Ventricular Arrhythmias in Apparently Normal Hearts

Who Needs an Implantable Cardiac Defibrillator?

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KEYWORDS

• Implantable cardiac defibrillator • Ventricular arrhythmia • Sudden cardiac arrest
• Premature ventricular complex

KEY POINTS

- Ventricular arrhythmias in patients without apparent heart disease are mostly benign; however, a small subset of patients may develop malignant ventricular arrhythmias, including monomorphic ventricular tachycardia (VT), polymorphic VT, and ventricular fibrillation (VF).
- The initiating malignant premature ventricular complex (PVC) often arises from locations similar to benign PVCs. The mechanisms by which otherwise benign PVCs trigger malignant sustained arrhythmias are not fully elucidated; therefore, therapies run the full gamut of the electrophysiologic spectrum, including radiofrequency ablation, antiarrhythmic medications, and implantable cardiac defibrillators (ICDs).
- ICDs are indicated for patients who survived VF arrest. ICDs should be considered for patients with high-risk features, such as syncope, and have nonsustained VT with malignant electrocardiographic criteria on Holter or telemetry.
- Where uncertainty exists, a thorough workup is necessary to elucidate the long-term arrhythmic prognosis, which includes MRI, ambulatory rhythm monitoring, and longitudinal clinical follow-up including periodic repetition of the aforementioned workup.
- In addition to a reversible cardiomyopathy, frequent PVCs may also induce a distinct form of cellular electrophysiologic remodeling characterized by increased action potential duration and cellular repolarization heterogeneity, an electrical substrate that may promote reentrant ventricular arrhythmias.

INTRODUCTION

Implantable cardiac defibrillators (ICDs) are the mainstay of therapy for patients with cardiomyopathy (CM) who are at high risk for malignant ventricular arrhythmias and consequently sudden cardiac death.[1] The benefits of ICDs in this group have been well documented in large clinical trials.[2–7] However, patients without apparent structural heart disease, or those with mildly impaired left ventricular ejection fraction (LVEF 40-50%), constitute most (>80%) patients who

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experience sudden cardiac death.[8,9] These patients are not well represented in clinical trials[2–6] and belong to a heterogeneous group whereby the individual benefits of ICD therapy are less clear-cut. Patients with idiopathic ventricular arrhythmias (IVA) fall into this category. By definition, IVA occurs in the absence of known structural heart disease detected by conventional imaging and, in most cases, by a nonreentrant arrhythmia mechanism with foci from certain locations, such as the ventricular outflow tract region, aortic cusps, His-Purkinje conduction system, atrioventricular valvular annuli, or papillary muscles.[10–13] These patients typically present with premature ventricular complexes (PVCs) or nonsustained ventricular tachycardia (NSVT). Thus, this is essentially a very large and heterogeneous group of different patient types. Within this group is a small subset of patients who may experience malignant ventricular arrhythmias in the form of monomorphic (MM) VT, polymorphic (PM) VT, or ventricular fibrillation (VF).[14] More recently, frequent PVCs (>20% burden) have been recognized to induce a potentially reversible form of CM with a prevalence of systolic dysfunction as high as 50% in patients presenting for PVC ablation.[15–17] Patients with a malignant arrhythmic presentation, or those with incompletely reversible systolic dysfunction due to a variety of reasons, are 2 groups of patients who are potential candidates for ICD therapy. Note that there are 2 other groups of patients without LV systolic dysfunction who might be prone to malignant ventricular arrhythmias and be ICD candidates, namely, those with inherited channelopathies, such as congenital long QT syndrome or Brugada syndrome, and those with specific structural derangements, such as hypertrophic CM and arrhythmogenic right ventricular dysplasia. However, ICD indications in these groups are outside the focus of this article.

PREVALENCE OF MALIGNANT VENTRICULAR ARRHYTHMIAS AND POTENTIAL IMPLANTABLE CARDIAC DEFIBRILLATOR BURDEN

To determine the potential burden of ICD therapy in this group, it is useful to examine the prevalence of malignant arrhythmias in patients with IVA. A survey of the literature, however, quickly reveals an absence of robust epidemiologic data to support any major conclusions. Sudden cardiac death was first reported in 1975 in a young patient with right ventricular outflow tract (RVOT) PVCs whose only prior symptom was palpitations.[18] Since then, most reported cases of idiopathic PVC-induced VF and sudden cardiac death have been in Purkinje-related VF.[15] Several case series have examined RVOT PVC-triggered malignant ventricular arrhythmias[14,15,17,19] and reported a prevalence of between 7% and 16% of malignant RVOT arrhythmias among a small group of patients presenting with RVOT PVC ablation. For example, Noda and colleagues[14] reported that 16 patients out of 101 consecutive patients (16%) who presented for ablation of RVOT PVCs had initiation of PM VT (N = 11) and VF (N = 5) by RVOT PVCs. In 2 other studies,[15,20] the investigators studied patients who had spontaneous VF or PM VT and found that 1 out of 14 patients (7%)[20] and 4 out of 27 (15%) patients had initiating PVCs arising from an RVOT origin.[15] The actual prevalence of malignant ventricular arrhythmias in patients with IVA is likely to be lower due to inherent referral bias and small numbers in these studies. The prevalence of malignant arrhythmias triggered by IVA from other foci[10,21] remains unclear.

PROPOSED MECHANISM FOR MALIGNANT ARRHYTHMIAS

The mechanisms of malignant arrhythmias have important implications to discriminate the need for long-term ICD therapy. A key feature to distinguish malignant arrhythmias triggered by IVA from idiopathic VF is to identify the triggering PVC as being unifocal (unlike, for example, fascicular VT or VF, which may be reentrant) and identical in origin to putatively benign PVCs that coexist in the same patient. The question is what leads to conversion of otherwise benign PVCs to malignant sustained arrhythmias?

The outflow tract artery junction is complex both in terms of its development and histology with multiple tissue types interfacing in this region.[22] Myocardial sleeves extend into the great arteries for variable distances and commonly extend into each of the 3 pulmonary valve cusps and beyond by up to 2 cm into the PA, analogous to the relationship between pulmonary vein and left atrium.[22,23] This anisotropy in the absence of organic conduction disease supports the hypothesis of slow conduction or functional conduction block of a rapid-firing focus leading to chaotic degeneration to PM VT or VF.[19,24] Rapid burst pacing from the origin of the VT can reproduce PM QRS, lending further support to the theory of delayed conduction in the vicinity of a PVC focus (**Fig. 1**).[14,19,24] Alternatively, localized anisotropy promotes microreentry from a single PVC focus, with subsequent degeneration to fast VT or VF. Third, multiple firing foci may be present given that the outflow tract region can contain remnants