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CME

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STATE-OF-THE-ART PAPER

Role of CMR Imaging in Risk Stratification for Sudden Cardiac Death

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CME Objective for This Article: At the end of this activity the reader should be able to: 1) recognize the presence of a possible link between myocardial scar and sudden cardiac death in patients with various cardiomyopathies; 2) recognize the role of cardiac magnetic resonance imaging in the risk assessment of sudden cardiac death; and 3) recognize the potential role of cardiac magnetic resonance imaging as a risk-stratifying tool to guide appropriate, effective, and efficient therapy.

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Role of CMR Imaging in Risk Stratification for Sudden Cardiac Death

Left ventricular ejection fraction as determined by echocardiography has a limited sensitivity in predicting risk for sudden cardiac death (SCD). Subsequent efforts to improve cost-effectiveness of device implantation and identify a better risk-stratifying tool have been quite desirable. The presence of scar and myocardial tissue heterogeneity has been linked to ventricular arrhythmia, which is believed to be the major cause of SCD. Cardiac magnetic resonance is a noninvasive imaging modality that visualizes and quantifies scar, with growing evidence delineating its additive value in identifying patients at higher risk for SCD. (J Am Coll Cardiol Img 2013;6:392–406) © 2013 by the American College of Cardiology Foundation

The use of implantable cardiac defibrillator (ICD) for prevention of sudden cardiac death (SCD) remains on the rise. Although the guidelines recommend an ICD for patients with left ventricular ejection fraction (LVEF) <35% (1), less than one-third receive an appropriate shock (2). The limited sensitivity and specificity of LVEF to predict SCD has been highlighted (3). Hence, subsequent efforts to improve cost-effectiveness of device implantation and identify a better risk-stratifying tool have been quite desirable. Evidence suggests that the presence and extent of myocardial tissue heterogeneity with regions of scar and interstitial fibrosis provide a substrate for ventricular arrhythmias that is believed to be the major cause of SCD, both in ischemic (ICM) and nonischemic cardiomyopathy (NICM) (4).

Cardiac magnetic resonance (CMR) is a noninvasive imaging modality that visualizes myocardial scar with late gadolinium enhancement (LGE), with proven histopathological correlation (5,6). Because of its high spatial resolution, it differentiates different scar patterns and detects areas with interstitial fibrosis or edema with T1- and T2-mapping techniques (7–10). There is growing evidence delineating the strength and additive value of CMR in identifying patients at risk for SCD (Tables 1 to 3), which will be the focus of this review.

Evaluation of Scar

One of the great successes with CMR is its ability to visualize myocardial scar. The technique of LGE was developed more than 1 decade ago and validated with histopathologic correlation (11,12). Gadolinium (Gd) is injected intravenously and diffuses outside the intravascular space but cannot cross intact myocardial cellular membrane. However, in areas with myocardial cell damage, there is increased distribution/unit volume. Gadolinium alters the T1-relaxation properties of the surrounding tissue, which appears bright on delayed imaging (11–13). The geographic distribution of LGE helps distinguish different types of cardiomyopathy. In addition, quantification of LGE is feasible and performed with semi-quantitative or automated measurements (although manual segmentation is still required) including full-width-at-half-maximal (14) and/or different SD thresholds of the mean signal intensity (SI) of remote myocardium in the same slice (15,16).The infarcted myocardium can be divided into: 1) core infarct zone; 2) gray or peri-infarct zone; and 3) total infarct = core + peri-infarct zones. The core and peri-infarct areas have been defined as areas with LGE SI ≥3 SD, and 2 SD ≤ SI<3 SD, respectively (with SD), as area ≥50% of the maximal SI of the infarct, and with SI ≥maximum SI of myocardium but <50% of maximal SI of the infarct, respectively (with full-width-at-half-maximal) (14–16). However, there is no consensus on agreed definitions.

Ischemic Cardiomyopathy

CMR quantifies LVEF and mass, which are independent predictor of ventricular arrhythmias (17). Also, the presence and extent of LGE in ICM (Figs. 1 and 2) correlate with outcomes (Table 2) (16,18–23).

Review of the published data revealed 7 studies (pooled number of patients 574, mean event rate/study approximately 20) with different endpoints (Table 2). Although LGE was associated with worse outcomes, 2 studies presented unadjusted data (18,20), whereas the rest adjusted for ejection fraction (EF), left ventricular (LV) volumes, functional class, and indication for ICD. Although there