Arrhythmogenic Right Ventricular Cardiomyopathy/Dysplasia
An Updated Imaging Approach

Stefan L. Zimmerman, MD

KEYWORDS

• Arrhythmogenic right ventricular cardiomyopathy/dysplasia • Task Force Criteria • Cardiac MRI • Pitfalls

KEY POINTS

- Regional abnormalities of right ventricular (RV) function, such as localized dyskinetic wall motion or microaneurysms, are the hallmark of arrhythmogenic right ventricular cardiomyopathy/dysplasia (ARVC/D).
- Regional wall motion abnormalities and global abnormalities of RV size or function are required to meet major or minor MR imaging Task Force Criteria.
- Although MR imaging can detect fat and fibrosis in the RV wall in ARVC/D patients, neither of these features are part of the diagnostic criteria, in part because of poor reproducibility and lack of specificity.
- Left ventricular abnormalities in ARVC/D are common, with both biventricular and left-dominant forms of the disease increasingly recognized.
- Knowledge of potential pitfalls and mimics in the evaluation of patients suspected of having ARVC/D is important in avoiding misdiagnosis.

INTRODUCTION

Arrhythmogenic right ventricular cardiomyopathy/dysplasia (ARVC/D) is a rare inherited cardiomyopathy characterized by progressive right ventricular (RV) dysfunction caused by fibrofatty replacement of the RV myocardium. Patients have an increased risk of sudden cardiac death from lethal ventricular arrhythmias, which in some cases may be the presenting symptom. Cardiac magnetic resonance (CMR) plays an important role in the diagnostic evaluation of patients and family members suspected of having ARVC/D. This article discusses the epidemiology and pathophysiology of ARVC/D, reviews typical CMR findings and diagnostic criteria, and summarizes potential causes for misdiagnosis in the CMR evaluation of patients suspected of having ARVC/D.

EPIDEMIOLOGY AND PATHOPHYSIOLOGY

ARVC/D is a rare disorder with an estimated prevalence of 1:5000 in the general population.[1] Patients are most often in the second through fifth decade of life with a slight male bias.[2] Patients present with a variety of symptoms ranging from palpitations, syncope, and chest pain to life-threatening arrhythmias. Although rare, ARVC/D

The author has nothing to disclose.
The Russell H. Morgan Department of Radiology and Radiological Sciences, Johns Hopkins University School of Medicine, 601 North Caroline Street, JHOC 3142, Box 0818, Baltimore, MD 21287, USA
E-mail address: stefan.zimmerman@jhmi.edu

Magn Reson Imaging Clin N Am 23 (2015) 69–79
http://dx.doi.org/10.1016/j.mric.2014.09.001
1064-9689/15/$ – see front matter

is an important cause of sudden cardiac death in athletes.[3] Treatment of ARVC/D relies on prevention of sudden death through prophylactic implantation of an internal cardioverter-defibrillator.

ARVC/D is a genetic disorder, although the culprit gene is identified in only approximately 30% to 50% of probands.[4] It is inherited in an autosomal dominant fashion with variable and incomplete penetrance. Five culprit genetic defects have been identified, most of which encode structural proteins crucial in the function of the desmosome, a structure critical to cell-cell junctions. These structural abnormalities result in progressive myocyte death and replacement of the RV myocardium with fat and fibrosis.[5] There is regional variation in the prevalence of ARVC/D-causing mutations; plakophilin-2 (PKP2) is the most common mutation in North American cohorts,[6,7] whereas in some European cohorts, desmoplakin (DSP) and desmoglein (DSG) are more prevalent.[8]

The diagnosis of ARVC/D is challenging for several reasons. Although inherited in an autosomal dominant fashion, ARVC/D has variable penetrance and expressivity. It can present over a wide range of ages with significant differences in phenotypic severity. In one large North American cohort of 108 probands with ARVC/D, age at diagnosis ranged from 12 to 63 years.[7] Screening of family members is particularly challenging, as even if a culprit genetic defect is identified, subjects harboring identical mutations may have dramatic differences in presentations and disease course. Adding to the challenge is the lack of a single specific diagnostic test for ARVC/D. At present, diagnosis is based on a group of clinical, imaging, and histopathologic parameters known as the Task Force Criteria (TFC), which were originally proposed in 1994 and subsequently revised in 2010.[9,10] The TFC designate a group of major and minor criteria, including personal and family history of sudden cardiac death, electrical abnormalities from electrocardiography (ECG) or Holter monitoring, functional and structural abnormalities of the right ventricle from cardiac imaging studies, genetic profile, and RV histopathology. CMR TFC under the 1994 and 2010 proposals are detailed in **Table 1**.

ROLE OF MR IMAGING IN ARRHYTHMOGENIC RIGHT VENTRICULAR CARDIOMYOPATHY/ DYSPLASIA

Cardiac MR imaging is uniquely suited for the evaluation of ARVC/D, given its strengths in imaging of the right ventricle. Echocardiography, the first-line noninvasive imaging test for cardiac evaluation, is limited for the right ventricle because of its operator dependency and difficulty resolving the RV wall in the near field. CMR is operator independent and provides high spatial and contrast

Table 1
Comparison of original 1994 and revised 2010 CMR Task Force Criteria for the diagnosis of ARVC/D

1994 Task Force Criteria	2010 Task Force Criteria
Major Criteria	
Severe dilatation and reduction of RV EF with no (or only mild) LV impairment Localized RV aneurysms (akinetic or dyskinetic areas with diastolic bulging) Severe segmental dilatation of the right ventricle	Regional RV akinesia or dyskinesia or dyssynchronous RV contraction And 1 of the following: Ratio of RV end-diastolic volume to BSA $\geq$110 mL/m^2 (male) or $\geq$100 mL/m^2 (female) Or RV EF $\leq$40%
Minor Criteria	
Mild global RV dilatation and/or EF reduction with normal left ventricle Mild segmental dilatation of the right ventricle Regional RV hypokinesis	Regional RV akinesia or dyskinesia or dyssynchronous RV contraction And 1 of the following: Ratio of RV end-diastolic volume to BSA $\geq$100 to <110 mL/m^2 (male) or $\geq$90 to <100 mL/m^2 (female) Or RV EF >40% to <45%

Abbreviations: ARVC/D, arrhythmogenic right ventricular cardiomyopathy/dysplasia; BSA, body surface area; EF, ejection fraction; LV, left ventricular; RV, right ventricular.

Adapted from Marcus FI, McKenna WJ, Sherrill D, et al. Diagnosis of arrhythmogenic right ventricular cardiomyopathy/dysplasia: proposed modification of the Task Force Criteria. Eur Heart J 2010;31(7):806–14.