Sudden Death in Athletes

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Sudden Death in Athletes

Speaker:
Professor Sanjay Sharma

Conflicts of interest:
None

Presentation slide distribution:
These presentation slides will be added to www.bsh.org.uk after the meeting
Sudden Death in Young Athletes
<table>
<thead>
<tr>
<th>POPULATION</th>
<th>AGE</th>
<th>DURATION</th>
<th>INCIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organised high school and college athletes</td>
<td>13-17</td>
<td>12 years</td>
<td>0.5/100,000/yr</td>
</tr>
<tr>
<td><strong>Competitive athletes</strong></td>
<td>14-35</td>
<td>25 years</td>
<td>2/100,000/yr</td>
</tr>
<tr>
<td>Marathon (London)</td>
<td>Mean 42</td>
<td>26 years</td>
<td>2.2/100,000 runs</td>
</tr>
<tr>
<td>Rhode island jogger</td>
<td>30-65</td>
<td>7 years</td>
<td>13/100,000/yr</td>
</tr>
</tbody>
</table>
Sudden Cardiac Death in Young Athletes


Incidence is approximately 1/50,000

Mean age at death in athletes 23 years-old

40% deaths in athletes aged < 18 years old

Males > females (9:1)

Black athletes > white athletes (5:1)

80 % deaths during or immediately after exertion
Sudden Cardiac Death in Sport

Hypertrophic Cardiomyopathy

Arrhythmogenic right ventricular cardiomyopathy
Coronary arteries and aorta

Anomalous coronary origin

Premature atherosclerotic coronary artery disease

Aortopathy
Sudden Cardiac Death with a Normal Heart

LQTS

Brugada

WPW
Relative Risk of SCD

Corrado D JACC 2003
Triggers for Sudden Cardiac Death

- Dehydration
- Adrenergic surges
- Electrolyte imbalance
- Acid/base disturbance

[Image of heart muscle and ECG trace]

[Logo: Centre for Sports Cardiology]
Screening Strategies for Detecting Athletes with Potentially Serious Cardiac Disease
## Screening Athletes

<table>
<thead>
<tr>
<th>Condition</th>
<th>History</th>
<th>Examn</th>
<th>ECG</th>
<th>Echo</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCM</td>
<td>Pos/Neg</td>
<td>Pos in 25%</td>
<td>Positive</td>
<td>Pos</td>
</tr>
<tr>
<td>ARVC</td>
<td>Pos/Neg</td>
<td>Negative</td>
<td>Positive</td>
<td>Neg/Pos</td>
</tr>
<tr>
<td>WPW</td>
<td>Pos/Neg</td>
<td>Negative</td>
<td>Positive</td>
<td>Neg</td>
</tr>
<tr>
<td>LQTS</td>
<td>Pos/Neg</td>
<td>Negative</td>
<td>Positive</td>
<td>Neg</td>
</tr>
<tr>
<td>Marfan</td>
<td>Pos/Neg</td>
<td>Positive</td>
<td>Negative</td>
<td>Pos</td>
</tr>
<tr>
<td>CAA</td>
<td>Pos/Neg</td>
<td>Negative</td>
<td>Negative</td>
<td>Neg</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>Pos/Neg</td>
<td>Pos/Neg</td>
<td>Pos/Neg</td>
<td>Pos</td>
</tr>
</tbody>
</table>

*INCREASING COST*
Medical history*

Personal history
1. Exertional chest pain/discomfort
2. Unexplained syncope/near-syncope†
3. Excessive exertional and unexplained dyspnea/fatigue, associated with exercise
4. Prior recognition of a heart murmur
5. Elevated systemic blood pressure

Family history
6. Premature death (sudden and unexpected, or otherwise) before age 50 years due to heart disease, in ≥1 relative
7. Disability from heart disease in a close relative <50 years of age
8. Specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long-QT syndrome or other ion channelopathies, Marfan syndrome, or clinically important arrhythmias

Physical examination
9. Heart murmur‡
10. Femoral pulses to exclude aortic coarctation
11. Physical stigmata of Marfan syndrome
12. Brachial artery blood pressure (sitting position)§
The effectiveness of screening history, physical exam, and ECG to detect potentially lethal cardiac disorders in athletes:

A systematic review/meta-analysis

Kimberly G. Harmon, M.D., a,b,* Monica Zigman, M.P.H., a Jonathan A. Drezner, M.D. a

a Department of Family Medicine, University of Washington, Seattle, WA, USA
b Department of Orthopaedics and Sports Medicine, University of Washington, Seattle, WA, USA

15 articles: 47,137 athletes

<table>
<thead>
<tr>
<th></th>
<th>Sens</th>
<th>Spec</th>
<th>False positive</th>
<th>Positive likelihood ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG</td>
<td>94%</td>
<td>93%</td>
<td>6%</td>
<td>14.8</td>
</tr>
<tr>
<td>History</td>
<td>20%</td>
<td>94%</td>
<td>8%</td>
<td>3.2</td>
</tr>
<tr>
<td>PE</td>
<td>9%</td>
<td>97%</td>
<td>10%</td>
<td>2.9</td>
</tr>
</tbody>
</table>

J of Electrocardiography. 2015; 48: 329-338
357 consecutive athletes. Mean age 29 ± 11 years old. 92% Male. 69% competitive.
2003-2013  514 deaths  79 sudden cardiac deaths (15%)

25% had a structurally normal heart
ECG in Patients with Cardiomyopathy

HCM
95%
Inferior and/or lateral TWI
ST segment depression
Pathological q waves

ARVC
40-50%
Anterior TWI (V2-V3/V4)
with isoelectric J point
Epsilon wave
Ventricular extra-systoles
Italy (Veneto region) 1979-1996 33,735 athletes screened

22 athletes diagnosed with HCM

3 identified on basis of family Hx (14%)

16 identified by abnormal ECG

2 identified on basis of murmur (9%)

73%
Does Cardiac Screening Save Lives?
TIME-TREND OF SUDDEN CARDIAC DEATH INCIDENCE IN ATHLETES VS NON-ATHLETES
Veneto Region of Italy 1979-2002

42,386 athletes; 55 deaths

3.6/100,000 person yrs

0.9/100,000 person years

Adapted from Corrado. JAMA 2006; 296:1593-1601
Concerns Relating to ECG Screening

- Low incidence of sudden cardiac death
- High number of false positives
- Cost
- Concerns relating to false negatives
- Other issues
# Prevalence of Young Athletes with Conditions Predisposing to SCD

<table>
<thead>
<tr>
<th>Reference</th>
<th>Population</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHA (2007)</td>
<td>Competitive athletes (U.S.)</td>
<td>0.3%</td>
</tr>
<tr>
<td>Fuller (1997)</td>
<td>5,617 high school athletes (U.S)</td>
<td>0.4%</td>
</tr>
<tr>
<td>Corrado (2006)</td>
<td>42,386 athletes age 12-35 (Italy)</td>
<td>0.2%</td>
</tr>
<tr>
<td>Wilson (2008)</td>
<td>2,720 athletes /children age 10-17</td>
<td>0.3%</td>
</tr>
<tr>
<td>Bessem (2009)</td>
<td>428 athletes age 12-35 (Netherlands)</td>
<td>0.7%</td>
</tr>
<tr>
<td>Baggish (2010)</td>
<td>510 collegiate athletes</td>
<td>0.6%</td>
</tr>
<tr>
<td>Sheikh (2015)</td>
<td>5000 British elite athletes</td>
<td>0.3%</td>
</tr>
</tbody>
</table>
Concerns Relating to ECG Screening

Low incidence of sudden cardiac death

High number of false positives

Cost

Concerns relating to false negatives

Other issues
ECG in Athletes

VAGOTONIA
Bradycardia
AV block
Repolarisation anomalies

CHAMBER ENLARGEMENT
Sokolow-Lyon Voltage criterion for LVH
Incomplete RBBB
Right axis deviation

Incomplete RBBB

Sinus bradycardia 45 bpm

SV1 + RV6 > 3.5 mV = LVH
ECG in Athletes

INFLUENCING FACTORS

- Age
- Sex
- Ethnicity
- Type of sport
- Intensity of sport

VAGOTONIA
- Bradycardia
- AV block
- Repolarisation anomalies

CHAMBER ENLARGEMENT
- Sokolow-Lyon Voltage criterion for LVH
- Incomplete RBBB
TWI in a Black Athletes

12.4%
ECG abnormalities in the athlete

(Group 1)
common (up to 80%)
- Sinus bradycardia
- First degree AV block
- Notched QRS in V1 or incomplete RBBB
- Early repolarization
- Isolated QRS voltage criteria for left ventricular hypertrophy

(Group 2)
Uncommon (< 5%)
- T-wave inversion
- ST-segment depression
- Pathological Q waves
- Left atrial enlargement
- Left axis deviation/left anterior hemiblock
- Right axis deviation/left posterior hemiblock
- Right ventricular hypertrophy
- Complete LBBB or RBBB
- Long or short QT interval
- Brugada-like early repolarization
- Ventricular arrhythmias
International recommendations for electrocardiographic interpretation in athletes

**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
- Sinus bradycardia or arrhythmia
- Ectopic atrial or junctional rhythm
- 1st AV block
- Mobitz Type I 2nd AV block

**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 2nd AV block
- 3rd AV block
- ≥ 2 PVCs
- Atrial tachyarrhythmias
- Ventricular arrhythmias

**Borderline ECG Findings**
- Left axis deviation
- Left atrial enlargement
- Right axis deviation
- Rights atrial enlargement
- Complete RBBB

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**Figure 1** International consensus standards for electrocardiographic interpretation in athletes. AV = atrioventricular; 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.
Impact of the International Recommendations for Electrocardiographic Interpretation on Cardiovascular Screening in Young Athletes

Dhutia H et al. JACC. 2017

4925 athletes
85% male and 85% white

3% positive ECG

66% reduction in the number of athletes requiring echocardiography
11,156 Soccer players screened with H/E/ECG/ECHO

Mean age 16.4 ± 1.2 Years       98% White       Serious diseases detected in 0.35%

<table>
<thead>
<tr>
<th>Method</th>
<th>Sens (%)</th>
<th>Spec (%)</th>
<th>PPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H and Examination</td>
<td>3</td>
<td>96</td>
<td>0.3</td>
</tr>
<tr>
<td>ECG (ESC 2010)</td>
<td>92</td>
<td>87</td>
<td>2.5</td>
</tr>
<tr>
<td>ECG (Seattle)</td>
<td>92</td>
<td>96</td>
<td>7.5</td>
</tr>
<tr>
<td>ECG (Refined)</td>
<td>92</td>
<td>97</td>
<td>11</td>
</tr>
<tr>
<td>ECG (International)</td>
<td>92</td>
<td>98</td>
<td>17</td>
</tr>
</tbody>
</table>
Concerns

Low incidence of sudden cardiac death

High number of false positives

Cost

Concerns relating to false negatives

Other issues
4,925 athletes

Screened cohort

Impact of Refined criteria

↓ >50% in positive screens

↓ 50%  
↓ 8%

↓ 12%

↓ 18%

No compromise in sensitivity

Dhutia et al. JACC. 2016
Potential use of savings

Screen an additional 2,120 athletes

Purchase an additional 95 AEDs

21% cost reduction

2010 ESC recommendations
Cost per athlete: $110
Cost per diagnosis: $35,993

Seattle criteria
Cost per athlete: $92
Cost per diagnosis: $30,251

Refined criteria
Cost per athlete: $87
Cost per diagnosis: $28,510

Dhutia et al. JACC. 2016
Concerns

Low incidence of sudden cardiac death

High number of false positives

Cost

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Other issues
Deaths Despite Screening with ECG

**False Negatives**
- Anomalous coronary arteries
- Premature atherosclerotic coronary disease
- Adrenergically driven ion channel disorders
- Incomplete expressions of cardiomyopathy

**Acquired conditions**
- Commotio cordis
- Myocarditis
- Electrolyte disorders
Alternative Strategies

Cardiopulmonary Resuscitation and use of AED

Athlete Education
Sudden Cardiac Death in Senior Athletes

- CAD: 80%
- SAD: 5%
- MVP: 5%
- Valves: 5%
- HCM: 5%
Sports-Related Sudden Death in the General Population

Marijon E. Circulation 2011
36 cases of SCA

Prompt CPR 94%
AED shock 83%

14 (high school)
Mean age 16

22 older non students
Mean age 57

64% survived to hospital discharge in each group
Higher survival rates may have been to the onsite AED (79%) and smaller number of cases of hypertrophic cardiomyopathy (21%)
Cardiac Arrest during Long-Distance Running Races

Jonathan H. Kim, M.D., Rajeev Malhotra, M.D., George Chiampas, D.O., Pierre d’Hemecourt, M.D., Chris Troyanos, A.T.C., John Cianca, M.D., Rex N. Smith, M.D., Thomas J. Wang, M.D., William O. Roberts, M.D., Paul D. Thompson, M.D., and Aaron L. Baggish, M.D., for the Race Associated Cardiac Arrest Event Registry (RACER) Study Group

**SCA**
- Survivor 29%
- Death 71%

**CPR**
- Time taken for Emergency Arrival (mins)
- VF
  - Survivors: 100%
  - VF: 3.3 mins
  - HCM: 88%
- HCM: 0%

Kim et al NEJM 2012
SCA 35-65 years old

5% occurred during exercise
Mean age 51.1 ± 8.8 yrs.     M:F 19

Witnessed SCA higher during sport (87% v 53%)
Bystander CPR higher for sport related SCA (44% v 25%)
Survival to discharge higher in sport related SCA (23.2% v 13.6%)

16% had pre-existing heart disease
56% had ≥ 1 risk factor for CAD
36% had typical symptoms of cardiovascular disease in the prior week.
Conclusions

• A large proportion of conditions implicated in sudden cardiac death (SCD) in young athletes can be detected or highlighted by the ECG

• Contemporary criteria are associated with a significantly lower false positive rate (2.5%) in young white athletes.

• A normal ECG does not protect from SCD

• CPR/AED and patient education are the best strategies for mature athletes
Sudden Death in Athletes

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