The Athletes EKG: Pitfalls in Interpretation




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Cardiovascular Performance Program

Financial Disclosures

Affiliations:

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- National Institutes of Health
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- Department of Defense
- National Football League Player’s Association
- American Medical Society for Sports Medicine

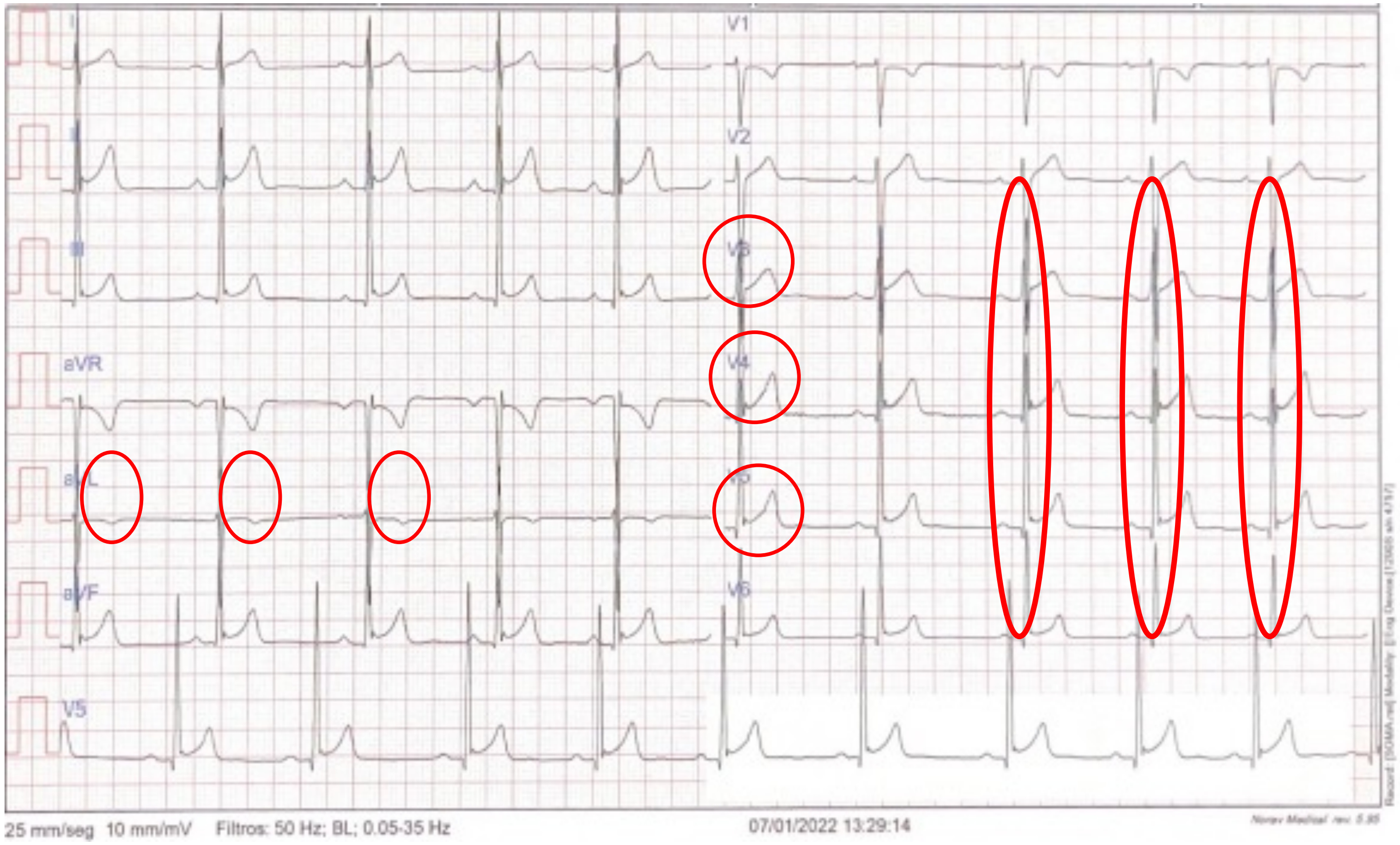
Opening Thoughts

"Hi Dr. Baggish, Dr. X and I just received this ECG and we're concerned about the:"

1. Massive LVH

2. The T-wave inversion in aVL

3. The anteroseptal acute MI pattern



Learning Objectives

Indeed, the "Athlete's ECG" can be dramatic……

Practical Considerations about the 12-lead ECG

✓**Technique** matters, first thing to consider is whether finding is a technical issue

Pre-test probability defines response to findings

ECG's in isolation are of limited value ≠ CLEARANCE

Diagnostic Criteria have been developed to help with this process

Consistency is key and requires repetition and systematic approach

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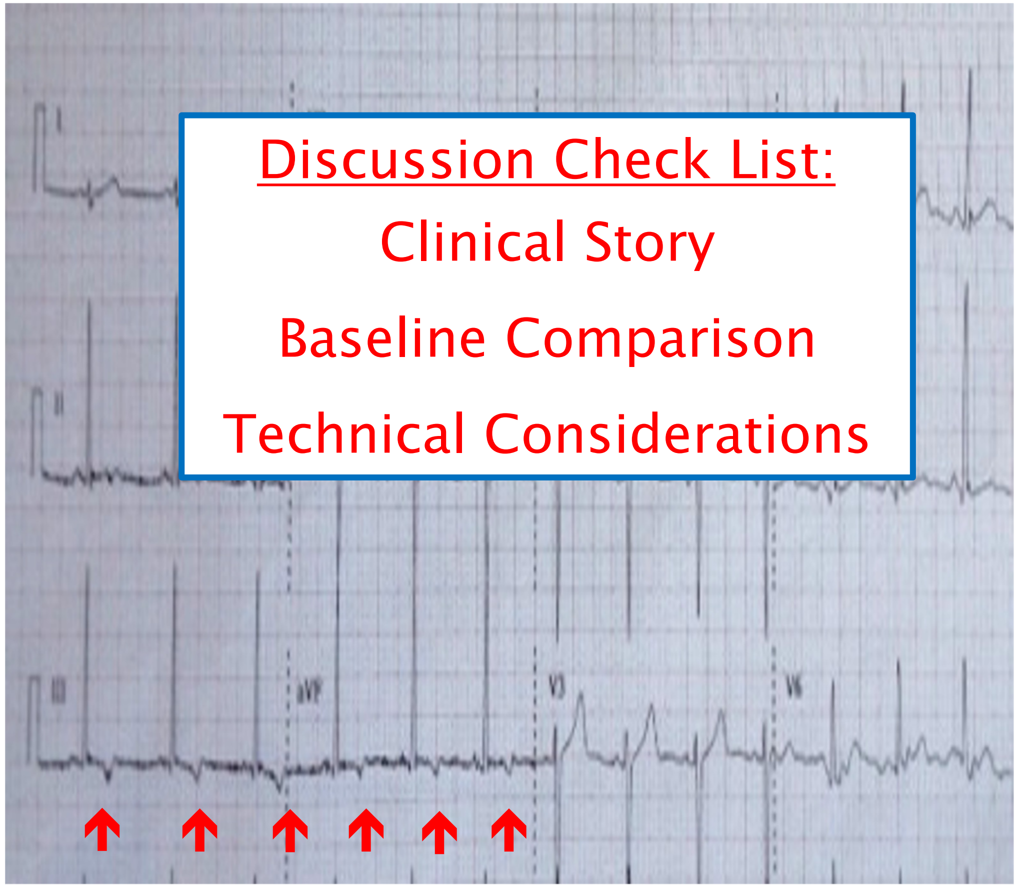
ECG: Technical Considerations

Cardiovascular Performance Program (MGH 1811)

19 y.o.M distance runner with allergies and chest tightness (Training Room #1)

Seated Tracing



Discussion Check List:

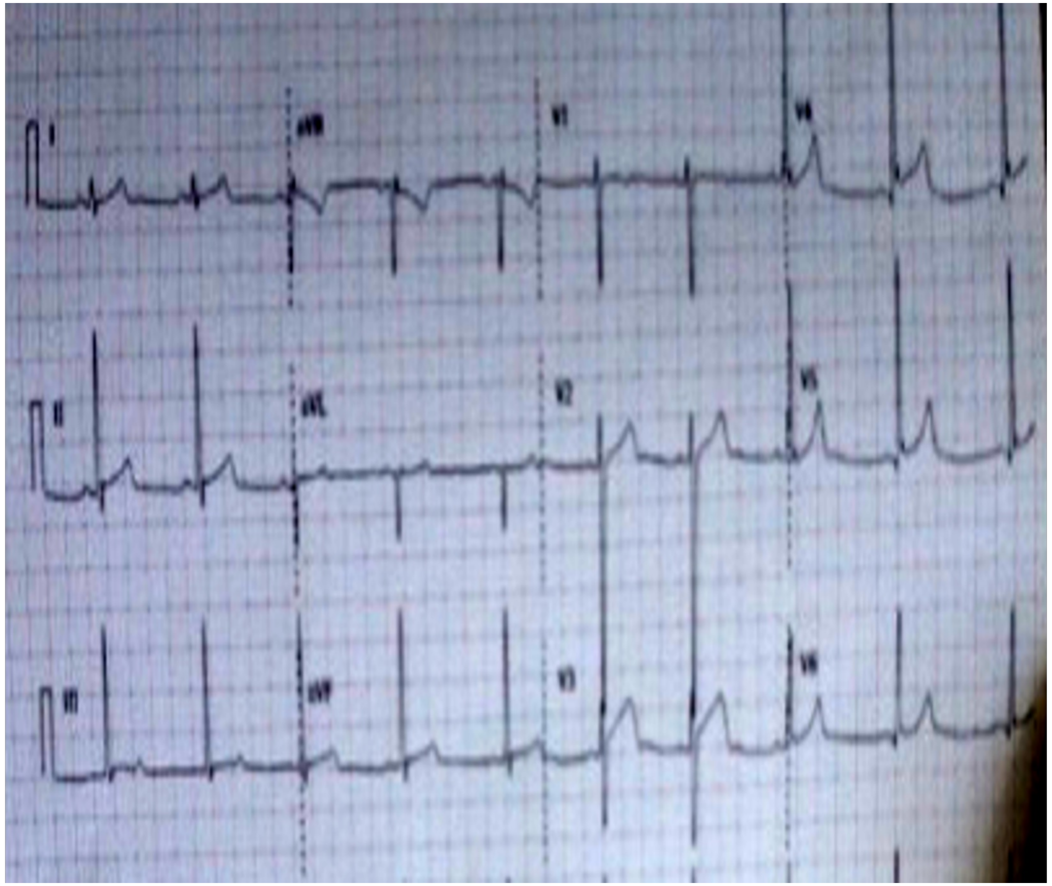
Clinical Story

Baseline Comparison

Technical Considerations

19 y.o.M distance runner with allergies and chest tightness (Training Room #2)

Supine Tracing

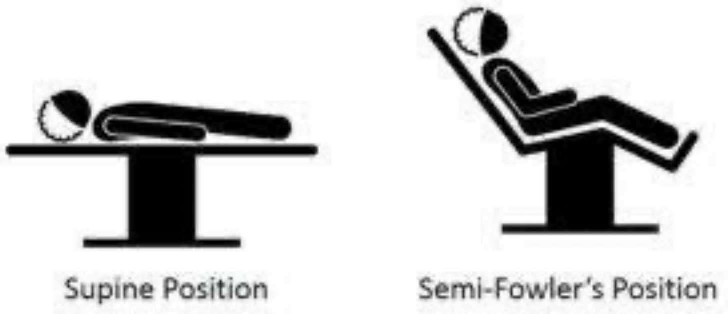


ECG: Technical Considerations

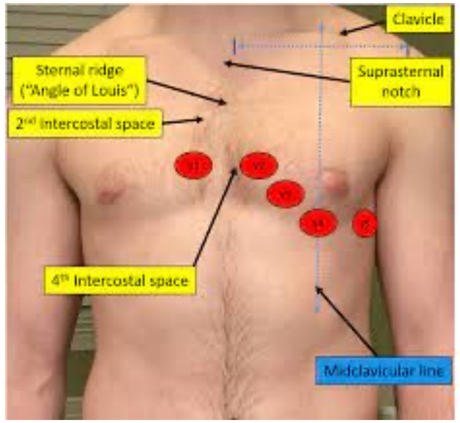
Resting Physiology

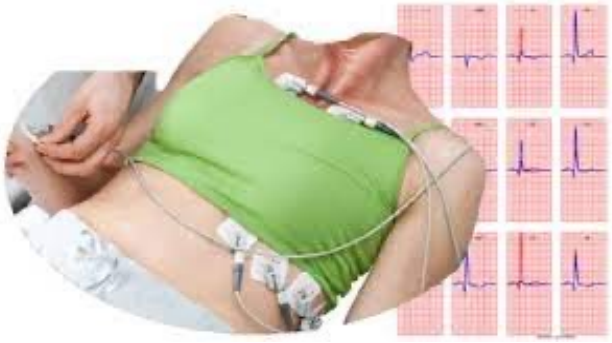
Baseline Comparator

Patient Position



Lead Placement





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MGH 1811 Cardiovascular Performance Program

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Pre-participation Screening

Cardiovascular Performance Program


WORLD ATHLETICS.

World Athletics
Health Promotion Policy Paper

April 2021

1. Personal history

- Syncope or near-syncope
- Exertional chest pain or discomfort
- Shortness of breath or fatigue out of proportion to the degree of physical effort
- Palpitations or irregular heartbeat

Resting symptoms have low specificity of pathology

The majority of “yes” response do not indicate true disease (low specificity)

Real-time follow-up determine need for further evaluation

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Pre-participation Screening

Cardiovascular Performance Program (MGH 1811)

1. Personal history

- Syncope or near-syncope

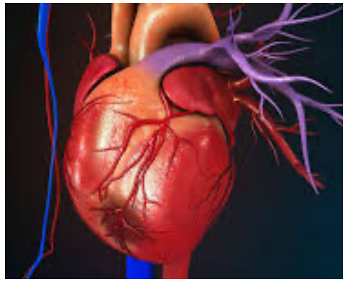
vs.

Neurally-Mediated (Rest ~10%)
Post-Exercise Collapse (2-5%)

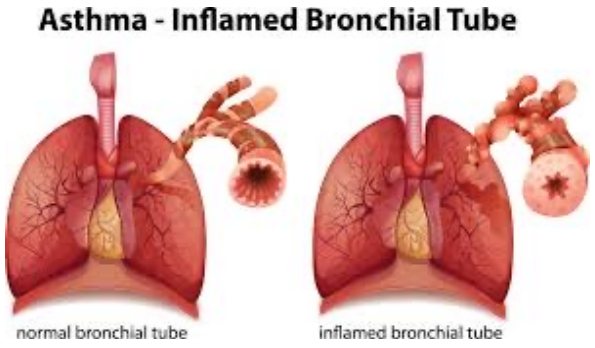
Arrhythmogenic
Syncope

- Exertional chest pain or discomfort

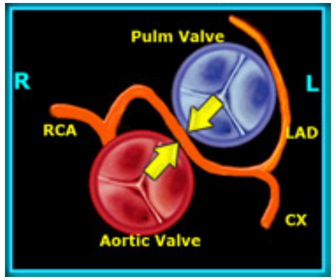
vs.



- Shortness of breath or fatigue out of proportion to the degree of physical effort



vs.



- Palpitations or irregular heartbeat

vs.

If you know and practice the nuanced follow-up, the specificity of H&P improves

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Pre-participation Screening

Cardiovascular Performance Program
MGH 1811

2. Family history

- Family history of one or more relatives with disability or death of heart disease (sudden/ unexpected) before age 50
- Family history of cardiomyopathy, coronary artery disease, Marfan syndrome, long QT syndrome, severe arrhythmias, or other disabling cardiovascular disease.

A good family history is worth it's weight in gold!
Take the time to do it well…

<u>Ask about:</u> unexplained drownings & car crashes, sport restriction, early life ICDs

<u>Use the names of the common diseases:</u>
HCM, AVC, Long QT Syndrome, Aortic Dissection, etc.

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The ECG in Isolation

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February 2014

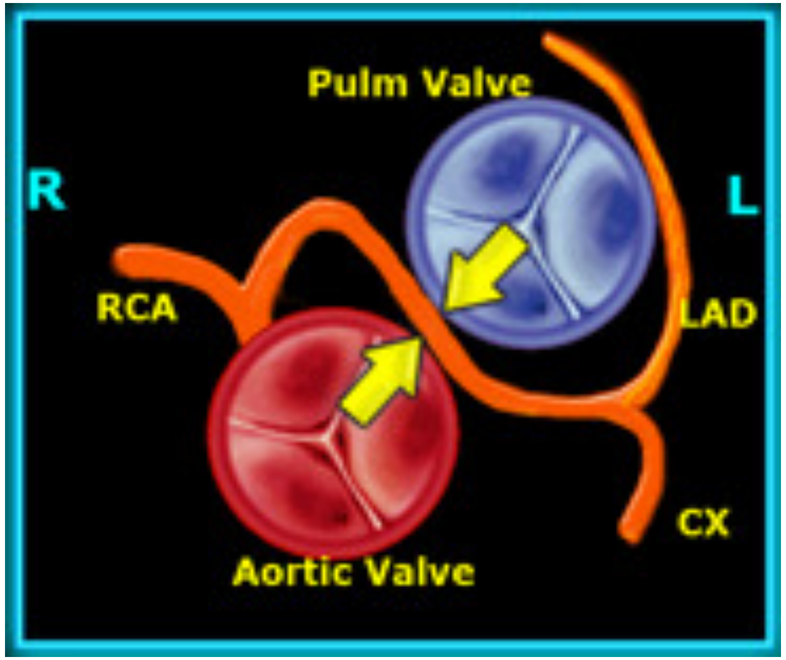
Sudden Cardiac Death

50K - Craftsbury VT

Elite Level Competitor

Long Standing Med-Refractory Asthma

Normal Screening ECG



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ECG Criteria: *The Evolution*

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Criteria (O.E.D.): A list of principles or standards by which something may be judged or decided

-Ubiquitous in medicine & science….**Appropriate Use** Criteria (A.U.C.)

-Provide **standardization** across time, space, and level of expertise

-**Starting point** for diagnostic decision making

-They are imperfect and only as good as the **data** & **experience** that generate them

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ECG Criteria: *The Evolution*

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ABSTRACT

Background For more than 20 years in Italy, young athletes have been screened before participating in competitive sports. We assessed whether this strategy results in the prevention of sudden death from hypertrophic cardiomyopathy, a common cardiovascular cause of death in young athletes.

Methods We prospectively studied sudden deaths among athletes and nonathletes (35 years of age or less) in the Veneto region of Italy from 1979 to 1996. The causes of sudden death in both populations were compared, and the pathological findings in the athletes were related to their clinical histories and electrocardiograms. Cardiovascular reasons for disqualification from participation in sports were investigated and follow-up was performed in a consecutive series of 33,735 young athletes who underwent preparticipation screening in Padua, Italy, during the same period.

Results Of 269 sudden deaths in young people, 49 occurred in competitive athletes (44 male and 5 female athletes; mean [±SD] age, 23±7 years). The most common causes of sudden death in athletes were arrhythmogenic right ventricular cardiomyopathy (22.4 percent), coronary atherosclerosis (18.4 percent), and anomalous origin of a coronary artery (12.2 percent). Hypertrophic cardiomyopathy caused only 1 sudden death among the athletes (2.0 percent) but caused 16 sudden deaths in the nonathletes (7.3 percent). Hypertrophic cardiomyopathy was detected in 22 athletes (0.07 percent) at preparticipation screening and accounted for 3.5 percent of the cardiovascular reasons for disqualification. None of the disqualified athletes with hypertrophic cardiomyopathy died during a mean follow-up period of 8.2±5 years.

Conclusions The results show that hypertrophic cardiomyopathy was an uncommon cause of death in these young competitive athletes and suggest that the identification and disqualification of affected athletes at screening before participation in competitive sports may have prevented sudden death. (N Engl J Med 1998;339:364-9.)

The New England Journal of Medicine

(N Engl J Med 1998;339:364-9.)

SCREENING FOR HYPERTROPHIC CARDIOMYOPATHY IN YOUNG ATHLETES

DOMENICO CORRADO, M.D., CRISTINA BASSO, M.D., MAURIZIO SCHIAVON, M.D., AND GAETANO THIENE, M.D.

TABLE 4. CARDIOVASCULAR CONDITIONS CAUSING DISQUALIFICATION FROM COMPETITIVE SPORTS IN 621 ATHLETES IN PADUA, 1979 TO 1996.

CONDITION	NO. (%)
Rhythm and conduction abnormalities	238 (38.3)
Systemic hypertension	168 (27.1)
Valvular diseases (including mitral-valve prolapse)	133 (21.4)
Hypertrophic cardiomyopathy	22 (3.5)
Others	60 (9.7)

TABLE 1. CRITERIA FOR A POSITIVE 12-LEAD ELECTROCARDIOGRAM.*

P wave

Left atrial enlargement: negative portion of the P wave in lead $V_1 \geq 0.1$ mV in depth and ≥ 0.04 sec in duration

Right atrial enlargement: peaked P wave in leads II and III or $V_1 \geq 0.25$ mV in amplitude

QRS complex

Frontal-plane axis deviation: right $\geq +120$ degrees or left -30 degrees to -90 degrees

Increased voltage: amplitude of R or S wave in a standard lead ≥ 2 mV, S wave in lead V_1 or $V_2 \geq 3$ mV, or R wave in lead V_5 or $V_6 \geq 3$ mV

Abnormal Q waves ≥ 0.04 sec in duration or ≥ 25 percent of the height of the ensuing R wave, or QS pattern in two or more leads

Right or left bundle-branch block with QRS duration ≥ 0.12 sec

R or R′ wave in lead $V_1 \geq 0.5$ mV in amplitude and R:S ratio ≥ 1

ST segment, T waves, and QT interval

ST-segment depression or T-wave flattening or inversion in two or more leads

Prolongation of QT interval corrected for the heart rate >0.44 sec

Rhythm and conduction abnormalities

Premature ventricular beats or more severe ventricular arrhythmia

Supraventricular tachycardia, atrial flutter, or atrial fibrillation

Short PR interval (<0.12 sec) with or without delta wave

Sinus bradycardia with resting heart rate ≤ 40 beats per minute and increasing to <100 beats per minute during limited exercise testing

First-degree (PR ≥ 0.21 sec, not shortening with hyperventilation or limited exercise testing), second-degree, or third-degree atrioventricular block

*The criteria are from Friedman,[17] Romhilt and Estes,[18] Morris et al.,[19] and Savage et al.[20]

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ECG Criteria: *The Evolution*

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ESC Report

Cardiovascular pre-participation screening of young competitive athletes for prevention of sudden death: proposal for a common European protocol

Consensus Statement of the Study Group of Sport Cardiology of the Working Group of Cardiac Rehabilitation and Exercise Physiology and the Working Group of Myocardial and Pericardial Diseases of the European Society of Cardiology

Domenico Corrado[1]*, Antonio Pelliccia[2], Hans Halvor Bjørnstad[3], Luc Vanhees[4], Alessandro Biffi[2], Mats Borjesson[5], Nicole Panhuyzen-Goedkoop[6], Asterios Deligiannis[7], Erik Solberg[8], Dorian Dugmore[9], Klaus P. Mellwig[10], Deodato Assanelli[11], Pietro Delise[12], Frank van-Buuren[10], Aris Anastasakis[13], Hein Heidbuchel[4], Ellen Hoffmann[14], Robert Fagard[4], Silvia G. Priori[15], Cristina Basso[19], Eloisa Arbustini[16], Carina Blomstrom-Lundqvist[17], William J. McKenna[18], and Gaetano Thiene[19]

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[5] *Department of Medicine, Sahlgrens University Hospital/Östra, Gothenburg, Sweden*
[6] *Department of Cardiology, Radboud University, Nijmegen, The Netherlands*
[7] *Sports Medicine, Aristotle University, Thessaloniki, Greece*
[8] *Klinikk Ullevål Sykehus, Oslo, Norway*
[9] *Wellness Medical Center, Stockport, UK*
[10] *Heart Center NRW, University Hospital, Bad Oeynhausen, Germany*
[11] *Department of Cardiology, University of Brescia, Italy*
[12] *Civil Hospital, Conegliano, Italy*
[13] *Division of Inherited Cardiovascular Diseases, University of Athens, Greece*
[14] *Department of Cardiology, University Hospital, Munich, Germany*
[15] *Molecular Cardiology, Fondazione S. Maugeri, Pavia, Italy*
[16] *Pathological Anatomy, University of Pavia, Italy*
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[19] *Pathological Anatomy, University of Padova, Italy*

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See page 428 for the editorial comment on this article (doi:10.1093/eurheartj/ehi154)

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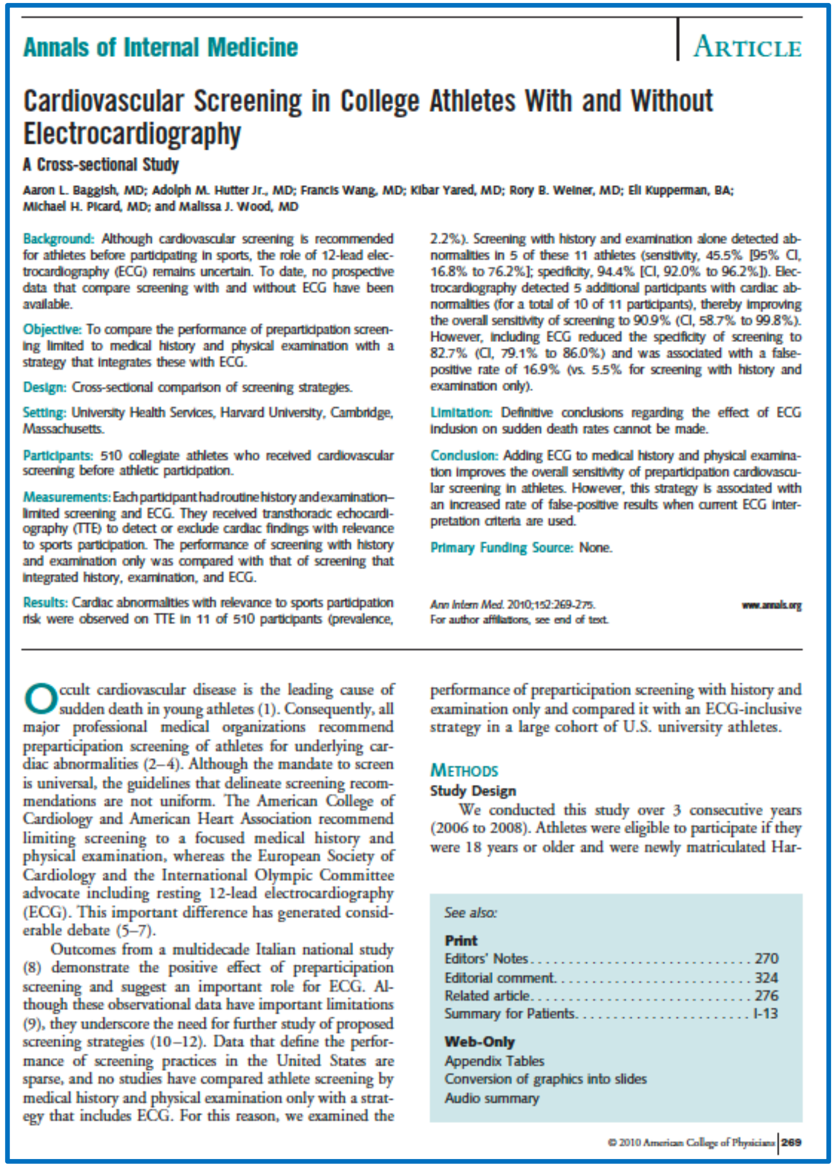
potential of preventing fatal events. The main purpose of the consensus document is to reinforce the principle of the need for pre-participation medical clearance of all young athletes involved in organized sports programmes, on the basis of (i) the proven efficacy of systematic screening by 12-lead ECG (in addition to history and physical examination) to identify hypertrophic cardiomyopathy—the leading cause of sports-related sudden death—and to prevent athletic field fatalities; (ii) the potential screening ability in detecting other lethal cardiovascular diseases presenting with ECG abnormalities. The consensus document recommends the implementation of a common European screening protocol essentially based on 12-lead ECG.

Table 3 Criteria for a positive 12-lead ECG

P wave
left atrial enlargement: negative portion of the P wave in lead V1 ≥ 0.1 mV in depth and ≥0.04 s in duration;
right atrial enlargement: peaked P wave in leads II and III or V1 ≥ 0.25 mV in amplitude.
QRS complex
frontal plane axis deviation: right ≥ + 120° or left −30° to −90°;
increased voltage: amplitude of R or S wave in in a standard lead ≥2 mV, S wave in lead V1 or V2 ≥ 3 mV, or R wave in lead V5 or V6 ≥ 3 mV;
abnormal Q waves ≥0.04 s in duration or ≥25% of the height of the ensuing R wave or QS pattern in two or more leads;
right or left bundle branch block with QRS duration ≥0.12 s;
R or R' wave in lead V1 ≥ 0.5 mV in amplitude and R/S ratio ≥1.
ST-segment, T-waves, and QT interval
ST-segment depression or T-wave flattening or inversion in two or more leads;
prolongation of heart rate corrected QT interval >0.44 s in males and >0.46 s in females.
Rhythm and conduction abnormalities
premature ventricular beats or more severe ventricular arrhythmias;
supraventricular tachycardias, atrial flutter, or atrial fibrillation;
short PR interval (<0.12 s) with or without 'delta' wave;
sinus bradycardia with resting heart rate ≤40 beats/min[a];
first (PR ≥ 0.21 s[b]), second or third degree atrioventricular block.

[a]Increasing less than 100 beats/min during limited exercise test.
[b]Not shortening with hyperventilation or limited exercise test.
Modified from Corrado *et al.*[3]

ECG Criteria: *The Evolution*


Annals of Internal Medicine | Article

Cardiovascular Screening in College Athletes With and Without Electrocardiography

A Cross-sectional Study

Aaron L. Baggish, MD; Adolph M. Hutter Jr., MD; Francis Wang, MD; Kibar Yared, MD; Rory B. Weiner, MD; Eli Kupperman, BA; Michael H. Picard, MD; and Malissa J. Wood, MD

Background: Although cardiovascular screening is recommended for athletes before participating in sports, the role of 12-lead electrocardiography (ECG) remains uncertain. To date, no prospective data that compare screening with and without ECG have been available.

Objective: To compare the performance of preparticipation screening limited to medical history and physical examination with a strategy that integrates these with ECG.

Design: Cross-sectional comparison of screening strategies.

Setting: University Health Services, Harvard University, Cambridge, Massachusetts.

Participants: 510 collegiate athletes who received cardiovascular screening before athletic participation.

Measurements: Each participant had routine history and examination–limited screening and ECG. They received transthoracic echocardiography (TTE) to detect or exclude cardiac findings with relevance to sports participation. The performance of screening with history and examination only was compared with that of screening that integrated history, examination, and ECG.

Results: Cardiac abnormalities with relevance to sports participation risk were observed on TTE in 11 of 510 participants (prevalence, 2.2%). Screening with history and examination alone detected abnormalities in 5 of these 11 athletes (sensitivity, 45.5% [95% CI, 16.8% to 76.2%]; specificity, 94.4% [CI, 92.0% to 96.2%]). Electrocardiography detected 5 additional participants with cardiac abnormalities (for a total of 10 of 11 participants), thereby improving the overall sensitivity of screening to 90.9% (CI, 58.7% to 99.8%). However, including ECG reduced the specificity of screening to 82.7% (CI, 79.1% to 86.0%) and was associated with a false-positive rate of 16.9% (vs. 5.5% for screening with history and examination only).

Limitation: Definitive conclusions regarding the effect of ECG inclusion on sudden death rates cannot be made.

Conclusion: Adding ECG to medical history and physical examination improves the overall sensitivity of preparticipation cardiovascular screening in athletes. However, this strategy is associated with an increased rate of false-positive results when current ECG interpretation criteria are used.

Primary Funding Source: None.

Ann Intern Med. 2010;152:269-275. www.annals.org
For author affiliations, see end of text.

Occult cardiovascular disease is the leading cause of sudden death in young athletes (1). Consequently, all major professional medical organizations recommend preparticipation screening of athletes for underlying cardiac abnormalities (2–4). Although the mandate to screen is universal, the guidelines that delineate screening recommendations are not uniform. The American College of Cardiology and American Heart Association recommend limiting screening to a focused medical history and physical examination, whereas the European Society of Cardiology and the International Olympic Committee advocate including resting 12-lead electrocardiography (ECG). This important difference has generated considerable debate (5–7).

Outcomes from a multidecade Italian national study (8) demonstrate the positive effect of preparticipation screening and suggest an important role for ECG. Although these observational data have important limitations (9), they underscore the need for further study of proposed screening strategies (10–12). Data that define the performance of screening practices in the United States are sparse, and no studies have compared athlete screening by medical history and physical examination only with a strategy that includes ECG. For this reason, we examined the performance of preparticipation screening with history and examination only and compared it with an ECG-inclusive strategy in a large cohort of U.S. university athletes.

Methods

Study Design

We conducted this study over 3 consecutive years (2006 to 2008). Athletes were eligible to participate if they were 18 years or older and were newly matriculated Har-

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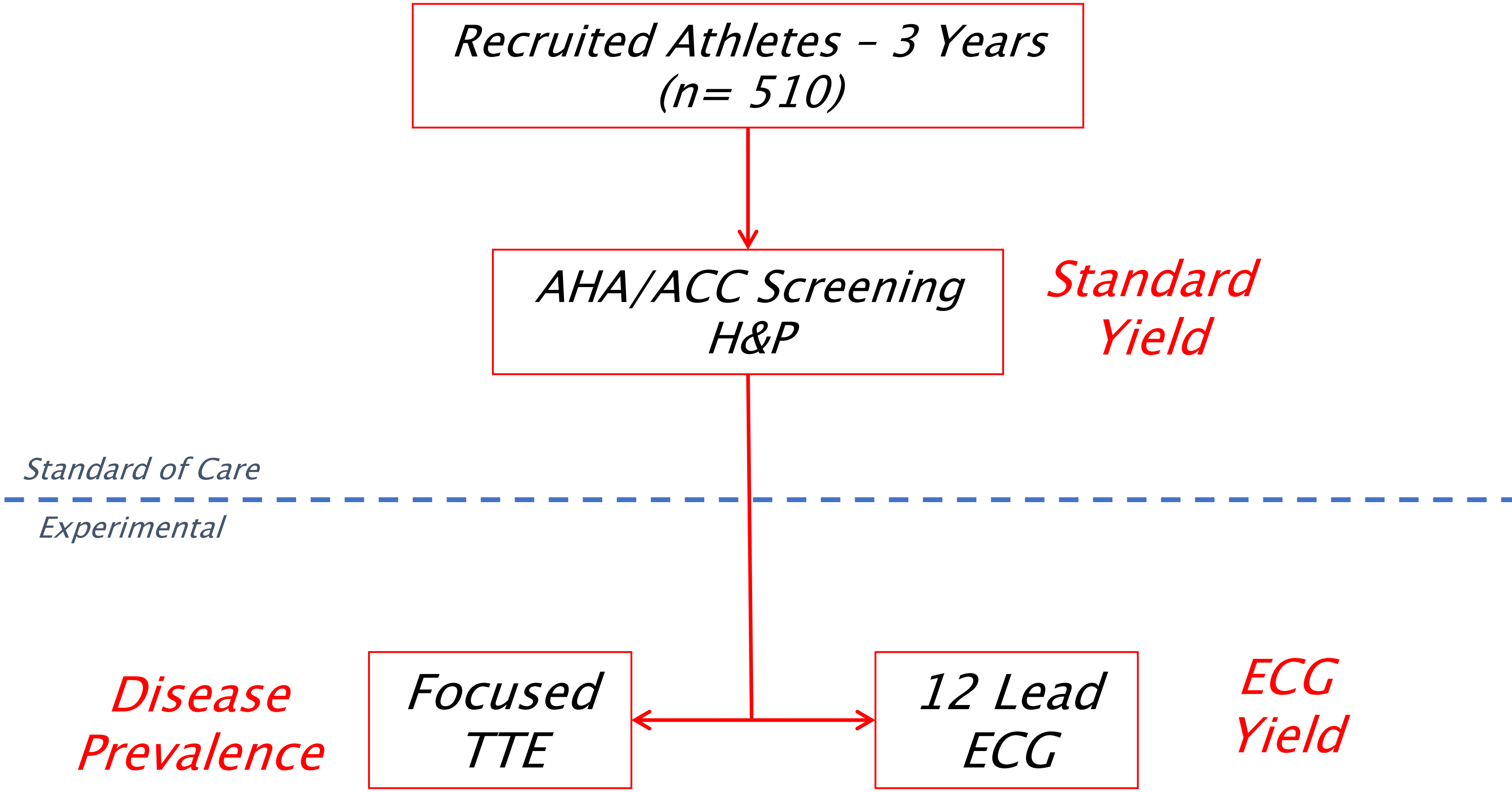
Harvard Athlete Initiative (2007-2009):
Studying Screening



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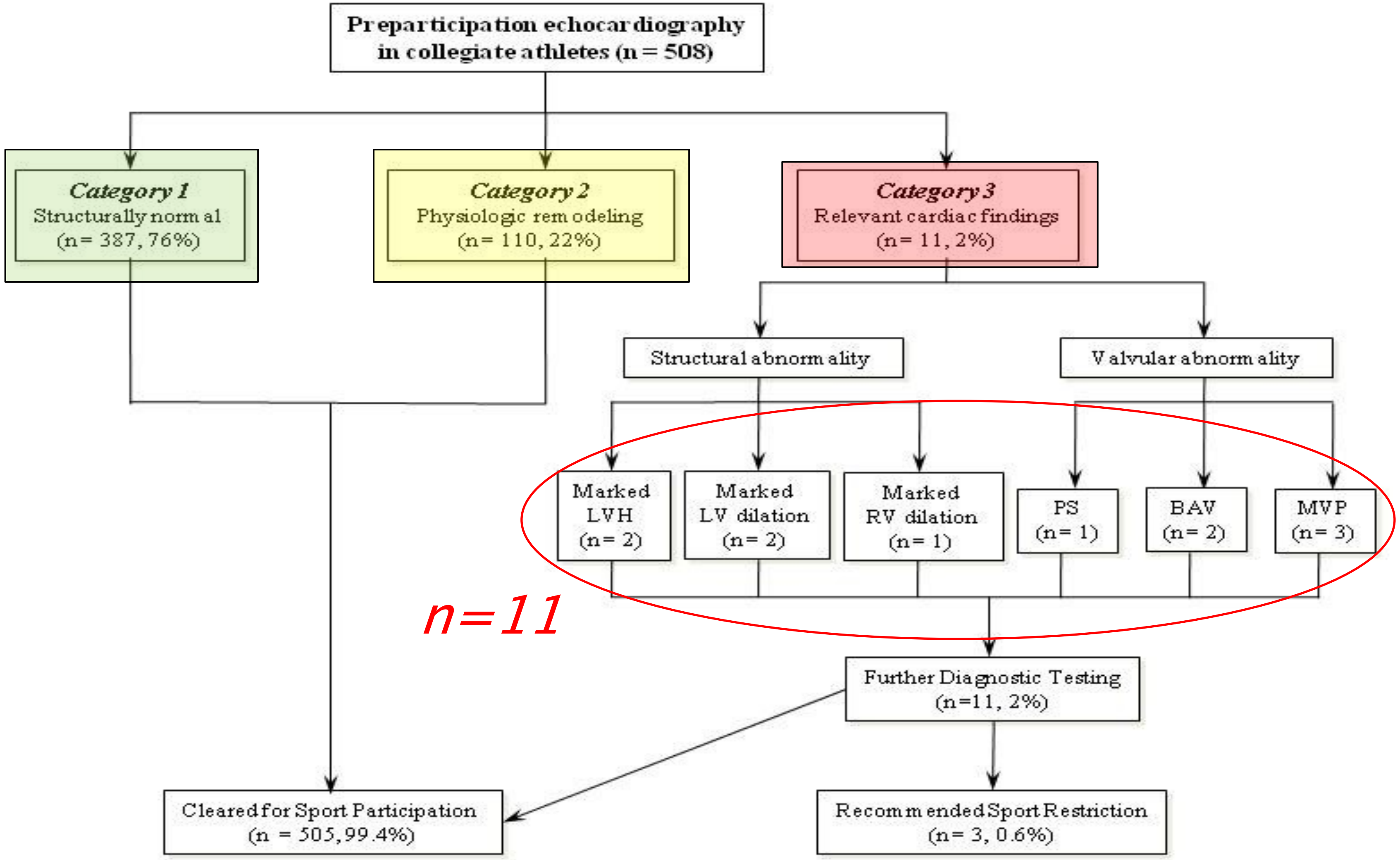

Annals of Internal Medicine, 152:269-275

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ECG Criteria: *The Evolution*

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False Positive Rate of 16.4%

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Appendix Tables
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Athlete	TTE Abnormality	MH/PE Finding	ECG Finding	Final Diagnosis Requiring Sport Participation Restriction
1	Bicuspid AoV			*None*
2	Bicuspid AoV			*None*
				None
				None
				None
				…derate pulmonic stenosis
				None
				…ertrophic cardiomyopathy
				None
				Post-viral myocarditis
11	RV dilation			*None*

Screening Strategy	
MH / PE	
MH/ PE + ECG	

Annals of Internal Medicine, 152:269–275

ECG Criteria: *The Evolution*

European Heart Journal (2010) 31, 243–259
doi:10.1093/eurheartj/ehp473

ESC REPORT

Recommendations for interpretation of 12-lead electrocardiogram in the athlete

Domenico Corrado[1*], Antonio Pelliccia[2], Hein Heidbuchel[3], Sanjay Sharma[4], Mark Link[5], Cristina Basso[6], Alessandro Biffi[2], Gianfranco Buja[1], Pietro Delise[7], Ihor Gussac[8], Aris Anastasakis[9], Mats Borjesson[10], Hans Halvor Bjørnstad[11], François Carrè[12], Asterios Deligiannis[13], Dorian Dugmore[14], Robert Fagard[3], Jan Hoogsteen[15], Klaus P. Mellwig[16], Nicole Panhuyzen-Goedkoop[17], Erik Solberg[18], Luc Vanhees[3], Jonathan Drezner[19], N.A. Mark Estes, III[5], Sabino Iliceto[1], Barry J. Maron[20], Roberto Peidro[21], Peter J. Schwartz[22], Ricardo Stein[23], Gaetano Thiene[6], Paolo Zeppilli[24], and William J. McKenna[25] on behalf of the Sections of Sports Cardiology of the European Association of Cardiovascular Prevention and Rehabilitation; and the Working Group of Myocardial and Pericardial Disease of the European Society of Cardiology

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Cardiovascular remodelling in the conditioned athlete is frequently associated with physiological ECG changes. Abnormalities, however, may be detected which represent expression of an underlying heart disease that puts the athlete at risk of arrhythmic cardiac arrest during sports. It is mandatory that ECG changes resulting from intensive physical training are distinguished from abnormalities which reflect a potential cardiac pathology. The present article represents the consensus statement of an international panel of cardiologists and sports medical physicians with expertise in the fields of electrocardiography, imaging, inherited cardiovascular disease, cardiovascular pathology, and management of young competitive athletes. The document provides cardiologists and sports medical physicians with a modern approach to correct interpretation of 12-lead ECG in the athlete and emerging understanding of incomplete penetrance of inherited cardiovascular disease. When the ECG of an athlete is examined, the main objective is to distinguish between physiological patterns that should cause no alarm and those that require action and/or additional testing to exclude (or confirm) the suspicion of an underlying cardiovascular condition carrying the risk of sudden death during sports. The aim of the present position paper is to provide a framework for this distinction. For every ECG abnormality, the document focuses on the ensuing clinical work-up required for differential diagnosis and clinical assessment. When appropriate the referral options for risk stratification and cardiovascular management of the athlete are briefly addressed.

Keywords Athlete's heart • Cardiomyopathy • Electrocardiogram • Ion-channel disease • Sudden death • Ventricular fibrillation • Ventricular tachycardia

Table I Classification of abnormalities of the athlete's electrocardiogram

Group 1: common and training-related ECG changes	Group 2: uncommon and training-unrelated ECG changes
Sinus bradycardia	T-wave inversion
First-degree AV block	ST-segment depression
Incomplete RBBB	Pathological Q-waves
Early repolarization	Left atrial enlargement
Isolated QRS voltage criteria for left ventricular hypertrophy	Left-axis deviation/left anterior hemiblock
	Right-axis deviation/left posterior hemiblock
	Right ventricular hypertrophy
	Ventricular pre-excitation
	Complete LBBB or RBBB
	Long- or short-QT interval
	Brugada-like early repolarization

RBBB, right bundle branch block; LBBB, left bundle branch block.

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ECG Criteria: *The Evolution*

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Performance of the 2010 European Society of Cardiology criteria for ECG interpretation in the athlete

Rory B Weiner,[1] Adolph M Hutter,[1] Francis Wang,[2] Jonathan H Kim,[1] Malissa J Wood,[1] Thomas J Wang,[1] Michael H Picard,[1] Aaron L Baggish[1]

2005 Criteria:

*False Pos. Rate = **16.4%***

Screening Strategy	Sensitivity	Specificity	PPV	NPV
MH / PE	45.5 (18.1,75.4)	94.4 (91.9,96.2)	15.0 (5.7,32.7)	98.7 (97.1 , 99.5)
MH/ PE + ECG	90.9 (57.1,99.5)	82.7 (79.0,85.9)	10.4 (5.4,18.7)	99.8 (98.4 , 100.0)

2010 Criteria:

*False Pos. Rate = **8.6%***

Screening Strategy	Sensitivity	Specificity	PPV	NPV
MH / PE	45.5 (18.1,75.4)	94.4 (91.9,96.2)	15.0 (5.7,32.7)	98.7 (97.1 , 99.5)
MH/ PE + ECG	90.9 (57.1,99.5)	91.3 (88.7,95.9)	6.5 (5.4,18.7)	100.0 (100.0 , 100.0)

Weiner et al. Heart 2010

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ECG Criteria: *The Evolution*

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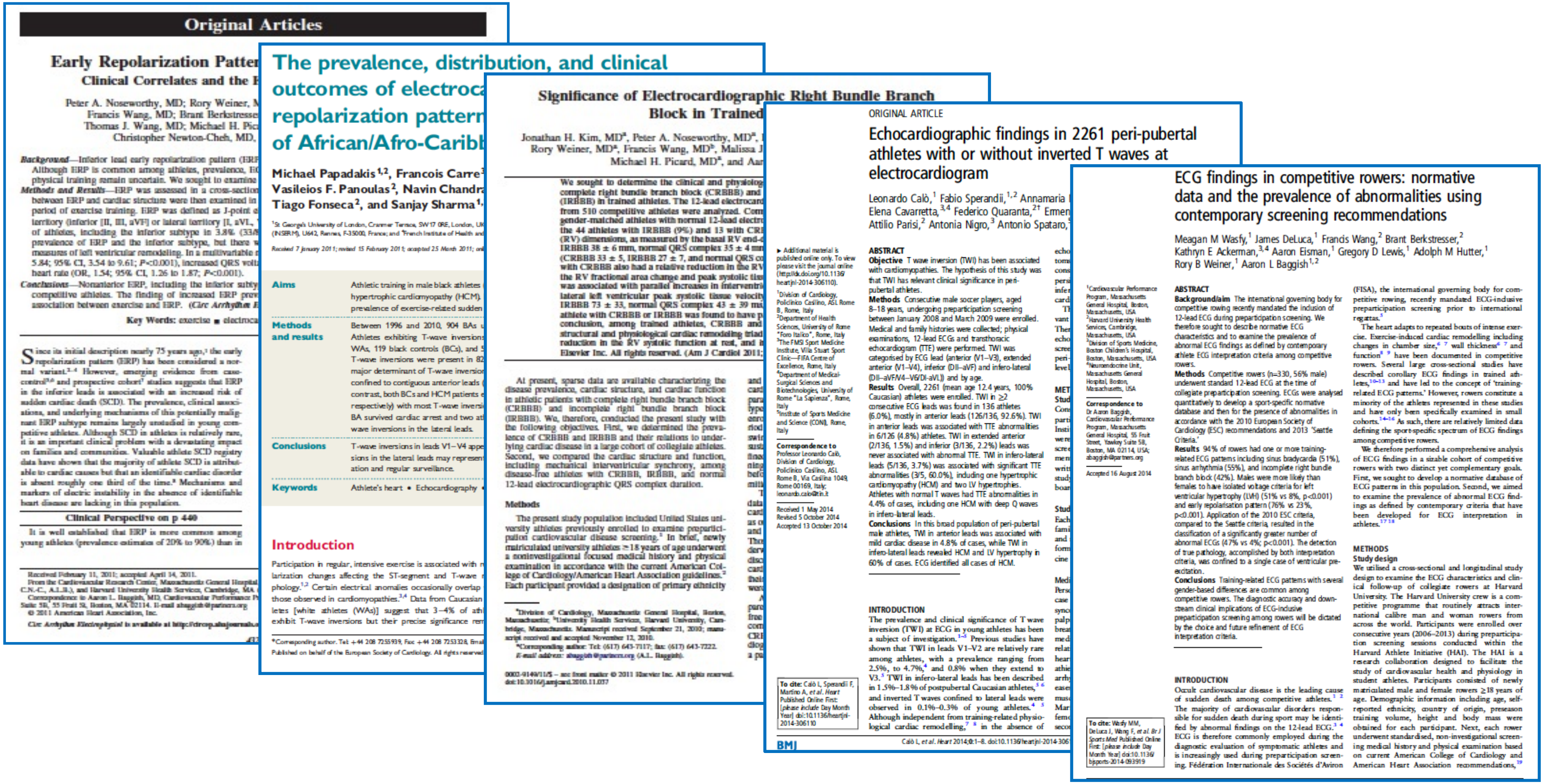
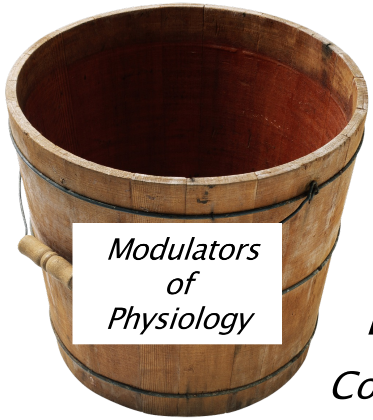


ECG Criteria: *The Evolution*

February 2012

AMSSM / F-MARC / ESC / PACES

Identify Key Sources of ECG Variability



Age

Gender

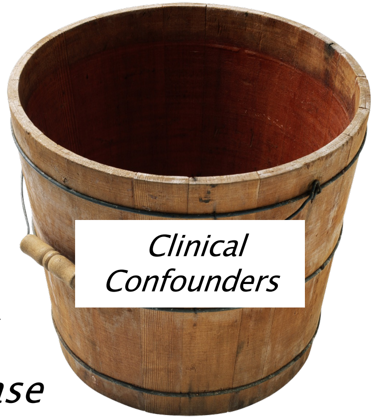
Ethnicity

Sport-type

Med / PEDs

Duration of play

Concomitant disease



Vs.

Population Focus
Maximal Sensitivity at the Expense of Outliers
Conservative & Safe
High False + Testing Rates

Patient Focus
Maximal Specificity at the Risk of Under diagnosis
? Cavalier
High False – Testing

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Pre-participation Screening

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International Recommendations for Electrocardiographic Interpretation in Athletes

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ABSTRACT

Sudden cardiac death (SCD) is the leading cause of mortality in athletes during sport. A variety of mostly hereditary, structural, or electrical cardiac disorders are associated with SCD in young athletes, the majority of which can be identified or suggested by abnormalities on a resting 12-lead electrocardiogram (ECG). Whether used for diagnostic or screening purposes, physicians responsible for the cardiovascular care of athletes should be knowledgeable and competent in ECG interpretation in athletes. However, in most countries a shortage of physician expertise limits wider application of the ECG in the care of the athlete. A critical need exists for physician education in modern ECG interpretation that distinguishes normal physiological adaptations in athletes from distinctly abnormal findings suggestive of underlying pathology. Since the original 2010 European Society of Cardiology recommendations for ECG interpretation in athletes, ECG standards have evolved quickly over the last decade; pushed by a growing body of scientific data that both tests proposed criteria sets and establishes new evidence to guide refinements. On February 26-27, 2015, an international group of experts in sports cardiology, inherited cardiac disease, and sports medicine convened in Seattle, Washington, to update contemporary standards for ECG interpretation in athletes. The objective of the meeting was to define and revise ECG interpretation standards based on new and emerging research and to develop a clear guide to the proper evaluation of ECG abnormalities in athletes. This statement represents an international consensus for ECG interpretation in athletes and provides expert opinion-based recommendations linking specific ECG abnormalities and the secondary evaluation for conditions associated with SCD. (J Am Coll Cardiol 2017;69:1057-75) © 2017 The Authors. Published by Elsevier Inc. on behalf of American College of Cardiology Foundation. All rights reserved.

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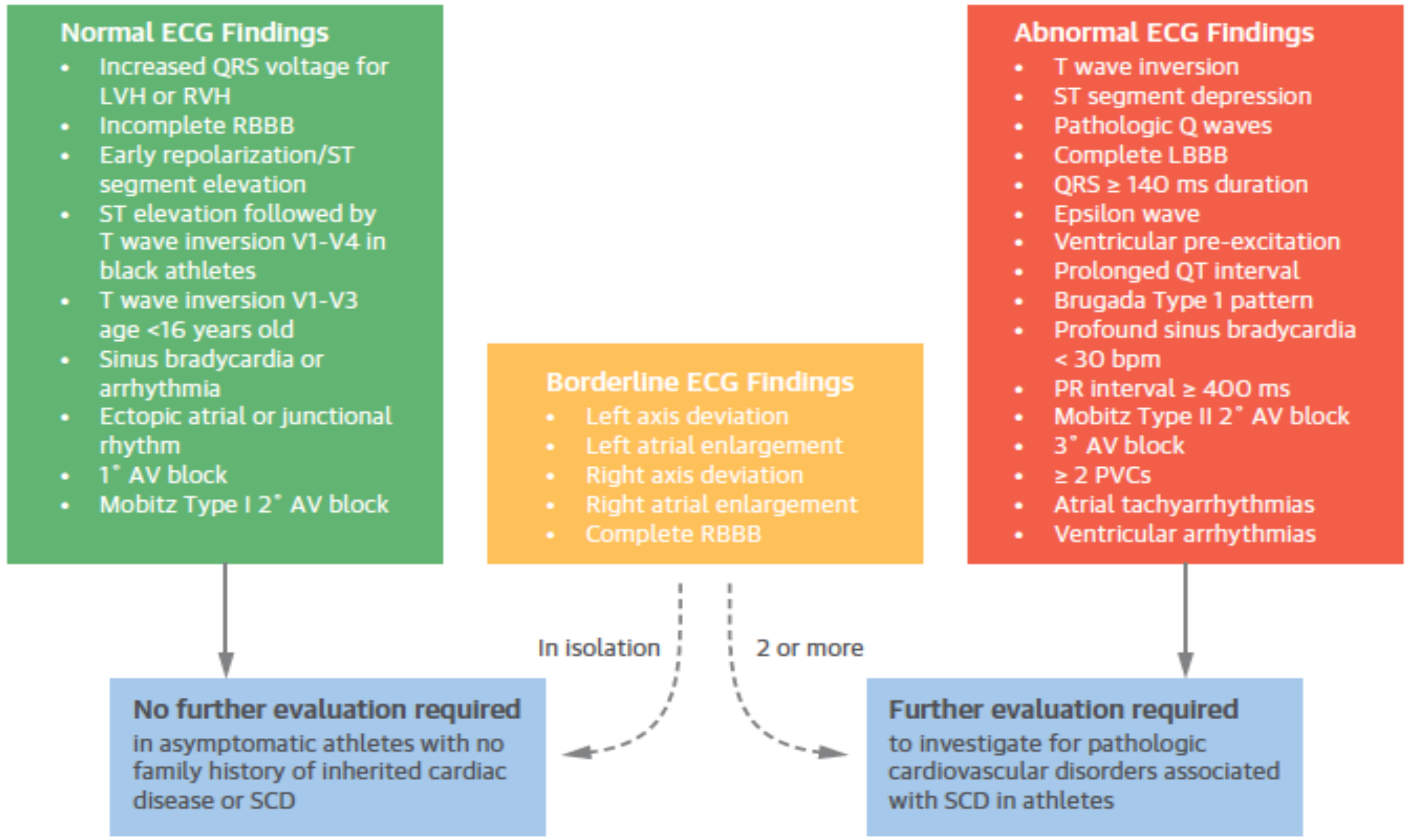
FIGURE 1 International Consensus Standards for Electrocardiographic Interpretation in Athletes



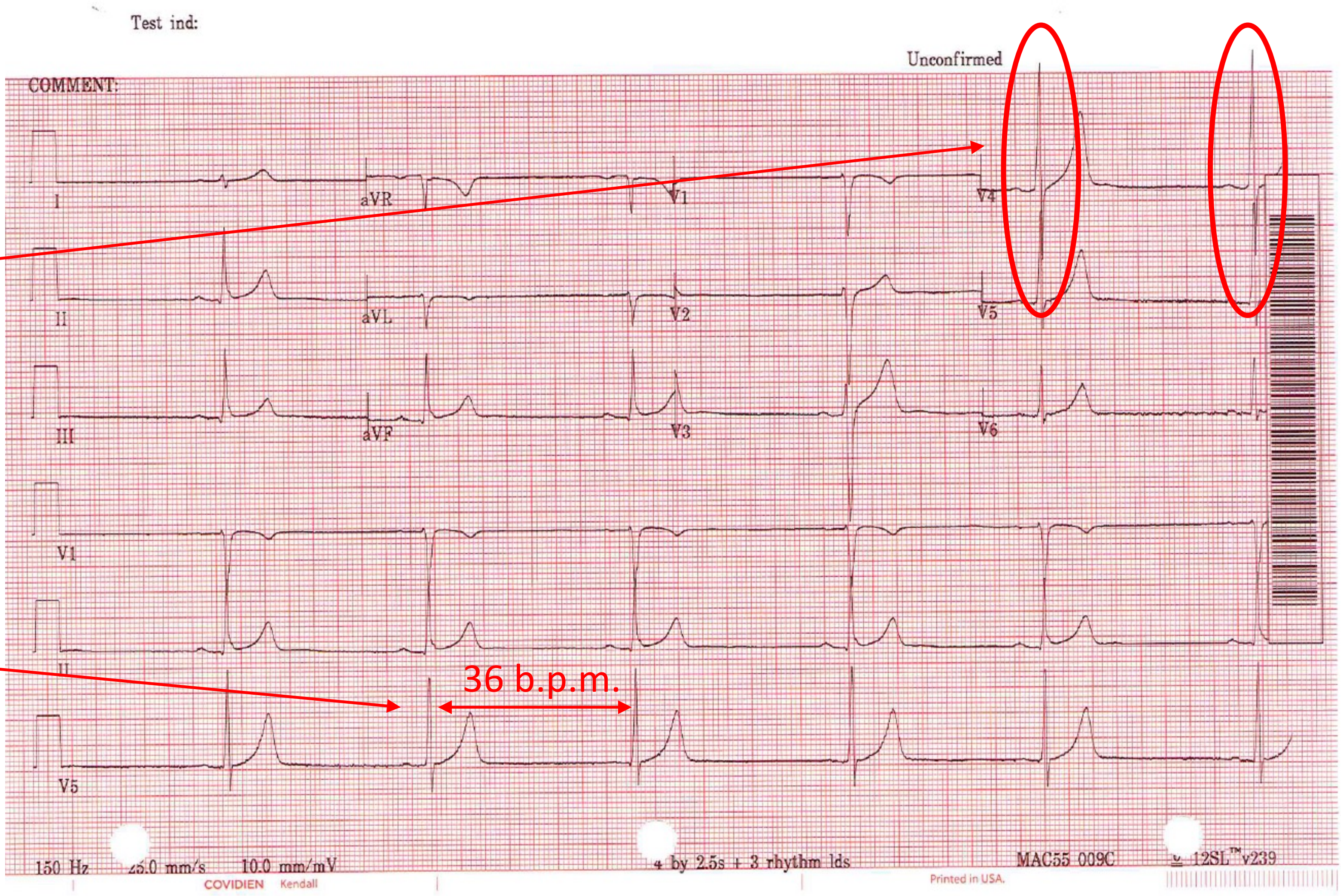
AV = atrioventriular block; LBBB = left bundle branch block; LVH = left ventricular hypertrophy; RBBB = right bundle branch block; RVH = right ventricular hypertrophy; PVC = premature ventricular contraction; SCD = sudden cardiac death.

Pre-participation Screening

22 y.o. White Male
Long Distance Runner

Normal ECG Findings

- Increased QRS voltage for LVH or RVH
- Incomplete RBBB
- Early repolarization/ST segment elevation
- ST elevation followed by T wave inversion V1-V4 in black athletes
- T wave inversion V1-V3 age <16 years old
- Sinus bradycardia or arrhythmia
- Ectopic atrial or junctional rhythm
- 1° AV block
- Mobitz Type I 2° AV block

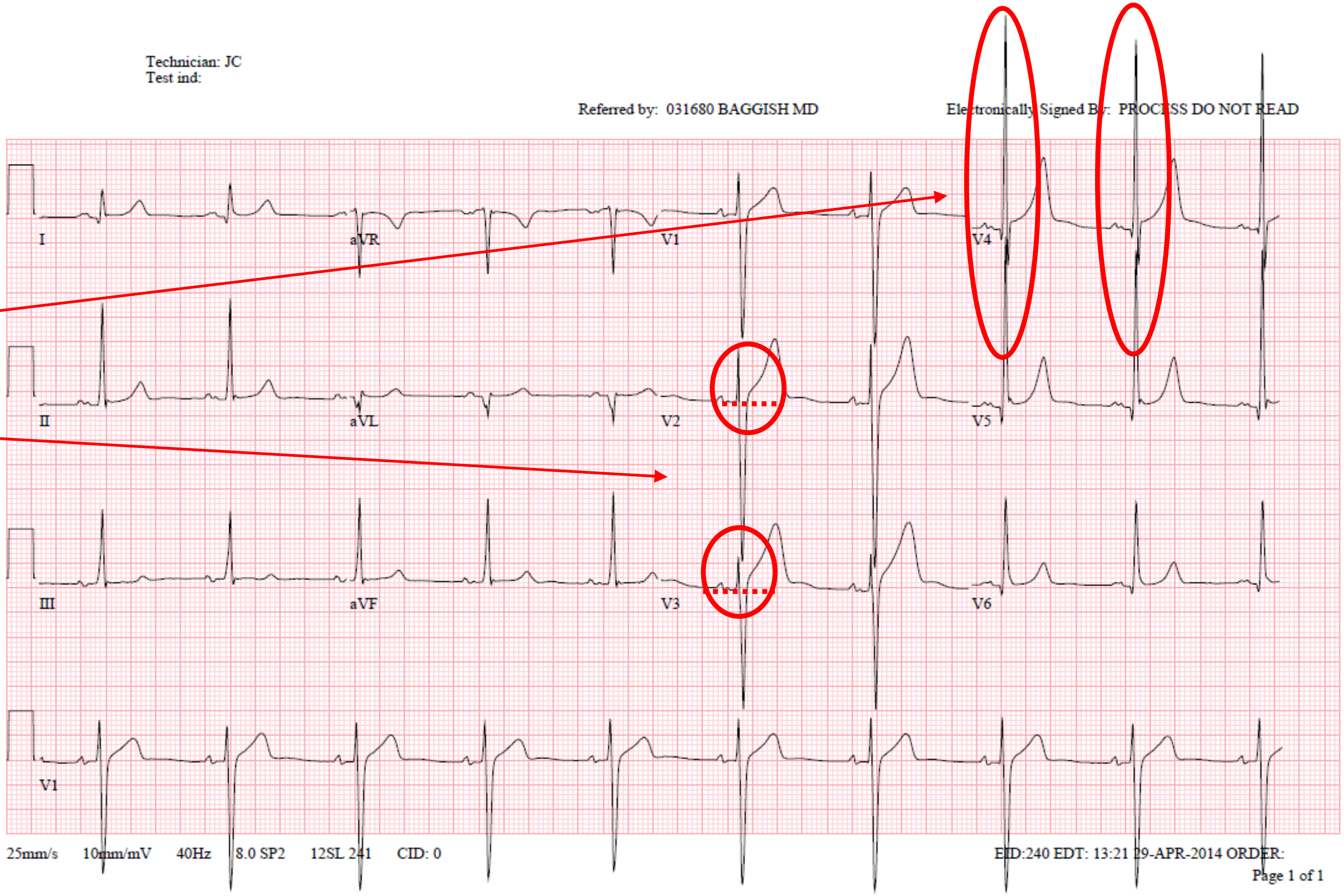


Pre-participation Screening

23 y.o. Black Female
Sprinter / Hurdler

Normal ECG Findings

- Increased QRS voltage for LVH or RVH
- Incomplete RBBB
- Early repolarization/ST segment elevation
- ST elevation followed by T wave inversion V1-V4 in black athletes
- T wave inversion V1-V3 age <16 years old
- Sinus bradycardia or arrhythmia
- Ectopic atrial or junctional rhythm
- 1° AV block
- Mobitz Type I 2° AV block



Pre-participation Screening

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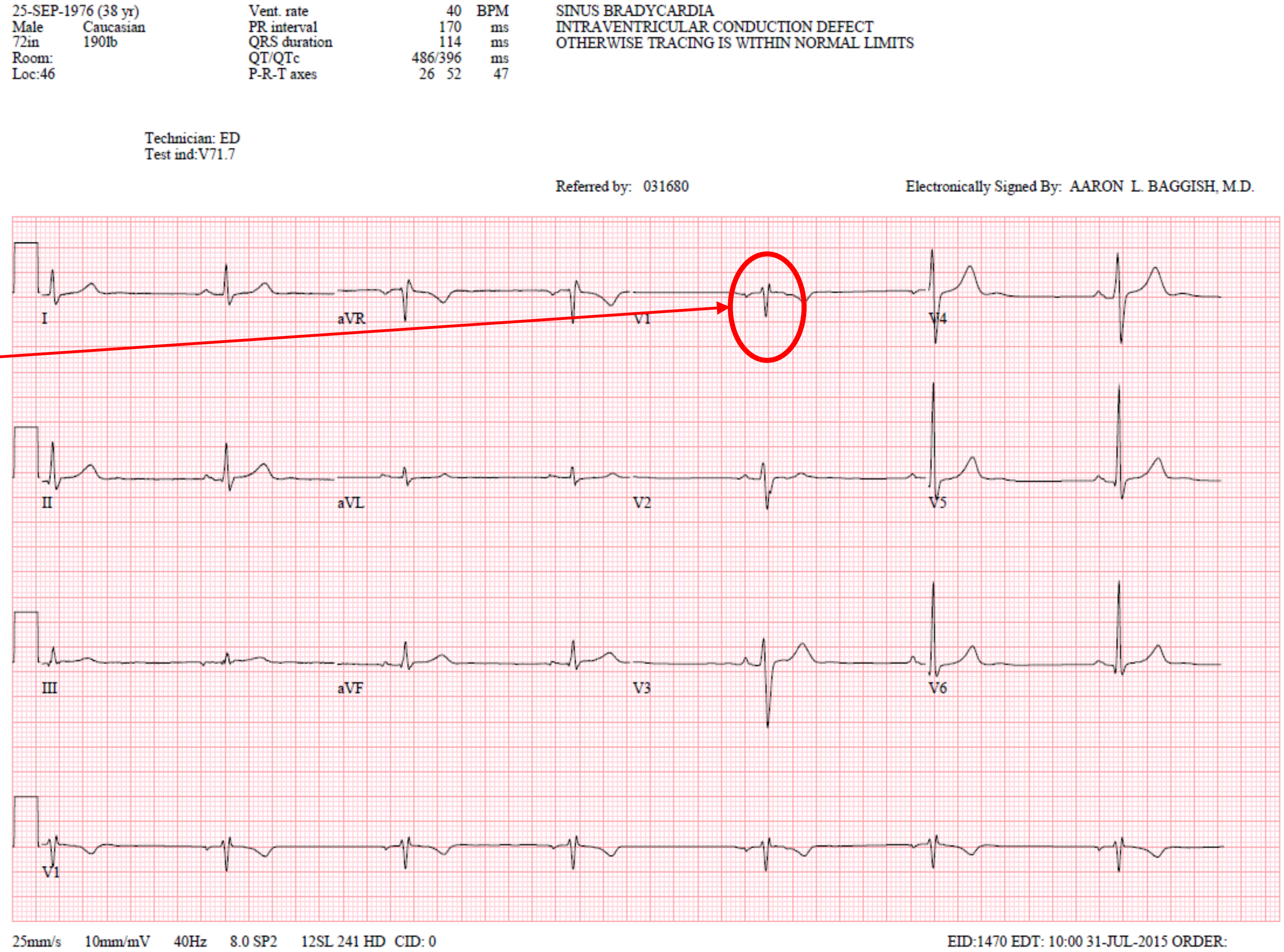
26 y.o. White Female
Long Distance Runner

Normal ECG Findings

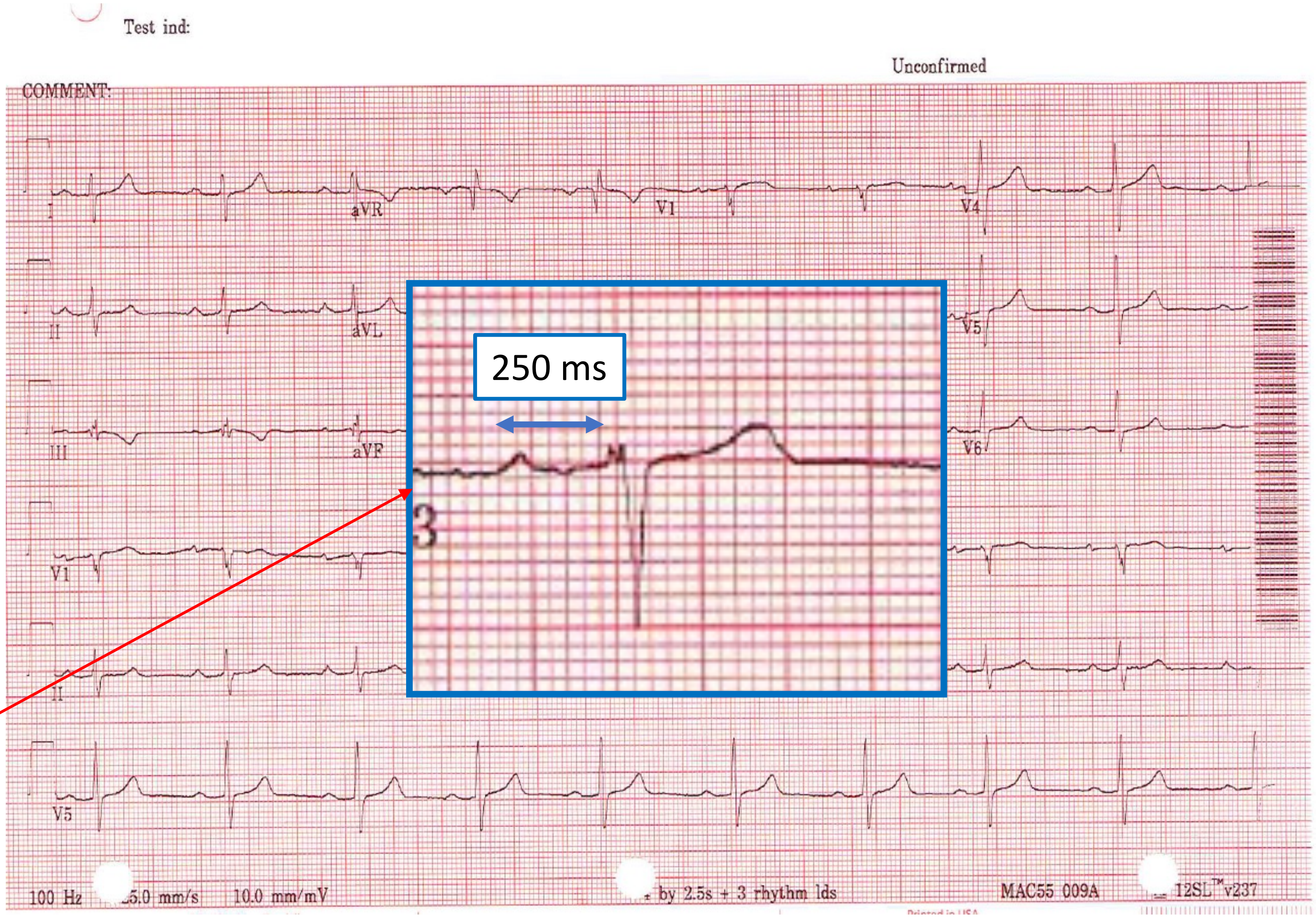
- Increased QRS voltage for LVH or RVH
- Incomplete RBBB
- Early repolarization/ST segment elevation
- ST elevation followed by T wave inversion V1-V4 in black athletes
- T wave inversion V1-V3 age <16 years old
- Sinus bradycardia or arrhythmia
- Ectopic atrial or junctional rhythm
- 1° AV block
- Mobitz Type I 2° AV block



Pre-participation Screening

31 y.o. Black Male Marathoner

Normal ECG Findings
- Increased QRS voltage for LVH or RVH
- Incomplete RBBB
- Early repolarization/ST segment elevation
- ST elevation followed by T wave inversion V1-V4 in black athletes
- T wave inversion V1-V3 age <16 years old
- Sinus bradycardia or arrhythmia
- Ectopic atrial or junctional rhythm
- 1° AV block
- Mobitz Type I 2° AV block



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Pre-participation Screening

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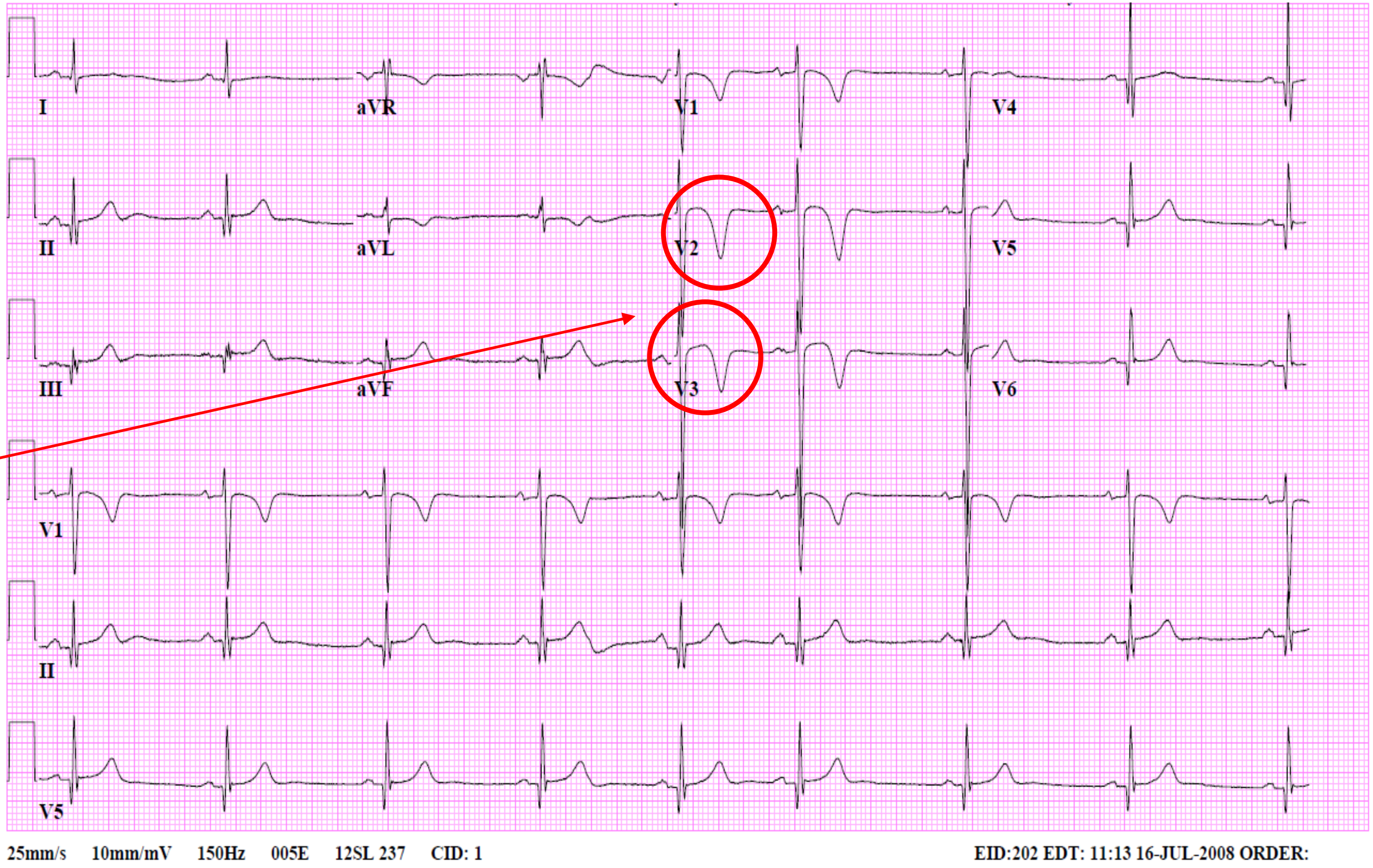
27 y.o. Black Male Sprinter

Normal ECG Findings

- Increased QRS voltage for LVH or RVH
- Incomplete RBBB
- Early repolarization/ST segment elevation
- ST elevation followed by T wave inversion V1-V4 in black athletes
- T wave inversion V1-V3 age <16 years old
- Sinus bradycardia or arrhythmia
- Ectopic atrial or junctional rhythm
- 1° AV block
- Mobitz Type I 2° AV block



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Pre-participation Screening

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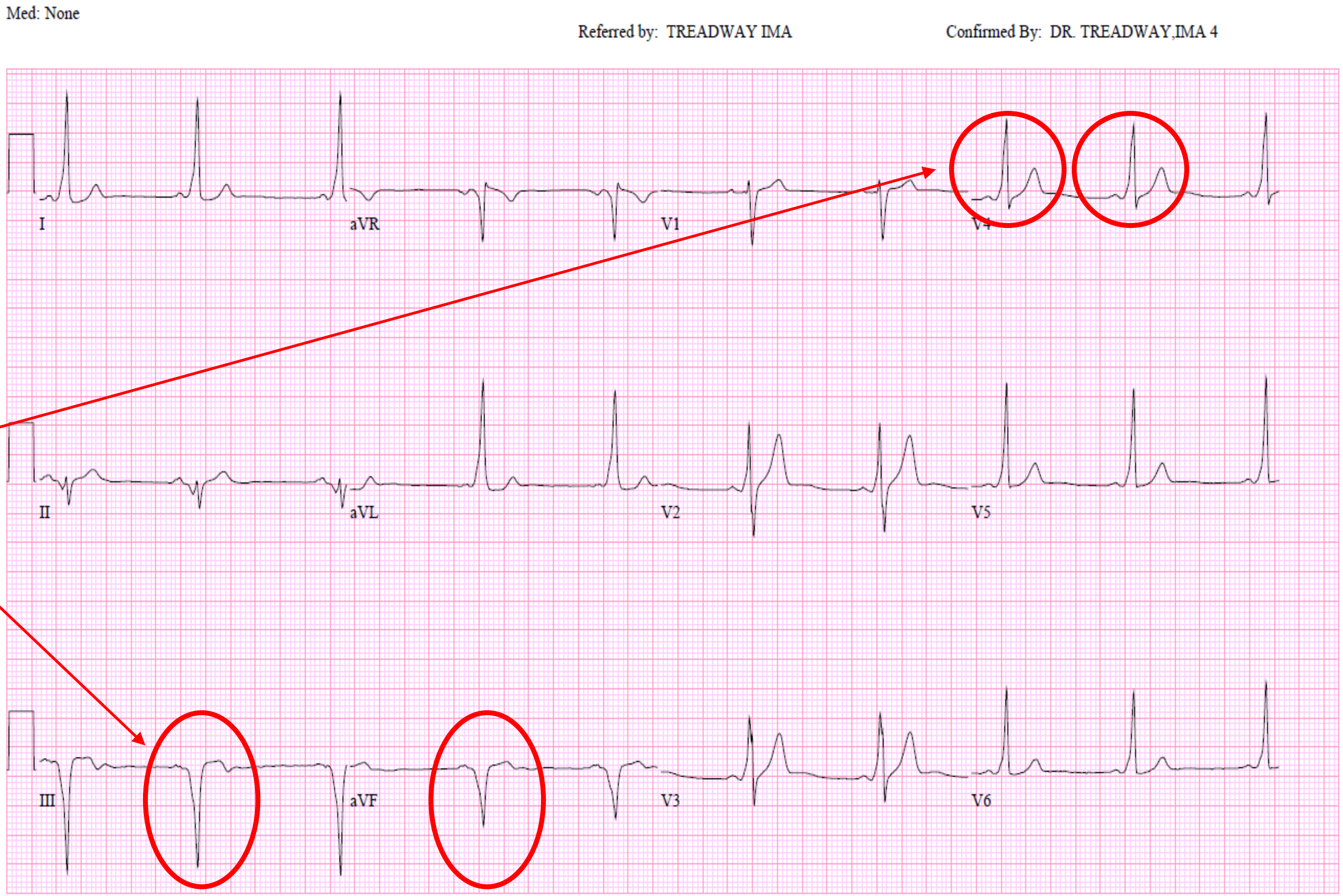
22 y.o. White Male Discus Thrower

Abnormal ECG Findings

- T wave inversion
- ST segment depression
- Pathologic Q waves
- Complete LBBB
- QRS ≥ 140 ms duration
- Epsilon wave
- Ventricular pre-excitation
- Prolonged QT interval
- Brugada Type 1 pattern
- Profound sinus bradycardia < 30 bpm
- PR interval ≥ 400 ms
- Mobitz Type II 2° AV block
- 3° AV block
- ≥ 2 PVCs
- Atrial tachyarrhythmias
- Ventricular arrhythmias



Pre-participation Screening

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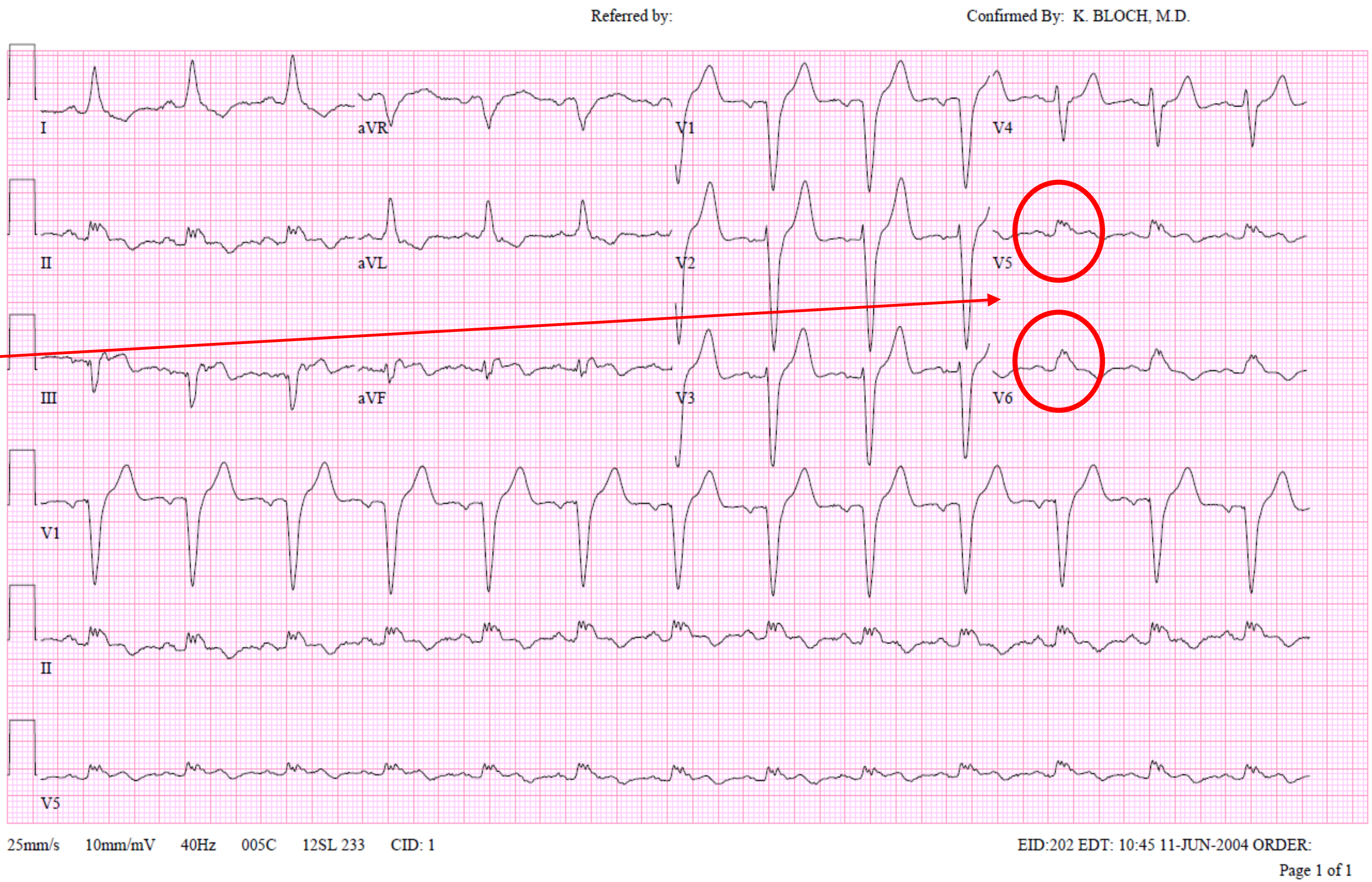
21 y.o. White Male XC Runner

Abnormal ECG Findings

- T wave inversion
- ST segment depression
- Pathologic Q waves
- Complete LBBB
- QRS ≥ 140 ms duration
- Epsilon wave
- Ventricular pre-excitation
- Prolonged QT interval
- Brugada Type 1 pattern
- Profound sinus bradycardia < 30 bpm
- PR interval ≥ 400 ms
- Mobitz Type II 2° AV block
- 3° AV block
- ≥ 2 PVCs
- Atrial tachyarrhythmias
- Ventricular arrhythmias



Pre-participation Screening

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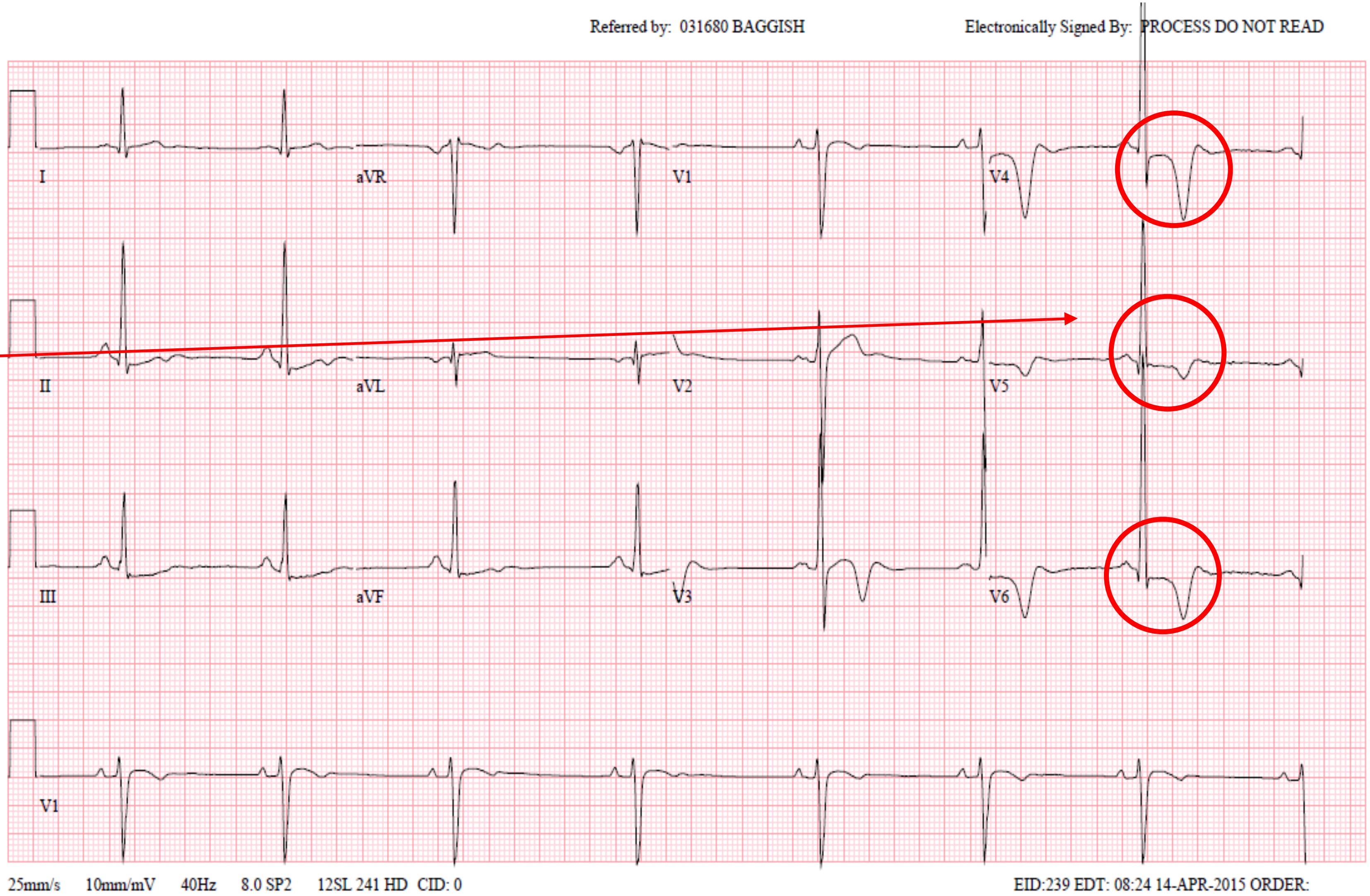
29 y.o. Black Male Shotput Thrower

Abnormal ECG Findings

- T wave inversion
- ST segment depression
- Pathologic Q waves
- Complete LBBB
- QRS ≥ 140 ms duration
- Epsilon wave
- Ventricular pre-excitation
- Prolonged QT interval
- Brugada Type 1 pattern
- Profound sinus bradycardia < 30 bpm
- PR interval ≥ 400 ms
- Mobitz Type II 2° AV block
- 3° AV block
- ≥ 2 PVCs
- Atrial tachyarrhythmias
- Ventricular arrhythmias



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Learning Objectives

Indeed, the "Athlete's ECG" can be dramatic……

Practical Considerations about the 12-lead ECG

√ **Technique** matters, first thing to consider is whether finding is a technical issue

√ **Pre-test probability** defines response to findings

√ **ECG's in isolation** are of limited value ≠ CLEARANCE

√ **Diagnostic Criteria** have been developed to help with this process

√ **Consistency** is key and requires repetition and systematic approach

SCD Prevention in Athletes

Practice

Discuss

Work with Experts

We will never be perfect, so let's be ready!

CPR/AED Training for All Athletes and Stakeholders

+

Rehearsed Emergency Action Plan for Cardiac Arrest

+

Regional Referral Centers and Uploaded Cardiac Information

Physician Leaders in the Community Have a Responsibility and an Opportunity

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Thank You

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