Medical Screening of the Athlete

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Learning Objectives

- Identify cardiac causes of sudden cardiac death (SCD) in the young
- Review relative risks of SCD in athletes
- Recognize limitations of widespread medical screening of athletes
- Understand the role of the primary care physician in athlete screening
The director of a high school athletic program is considering implementation of a requirement that all student athletes undergo cardiac screening by a physician before participating in any school-sponsored athletic team.
Clinical Case Vignette

The athletic director seeks your advice and asks you to vote for the response below that you favor most:

1. Young athletes should NOT be required to undergo cardiac screening before participating in sports.

2. Young athletes should undergo screening consisting of a detailed history and physical exam.

3. Young athletes should undergo screening consisting of a detailed history, physical exam, and ECG.
Clinical Case Vignette

Show interactive audience responses
Clinical Case Vignette

2013 AHA Session

- No Screen: 60%
- Hx and PE: 30%
- Hx, PE + ECG: 10%

NEJM Online Poll

- No Screen: 45%
- Hx and PE: 35%
- Hx, PE + ECG: 20%

JA Colbert, N Engl J Med 2014
Sudden Cardiac Death and the Competitive Athlete

Hank Gathers, West Coast Conference Tournament, March 1990
Common Causes of Sudden Cardiac Death in Young Athletes

- Structural
  - HCM
  - ARVC
  - Coronaries
  - Marfan

- Electrical
  - LQTS
  - CPVT
  - WPW
  - Brugada

- Acquired
  - Myocarditis
Hypertrophic Cardiomyopathy (HCM)

- Autosomal Dominant inheritance with variable penetrance
  - Prevalence 0.2% in general population (0.08% in athletes)
  - Diagnosis most often made by ECG
    - ECG abnormal in > 90% affected individuals

- Left ventricular hypertrophy in absence of abnormal loading conditions and myocardial disarray on histology
  - Sudden Cardiac Death (SCD) often 1st clinical manifestation

- Most common cause of SCD in USA (36% of all cases)
  - Deaths most common in start-stop type sports
  - Rare in endurance events
Hypertrophic Cardiomyopathy (HCM)
Hypertrophic Cardiomyopathy (HCM)

Pathologic T wave inversion and ST depression in the lateral precordial leads
Congenital Long QT Syndromes

- A group of hereditary ion channelopathies
  - Incidence ~0.05% in general population

- Abnormal cardiac repolarization predisposes to polymorphic VT/VF
  - 2-4% of SCD cases attributable to LQTS

- Diagnosis typically made by ECG QTc calculation
  - QTc calculation can be complicated in athletes
    - A percentage of highly trained athletes exhibit QT intervals greater than 440 - 460 msec.
Congenital Long QT Syndromes
Congenital Long QT Syndromes
Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)

- Inherited myocardial disease caused by mutations in cardiac desmosomal proteins
  - Accounts for ~3% of SCD in US athletes (>25% of SCD in Italy)
- RV dilation/dysfunction results in ventricular arrhythmia
- Diagnosis relies on symptoms and family history
  - EKG changes demonstrate T wave inversion in multiple right precordial leads
  - MRI is usually required for definitive diagnosis
Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)

Inverted T waves extending beyond V3
Wolff-Parkinson-White Syndrome

- Ventricular pre-excitation due to accessory AV pathway is a substrate for re-entrant tachycardia
  - Incidence 0.1-0.3% in general population

- If atrial fibrillation develops there is a risk for SCD from VF due to rapid anterograde conduction via the accessory pathway

- Diagnosis by ECG
  - Delta wave, short PR interval, prolonged QRS duration
Wolff-Parkinson-White Syndrome

Short PR interval, delta wave and prolonged QRS
Catecholaminergic Polymorphic Ventricular Tachycardia (CPVT)

- Associated with mutations in the ryanodine receptor, calsequestrin, and ankyrin-B proteins,
- Predisposed to adrenergically mediated polymorphic VT and recurrent syncope provoked by exercise or stress
- ECG is typically normal
  - Exercise stress testing may provoke VT/bidirectional VT
Myocarditis

- Typically caused by viral infections (e.g. Coxsackie B)
- Account for 7% of SCD in athletes
- Presentation with recent viral illness, exercise intolerance, chest pain, clinical signs of cardiac failure
- ECG usually shows ST segment changes
- Athletes diagnosed with myocarditis should refrain from sports for a 6 month convalescent period to reduce risk of SCD
Congenital Coronary Artery Anomalies

- Reported to cause 12-33% of all SCD in athletes
- SCD results from ventricular arrhythmia triggered by ischemia during exercise.
- Most commonly implicated coronary anomaly is the left coronary artery arising off the right sinus of Valsalva
- Diagnosis by ECG, echo and exercise testing is difficult
  - MRI and CT are gold standards for diagnosis confirmation
Sudden Cardiac Death (SCD) in NCAA Athletes

- Between 2004-2008, there were 273 deaths in NCAA athletes
  - Most deaths due to non-medical causes
  - Cardiac-related deaths accounted for 56% of medical causes
    - **75% of sudden deaths during exertion had a cardiac cause**

- SCD occurs more frequently in certain sports
  - Basketball, football, swimming, lacrosse
  - Basketball has highest SCD rate (8.78/100,000 per year)
    - D1 black male basketball players had highest SCD risk (31.99/100,000 per year!)

Harmon, et al., Circulation 2011
The big question

Is there an “optimal” screening strategy for effectively identifying teens and young adults at risk for dying suddenly during athletic participation?
Pre-participation athletic screening (PAS) is endorsed by both the American Heart Association (AHA) and European Society of Cardiology (ESC).

The ESC and the International Olympic Committee recommend PAS include a 12 lead ECG.

- ECG improves identification of conditions capable of causing sudden cardiac death.

The AHA does not currently support use of ECG’s for PAS.

- In the US, only a 12 point screening PAS is recommended.

Viskin et al., JACC 2012
AHA Pre-Participation Athletic Screening Protocol (12 elements)

- **Personal History**
  - exertional chest pain
  - unexplained syncope
  - excessive exertional dyspnea
  - Hx of murmur
  - Hx of elevated BP

- **Family History**
  - premature death before age 50 due to heart disease
  - disability from heart disease in close relative < 50 years of age
  - specific knowledge of certain cardiac conditions in family members

- **Physical Exam**
  - heart murmur (supine and standing evaluation)
  - femoral pulses
  - features of Marfan’s
  - BP in sitting position

Maron, et al., Circulation 2007
Evaluation of the AHA Pre-Athletic Screening Protocol

- Only 3% of athletes who experienced sudden cardiac death were suspected of having cardiac disease by the Pre-Athletic screening protocol
  - HCM difficult to detect
  - Chest pain and lightheadedness are common
  - Syncope is a risk factor that may be underappreciated

- While the AHA Pre-Athletic Screening protocol has low sensitivity and specificity screening EKG is “probably impractical” is the US

Maron, et al., JAMA 1996
Maron et al., Circulaiton 2007
Arguments against including ECG into the PAS Protocol

- Cost effectiveness?
  - Costs of ECG
  - Additional downstream diagnostic testing costs
    - ECG false positive rate ~5-7%

- Framework and resources to screen cohort of US student athletes (~10,000,000) do not exist
  - Additional 223 ECG’s per day for each US Pediatric Electrophysiologist to evaluate!

Hill AC et al., J Pediatr 2011
Can ECG costs be lowered?

- Non-profit organizations are focusing on cost effective cardiac screening of student athletes
  - ECG equipment taken to schools
  - ECGs performed by trained staff/athletic trainers
  - ECG’s uploaded for a Cardiologist to read as the first step.
    - Staff communicates interpretations with schools
    - Programs also offer echos as a second stage or optional part of screening.
  - Charge $10-$15 for ECG screening in Texas

http://www.cypressecgproject.org/
Can the rate of false positive ECGs be reduced in athletic screenings?

- SCD is rare
- A high percentage of athletes have borderline/abnormal ECGs
  - Applying established pediatric ECG guidelines to athletes generates false positive rates between 4% and 7%

Hill et al., J Pediatr 2011
Refined ECG Interpretation for Athletes: The “Seattle Criteria”

- American Medical Society for Sports Medicine (AMSSM) and FIFA Medical Assessment and Research Center (F-MARC) held a “Summit on ECG Interpretation in Athletes” in Seattle on Feb 13-14, 2012 with the following goals:
  - Define ECG standards to help distinguish normal ECG alterations in athletes from abnormal ECG findings that require additional evaluation for conditions associated with SCD
  - Develop online resource and training course for ECG screening: [http://learning.bmj.com/ECGathlete](http://learning.bmj.com/ECGathlete)

Seattle Criteria
Normal ECG Findings in Athletes

- Sinus bradycardia (HR ≥ 30 bpm)
- Sinus arrhythmia, Ectopic atrial rhythm, junctional escape, 1\textsuperscript{st} degree heart block, Mobitz Type I AV block
- Incomplete RBBB
- Isolated QRS voltage criteria for LVH
- Early repolarization
- “Domed” ST elevation combined with T wave inversion in leads V1-V4 in black/African athletes

If the possibility of heart disease is raised withdrawal from competition is mandatory until a specialty consultation has been pursued

Differentiating innocent from pathologic murmurs is difficult

Reliably raising suspicion of potential lethal cardiac conditions may fall beyond the clinician’s comfort level or expertise
Liability Concerns for the PCP and athlete pre-participation screening

- Liability issues in screening and management of competitive athletes are of increasing concern to the medical community.

- The law generally requires physicians use reasonable care in detecting foreseeable medical abnormalities that may cause sudden death or serious injury to athletes.
  - Lawsuits may arise when a breach of the physician's duty has occurred.

- Strict adherence to the AHA pre-participation athlete screening protocol is recommended.

Maron, et al., Circulation 2007
SUMMARY: Pre-participation Athlete Screening - No easy answers

- There is an inherent conflict between the (relatively) low incidence of sudden cardiac death in athletes and the (currently) high costs of screening
  - On a population basis, screening costs should outweigh the harm caused by not screening
  - Most communities have no tolerance for SCD in young athletes

- Opportunities to improve athlete screening approaches?
  - Explore strategies/technologies to minimize ECG costs
  - Minimize “false positive” ECGs by refining algorithms to focus on identifying cardiac conditions associated with SCD in the athlete
  - Will the Seattle Criteria prove to be a better ECG screening tool for athletes?
No simple, cost effective screening method to detect athletes at risk for sudden cardiac death

History and physical exam are currently the cornerstones for detection of “at-risk” athletes in the US

Recommend strict adherence to the AHA pre-participation athlete screening protocol
# 2012-2013 ANNUAL PREPARTICIPATION PHYSICAL EVALUATION

(The Parent or Guardian should fill out this form with assistance from the student athlete.)

**Name**

**Sex**

**Age**

**Date of Birth**

**Grade**

**School**

**Sport(s)**

**Address**

**Phone**

**Personal Physician**

**Hospital Preference**

**In case of emergency, contact:**

**Name**

**Relationship**

**Phone (H):**

**W:**

**C:**

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<table>
<thead>
<tr>
<th>Explain &quot;Yes&quot; answers below.</th>
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<tbody>
<tr>
<td><strong>Circle questions you don't have the answers to.</strong></td>
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<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
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<tbody>
<tr>
<td>1. Has a doctor ever denied or restricted your participation in sports for any reason?</td>
<td>□ YES</td>
<td>□ NO</td>
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<tr>
<td>2. Do you have any ongoing medical condition (e.g., diabetes, asthma)?</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>3. Are you currently taking any prescription or nonprescription (over-the-counter) medications or supplements? (Specify):</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>4. Do you have allergies to medicines, pollen, foods, or stinging insects? (Specify):</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>5. Have you ever passed out or nearly passed out during exercise?</td>
<td>□ YES</td>
<td>□ NO</td>
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<tr>
<td>6. Have you ever passed out or nearly passed out after exercise?</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>7. Have you ever had discomfort, pain, or pressure in your chest during exercise?</td>
<td>□ YES</td>
<td>□ NO</td>
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<tr>
<td>8. Does your heart race or skip beats during exercise?</td>
<td>□ YES</td>
<td>□ NO</td>
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<tr>
<td>9. Has a doctor ever told you that you have high blood pressure?</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>10. Has a doctor ever ordered a test for your heart? (e.g., ECG, echocardiogram):</td>
<td>□ YES</td>
<td>□ NO</td>
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<tr>
<td>11. Has anyone in your family died of no apparent reason?</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>12. Does anyone in your family have a heart problem?</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>13. Has any family member or relative died of heart problems or sudden death before age 50?</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>14. Does anyone in your family have Marfan syndrome?</td>
<td>□ YES</td>
<td>□ NO</td>
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<tr>
<td>15. Have you ever spent the night in the hospital?</td>
<td>□ YES</td>
<td>□ NO</td>
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<td>16. Have you ever been in surgery?</td>
<td>□ YES</td>
<td>□ NO</td>
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<tr>
<td>17. Have you ever had an injury (sprain, muscle tear, etc.) that caused you to miss practice or games? If yes, circle affected area in the boxes below:</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>18. Have you had any broken/bent bones or dislocated joints? If yes, circle affected area in the boxes below:</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>19. Have you had any bone/joint injury that required x-rays, MRI, CT, surgery, injections, rehabilitation, physical therapy, a brace, a cast, or surgery? If yes, circle affected area in the boxes below:</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>20. Have you had a stress fracture?</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>21. Have you been told that you have or may have had an aortic valve or heart murmur?</td>
<td>□ YES</td>
<td>□ NO</td>
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<tr>
<td>22. Do you regularly use a brace or assistive device?</td>
<td>□ YES</td>
<td>□ NO</td>
</tr>
<tr>
<td>23. Has a doctor told you that you have whiplash or allergies?</td>
<td>□ YES</td>
<td>□ NO</td>
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I hereby state that, to the best of my knowledge, my answers to the above questions are complete and correct. Furthermore, I acknowledge and understand that my eligibility may be revoked if I have not given truthful and accurate information in response to the above questions.

**Signature of athlete**

**Signature of parent/guardian**

**Date**

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FORM 18-A 8/3/17
AIA Pre-participation Evaluation
Cardiac Screening Questions

5. Have you ever passed out or nearly passed out during exercise?
6. Have you ever passed out or nearly passed out after exercise?
7. Have you ever had discomfort, pain, or pressure in your chest during exercise?
8. Does your heart race or skip beats during exercise?
9. Has a doctor ever told you that you have (check all that apply):
   - High blood pressure
   - High cholesterol
   - A heart murmur
   - A heart infection
10. Has a doctor ever ordered a test for your heart? (ex: ECG, echocardiogram)
11. Has anyone in your family died for no apparent reason?
12. Does anyone in your family have a heart problem?
13. Has any family member or relative died of heart problems or of sudden death before age 50?
14. Does anyone in your family have Marfan syndrome?
What about Automated External Defibrillators (AEDs)?

- In the event of SCD, survival is improved by prompt recognition, trained individuals, and early access to an AED

- Creation of emergency response plans at HS sports venues may improve the outcomes

- A recent analysis of US high schools with AED on site showed 23/36 SCD were rescued (64% rescue rate)

Drezner, et al., Heart Rhythm 2006
A heart murmur is detected on a pre-participation athletic screening exam. The athlete’s team starts practice prior to the next available cardiology appointment and he/she is asymptomatic. Do you need to restrict activities until the cardiology evaluation?

- Yes
- No
Post-talk questions

Show interactive audience responses
A heart murmur is detected on a pre-participation athletic screening exam. The athlete’s team starts practice prior to the next available cardiology appointment and he/she is asymptomatic. Do you need to restrict activities until the cardiology evaluation?

- Yes
- No

*If the possibility of heart disease is raised on a PAS, withdrawal from competition is mandatory until a specialty consultation has been pursued.*
Which of the following responses on a pre-participation athletic screening would NOT prompt cardiology referral?

- Hx of chest pain on exertion
- Hx of syncope standing in the juice line after donating blood
- Disability from heart disease in close relative < 50 yrs of age
- Physical features suggestive for a connective tissue disorder
Post-talk questions

Show interactive audience responses
Post-talk questions

Which of the following responses on a pre-participation athletic screening would NOT prompt cardiology referral?

- Hx of chest pain on exertion
- Hx of syncope standing in the juice line after donating blood
- Disability from heart disease in close relative < 50 yrs of age
- Physical features suggestive for a connective tissue disorder

A history of unexplained syncope is a trigger for referral according to the AHA 12 point PAS; this patient’s history is consistent with vagally mediated syncope.

All other responses meet AHA PAS criteria for cardiology referral prior to endorsement for competitive sports.
Contributors

- Santiago Valdes, M.D.
- Ric Samson, M.D.
Seattle Criteria
Abnormal ECG Findings in Athletes

- T wave inversion: >1 mm in ≥ 2 leads (excludes III, aVR and V1)
- ST depression: ≥ 0.5 mm in ≥ 2 leads
- Pathologic Q waves: > 3 mm or > 40 ms in ≥ 2 leads (excludes III and aVR)
- LBBB, LAD, LAE
- RVH pattern: R(V1) + S(V5) > 10.5 mm and RAD > 120°
- Pre-excitation (WPW)
- Long QT interval: QTc ≥ 470 ms (female); ≥ 480 ms (male)
- Short QT interval: QTc ≤ 320 ms
- Profound bradycardia: HR < 30 bpm or sinus pauses ≥ 3 sec
- PVC’s/arrhythmias: ≥ 2 PVC per 10 sec tracing