

contrast, palpitations that emerge or intensify during exercise should be considered pathologic until proven otherwise thereby prompting a comprehensive evaluation including non-invasive imaging. All CA with suspected arrhythmia should undergo electrocardiographic capture of the arrhythmia with provocative exercise testing, ambulatory rhythm monitoring or implantable monitoring, and in limited cases drug infusion and invasive electrophysiology study. The primary objective of ambulatory rhythm monitoring is to differentiate malignant ventricular arrhythmias from the more benign variants that arise from the atria or atrioventricular junction. The writing panel suggests a comprehensive TTE examination for CA presenting with palpitations or subjective arrhythmias that occur or intensify during exercise. The role of imaging in athletes with suspected arrhythmia is to diagnose or exclude an underlying causal cardiac abnormality, particularly in the setting of confirmed or suspected ventricular arrhythmias, as arrhythmias may arise from abnormal myocardial substrate including genetic, congenital or acquired cardiomyopathy, edema and inflammation in the setting of acute myocarditis, or scar from prior myocardial injury. Alternatively, arrhythmias may be caused by subendocardial ischemia from obstructive atherosclerotic disease, congenital coronary anomalies, or pressure/volume overload in the context of valvular pathology. Finally, arrhythmias in CA may be attributable to primary disorders of electrical conduction, including ventricular pre-excitation and genetic channelopathies. Ventricular pre-excitation on the 12-lead electrocardiogram, either detected during PPCS in an asymptomatic CA or in a CA presenting with arrhythmic symptoms, should prompt imaging to exclude associated cardiac conditions including Ebstein's anomaly,¹⁴⁷ PRKAG2 gene-mediated hypertrophic cardiomyopathy,¹⁴⁸ and complex forms of congenital heart disease. The primary channelopathies/inherited arrhythmia syndromes, including long QT syndromes, catecholaminergic polymorphic ventricular tachycardia, Brugada syndrome, and idiopathic ventricular tachycardia are not associated with underlying myocardial, valvular, or coronary abnormalities that can be detected with contemporary imaging. Nonetheless, this writing group recommends a comprehensive TTE to exclude alternative diagnoses,¹⁴⁹ when history or 12-lead ECG suggests one of these entities. CTA and CMR imaging in CA with suspected arrhythmia should be considered second line and be performed as dictated by suspected or confirmed pathology following TTE. Specifically, CMR should be performed following a normal TTE examination among CA with documented complex ventricular arrhythmia to evaluate for underlying myocardial scar.

Key Points

1. CA presenting with palpitations or subjective arrhythmias that occur or intensify during exercise should undergo TTE to diagnose or exclude underlying structural disease. Additional imaging with CMR may be appropriate on a case-by-case basis.
2. CA presenting with palpitations or subjective arrhythmias that occur or intensify during exercise should undergo maximal effort-limited exercise testing with or without adjunctive imaging as dictated by current guidelines.
3. All CA undergoing evaluation for ventricular pre-excitation, both asymptomatic and symptomatic, should undergo TTE to exclude concomitant Ebstein's anomaly, PRKAG2 gene-mediated hypertrophic cardiomyopathy, and complex forms of congenital heart disease.

D. Inappropriate Exertional Dyspnea

Perceived breathlessness during exertion is common among CA and may be a manifestation of underlying CVD.^{150,151} The neurophysiology of dyspnea is not well understood but the sensation can be generated by neural feedback mechanisms from the cardiovascular, respiratory, and musculoskeletal systems.¹⁵² A careful history focusing on the duration and intensity of exercise is often adequate to determine if the corollary sensation of breathlessness is appropriate or inappropriate for that individual athlete. Subjective breathlessness is typically appropriate as CA approach their physiological upper limits of exercise capacity as often occurs during training escalation or after prolonged deconditioning. In contrast, dyspnea at previously tolerable exercise intensities and new-onset dyspnea without change in training regimen or competition should be considered inappropriate and thus trigger further evaluation. Associated symptoms including stridor, wheezing, chest tightness, chest pain, palpitations, and presyncope/syncope are useful in dictating the subsequent evaluation. Non-cardiac etiologies, including reactive airway disease with or without exercise-induced bronchospasm, paradoxical vocal fold movement disorder, upper respiratory infection, allergic and non-allergic rhinitis, and dysfunctional breathing account for the majority of inappropriate exertional dyspnea in young CA.¹⁵³ CA presenting with history and physical examination consistent with one of these diagnoses do not require any form of cardiac imaging prior to empiric treatment. However, failure to respond adequately to medical therapy, particularly in CA with suspected exercise-induced bronchospasm, should raise consideration of alternative, possibly cardiac etiologies.

Most forms of underlying CV disease can cause inappropriate exertional dyspnea. This writing group recommends a comprehensive TTE in CA presenting with inappropriate exertional dyspnea, and in CA with previously diagnosed non-cardiac cause of inappropriate exertional dyspnea who do not demonstrate adequate response to therapy. Exercise testing, with or without concomitant imaging, should also be performed in both situations. Assessment of gas exchange, in the form of both pulmonary function testing and cardiopulmonary exercise testing, is often valuable in patients with inappropriate exertional dyspnea. The role of tomographic imaging in CA with inappropriate exertional dyspnea should be considered second line and be performed as dictated by suspected or confirmed pathology following TTE.

Key Points

1. Inappropriate exertional dyspnea may occur in the context of numerous cardiovascular diseases. Comprehensive TTE should be performed in CA presenting with inappropriate exertional dyspnea, and in CA with a previously diagnosed non-cardiac cause of inappropriate exertional dyspnea who do not demonstrate adequate response to therapy.
2. Patients presenting with Inappropriate exertional dyspnea should undergo maximal effort-limited exercise testing with or without adjunctive imaging as dictated by current guidelines.

E. Athletic Performance Decrement

CA presenting for clinical evaluation in the context of performance decrement pose a difficult diagnostic dilemma with a broad differential diagnosis. A comprehensive history and physical should include