Cost and yield of adding electrocardiography to history and physical in screening Division I intercollegiate athletes: A 5-year experience

Rohit Malhotra, MD,*† J. Jason West, MD,*† John Dent, MD,*† Max Luna, MD,*† Christopher M. Kramer, MD,*† J. Paul Mounsey, BM, BCh, PhD,¶ Robert Battle, MD,*† Ethan Saliba, PhD,‡§‖ Benjamin Rose,§ Dilaawar Mistry, MD,*‡§‖ John MacKnight, MD,*‡§ John. P. DiMarco, MD, PhD, FHRS,* Srijoy Mahapatra, MD, FHRS*†§

*From the *Department of Internal Medicine, †Division of Cardiology, University of Virginia, Charlottesville, Virginia, ‡Orthopedics, University of Virginia, Charlottesville, Virginia, §University of Virginia, Sports Medicine, ‖Department of Physical Medicine and Rehabilitation, University of Virginia, Charlottesville, Virginia, and ¶Department of Medicine, Division of Cardiology, University of North Carolina, Chapel Hill, North Carolina.*

BACKGROUND Electrocardiographic screening of intercollegiate athletes is controversial because the costs and yield are not well defined. Both the American Heart Association (AHA) and the European Society of Cardiology (ESC) have different criteria for screening, partly because the populations being screened are different.

OBJECTIVE The purpose of this study was to determine the cost and yield of a 5-year ECG screening program at a United States Division I college.

METHODS At the University of Virginia, all 1,473 competitive athletes over the course of 5 years were screened with history and physical and with ECGs using ESC guidelines with follow-up testing as dictated by clinical symptoms and ECG findings.

RESULTS History and physical alone uncovered five significant cardiac abnormalities. ECGs were abnormal in 275 (19%), resulting in 359 additional tests. Additional testing confirmed eight significant cardiac abnormalities that were not found by history and physical: 1 bicuspid aortic valve, 4 rapidly conducting accessory pathways, 1 long QT patient, 1 with frequent premature ventricular contractions and low ejection fraction, and 1 with frequent premature ventricular contractions but normal ejection fraction. No cases of hypertrophic cardiomyopathy were found. Total cost of the program was US $894,870. Cost of history and physical screening alone was $343,725 or $68,745 per finding. The marginal cost of adding ECG screening, including resulting tests and procedures. was US$551,145 or US$68,893 per additional finding.

CONCLUSION ECG screening of U.S. college athletes can uncover significant cardiac pathology not discovered by history and physical alone. Although ECG screening also results in many false positives resulting in additional tests, the overall cost per diagnosis of adding ECG screening is similar to that of history and physical screening alone.

KEYWORDS Athlete; Atrial fibrillation; Electrocardiography; Screening; Supraventricular tachycardia; Ventricular tachycardia; Wolff-Parkinson-White syndrome

ABBREVIATIONS **AHA** = American Heart Association; **ARVC** = arrhythmogenic right ventricular cardiomyopathy; **ECG** = electrocardiogram; **EPS** = electrophysiologic study; **ESC** = European Society of Cardiology; **HCM** = hypertrophic cardiomyopathy; **LVH** = left ventricular hypertrophy; **MRI** = magnetic resonance imaging; **PVC** = premature ventricular contraction

(Heart Rhythm 2011;8:721–727)

Introduction

Preparticipation athletic screening with electrocardiograms (ECGs) is controversial. Whereas European Society of Cardiology (ESC) guidelines[1] recommend preparticipation ECGs in addition to history and physical in all competitive athletes younger than 35 years, the American Heart Association (AHA)[2,3] in the United States recommends only history and physical without ECG. The rationale for these two recommendations rests on disparate findings regarding cost and yield. One potential reason for this is that the United States is more ethnically diverse and thus may have a different prevalence of any given genetic condition. For example, in Italy, the incidence of arrhythmogenic right ventricular cardiomyopathy (ARVC) appears to be higher than in the United States.[4] The U.S. population has grown more diverse, and few data from the modern era are available on the cost and yield of ECG screening in a U.S.

Presented in part at the Heart Rhythm Society Annual Meeting, Denver, Colorado, May 14, 2010. **Address reprint requests and correspondence:** Dr. Srijoy Mahapatra, P.O. Box 800158, University of Virginia, Charlottesville, Virginia 22908. E-mail address: Srijoysm@gmail.com. (Received November 14, 2010; accepted December 13, 2010.)

1547-5271/$ -see front matter doi:10.1016/j.hrthm.2010.12.024

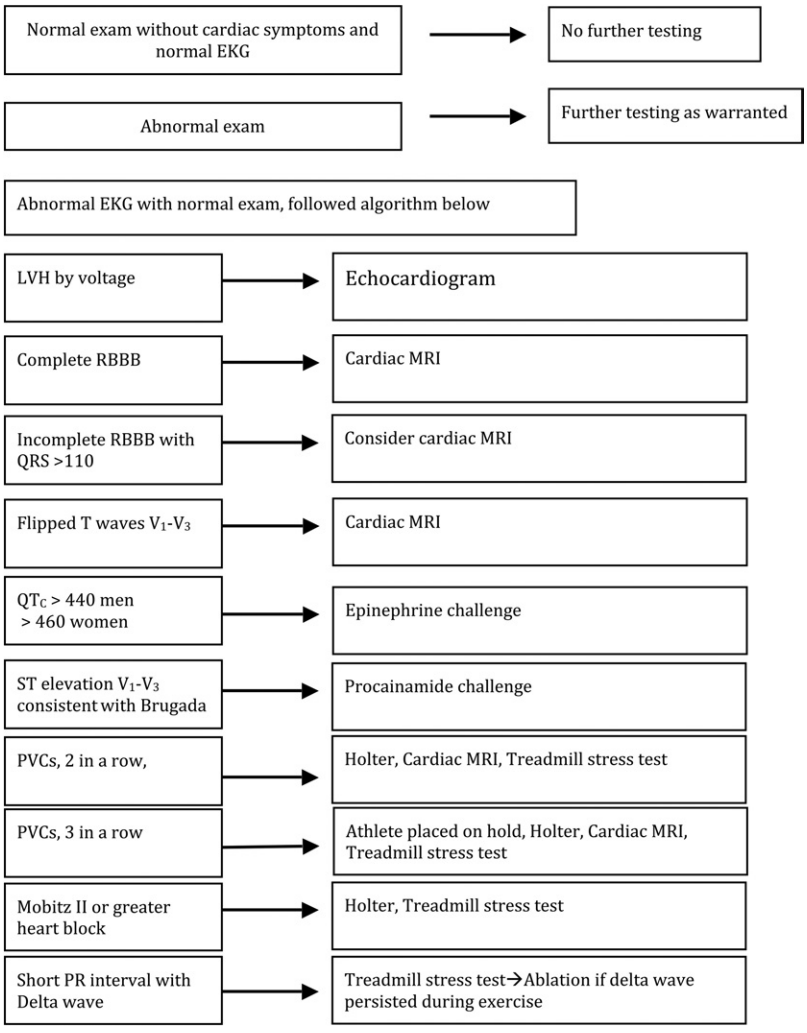

Figure 1 Testing algorithm depicting the electrocardiographic abnormality identified and the subsequent testing performed. LVH = left ventricular hypertrophy; MRI = magnetic resonance imaging; PVC = premature ventricular contraction; RBBB = right bundle branch block.

college population. The few studies that exist include fewer than 600 patients.[5] At the University of Virginia, we have performed ECG screening in all 1,473 competitive athletes since 2005. We report the yield and cost of an ECG screening program in addition to history and physical in a National Collegiate Athletic Association Division I college athlete population, the most elite of the U.S. college athlete divisions.

Methods

From 2005 to 2010, all 1,473 National Collegiate Athletic Association Division I athletes regardless of sport underwent screening with history and physical and with ECG. The screening was a requirement that was disclosed to athletes and their parents prior to the athletes accepting an athletic position at the University of Virginia. The history and physical was performed by a team of physicians, including two internists with input from a cardiologist. Tests including echocardiograms were ordered as dictated by the history and physical.

An ECG was performed and reviewed by an internist and over-read by a cardiac electrophysiologist. A prospectively defined protocol base was used to guide additional testing and athletic restrictions (Figure 1). The protocol directed additional testing, including transthoracic echocardiograms, magnetic resonance imaging (MRI), treadmill stress testing, and drug challenges. Abnormalities were defined as newly found conditions requiring invasive procedures, periodic follow-up testing, or exclusion from athletic participation.

On the screening ECG, left ventricular hypertrophy (LVH) criteria were taken from the ESC recommendations and included an R or S wave in a standard lead >2 mV, S wave in lead V_1 or V_2 >3 mV, or an R wave in V_5 or V_6 $>$ 3 mV.[1] If patients met these criteria, an echocardiogram was performed either at the University of Virginia or by the athlete's local physician to rule out hypertrophic cardiomyopathy (HCM). In order to differentiate HCM from athletic heart, two cardiologists with extensive experience in echocardiography examined echocardiograms to rule out left atrial dilation, abnormal diastolic function, and left ventricular thickness >12 mm.[1] If the patient met none of these criteria and had no history of exercise-induced syncope, the patient was declared not to have HCM. We did not detrain