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Palpitations, syncope and sudden death in children: Who's at risk?

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Palpitations and syncope are not infrequent presenting complaints to primary health care providers. Although mostly benign, these worrisome symptoms may be the prodrome of significant cardiac events. Their devastating end results may include brain damage and sudden cardiac death (SCD). It is important to differentiate the relatively benign forms of palpitations and syncope from those that are associated with an increased risk of SCD.

Palpitations

Palpitations are a subjective sensation of an unduly strong, rapid or irregular heart beats. These may or may not be related to cardiac arrhythmias. They may be due to physiologic causes like sinus tachycardia associated with anxiety or exercise. Conversely pathologic causes like ventricular tachycardia in the long Q-T syndrome may be at fault. Patients who have had palpitations should be carefully evaluated to rule any significant arrhythmia before being allowed to participate in any competitive sports.

A complete history is necessary to understand the nature of the palpitations. Inquiry should be made into such things as the timing and circumstances that led to the palpitations. Other associations with the onset of palpitations like behavioral change should be sought. Likewise, questions should be asked about a family history of syncope, palpitations or SCD. A physical exam should be undertaken to rule out structural heart disease and systemic disorders. While laboratory tests are most often normal, a chest X-ray is advised to rule out congenital heart disease and lung disease. An ECG is needed to evaluate P waves, the presence of premature atrial beats or premature ventricular beats, and the Q-T interval. Commonly these tests indicate a benign nature of the palpitations leading to the great relief of those involved.

Asymptomatic patients with premature atrial contractions and/or premature ventricular contractions, even if frequent, or short runs of unifocal ventricular tachycardia do not need a referral to a cardiologist. Only reassurance is needed for the patient and family. If a suspicion of cardiac origin of the palpitations is discovered an extended work-up is usually undertaken in collaboration with a pediatric cardiologist. This may include an echocardiogram, holter monitor and exercise stress test and possibly electrophysiologic testing.

Syncope

Syncope is a temporary loss of consciousness due to generalized cerebral ischemia usually followed by rapid and complete recovery. In rare instances anoxic seizures may result. Syncope may be preceded by light-headedness, dizziness, weakness, pallor, nausea, cold sweat, blurred vision, or hearing loss. Prompt relief from all symptoms usually occurs after lying down. Syncope may result from impaired response of the autonomic nervous system or from cardiac structural defects, especially those obstructing blood flow or from cardiac arrhythmias. The relatively uncommon long QT syndrome is an especially worrisome cause of syncope (vida infra). Non-cardiac mechanisms such as metabolic, neurologic, and psychologic disorders may also cause syncope. Driscoll et al. reported the incidence of syncope coming to medical attention was 72-126 per 100,000 population[1]. It was higher for females than for males and peaked in the 15-19-year-old patients. Nearly one quarter of the episodes were associated with acute illness or noxious stimuli.

Neurally mediated syncope, also referred to as vasovagal or neurocardiogenic syncope, is by far the most common form of syncope in children. It is often associated with orthostatic intolerance. In such cases the mechanism of syncope is reflex mediated and originates from a decreased systemic venous return which leads to decreased left ventricular end diastolic volume. Increased mechanical contractility then leads to stimulation of cardiac vagal fibers, and ultimately a paradoxical response of marked bradycardia, vasodilation, and hypotension. This chain of events is referred to as the Bezold-Jarisch reflex. Reflex syncope may also result from a hypersensitive autonomic response from different afferent input, such as micturation, swallowing, deglutition, coughing, sneezing or defecation. Neurally mediated syncope may present in one of the three clinically recognized forms: cardioinhibitory (low blood pressure, bradycardia / asystole), vasodepressor (low blood pressure, no bradycardia) or mixed (low blood pressure, bradycardia).

Physical exhaustion, prolonged recumbency, conditions predisposing to peripheral vasodilation (exercise, hot weather), and pregnancy enhance the chance of having neurally mediated syncope. It is also enhanced by emotional stress, pain, hunger, humidity, heavy meals, recent illness, blood drawing, sight of blood, fatigue, and poorly ventilated environments. It has been reported that chronic fatigue syndrome in adolescents may be related to the orthostatic intolerance. These patients show a decrease in blood pressure and heart rate with tilt table testing similar to that observed in vasodepressor syncope[2]. Neurally mediated syncope is rarely associated with sudden death.

As certain causes of syncope may be related to life threatening conditions, a detailed evaluation should be undertaken whenever patients present with syncope. Those with a family history of syncope, sudden death, myocardial disease or arrhythmias and those with exercise associated syncope are at a particularly higher risk of SCD[1]. An electrocardiogram should be a part of the initial evaluation in all patients presenting with syncope. A cardiology consult is indicated when the cause of syncope cannot be identified, cardiac or arrhythmogenic syncope is identified, or a pacemaker is indicated for severe and recurrent syncope unresponsive to medical management. Further workup by the pediatric cardiologist often includes event monitoring, exercise stress testing and tilt table testing.

Tilt table testing may be indicated under certain situations where the cause of syncope is not clear. The American College of Cardiology published guidelines in 1996 on the indications of tilt table testing[3]. The general agreement is that tilt table testing should be done in patients with

recurrent syncope or in high risk patients after a single syncopal episode. However, adolescents who describe prodromes of lightheadedness, nausea, and sweating before syncope most likely have neurally mediated syncope. These prodromes strongly suggest that tilt table testing is not necessary in these patients. The tilt table test consists of placing the patient in a head-up tilted position after a short period of lying prone. The tilt angle is between 60 and 80 degrees on a table with footplate and safety straps. The appropriate end point is induction of syncope or presyncope associated with intolerable hypotension and resulting in an inability to maintain postural tone. A head up tilt for 10 minutes without adverse events is considered negative. Should this be the case another tilt during an infusion of an adrenergic agonist like isoproterenol may enhance the results.

Fluid therapy may be an effective therapy for neurally mediated syncope especially of the vasodepressor type. It should be the primary mode of intervention in such patients. Other modes of therapy that have been described include beta-blockers, volume expansion (salt and fludrocortisone), pseudoephedrine, disopyramide and newer medications such as midodrine. These can be used individually or in combination[4]. In cases where the neurally mediated syncope is frequent or severe enough to cause anoxic seizures and unresponsive to conventional medical treatment implantation of a pacemaker may be warranted[5]. Patients with syncope should not participate in competitive sports until the cause of syncope has been determined and treated.

Sudden Cardiac Death (SCD)

SCD is any natural death that occurs due to cardiac causes within minutes to 24 hours after onset of symptoms. Cardiac deaths have been classified as arrhythmic deaths or due to circulatory collapse. SCD in children is relatively rare. There are about 600 SCDs in children annually compared with 7,000-10,000 deaths from sudden infant death syndrome (SIDS) in infants and 300,000-400,000 SCDs deaths in adults[6]. The prevalence of SCD increases with age accounting for 19% of sudden deaths in children between 1 and 13 years of age and 30% between 14 and 21 years[6].

The risk of sudden cardiac death may be slightly higher in athletes involved in strenuous training. In a population of high school athletes, the risk of SCD was reported to be in the range of 1 in 200,000 per year and higher in male athletes[7]. This low occurrence of SCD in competitive sports makes structuring cost effective broad-based participation screening guidelines for high school and college athletes difficult. In addition, the range of causes of sudden death in the athletic field may include causes that are impossible to screen for. In rare instances an athlete with a structurally normal heart and no underlying pathology may suffer a blunt trauma to the chest that causes a ventricular dysrhythmia and SCD. This is believed to be induced by the abrupt, blunt blow to an electrically vulnerable phase of electrical excitability within the myocardium[8]. The current recommendations for disqualification from competitive athletics are based on the guidelines from the 26th Bethesda Conference[9].

Structural Heart Diseases Predisposing to Sudden Death

The incidence of SCD in patients with congenital heart disease is particularly high after repair of certain lesions. Patients following tetralogy of Fallot (TOF) repair have a 2-5% incidence of SCD with ventricular arrhythmias being identified as the most likely etiology[10]. These patients should be

allowed to participate in all competitive sports provided they have no evidence of rhythm abnormality[9].

Other surgically repaired lesions associated with a high incidence of arrhythmias and SCD include the Mustard or Senning operation for transposition of the great arteries, and the Fontan operation for a single ventricle physiology. The latter includes those with hypoplastic left ventricles who have had prior Norwood operations. Patients in these categories are usually limited to low intensity competitive sports like golf, bowling, billiards and bowling although certain individuals with excellent surgical results and a normal exercise test may be allowed to participate in more dynamic sports[9]. Atrial arrhythmias tend to dominate in these lesions.

About 40% of SCD in pediatric patients occur in patients with unoperated congenital or acquired heart disease[11]. Several subgroups of such heart disease have been identified:

1.Cardiomyopathies and Myocarditis:

Cardiomyopathies in the form of restrictive, hypertrophic or dilated may predispose the patient to SCD. Of these hypertrophic cardiomyopathy is the most common cause of SCD in adolescents in the US. Patients may present with symptoms of chest pain, syncope, and palpitations associated with exercise or sudden death during exercise. Factors that are associated with an increased risk of SCD in patients with hypertrophic cardiomyopathy include a strong family history of sudden death, clinical symptoms, a young age, presence of ventricular arrhythmia, and a thickened intraventricular septum. Electrocardiograms may show left ventricular hypertrophy, ST-T wave changes, and deep and wide Q waves in the left precordial leads. All patients with hypertrophic cardiomyopathy should be disqualified from participating in competitive sports. Even though hypertrophic cardiomyopathy is a common cause of SCD in athletes in the US, it is a rare cause of SCD in athletes in Italy. This may be related to the much more aggressive screening and disqualification from sports of patients with hypertrophic cardiomyopathy by Italian law[12].

Arrhythmogenic right ventricular dysplasia and right ventricular cardiomyopathy have been reported as the leading cause of SCD in athletes in studies done in Italy[12], although it is apparently less common in other geographic regions including the United States. These lesions are associated with a high frequency of cardiovascular symptoms and complications. Patients may present with ventricular arrhythmias (45%), congestive heart failure (25%), heart murmur (10%), complete heart block (5%), or sudden death (5%)[13]. First order relatives are affected in 30% of the patients. The electrocardiogram usually shows a left bundle-branch pattern. As limited data is available with regards to the risks of athletic participation in such patients, they are best advised to refrain from participation in any competitive sports.

SCD has been reported in 14-42% of the patients with acute and chronic myocarditis who died either at rest or during exercise[14]. These patients may present with a wide range of symptoms from subtle findings such as persistently increased heart rate or low-grade ventricular ectopy to severe congestive heart failure with cardiomegaly and poor exercise tolerance. Viral etiology has been identified as the most common cause of acute or chronic myocarditis. Athletes thought to have myocarditis should be withdrawn from all competitive sports for a convalescent period of approximately 6 months, and allowed to return to training only after a thorough cardiac assessment[15].

2. Coronary Artery Disease:

Patients with congenital or acquired coronary artery disease may present with SCD with the disease being diagnosed at autopsy. The most common coronary artery anomaly leading to SCD is the left main coronary artery arising from the right sinus of valsalva[16]. It may be difficult to recognize

these patients prospectively, as they are usually asymptomatic until the initiating event that is related to exercise. Routine 12 lead ECG and exercise stress test are not much help in diagnosing these patients. A history of syncope, palpitations or chest pain related to exercise is associated with an increased risk of anomalous origin of the coronary artery and warrants an echocardiogram to define the coronary arteries[17]. It is reasoned that compression of the left coronary artery, which runs between the aorta and the pulmonary artery, causes coronary insufficiency and acute ischemia. This in turn predisposes the patient to fatal arrhythmias. Occasionally patients with an anomalous origin of the left coronary artery from the pulmonary artery may present in infancy with congestive heart failure. They too may die suddenly, presumably of an ischemic arrhythmia or cardiogenic shock. Athletes with congenital coronary anomalies should be restricted from participation in all competitive sports until surgical treatment is undertaken[9].

Acquired coronary artery disease is usually associated with Kawasaki disease. Kawasaki disease may present with SCD in up to 2% of untreated patients, which in turn may be related to rupture of large coronary artery aneurysm, acute myocarditis or large coronary artery thrombosis[18]. Athletes with Kawasaki disease who have never had coronary involvement or who have documented resolution of any previous aneurysms can participate in all competitive sports. On the other hand, those patients with residual abnormalities are allowed to participate in only limited athletic activities[9]. Familial hyperbetalipoproteinemia is an atherosclerotic heart disease inherited in an autosomal-dominant pattern and may present as SCD in adolescence.

3. Valvular Heart Disease:

Patients with aortic valve disease including aortic stenosis and chronic aortic regurgitation may be asymptomatic or present with symptoms such as syncope, dyspnea, or chest pain. When palpitations are present, the patient may be suffering from arrhythmias associated with myocardial ischemia. Symptomatic patients usually have severe left ventricular obstruction and left ventricular hypertrophy. A high estimated valve gradient (>75 torr) by echocardiography indicates risk for SCD. Recommendations for athletic participation are based on the severity of aortic stenosis. Athletes with mild aortic stenosis are not restricted from any competitive sports and those with severe aortic stenosis are restricted from all competitive sports[9]. A cardiologist should carefully evaluate athletes with a mild aortic stenosis and a history of syncope.

Mitral valve prolapse (MVP) is a relatively common and benign finding in the pediatric population with an excellent prognosis. However, patients with MVP and ventricular arrhythmias, mitral regurgitation, prolonged Q-T interval, history of syncope or presyncope, and family history of sudden death should be considered at a high risk to develop SCD[19]. MVP is also frequently seen in association with Marfan's syndrome and other connective tissue diseases. Isolated MVP or in association with premature ventricular contractions (PVC) does not require any treatment other than prophylaxis for bacterial endocarditis. These patients may be allowed to participate in all physical activities without any restrictions. However, patients with MVP and a history of syncope or complex ventricular arrhythmias, significant mitral regurgitation, or family history of sudden death should restrict their activities to leisurely, noncompetitive sports.

4. Arrthythmias and Long QT Syndrome

Primary arrhythmias with no congenital cardiac malformation are frequently encountered in the pediatric population and may rarely lead to SCD. These include Wolf-Parkinson-White (WPW)

syndrome, isolated sick sinus syndrome, congenital complete atrioventricular block, and ventricular and supraventricular tachycardias. Syncope and palpitations are common presenting complaints in patients with supraventricular tachycardias from WPW. SCD is rare in these patients and may occur from rapid conduction via the accessory pathway leading to ventricular fibrillation. As digoxin may potentiate this conduction via the accessory pathway, its use in treating WPW is controversial. Athletes without structural heart disease and WPW can usually participate in all competitive sports, although in younger children (<20 years old) a more in-depth evaluation may be recommended before allowing participation in moderate to high intensity competitive sports[9].

Complete heart block usually presents in infancy and in such patients SCD is usually related to extreme bradycardia and a tendency to develop ventricular arrhythmias[20]. Participation in competitive sports is usually dependent on the presence of symptoms like syncope or near syncope, ventricular rate, and cardiac function[9].

Sick sinus syndrome may manifest as marked sinus bradycardia, sinus arrest with slow junctional escape, tachycardia- bradycardia syndrome, or atrial fibrillation. These patients are allowed to participate in all competitive sports provided the bradycardic rate increases appropriately with exercise[9]. Athletes with syncope or near syncope warrant a more thorough work-up to determine the cause of their syncope. Those with symptomatic tachycardia-bradycardia syndrome should be medically treated and allowed to participate in low intensity competitive sports after a 3-6-month symptom free period[9].

Patients with long Q-T interval syndrome are at an increased risk for ventricular arrhythmias and SCD. They usually present with episodes of syncope and a family history of syncope and sudden death. The long QT syndrome is inherited in an autosomal dominant pattern with female predominance[21]. The risk of cardiac events is higher in males until puberty and higher in females during adulthood. On their electrocardiograms they have a prolonged QT interval and at times profound bradycardia and ST-T wave changes. Medical therapy is initiated with beta-blocking drugs such as propranolol or atenolol. Beta –blockers are associated with a significant reduction in cardiac events in the long QT syndrome patients. However, syncope, aborted cardiac arrest, and long QT syndrome related death continue to occur while patients are on prescribed beta-blockers, particularly those who were symptomatic before starting this therapy[22]. Athletes with the prolonged QT interval syndrome are at an increased risk for sudden death and should be restricted from all competitive sports[9].

5. Other Cardiac Diseases*:*

Pulmonary Hypertension is another significant risk factor for SCD. Among patients who died of SCD, 11-17% were patients with pulmonary hypertension associated with heart disease and another 4% with primary pulmonary hypertension[11]. Syncopal episodes and arrhythmias in the patients is usually a poor prognostic indicator. Such patients are at an increased risk for SCD during pregnancy and delivery and during strenuous physical activities. Their physical activity limitations are tailored to their degree of pulmonary hypertension.

Marfan's syndrome is associated with a decreased life expectancy, with 30-60% of the patients having cardiovascular anomalies. Rupture of the dilated aortic root is the most common cause of SCD in these patients. Patients with aortic root dilation and aortic valve insufficiency should refrain from strenuous and isometric physical activities. Mitral valve prolapse with insufficiency is also common in patients with the syndrome. Beta-blocker therapy is recommended for Marfan patients with valve disease.

Conclusion

It is important for the primary health care provider to understand the various cardiac and non-cardiac causes of syncope and palpitations. SCD in the young is rare[11]. Often times a judicious work-up of these patients can determine if the symptoms predispose the patient to a higher risk of SCD. This in turn may substantially reduce the risk of SCD and prevent unnecessary restrictions on others in whom the symptoms may be secondary to a benign or easily treatable cause.

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