Evolution of Athlete Specific ECG Criteria

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Conflicts: None

Athletic Affiliations:

Funding Sources:
- National Institutes of Health
- American Heart Association
- American Society of Echocardiography
- Department of Defense
- National Football League Player’s Association
**ECG Criteria: An Evolution**

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

- Ubiquitous in medicine & science… 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
ECG Criteria: An Evolution

ECG Criteria: An Evolution

Screening for Hypertrophic Cardiomyopathy in Young Athletes

Domenico Cosimini, M.D., Cristina Basio, M.D., Maria Schiavo, M.D., and Giuseppe Tavecchio, M.D.

Table 1. Criteria for a Positive 12-Lead Electrocardiogram.*

<table>
<thead>
<tr>
<th>P wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left atrial enlargement: negative portion of the P wave in lead V_1 ( \geq 0.1 ) mV in depth and ( \geq 0.04 ) sec in duration.</td>
</tr>
<tr>
<td>Right atrial enlargement: peaked P wave in leads II and III or V_1 ( \geq 0.25 ) mV in amplitude.</td>
</tr>
</tbody>
</table>

QRS complex

| Frontal-plane axis deviation: right \( \geq +120 \) degrees or left \( \geq -30 \) degrees to \( \geq -90 \) degrees. |
| Increased voltage: amplitude of R or S wave in a standard lead \( \geq 2 \) mV, S wave in lead V_1, V_2 \( \geq 3 \) mV, or in lead V_1 or V_2 \( \geq 3 \) mV. |
| Abnormal Q waves: \( \geq 0.04 \) sec in duration or \( \geq 25 \) 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 \( \geq 0.12 \) sec. |
| R or R' wave in lead V_1 \( \geq 0.5 \) mV in amplitude and R:S ratio \( \geq 1 \). |

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 \( \geq 40 \) beats per minute and increasing to \( <100 \) beats per minute during limited exercise testing. |
| First-degree (PR \( \geq 0.21 \) 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

Abstract

For more than 20 years in Italy, young athletes have been screened before participating in competitive sports. We assessed whether this strategy resulted 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 (ages 20 years or older) in the Veneto region of Italy from 1975 to 1995. The causes of sudden death in both populations were compared, and the pathological findings in the athletes were reviewed in their clinical histories and electrocardiograms. Cardiovascular disease, revascularization, and the presence of congenital anomalies were not considered as causes of death.

Results: Of 200 sudden deaths in young people, 49 occurred in competitive athletes (44 male and 5 female athletes; mean 19.25 years, 8.76 years). The most common causes of sudden death in athletes were hypertrophic cardiomyopathy (72.7 percent), coronary artery disease (10.2 percent), and arrhythmia (9.9 percent). Risk factors for sudden death in athletes were coronary artery disease, arrhythmia, and history of sudden death in the family.

Conclusions: A positive electrocardiogram with significant ST-T wave changes in at least two leads is a strong predictor of hypertrophic cardiomyopathy and should be considered as a sign of abnormal prolongation of the QT interval.
ECG Criteria: An Evolution

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

Table 3  Criteria for a positive 12-lead ECG

<table>
<thead>
<tr>
<th>P wave</th>
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<tbody>
<tr>
<td>left atrial enlargement: negative portion of the P wave in lead V1 ≥ 0.1 mV in depth and ≥0.04 s in duration;</td>
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<td>right atrial enlargement: peaked P wave in leads II and III or V1 ≥ 0.25 mV in amplitude.</td>
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</table>

<table>
<thead>
<tr>
<th>QRS complex</th>
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<tbody>
<tr>
<td>frontal plane axis deviation: right ≥ +120° or left -30° to -90°;</td>
</tr>
<tr>
<td>increased voltage: amplitude of R or S wave in in a standard lead ≥2 mV, S wave</td>
</tr>
<tr>
<td>in lead V1 or V2 ≥ 3 mV, or R wave in lead V5 or V6 ≥ 3 mV;</td>
</tr>
<tr>
<td>abnormal Q waves ≥0.04 s in duration or ≥25% of the height of the ensuing R wave or QS pattern in</td>
</tr>
<tr>
<td>two or more leads;</td>
</tr>
<tr>
<td>right or left bundle branch block with QRS duration ≥0.12 s;</td>
</tr>
<tr>
<td>R or R' wave in lead V1 ≥ 0.5 mV in amplitude and R/S ratio ≥1.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ST-segment, T-waves, and QT interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST-segment depression or T-wave flattening or inversion in two or more leads;</td>
</tr>
<tr>
<td>prolongation of heart rate corrected QT interval &gt;0.44 s in males and &gt; 0.46 s in females.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rhythm and conduction abnormalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>premature ventricular beats or more severe ventricular arrhythmias;</td>
</tr>
<tr>
<td>supraventricular tachycardias, atrial flutter, or atrial fibrillation;</td>
</tr>
<tr>
<td>short PR interval (&lt;0.12 s) with or without ‘delta’ wave;</td>
</tr>
<tr>
<td>sinus bradycardia with resting heart rate ≤40 beats/min(^a);</td>
</tr>
<tr>
<td>first (PR ≥ 0.21 s(^b)), second or third degree atrioventricular block.</td>
</tr>
</tbody>
</table>

\(^a\)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: An Evolution

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

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. False Positive Rate of 16.4%
~1500 athletes
• H & P + ECG on all
• ECG + in 19%
• Detection of 8 path. conditions
• 395 Additional tests
• Similar cost / finding

~1000 athletes
• H & P + ECG + Echo on all
• ECG “distinctly” + in 10%
• Detection of 9 path. conditions
• Blacks and females more ECG+
• Echo not incrementally useful

Heart Rhythm 2011

Am J Med 2011
ECG Criteria: An Evolution

An ECG False Positivity Rate of 10-20%

BIG TROUBLE
**ECG Criteria: An Evolution**

**Table 1** Classification of abnormalities of the athlete’s electrocardiogram

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

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

**Recommendations for interpretation of 12-lead electrocardiogram in the athlete**

Domenico Comrado14, Antonio Pelliccia1, Hein Heidbuchel1, Sanjay Sharma1, Mark Link2, Cristina Bassi2, Alessandro Pili2, Pietro Dei2, Ilhor Gussak1, Aris Anastasakis1, Mats Björnsson15, Hans Halvor Bjørnestad11, François Carre1, Asterios Deligiannis13, Dorian Dugmoro14, Robert Fagard1, Jan Hoogsteen15, Klaus P. Meiliwig16, Nicole Panhuysen-Goodkop17, Erik Solberg18, Luc Vanhees1, Jonathan Drezen19, N.A. Mark Estes III1, Sabino Illiceto1, Barry J. Maron12, Roberto Peidro21, Peter J. Schwartz22, Ricardo Stein23, Gaetano Thiene4, Paolo Zoppilli24, and William J. McKenna26 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 Cardiology of the European Society of Cardiology

Cardiovascular remodeling 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 arrhythmias and sudden death 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 field of electrocardiography, imaging inherited cardiovascular diseases, cardiovascular physiology, 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 persistence of inherited cardiovascular disorder.

Keywords

- Athlete's heart
- Cardiomyopathy
- Electrocardiogram
- ionchannel disease
- Sudden death
- Ventricular tachycardia
- Ventricular arrhythmias
**ECG Criteria: An 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 Baggish1

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**2005 Criteria**

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

**False Pos. Rate = 16.4%**

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**2010 Criteria**

<table>
<thead>
<tr>
<th>Screening Strategy</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>MH / PE</td>
<td>45.5 (18.1,75.4)</td>
<td>94.4 (91.9,96.2)</td>
<td>15.0 (5.7,32.7)</td>
<td>98.7 (97.1, 99.5)</td>
</tr>
<tr>
<td>MH/ PE + ECG</td>
<td>90.9 (57.1,99.5)</td>
<td><strong>91.3 (88.7,95.9)</strong></td>
<td>6.5 (5.4,18.7)</td>
<td>100.0 (100.0, 100.0)</td>
</tr>
</tbody>
</table>

**False Pos. Rate = 8.6%**

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*Weiner et al. Heart 2010*
ECG Criteria: An Evolution

**Original Articles**

**Early Repolarization Pattern in Comp Clinical Correlates and the Effects of Exe**

Beter A. Nouwens, MD; Rory Weiner, MD; Jonathan Kim, Francis Wood, MD; Rorc Sarkislian, MS, ATC, Male; Talhunt, I. W. A. B. MD; Michael H. Fox, MD; Adolph J. Christopher Newton-Cheh, MD; MPH, Aeron I. B.

**Aims**

The prevalence, distribution, and clinical outcomes of electrocardiographic repolarization patterns in male athletes of African/Afro-Caribbean origin

**Methods**

Between 2014 and 2016, 908 Black athletes underwent cardiac evaluations. Athletes with T wave inversion were investigated for hypertension (H), Family history, and Black (G). T wave inversion was considered in patients with hypertension. A significant T wave pattern was observed in patients with hypertension. T wave inversion was associated with ventricular arrhythmia and an increase in the risk of sudden cardiac death.

**Findings**

The study found that athletes with T wave inversion are at increased risk for sudden cardiac death. This finding is consistent with previous studies showing a higher risk of sudden cardiac death in athletes with T wave inversion.

**Conclusions**

T wave inversion in athletes is associated with an increased risk of sudden cardiac death. Early recognition and management of this condition are crucial to prevent adverse outcomes.

**Keywords**

Athlete's heart, Echocardiography, Electrocardiography, Electrolytes, Hypertension

**Introduction**

Participation in regular exercise is associated with repolarization changes affecting the ST segment and T wave morphology. Certain electrocardiographic patterns, especially those observed in athletes, differ from those found in the general population. Variations in T wave shape and T wave inversion have been reported in athletes, suggesting potential differences in repolarization dynamics.

**ECG Criteria: Cardiovascular Performance Program**

**Signalntce of Electrocardiographic Right Bundle Branch Block in Trained Athletes**

Jonathan H. Kim, MD, Peter A. Nouwens, MD, David McCarty, MD, Michael H. Picard, MD, Aeron I. B. Haggitt, MD, Rory Weiner, MD, Francis Wood, MD, Melissa J. Wood, MP, Adolph M. Hutter, MD, Michael H. Picard, MD, and Aeron I. B. Haggitt, MD

We sought to determine the clinical and physiological significance of electrocardiographic complete right bundle branch block (CRBBB) and incomplete right bundle branch block (IRBBB) in trained athletes. The 12-lead electrocardiograms of 800 competitive athletes were analyzed. Comparison to the age, sport and training type, and heart rate of the athletes who had CRBBB or IRBBB were evaluated. The results showed that CRBBB was associated with a higher heart rate and average QRS duration, while IRBBB was associated with a lower heart rate and average QRS duration. These findings support the hypothesis that CRBBB and IRBBB are not pathological conditions in athletes, but rather physiological adaptations to training.

**Keywords**

Electrocardiography, Right bundle branch block, Athletes, Cardiovascular performance program.
Normal electrocardiographic findings: recognising physiological adaptations in athletes


This document was developed in collaboration between the American Medical Society for Sports Medicine (AMSM), the Section on Sports Cardiology of the European Association for Cardiovascular Prevention and Rehabilitation (EACPR), a branch of the European Society of Cardiology (ESC), the IHA Medical Assessment and Research Center (PARMAC), and the Pediatric & Congenital Electrophysiology Society (PACS).

ABSTRACT
Electrocardiographic changes in athletes are common and usually reflect intrinsic structural and electrical remodelling of the heart as a physiological adaptation to regular and sustained physical training (athlete's heart). The ability to identify an abnormality on the 12-lead ECG without evidence of underlying cardiac disease is based on a sound working knowledge of the normal ECG characteristics within the athletic population. This document will assist physicians in identifying normal ECG patterns commonly found in athletes. The ECG findings presented as normal in athletes were established by an international consensus panel of experts in sports cardiology and sports medicine.

INTRODUCTION
Sudden death from intrinsic cardiac conditions remains the leading cause of mortality in athletes during sport. A resting 12-lead ECG is utilized as a diagnostic tool in the evaluation of both symptomatic and asymptomatic athletes for conditions associated with sudden cardiac death (SCD). The purpose of this article is to provide medical services for participation in sport through a standardized evaluation intended to identify pre-existing cardiovascular abnormalities, and thereby reduce the potential for adverse cardiovascular events and loss of life. Many pre-participation screening programmes include an ECG. Physicians responsible for the cardiovascular care of athletes should be familiar with the physiological cardiac adaptations to regular exercise that are manifest on the ECG.

ECG changes in athletes are common and usually reflect the electrical and structural remodelling of the myocardium and, in athletes. The ECG changes in athletes are usually recognized and are considered normal in athletes. The ECG criteria for LVH include a left ventricular hypertrophy (LVH). The extent of these changes is also dependent on the athlete's training, age, gender, training discipline and level of training and competition. The ability to identify an abnormal ECG suggestive of underlying cardiac disease is based on a sound understanding of ECG normality within a broad spectrum of athletic populations.

Box 1 Normal ECG findings in athletes

1. Sinus bradycardia (≥30 bpm)
2. Sinus arrhythmia
3. Ectopic atrial rhythm
4. Junctional escape rhythm
5. First-degree AV block (PR interval > 200 ms)
6. Mobitz type I (Wenckebach) second-degree AV block
7. Incomplete RBBB
8. Isolated QRS voltage criteria for LVH
   - Except QRS voltage criteria for LVH occurring with any non-voltage criteria for LVH such as left atrial enlargement, left axis deviation, ST segment depression, T wave inversion or pathological Q waves
9. Early repolarisation (ST elevation, J-point elevation, J waves, or terminal QRS slurring)

These common training-related ECG alterations are physiological adaptations to regular exercise, considered normal variants in athletes, and do not require further evaluation in asymptomatic athletes.

AV, atrioventricular; bpm, beats per minute; LVH, left ventricular hypertrophy; RBBB, right bundle branch block.
Some overview thoughts about the ECG…

1.) It is an imperfect tool even in the best of hands...

2.) Competence requires criteria familiarity & practice...

3.) It is only one component of patient evaluation....

An ECG in the wrong hands can be a dangerous thing!
Now, let’s put what we’ve learned about ECG interpretation in athletes to use…..
ECG Interpretation:
Read with the Experts

Aaron L. Baggish MD
Cardiovascular Performance Program
Division of Cardiology
Massachusetts General Hospital
Boston, MA
Conflicts: None

Athletic Affiliations:

Funding Sources:

- National Institutes of Health
- American Heart Association
- American Society of Echocardiography
- Department of Defense
- National Football League Player’s Association
Our Task:

- 20 ECGs to review

- Included on each ECG:
  - Machine generated HR, intervals, & axes
  - Athlete age, ethnicity, gender, and sport

- Not included with each ECG:
  - Medical history, physical exam data

- We will assume these are all “asymptomatic” people encountered in a screening setting.

- Our goal, “Is tracing within excepted normal ‘limits’ for a youthful athletic population.

- 2 rounds, one with ARS input, “clear” or “not clear”, one with discussion
ECG#1 22 y.o. White Male Distance Runner

- Vent. rate: 36 bpm
- PR interval: 194 ms
- QRS duration: 118 ms
- QT/QTc: 492/380 ms
- P-R-T axes: 68 89 72
ARS ECG #1:

Clear or Evaluate Further?
ECG#2

26 y.o. White Female Triathlete
ARS ECG #2:

Clear or Evaluate Further?
Poll: What would you do?
ECG#3  18 y.o. Black Male Lacrosse Player

- Vent. rate: 59 bpm
- PR interval: 120 ms
- QRS duration: 118 ms
- QT/QTc: 412/407 ms
- P-R-T axes: 28 33 27
ARS ECG #3:

Clear or Evaluate Further?
Poll: What would you do?

CNF i/o, 6/16/2016
ECG#4

26 y.o. White Male Hockey Player
ARS ECG #4:

Clear or Evaluate Further?
Poll: What would you do?
ECG#5

19 y.o. White Male Rower
ARS ECG #5:

Clear or Evaluate Further?
Poll: What would you do?
ECG#6 18 y.o. White Male Hurdeler
ARS ECG #6:

Clear or Evaluate Further?
ECG#7

31 y.o. White Male Marathoner

Vent. rate 57 bpm
PR interval 244 ms
QRS duration 102 ms
QT/QTc 446/434 ms
P-R-T axes 36 117 -6
ARS ECG #7:

Clear or Evaluate Further?
Poll: What would you do?

CNF i/o, 6/16/2016
ECG#8

21 y.o. Black Male Soccer Player
ARS ECG #8:

Clear or Evaluate Further?
Poll: What would you do?
CNF i/o, 6/16/2016
ECG#9 22 y.o. Black Male Soccer Player
ARS ECG #9:

Clear or Evaluate Further?
Poll: What would you do?

CNF i/o, 6/16/2016
ARS ECG #10:

Clear or Evaluate Further?
Poll: What would you do?
ECG#11 19 y.o. White Female Rower

Vent. rate  56  BPM
PR interval  100  ms
QRS duration  112  ms
QT/QTc  430/421  ms
P-R times  240  60  -28

Referred by: 30656
Confirmed By: J.R. LEVINSON, M.D.
ARS ECG #11:

Clear or Evaluate Further?
Poll: What would you do?
ECG#12

19 y.o. White Male Distance Runner
ARS ECG #12:

Clear or Evaluate Further?
Poll: What would you do?
ECG#14 20 y.o. White Male Football Player

Ventricular rate: 65 BPM
PR interval: 152 ms
QRS duration: 88 ms
QTc: 370 ms
P-R-T axes: 59 84 -3

Referred by: 031680 BAGGISH
Electronically Signed By: PROCESS DO NOT READ

25mm/s 10mm/mV 40Hz 8.0 SP2 12SL 241 CID: 0
ARS ECG #13:

Clear or Evaluate Further?
Poll: What would you do?
CNF i/o, 6/16/2016
ECG#14 20 y.o. White Female Basketball Player
ARS ECG #14:

Clear or Evaluate Further?
Poll: What would you do?
ECG#15

26 y.o. White Male Triathlete

Referred by: 031680 BAGGISH

Electronically Signed By: PROCESS DO NOT READ
ARS ECG #15:

Clear or Evaluate Further?
Poll: What would you do?
ECG#16 21 y.o. White Male Middle Distance Runner

Technician: TN
Test Ref: NOBILL

Referred by:  
Confirmed By:

(Ventricular rate 79 BPM, PR interval 174 ms, QRS duration 140 ms, QT/QTc 438/502 ms, P-R-T axes 50-9 174)

25mm/s  10mm/mV  40Hz  005C  12SL 233  CID: 1

EID:202 EDT: 10:45 11-JUN-2004 ORDER:
Page 1 of 1
ARS ECG #16:

Clear or Evaluate Further?
Poll: What would you do?
ARS ECG #17:

Clear or Evaluate Further?
Poll: What would you do?
CNF i/o, 6/16/2016
ECG#18 21 y.o. White Male Rower

Ventricular rate: 100 BPM
PR interval: 154 ms
QRS duration: 134 ms
QT/QTc: 374/482 ms
P-R-T axes: 44 -66 16
ARS ECG #18:

Clear or Evaluate Further?
Poll: What would you do?
ECG#19

24 y.o. Asian Male Golfer

Vent. rate  75  BPM
PR interval  175  ms
QRS duration  117  ms
QT/QTc  363/405  ms
P-R-T axes  78  36  85
ARS ECG #19:

Clear or Evaluate Further?
ECG#20 18 y.o. White Female Cheerleader
ARS ECG #20:

Clear or Evaluate Further?
Round 2
ECG#1  22 y.o. White Male Distance Runner

- Vent. rate: 36 bpm
- PR interval: 194 ms
- QRSD duration: 118 ms
- QT/QTc: 492/380 ms
- P-R-T axes: 68, 89, 72
ARS ECG #1:

Audience Response
ECG#1 22 y.o. White Male Distance Runner

VENT. rate 36 bpm
PR interval 194 ms
QRS duration 118 ms
QT/QTc 492/380 ms
P-R-T axes 68 89 72
ECG#2 26 y.o. White Female Triathlete
ARS ECG #2:

Audience Response
ECG#2 26 y.o. White Female Triathlete
ECG#3 18 y.o. Black Male Lacrosse Player

VENT. RATE 59 bpm
PR INTERVAL 120 ms
QRS DURATION 118 ms
QT/QTc 412/407 ms
P-R-T AXES 28 33 27

COMMENT:

Unconfirmed
ARS ECG #3:

Audience Response
ECG#3

18 y.o. Black Male Lacrosse Player
ECG#4 26 y.o. White Male Hockey Player
ARS ECG #4:

Audience Response
ECG#5

19 y.o. White Male Rower

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vent. rate</td>
<td>38 BPM</td>
</tr>
<tr>
<td>PR interval</td>
<td>150 ms</td>
</tr>
<tr>
<td>QRS duration</td>
<td>104 ms</td>
</tr>
<tr>
<td>QT/QTc</td>
<td>442/433 ms</td>
</tr>
<tr>
<td>P-R-T axes</td>
<td>30, 74, 37</td>
</tr>
</tbody>
</table>

Referred by: 031680 BAGGISH MD

Electronically Signed By: PROCESS DO NOT READ

ECG Diagram
ARS ECG #5:

Audience Response
ECG#6

18 y.o. White Male Hurdeler
ARS ECG #6:

Audience Response
ECG#6 18 y.o. White Male Hurdeler

ID:005413558

- Vent. rate: 62 BPM
- PR interval: 174 ms
- QRS duration: 102 ms
- QT/QTc: 382/387 ms
- P-R Times: 50 67 51

Referrer by: 031680 BAGGIS MD
Electronically Signed By: PROCESS DO NOT READ
ECG#7  31 y.o. White Male Marathoner

- Vent. rate 57 bpm
- PR interval 244 ms
- QRS duration 102 ms
- QT/QTc 446/434 ms
- P-R-T axes 36 117 -6
ARS ECG #7:

Audience Response
ECG#7

31 y.o. White Male Marathoner
ECG#8

21 y.o. Black Male Soccer Player
ARS ECG #8:

Audience Response
ECG#9  22 y.o. Black Male Soccer Player

VENT. RATE 58 bpm
PR INTERVAL 144 ms
QRS DURATION 98 ms
QT/QTc 430/414 ms
P-R-T AXES 31 35 15
ARS ECG #9:

Audience Response
ECG#9

22 y.o. Black Male Soccer Player
ECG#10 22 y.o. White Female Soccer Player

Vent. rate 50 BPM
PR interval 170 ms
QRS duration 90 ms
QT/QTc 442/402 ms
F-R-T axes 45 51 81
ARS ECG #10:

Audience Response
ECG#11 19 y.o. White Female Rower

Referred by: 30656
Confirmed By: J.R. LEVINSON, M.D.
ARS ECG #11:

Audience Response
ECG#11 19 y.o. White Female Rower
**ECG#12**

19 y.o. White Male Distance Runner

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vent rate</td>
<td>55 BPM</td>
</tr>
<tr>
<td>PR interval</td>
<td>116 ms</td>
</tr>
<tr>
<td>QRS duration</td>
<td>132 ms</td>
</tr>
<tr>
<td>QT/QTc</td>
<td>400/382 ms</td>
</tr>
<tr>
<td>P-R-T axes</td>
<td>48 -36 19</td>
</tr>
</tbody>
</table>
ARS ECG #12:

Audience Response
ECG#12

19 y.o. White Male Distance Runner

- Vent rate: 55 BPM
- PR interval: 116 ms
- QRS duration: 132 ms
- QT/QTc: 400/382 ms
- P-R-T axes: 48 -36 19
ECG#14 20 y.o. White Male Football Player

Ventricular rate: 65 BPM
PR interval: 152 ms
QRS duration: 88 ms
QTc: 370/384 ms
P-R-T axes: 59/84/-3
ARS ECG #13:

Audience Response
ECG#14 20 y.o. White Male Football Player
ARS ECG #14:

Audience Response
ECG#14

20 y.o. White Female Basketball Player
ARS ECG #15:

Audience Response
ECG#15 26 y.o. White Male Triathlete
ECG#16 21 y.o. White Male Middle Distance Runner

Vent. rate 79 BPM
PR interval 174 ms
QRS duration 140 ms
QTc 438/502 ms
P-R-T axes 50 -9 174

Technician: TN
Test ref: NOBILL.
ARS ECG #16:

Audience Response
ECG#16 21 y.o. White Male Middle Distance Runner

Technician: TN
Test ref: NOBILL

Referred by: 
Confirmed By: 

25mm/s  10mm/mV  40Hz  005C  12SL 233  CID: 1

EID: 202  EDT: 10:45  11-JUN-2004  ORDER:
ECG#17 30 y.o. White Male Power Lifter

ID:001043903
Vent. rate 81 BPM
PR interval 246 ms
QRS duration 146 ms
QT/QTc 371/431 ms
P-R-T axes 72 -81 83
ARS ECG #17:

Audience Response
ECG#17

30 y.o. White Male Power Lifter

ID: 001043903

- Vent rate: 81 BPM
- PR interval: 246 ms
- QRS duration: 146 ms
- QT/QTC: 371/431 ms
- P-R-T axes: 72 81 83

Referred by: Unconfirmed

25mm/s 10mm/mV 100Hz 00S 12SL 80 CID 1
ECG#18 21 y.o. White Male Rower
ARS ECG #18:

Audience Response
ECG#18 21 y.o. White Male Rower
ARS ECG #19:

Audience Response
ECG#19

24 y.o. Asian Male Golfer
ECG#20 18 y.o. White Female Cheerleader
ARS ECG #20:

Audience Response
ECG#20  18 y.o. White Female Cheerleader

Vent rate 96 BPM
PR interval 146 ms
QRS duration 100 ms
QT/QTc 333/421 ms
P-R-T axes 80 117 27
Thank You!