Advanced Imaging of Athletes

Added Value of Coronary Computed Tomography and Cardiac Magnetic Resonance Imaging

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KEYWORDS

- Cardiac MRI • Cardiac CT • Athletes • Sports
- Hypertrophic cardiomyopathy (HCM)
- Arrhythmogenic right ventricular cardiomyopathy (ARVC) • Dilated cardiomyopathy

KEY POINTS

- Advanced imaging is complementary with the best option being based on the clinical question.
- Cardiac computed tomography (CCT) is a robust method for the assessment of anatomic structures of athletes, while cardiac magnetic resonance imaging (CMR) is a robust method for the assessment of athlete volumes and function.
- CMR for evaluation of scar/fibrosis is a powerful risk predictor for myocardial disease.
- CCT with and without contrast is a robust tool for the coronary arteries.

Videos of a steady state free precession (SSFP – white blood) cine image of hypertrophic cardiomyopathy with an apical aneurysm and a contrast enhanced gated computed tomography image illustrating a bicuspid aortic valve in short axis accompany this article at http://www.sportsmed.theclinics.com/

INTRODUCTION

Adaptations of the athlete, often termed as the athlete's heart, refers to the pattern of morphologic, functional, and electrical changes that result from intensive training. Assessment of athletes has led to the discovery of reversible training-related electrocardiographic (ECG) changes, diastolic parameters, atrial and ventricular dimensions, and more recently the possibility of intramyocardial fibrotic changes associated with exercise. When evaluating athletes each of these is encountered, some more often

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than the others. The distinction between physiologic adaptation of the athlete's heart and sinister disease is problematic because of the substantial overlap between normal and pathologic changes. This controversial area referred to as the gray zone first emerged as a description of overlap for left ventricular (LV) wall thickness.[1,2] However, physiologic adaptations related to training are not limited to LV wall thickness but include enlargement of both the LV and the right ventricle (RV).[3–6] Most agree that exercise testing and echocardiography are the initial diagnostic steps for evaluating athletes when cardiac abnormalities are suspected. In the recent decades there has been rapid growth and use of advanced imaging modalities such as CMR and CCT. These modalities are now integral tools for most practices to assess cardiovascular disease and are now increasingly used for the evaluation of athletes with suspected cardiac disease. Causes of sudden cardiac arrest (SCA) differ by age with a larger proportion of those younger than 30 years having hypertrophic cardiomyopathy (HCM) and those older than 30 years having coronary artery disease.[7] This article provides a practical guide for CMR and CCT assessment of young and adult athletes.

IMAGING BACKGROUND

Both CMR and CCT provide highly reproducible and accurate assessments of cardiovascular structures. CCT is faster and less operator dependent than CMR. In some instances they are complementary, but for patient evaluations, the best choice depends on the clinical question (**Fig. 1**).

Cardiac Magnetic Resonance Imaging

CMR provides superior image quality with accuracy and reproducibility that exceeds those of most other techniques without requiring contrast media administration or ionizing radiation. CMR measures cardiac volumes including atrial volumes, ventricular volumes, and mass by acquiring a 3-dimensional stack of contiguous short-axis images. LV as well as RV volume and mass are determined by planimetry for each slice and summed for the entire ventricle. The accuracy of the volume assessments allows normalization of the measurements to body size, gender, and age to provide a confident diagnosis of both normal adaptations and abnormal conditions. Contrast-enhanced CMR is widely used for MRI of the vessels with near-instantaneous imaging after contrast injection. However, the myocardium can be assessed for abnormal myocardial interstitium using contrast-enhanced CMR to identify late gadolinium enhancement (LGE) (**Fig. 2**).[8,9] Gadolinium bound to diethylenetriamine pentaacetic acid localizes to the interstitial space in areas where there is cell membrane disruption resulting in increased concentrations of gadolinium in areas of myocardial scar or fibrosis (LGE), which is distinctly different from the normal myocardium.[10–12] LGE, as its name implies, occurs late and requires the contrast to wash in and out of myocardium before myocardial imaging is done. LGE has emerged as a newer technique for cardiovascular assessment and has the unique ability to illustrate both ischemic scar tissue and nonischemic fibrosis.[10,13–16]

Cardiovascular Computed Tomography

Initially, CCT emerged as a rudimentary tool with limited image quality primarily because of the small caliber and near-continuous motion of the coronary vessels during the cardiac cycle. Rapid evolution in CT technology has led to modern CT scanners with improved spatial and temporal resolution allowing cardiovascular details well beyond the initial images. In the current era, 64-slice or more multidetector CT is used to provide noninvasive coronary artery visualization, which in many instances