VENTRICULAR ARRHYTHMIAS IN CHILDHOOD

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Abstract

Isolated premature ventricular beats may be seen in 15% of normal newborns, 30% of normal adolescents and 66% of adolescents with repaired heart disease. Sustained ventricular arrhythmias are relatively rare in young normal hearts. Sudden cardiac death is also rare in young with normal hearts, although there is an increased incidence in dilated and hypertrophic cardiomyopathies and following repair of particular congenital heart lesions.

Patients with cardiomyopathy (CM) often have ventricular arrhythmias, although the risk of mortality is more closely linked to ventricular function. There are many infants and pediatric patients with apparently normal hearts who have asymptomatic nonsustained ventricular tachycardia.

The main concern is to identify diagnoses such as long QT syndrome associated with recurrent cardiac syncope so that appropriate choices can be made regarding drug and/or device therapy.

Key words: Ventricular tachycardia, sudden death, cardiomyopathy, congenital heart disease.

Ventricular arrhythmias may occur in the setting of congenital heart disease, cardiomyopathies and inflammatory myocardial disease, electrical myopathies, or even in a structurally and functionally normal heart.

Arrhythmias can be identified on incidental examination or because of symptoms such as palpitations, chest pain, or syncope. The primary concerns are identifying patients at risk of sudden cardiac arrest and attempting to modify that risk. The relative frequency of ventricular arrhythmia and the relative rarity of sudden death in pediatric patients complicate management choices and introduce controversy and uncertainty when interpreting historical data.

The frequency and natural history of ventricular arrhythmias is highly dependent on the underlying substrate. More than 50% of pediatric patients with sustained or symptomatic ventricular arrhythmias have evidence of organic heart disease. Of those without overt heart disease, up to 50% may have at least subtle evidence of myopathy. With organic heart disease, ventricular arrhythmias are common, with frequent ventricular ectopy detected in up to 60%, particularly following late repair of tetralogy of Fallot, aortic valve replacement, or with pulmonary vascular disease. Without apparent heart disease, isolated premature ventricular contractions (PVCs) are seen in 10% to 15% of infants and 20% to 35% of adolescents, whereas higher grade ectopy and ventricular tachycardia are uncommon.

Ventricular arrhythmias are a clear mechanism of sudden cardiac arrest, although other cardiac concerns can contribute to both mortality and symptoms.

Hemodynamic impairment also contributes to outcome, complicating our understanding of mortality risk.

1. Congenital Heart Disease

Several congenital heart defects have been associated with late sudden death, in particular tetralogy of Fallot. There are no data on the incidence of ventricular ectopy when these patients reach adolescence. Because of its high prevalence, low-grade ventricular ectopy cannot serve as an adequate marker of patients at high risk, but the absence of ectopy may be one marker of lower risk.

Tetralogy of Fallot is the most frequent form of cyanotic congenital heart disease and has the longest follow-up, providing a model for assessing risk associated with ventricular arrhythmias.

The incidence of isolated premature ventricular contractions and nonsustained ventricular tachycardia in postoperative patients with tetralogy of Fallot is relatively high. When electrocardiogram (ECG), Holter, and exercise reports are combined, up to two thirds of older tetralogy of Fallot patients will have frequent PVCs and 8% will have nonsustained ventricular tachycardia (VT). The frequency of PVCs is notably lower in early school age children repaired in infancy and with transatrial repairs. These patients were repaired at a younger age and with modern techniques of cardiac protection, which may contribute to these encouraging results.

Sustained ventricular arrhythmias are much less common. Certainly some congenital heart disease patients present with spontaneous sustained monomorphic ventricular tachicardia (VT), although large population-based data are lacking. Sudden death may occur in 2.7% to 6% of surgical case series and is presumed to be due to ventricular arrhythmia.

Hemodynamic, historical, and ECG markers continue to be used for initial identification of patients at risk. These include residual right ventricular outflow tract obstruction, residual ventricular septal defect, prior shunts, older age at initial surgery, pulmonary insufficiency, and longer duration of follow-up. ECG markers are proposed to further or more easily stratify risk: The results are dependent on the apparent prior risk of the group. Several studies have correlated risk of mortality and/or induced sustained monomorphic VT with QRS durations ≥ 70 to 180 msec and/or increased QT/JT dispersion. Individually these approaches have potentially spectacular test characteristics, although examination of the

data suggests they are dependent on the preexisting risk of the underlying population.
Together these studies suggest that noninvasive markers offer hope for rapid, although imprecise stratification of individual patients. There are no current techniques
to exclude the risk of sudden cardiac death. Marginal hemodynamics, well recognized for each type of congenital heart disease, clearly contribute to mortality and cannot be fully corrected. Although more data are clearly required, a combination of multiple noninvasive risk factors, including symptoms in young adults with repaired congenital heart disease, and inducible VT on programmed ventricular stimulation is likely to identify a group with exceptionally high risk of sudden cardiac death. Unfortunately, therapy choices also remain imperfect. For this group of patients, approaches such as pulmonary valve replacement and implantable cardioverter–defibrillator therapy alone or in combination with antiarrhythmic therapy may be justified.

2. Structurally Normal Hearts

Risk assessment and management of ventricular arrhythmias in structurally normal hearts involves identifying reversible causes (intracardiac catheters, isolated cardiac trauma, marked metabolic isturbances, and some drug toxicities). Once these isolated triggers are identified and treated, the risk associated with that ventricular arrhythmia is removed. For most other patients with structurally and functionally normal hearts, the key issue is appropriately classifying them as having benign VT or uncommon but identifiable electrical myopathies with associated risk of sudden cardiac death. For patients with depressed ventricular function, an additional goal is identifying those with reversible causes of cardiomyopathy (as tachycardia mediated CM) and those who have irreversible cardiomyopathy for which supportive care and transplant may be required. There are specific patterns that help distinguish these groups. Selective use of echocardiography, ambulatory ECG and Holter monitoring, and exercise testing each offer complementary information. Further investigations, including the use of intracardiac studies, biopsies, angiography, and magnetic resonance imaging, may provide potential information but are recommended selectively.

3. Cardiomyopathy

a. Dilated Cardiomyopathy and Inflammatory Myocarditis

The prognosis of pediatric patients with dilated cardiomyopathy is poor, with 25% to 30% 1-year mortality in infants and younger children and possibly worse in older symptomatic patients. Mortality is frequently associated with complex ventricular and supraventricular arrhythmias. Risk stratification beyond following congestive symptoms and ventricular function is controversial. The presence of inducible VT during programmed stimulation does not increase this precision, suggesting that the substrate of sudden death may be different from either spontaneous nonsustained VT or induced VT. Initial implantable cardioverter–defibrillator
experience in adults suggest some benefit from implantable cardioverter–defibrillator therapy in patients with recurrent sustained VT awaiting transplant. Studies comparing implantable cardioverter–defibrillators, amiodarone, or beta-blockade are in progress in adults. There are not adequate data to make these choices in either adults or children.

In myocarditis ggressive supportive and antiarrhythmic therapy, possibly including mechanical support, allows time for evaluation and management of the underlying process. Even when myocardial performance improves following apparent myocarditis, there remains a background incidence of ventricular arrhythmias of uncertain significance

b. *Hypertrophic Cardiomyopathy*

Hypertrophic cardiomyopathy is generally an autosomal dominant condition secondary to defects in sarcomeric protein genes. Male athletes may have sufficient left ventricular hypertrophy to consider the diagnosis of hypertrophic cardiomyopathy, although intraventricular cavity diameters are preserved, wall thickness is generally less than hypertrophic cardiomyopathy, and deconditioning will resolve the hypertrophy. With an overall incidence as high as 1/500, there is hetergeneity in presentation, penetrance, and prognosis with referral populations having incidence of sudden cardiac death of 3% or higher, whereas less select populations have mortality incidences of 1% or lower.

Nonsustained VT on ambulatory monitoring or surface ECG is common and seen in 10% to 16% of children with hypertrophic cardiomyopathy. Sustained VT can be acause of syncope, sudden cardiac arrest, and mortality. Younger age at diagnosis, nonsustained VT on Holter, syncope, left ventricular outflow tract obstruction
on echo and examination, exercise-induced hypotension,
inducible VT with programmed stimulation, QRS prolongation, QT prolongation and increased dispersion, have all been proposed as identifiable risk factors for sudden death in hypertrophic cardiomyopathy.

Although the utility of any of these findings in
young adults to predict outcome is controversial, their utility in pediatric patients is even less clear. Until genotype/phenotype identification is improved, careful monitoring for symptoms, exercise restriction, and antiarrhythmic drug and device therapy in selected patients represents a reasonable stepwise approach.
Beta-blockade, verapamil, myomectomy, and possibly dual-chamber pacing or septal ablation appear to have a role in decreasing symptoms although they do not appear to modify survival. Managing associated Wolff Parkinson–White syndrome and other supraventricular tachycardia is clearly part of the overall arrhythmia management of this difficult population.

4. **Electrical Myopathy**

In contrast to patients with clinically apparent ventricular arrhythmias, or known congenital heart disease, long QTsyndrome (LQTS) and many other rare causes of sudden cardiac death may only present with recurrent

cardiac syncope or unexpected sudden cardiac death. It is not clear that these conditions are substrates for recurrent nonsustained VT. Hypertrophic cardiomyopathy is the most common cause of sudden cardiac death in apparently healthy athletes. Primary electrical myopathies, such as LQTS, Brugada syndrome, arrhythmogenic right ventricular dysplasia and catecholaminergic VT, are much less common.

Untreated, the annual mortality in LQTS may be as high as 3%, with particular risk in LQTS infants presenting with functional 2:1 block and marked QT prolongation. The challenge with these disorders is in recognizing the patients (and families) and then planning effective therapy. Abrupt onset of unconciousness, injury, or onset of symptoms with exercise all potentially indicate cardiac syncope, although each can be seen with neurally mediated syncope. Benign causes of related symptoms, such as neurally mediated syncope, are very common, with up to 0.1% of the adolescent population seeking medical care for syncope and more than 25% reporting episodes of near syncope in response to head-up tilt. Even in apparently high-risk settings, such as syncope with exercise, there may be benign explanations.

Because the diagnosis of neurally mediated syncope is essentially both a diagnosis of exclusion and a diagnosis based on a typical history, the lack of diagnostic precision identifying LQTS and related rare disorders is a major challenge

For most of these patients, sufficient investigation includes detailed review of the event history, family history, ECG, and probably a Holter and exercise testing specifically searching for repolarization abnormalities. Echocardiography is useful to evaluate structural causes of cardiac syncope not apparent on physical examination: Hypertrophic and dilated cardiomyopathy and anomalous coronary patterns are the most frequent diagnoses in unexpected sudden death in young people.

In patients with documented VT/ventricular fibrillation who do not yet have a diagnosis after echo, ECG monitoring, and detailed history, there is potentially a high yield with intracardiac programmed atrial and ventricular stimulation: Recurrence risk is difficult to accurately assess, although it is certainly related to the specific diagnosis. Implantable cardioverter–defibrillator therapy, often in combination with beta-blockade or other antiarrhythmic therapy, offers the potential for secondary prevention, even without a clear diagnosis.

Survival advantage of any of these therapy choices is not yet demonstrated in pediatric patients. The potential for drugs, including tricyclic antidepressants and cisapride to induce repolarization changes and arrhythmias suggests the possibility of a pool of individuals genetically susceptible to QT prolongation who can be identified with systematic screening. Certainly, in patients with apparent cardiac syncope and even intermediate probability of LQTS by clinical criteria, avoidance of these drugs appears prudent.

Conclusions

The primary concern of families with ventricular arrhythmias and of the pediatricians and cardiologists caring for these families is to prevent the sudden cardiac death. Fortunately, with rare exceptions, the prognosis of congenital heart patients with ventricular arrhythmias is very good. Unfortunately, the ability to identify patients at particularly high risk of sudden death is limited in most clinical situations. Alternative causes of symptoms, including supraventricular tachycardia and neurally mediated syncope, are relatively common. Therapy remains imperfect and may also contribute to mortality.

The basic approach with documented or possible ventricular arrhythmias is to always worrisome, observe and manage selective patients carefully. Recognizing benign patterns of ventricular arrhythmias allows a more permissive management approach: these are almost always characterized by normal sinus rhythm repolarization patterns, lack of serious symptoms, normal ventricular function, and no significant past medical history or family history of early mortality.

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