiac arrhythmias

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Running title: Palpitations with tachycardia and cardiac arrhythmia

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ABSTRACT

Aim: This retrospective study reviewed the prevalence and long-term prognosis of children aged 0-18 with palpitations who were admitted to the emergency department of an Italian paediatric hospital.

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Methods: We examined all admissions to the emergency department of the IRCCS Burlo Garofolo between January 2009 and December 2015 by selecting triage diagnoses of palpitations. The hospital discharge cards were reviewed to assess vital parameters, physical examinations, diagnostic tests, cardiology consultations and final diagnoses.

Results: Of the 142,803 patients who attended our emergency department for any reason, 96 (0.07%) complained of palpitations. Despite this low prevalence, it was noteworthy that 13.5% had a real underlying arrhythmic cause and needed medical assistance. Over half (52.1%) were female and the mean age was 12.7 years. At the long-term follow up, at a mean of 47 ± 23 months, 53.8% of patients with a cardiac arrhythmia had received medical therapy and 46.1% had undergone trans-catheter ablation for supraventricular tachycardia. A heart rate above 146 beats per minute or palpitations for more than an hour were statistically related to a cardiac arrhythmia.

Conclusion: Palpitations were an infrequent cause of admission to our emergency department, but 13.5% who displayed them had an underlying cardiac arrhythmia.

Key notes

- We reviewed 96 children aged 0-18 who were admitted to the emergency department of an Italian paediatric hospital with palpitations.
- Despite being an infrequent cause of access to the paediatric emergency department, with a prevalence of 0.07%, palpitations were notably caused by an arrhythmia in 13.5% of those patients

- Tachycardia on admission and palpitations that lasted more than an hour were statistically related to a diagnosis of cardiac arrhythmia.

Key words: cardiac arrhythmias, children, emergency department, palpitations, supraventricular tachycardia

List of abbreviations: bpm, beats per minute; ED emergency department; ECG electrocardiogram; SVT supraventricular tachycardia

BACKGROUND

Palpitations are a cause for concern for paediatric patients and their families and their relationship with cardiac diseases is not well described in children in the emergency department (ED) setting.

Palpitations are defined as a person's perception or simple awareness of their heartbeat and in some cases they are caused by a simple change in heart rate, cardiac rhythm or myocardial contractility (1,2). These conditions lead the patient to describe their heart beat as rapid, irregular or simply stronger than normal (2). While palpitations in adults are often the expression of an underlying cardiac disease, in children they tend to be the by-product of para-physiological conditions, such as anxiety, fear, exercise or fever (3-5).

Probst et al showed that palpitations were the main reason for 5.8 per 1,000 ED visits for both children and adults (6). The overall incidence of arrhythmias has been reported to be 55.1 per 100,000 paediatric ED visits and most children who present with palpitations do not have an arrhythmia (4,5).

Sinus tachycardia is by far the most commonly reported arrhythmia, accounting for nearly 50% of all cases, followed by paroxysmal supraventricular tachycardia (SVT) (13%), non-specific arrhythmia (10.6%), bradycardia (6%) and atrial fibrillation (4.6%) (4,5). SVT has an estimated prevalence of 0.1 to 0.4% in paediatric populations (4,5) and it is usually paroxysmal and characterised by abrupt onset

and termination. Most SVT episodes occur at rest, although exercise can be a trigger in some patients. Some episodes of SVT last only one to two minutes, while others persist for hours (4,7). Heart rate during SVT episodes is age-dependent and is usually greater than 220 beats per minute (bpm) in infants and greater than 180 bpm in children and adolescents. (4,7,8). Common symptoms of SVT in children and adolescents include palpitations, chest discomfort or pain and fatigue. Syncope is an uncommon presentation of SVT, but may be a warning sign for increased risk of sudden death (9). Hurst et al described a series of paediatric syncope cases presenting to an ED to identify the historical features associated with an underlying cardiac diagnosis. This study confirmed that newly diagnosed cardiac causes in children presenting with syncope to an ED were rare (10).

Identifying the cause of palpitations in children can be challenging, because both cardiac and non-cardiac causes must be ruled out (11,12). However, despite a frequently benign aetiology, the emphasis is still on excluding possible underlying cardiac arrhythmias. Palpitations are generally a transitory symptom and, at the time of the clinical evaluation, the patient is often asymptomatic and the diagnostic evaluation focuses on the search for pathological or physiological conditions that may be responsible for the symptom (11-13). In the ED setting, the physician is charged with determining which patients require immediate management and referral to the paediatric cardiologist. An electrocardiogram (ECG) and a specialistic examination, which are both time-consuming and costly, are warranted in selected patients, whereas other patients with palpitations may not require such careful follow up (11-13). Many studies have described arrhythmias in paediatrics with details on prevalence, therapeutic approach and prognosis. Moreover, palpitations are mentioned in papers that focused on clinical syndromes, psychiatric disorders and several medical conditions. However, to the best of our knowledge there have not been any studies that have only analysed palpitations in children and adolescents as the chief complaint in the paediatric ED.

Therefore, aim of this study was to review the prevalence and long-term prognosis of children aged 0-18 with palpitations who were admitted to the emergency department of an Italian paediatric hospital.

METHODS

This study focused on the ED of a tertiary level teaching children's hospital, the Institute for Maternal and Child Health Burlo Garofolo, Trieste, Italy. The hospital serves all the paediatric patients from birth to the age of 18 in the area, which has about 300,000 inhabitants and no other paediatric cardiology paediatric ED facilities.

In this retrospective study we examined all admissions to the ED between January 2009 and December 2015 by selecting triage diagnoses of palpitations. In order to primarily evaluate the patient's reported symptoms, children under four years of age were excluded. We reviewed hospital discharge cards to assess the admission mode to the ED, namely with parents or by ambulance, vital parameters and physical examinations, personal and family histories, diagnostic tests performed and final diagnoses. Tachycardia was defined on the basis of centile charts for vital parameters in children, that consider centile related to age (14).

In addition, all cardiology consultations at the time of admission or after discharge from the ED were considered for the analysis. In order to describe long-term prognoses, the parents of all patients were subsequently contacted by telephone up to November 2016, a mean follow up 47 ± 23 months, to identify any diagnoses of cardiac arrhythmia made afterwards and missed at the first access to the ED. Parents were asked to report if other medical staff were consulted with regard to palpitations any outcomes, including medication and, procedures.

The study was approved by the Hospital's Ethical Committee and the parent provided a written consent form.

RESULTS

From January 2009 and December 2015 our ED registered 142,803 paediatric admissions (52.1% female) and 96 had a triage diagnosis of palpitations, which equated to 0.07% of all admissions with a 95% confidence interval (95% CI) of 0.06% to 0.08%. The diagnostic work-ups in the ED included collecting personal and family histories, evaluating vital parameters and physical examinations.

We only included patients from four to 18 years of age and the patients had a mean age of 12.7 years.

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ED admissions for palpitations were more common in teenagers older than 14 years and they represented 63.5% of the patients in our series.

Children were accompanied to the ED by their parents in most all cases and only 9.4% of patients, all with an onset of symptoms at school, were brought in by ambulance. In 85.4% of cases palpitations occurred at rest, while in 14.6% of cases they occurred under physical or psychological stress.

In 23.9% of patients the palpitations lasted over an hour, while in all other cases they lasted for a few minutes. Information about the mode of onset and termination of the symptom was not always specified in the medical records. Of the 57.3% of patients who had previously reported the symptom, 16.7% had previously been admitted to the ED for palpitations. No patient had a family history of sudden death, while three patients had family history of arrhythmias: two were SVT and one was ventricular ectopic beats. Only two patients had a history of congenital heart disease and in both cases it was a mild prolapse of the mitral valve. As far as the physical examination was concerned, 82.3% of patients had normal vital parameters, while 17.7% had tachycardia on the basis of centile charts for children, including 4.1% during fever. The most commonly associated symptoms were chest pain (28.1%), dyspnoea (25%) and vertigo (14.6%), while in 42.7% of cases the palpitations were isolated. No patient or parent referred to a history of syncope. An ECG was performed at admission to the ED in all patients with tachycardia or in the presence of clinical suspicion of arrhythmia due to the medical history or physical examination (44.7%). Moreover, it was performed in all patients referred to the paediatric cardiologist who had not undergone an ECG on admission to the ED (12.5%). More than half (57.2%) of the patients underwent an ECG.

Diagnosis

ECGs confirmed the presence of cardiac arrhythmias, all SVT, in 10 patients (10.4%) and these patients all presented with tachycardia on admission to the ED following a sudden onset and cessation of palpitations. Conversion to sinus rhythm was achieved in all 10 cases by the ED's medical staff. All patients with arrhythmia were subsequently referred to a cardiologist.

In 25 patients (26.1%), palpitations were diagnosed as due to panic attacks, anxiety crises or social stress conditions, such as school examinations or family problems. Some of these patients were already receiving psychological treatment. In eight out of these 25 patients neuropsychiatric counselling was required. In the remaining 61 patients (63.5%), the initial diagnosis was reported palpitations, indicating the absence of palpitations on admission to the ED and the lack of elements for an underlying cardiac disease, or idiopathic palpitations, indicating the presence of palpitations of unknown origin on admission to the ED. Cardiology referrals were made for 23 patients of the 61 patients with reported idiopathic palpitations. The decision for a cardiology evaluation was based on the paediatrician's gut feeling about the specific case, mainly based on the child's medical history and characteristics of the symptom, such as arrhythmic heart sounds on physical examination or palpitations that lasted more than an hour. An ECG was performed on all patients referred to the paediatric cardiologist who had not received an ECG on admission to the ED. Holter monitoring for 24 hours was performed on nine of the patients referred to the paediatric cardiologist and this identified one additional case of SVT, bringing the total to 11.4%, and two cases of ventricular extrasystole (2.1%). In the final analysis, palpitations were caused by an arrhythmia in 13.5% of our patients (Figure 1).

Predictors of arrhythmic palpitations

The strongest predictor for a diagnosis of arrhythmia was the presence of tachycardia on admission ($p < 0.01$). As shown in Figure 2, 10 of the 11 patients with SVT had tachycardia with a heart rate above 146 bpm on admission. On the other hand, the two patients with ectopic heartbeats were not identified on the basis of their heart rate at presentation. The receiver operating characteristic analysis showed that a heart rate above 146 bpm identified patients with arrhythmia with 77% sensitivity and 99% specificity, with an area under the curve of 0.78 ($p < 0.001$). In addition, palpitations that lasted for more than an hour, rather than seconds or minutes, were significantly related with a diagnosis of arrhythmia ($p = 0.01$). Sex, a family history of arrhythmia and multiple admissions to the ED for palpitations did not correlate with the final diagnosis of arrhythmia ($p = 0.5$, $p = 0.4$ and $p = 0.26$,

respectively). Furthermore, there was no association between palpitations during activity and arrhythmia or between being brought in by ambulance and the severity of arrhythmia.

Treatment and follow up

We managed to follow up all 96 cases who attended the ED during the study period. In 81.2% of all cases of palpitations no treatment was required. In the remaining cases, vagal manoeuvres were performed and adenosine or diazepam were administered. Patients were discharged at home in 93.7% of cases, while the remaining patients were temporarily observed and only one patient was hospitalised. Of the 13 patients with arrhythmia, seven received chronic medical therapy, four with flecainide or propafenone and three with beta-blocking agents. Successful trans-catheter ablation was performed in six out of the 11 patients with SVT. During the long-term follow up to November 2016, which was a mean follow up 47 ± 23 months, 15% of the patients with a diagnosis of anxiety or reported palpitations had a cardiologic evaluation based at their parents' request and all the results were negative.

DISCUSSION

Admission to the ED for palpitations was not frequent in patients aged 4-18 and they only accounted for 0.07% of all such admissions during a seven-year period. This prevalence was lower than the rates reported by Probst et al (6), possibly because our series was only based on paediatric ED visits and did not include adults. To the best of our knowledge this was the first published study to define the prevalence of palpitations in an exclusively paediatric ED population. This is possibly due to the fact that paediatric patients with palpitations are mainly referred to their general practitioner and eventually to a cardiologist, which suggests that patients admitted to the ED may represent a somewhat select population. Although the prevalence of palpitations in this specific setting was very low, this study showed that a significant percentage (13.5%) of patients with palpitations had a cardiac arrhythmia: 11.4% had SVT and 2.1% had ventricular extrasystole. The overall incidence of

arrhythmia in our series was 9.1 per 100,000 ED visits, which was lower than other studies on this subject (4). The presence of tachycardia on presentation allowed to identify almost all cases of SVT. Indeed, 10 of 11 patients with SVT had tachycardia with a heart rate that was above 146 bpm on admission. On the other hand, only three patients with palpitations with a normal heart rate at physical examination had a diagnosis of arrhythmia, identified with a 24- hour Holter record. These accounted for 3.1% of our series.

Since 2015 most Italian children have receive a screening ECG at least once in their life, to evaluate their suitability for sports activities as required by Italian law. Despite this the indication to perform an ECG on every child with palpitations was not formally recommended in our ED during the study years of 2009-2015 and the decision was made by the attending physician on a clinical basis.

Our results suggest that an ECG should be obtained for all patients admitted with palpitations, even with a normal heart during the clinical evaluation. Exceptions could be the absence of a recently recorded normal ECG or the absence of a clear correlation with other triggers of palpitations, such as fever or pain.

The heart rate adapts during childhood and the presence of tachycardia is strongly correlated to age. Moreover, the perception of a child's heart rate depends on the level of their psychological maturity and on their ability to communicate (8,15). In fact, this symptom is not frequently reported by children under five years of age (2,4,5). As this was a study based on palpitations as a symptom, we decided to rule out children under four years of age. In this study palpitations were more common among teenagers older than 14 years. This finding probably reflects the fact that palpitations underlie multiple conditions, including anxiety, and this was the most frequent cause in our population. Indeed, symptoms related to psychological uneasiness are more frequent during adolescence and recognising palpitations caused by a psychological background might be particularly challenging for the clinician (7,8,12). Analysing the approach to palpitations in our ED showed that patients with a presumptive diagnosis of anxiety, rather than arrhythmia, were less likely to undergo an urgent ECG ($p=0.03$). ECG documentation of an arrhythmia during symptoms provides the strongest evidence of causality.

By contrast, palpitations are considered to be of non-arrhythmic origin when the ECG shows sinus rhythm or sinus tachycardia (15,16).

Even though anxiety may well be a feature of SVT, it still remains the most frequent cause of non-arrhythmic palpitations in adolescents, and must be considered the most likely diagnosis in the absence of tachycardia, a history of heart disease and a recent normal ECG. This suspicion could be strengthened in presence of other accompanying symptoms, especially if vague and recurrent symptoms are reported, such as abdominal pain, headaches, limb and back pain and shortness of breath. These can all be associated with specific clues relating to family or school related problems, such a lot of school absences.

Strengths and limitations

A limitation of this study was that when we analysed the hospital discharge cards we were unable to determine whether the ECG was recorded while palpitations were present. In fact, an ECG recorded when the symptoms are not actually present does not allow clinicians to exclude the absence of a heart-related cause for palpitations. In addition, performing an ECG in patients with a normal heart rate, but who complain of palpitations, may enable clinicians to recognise ventricular extrasystole, especially in younger children with sinus arrhythmia, where the distinction between extrasystole and sinus arrhythmia may be difficult during the physical examination. It is also easier for a parent to accept that there is no cardiac arrhythmia if an ECG is carried out, rather than just receiving reassurance based on the child's clinical history and the physical examination. This was evidenced by the frequent use of further cardiac evaluations in the 15% of patients discharged with a final diagnosis of reported or idiopathic palpitation, who had not received an ECG or an urgent cardiology consult in the ED. From a practical point of view, it may be useful to recommend that patients who are discharged with a diagnosis of idiopathic palpitation should return to the ED if they experience further episodes of palpitations as soon as the symptoms begin. This will enable them to receive a prompt ECG before the symptoms disappear. Indeed, the use of Holter monitoring may only be useful when

there are frequent episodes of palpitations (15,16). Moreover, the recording of an ECG might be of utmost importance, especially when a history of sudden death in the family is reported. Indeed, genetic disorders like Brugada syndrome, long QT syndrome, hypertrophic cardiomyopathy and many others might be diagnosed or suspected on the basis of an ECG, especially if there is a family history of such issues. In our cohort, only three patients had a history of arrhythmia in close relatives, but there were no sudden deaths or genetic arrhythmic disorders reported. Although the main cause of palpitations was anxiety, and the majority of patients with a cardiac arrhythmia were tachycardic, an arrhythmia was still diagnosed in patients with a normal heart rate on admission in 3.1% of our series. Therefore, this study highlights the importance of performing the ECG during palpitations, both for diagnostic purposes and to reassure children and their parents that the symptoms are benign.

The main limitation of this study was its retrospective nature, as this that did not allow us to gather complete anamnestic information in some cases and to determine if the ECG was performed when the symptoms were present in all patients. In particular, the information about sudden or progressive onset and termination of palpitations was not constantly reported in the ED reports. This particular aspect is usually mentioned in textbooks as one of the main distinctive features that discriminates between arrhythmic and non-arrhythmic palpitations, so it's quite disappointing that these data were missing. However, it is noteworthy that atrial tachycardia, one of the most frequent SVTs in children, may display warming up and cooling down behaviour, so it would be unreliable to count on the mode of onset and disappearance. The point of strength of our study was the long-term follow up and the fact that we were able to recall all 96 patients. We could not compare these results with other studies since, to the best of our knowledge, there are no similar studies with a large cohort of just paediatric patients.

Another limitation of our study was that only a minority of our cohort underwent a complete cardiological evaluation with 24-hour Holter monitoring, meaning that there might have been some missed diagnoses. As a matter of fact, we believe that the number of false negatives was probably low, because we performed a long-term follow and no patients had a further diagnosis of arrhythmia, there were no new visits to the ED for arrhythmic palpitation and no patients were lost to follow up.

We believe that the reason why only a small percentage of patients underwent a complete cardiological evaluation was that even a less invasive diagnostic test, like 24-hour Holter monitoring, can only be prescribed in the presence of high clinical suspicion, that is high pre-test probability of positive result. Otherwise, all patients with palpitations would undergo cardiological tests like an ECG or Holter monitoring, and that would be a questionable cost benefit ratio for our national health system.

CONCLUSION

Palpitations were a rare cause of admissions to our paediatric ED over a seven-year period and they mainly affected teenagers. Although most palpitations have a non-cardiac origin, there was still a non-negligible percentage of patients with palpitations due to a real arrhythmia. Tachycardia and the duration of palpitations on admission to the ED were related to the diagnosis of arrhythmias.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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