Screening for Risk of Sudden Cardiac Death in Young Athletes

27th Annual Symposium on Critical Care and Emergency Medicine 2011

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Sudden Death in Athletes is Rare

- SIDS 50-100/100,000
- Wide range of incidence in athletes:
  - 0.5/100,000 15 to 17 y/o in US
  - 2/100,000 in Italy (same event rate as US)
- Less than 100 deaths in US/year in young athletes from cardiac causes.

Annals of Internal Medicine 2010
Sudden Death in Young Competitive Athletes

- Cardiovascular causes 56%
- Blunt Trauma/Structural Damage 22%
- Commotio Cordis 3%
- Heat Stroke 2%

- Maron n= 1866, Circ 2009

Demographics of Sudden Death in Young Athletes  Maron, Circ 2009

<table>
<thead>
<tr>
<th>Sport</th>
<th>No. (%)</th>
<th>Age in yrs</th>
<th>Trauma</th>
<th>Commotio</th>
<th>CV disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Football</td>
<td>565 (30)</td>
<td>17 +/- 4</td>
<td>140 (25)</td>
<td>12 (2)</td>
<td>281 (50)</td>
</tr>
<tr>
<td>Basketball</td>
<td>405 (22)</td>
<td>17 +/- 4</td>
<td>4 (1)</td>
<td>0</td>
<td>348 (86)</td>
</tr>
<tr>
<td>Soccer</td>
<td>115 (6)</td>
<td>16 +/- 4</td>
<td>11 (10)</td>
<td>4 (4)</td>
<td>80 (70)</td>
</tr>
<tr>
<td>Baseball</td>
<td>111 (6)</td>
<td>16 +/- 4</td>
<td>16 (14)</td>
<td>30 (27)</td>
<td>54 (49)</td>
</tr>
<tr>
<td>Track &amp; Field</td>
<td>96 (5)</td>
<td>17 +/- 4</td>
<td>25 (26)</td>
<td>0</td>
<td>61 (64)</td>
</tr>
<tr>
<td>Wrestling</td>
<td>69 (4)</td>
<td>22 +/- 8</td>
<td>7 (10)</td>
<td>1 (1.4)</td>
<td>37 (54)</td>
</tr>
<tr>
<td>Boxing</td>
<td>56 (3)</td>
<td>25 +/- 6</td>
<td>42 (75)</td>
<td>0</td>
<td>11 (1.8)</td>
</tr>
<tr>
<td>Swimming</td>
<td>46 (2)</td>
<td>17 +/- 4</td>
<td>0</td>
<td>0</td>
<td>35 (76)</td>
</tr>
<tr>
<td>Cross Country</td>
<td>38 (2)</td>
<td>17 +/- 4</td>
<td>0</td>
<td>0</td>
<td>28 (76)</td>
</tr>
</tbody>
</table>
Demographics of Sudden Death in Young Athletes  
Maron, Circ 2009

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<th>CV disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hockey</td>
<td>29 (1.5)</td>
<td>18 +/-5</td>
<td>4 (14)</td>
<td>7 (24)</td>
<td>11 (38)</td>
</tr>
<tr>
<td>Horse Riding</td>
<td>27 (1.4)</td>
<td>27 +/-8</td>
<td>24 (89)</td>
<td>0</td>
<td>2 (7)</td>
</tr>
<tr>
<td>Softball</td>
<td>22 (1.2)</td>
<td>19 +/-6</td>
<td>3 (14)</td>
<td>1 (5)</td>
<td>12 (55)</td>
</tr>
<tr>
<td>Marathon</td>
<td>20 (1.1)</td>
<td>28 +/-7</td>
<td>0</td>
<td>0</td>
<td>13 (65)</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>19 (1.0)</td>
<td>18 +/-2</td>
<td>1 (5)</td>
<td>8 (42)</td>
<td>9 (47)</td>
</tr>
<tr>
<td>Skiing</td>
<td>19 (1.0)</td>
<td>25 +/-8</td>
<td>15 (79)</td>
<td>0</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Triathlon</td>
<td>17 (0.9)</td>
<td>32 +/-5</td>
<td>3 (18)</td>
<td>0</td>
<td>8 (47)</td>
</tr>
<tr>
<td>Martial Arts</td>
<td>15 (0.8)</td>
<td>23 +/-7</td>
<td>5 (33)</td>
<td>2 (13)</td>
<td>2 (13)</td>
</tr>
<tr>
<td>Rowing</td>
<td>11 (0.6)</td>
<td>22 +/-6</td>
<td>0</td>
<td>0</td>
<td>9 (82)</td>
</tr>
</tbody>
</table>

Demographics of Sudden Cardiac Death

- Demographics;
- Most during or shortly after exceptional exertion
- Basketball, Volleyball & Soccer overrepresented

- Maron, Circulation 2007...
CV causes of Sudden Death in Young Competitive Athletes, n 1866 Maron

- HCM 36%
- Indeterminate LVH/Possible HCM 8%
- Coronary Artery Anomalies 17%
- Myocarditis 6%
- Arrhythmogenic Rt Vent Cardiomyopathy 4%
- Ion Channelopathy 4%
- MVP 4% (Marfans?) avg 66/year

Maron Circ 2009

CV Causes of Sudden Death
1435 young comp athletes
Hypertrophic Cardiomyopathy

Coronary Artery Origins, Normal vs Anomalous
Pulmonary Origin of Left Coronary Artery

Anomalous origin of the left coronary artery from the pulmonary artery (ALCAPA).

Hauser M Heart 2005;91:1240-1245

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### Latent Heart Disease
#### Potential for Detection

<table>
<thead>
<tr>
<th>Condition</th>
<th>History</th>
<th>Examination</th>
<th>ECG</th>
<th>Echo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertrophic Cardiac Myopathy</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Arrhy Rt Vent Cardiomyopathy</td>
<td>+</td>
<td>0</td>
<td>0/+</td>
<td>+</td>
</tr>
<tr>
<td>Long QT Syndrome</td>
<td>+</td>
<td>0</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td>Catech Polymorph Vent Tach</td>
<td>0/+</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Brugada Syndrome</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Anomom. Origin Coronary Art</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>WPW Syndrome</td>
<td>0</td>
<td>0</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Marfan’s Syndrome</td>
<td>+</td>
<td>++</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Overall</td>
<td>3%</td>
<td>3%</td>
<td>&lt;50%</td>
<td>&lt;50%</td>
</tr>
</tbody>
</table>

### Latent Heart Disease, Child and Adolescent
#### Prevalence and Risk

<table>
<thead>
<tr>
<th>Condition</th>
<th>Prevalence</th>
<th>Sudden Deaths /million/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertrophic Cardiac Myopathy</td>
<td>1:5000</td>
<td>0.1</td>
</tr>
<tr>
<td>Arrhy Rt Vent Cardiomyopathy</td>
<td>Rare</td>
<td>0.08</td>
</tr>
<tr>
<td>Long QT Syndrome</td>
<td>1:5000</td>
<td>?</td>
</tr>
<tr>
<td>Catech Polymorph Vent Tach</td>
<td>Rare</td>
<td>Rare</td>
</tr>
<tr>
<td>Brugada Syndrome</td>
<td>Rare</td>
<td>Rare</td>
</tr>
<tr>
<td>Anom Origin Coronary Arteries</td>
<td>1:1000</td>
<td>0.05</td>
</tr>
<tr>
<td>WPW Syndrome</td>
<td>1:1000</td>
<td>Rare</td>
</tr>
<tr>
<td>Marfan’s Syndrome</td>
<td>1:20,000</td>
<td>Rare</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>?</td>
<td>0.05</td>
</tr>
<tr>
<td>Overall</td>
<td>3:1000</td>
<td>0.40</td>
</tr>
</tbody>
</table>
AHA Guidelines

AHA PPE CV screen Competitive Athletes; 16 parts;
- Personal Hx; was 5 questions, now 8
- Family Hx; was 3 questions, now 4
- Physical Exam; 4 Elements

Maron Circulation 2007, AAFP…2010

AHA Guidelines Practical Tool

- PPE, 4th Ed, Monograph and Downloadable Forms
- 2010 Consensus
- AAP, AAFP, AAP, ACSM, AOSSM, AMSSM, AOASM

- Download free at AMSSM.org under publications
AHA Personal History Questions

1. Passed out or nearly, DURING or AFTER exercise?
2. Pain, discomfort, tight or pressure in your chest c ex?
3. Heart race or skip beats during exercise?
4. Hx of heart problems? HTN, High Cholesterol, Kawasaki, murmur or heart infection?
5. Ever had a heart test? ECG, Echo?
6. Light headed or short of breath with exercise?
7. Unexplained seizure?
8. More tired, short of breath than friends in exercise?

Family History Questions

1. Premature death (sudden, unexpected unexplained) before age 50 yrs, due to cardiac disease?
2. Hypertrophic or dilated cardiomyopathy, Long or Short QT or Brugada or Marfans Syndrome, or catecholaminergic polymorphic ventricular tachycardia, or Arrhythmogenic right ventricular cardiomyopathy?
3. Heart problem, pacemaker, or implanted defibrillator?
4. Unexplained fainting, seizures or near drowning
AHA CV Physical Exam Components

1. Heart Murmur Assessment
   - Supine/Squatting
   - Standing/Valsalva (HCM murmur louder)
2. Femoral Pulses to exclude coarctation
3. Physical Stigmata of Marfans Syndrome
4. Radial artery blood pressure

Marfan’s Syndrome Diagnosis; Major Cr.

- Dx in parent of sib, Genetic mutation known
- Aortic root dilatation/ascending Aorta dissection
- Ectopia lentis
- Skeletal (4) pectus,pes planus, wrist/thumb sign, scoliosis, spondylolisthesis, Arm/hgt span 1.05, Protrusio acetabulae, poor elbow extension
- LS dural ectasia
Marfan’s Syndrome Minor Cr.

- Mitral Valve Prolapse/calcification
- Pulm Art dilitation, Descending Aorta diss
- Myopia and flat cornea or elongated globe
- High narrow arched palate, pectus, joint hypermobility
- Spontaneous pneumothorax, apical bulla
- Striae, recurrent incisional hernias

Secondary Prevention; AEDs

- Chain of Survival is significantly improved with programs that utilize AEDs
- 2.1% of schools reported SCA 36 victims
- 14 high school students (athletes),
- 22 older nonstudents
- 64% survived
  - Drezner Circulation 2009
ECG criteria changing

- Interpretation of Electrocardiogram of Young Athletes, Uberoi Circulation 2011
- Describes changes to the athletic heart in detail
- Voltage criteria for LVH alone will no longer exclude a patient from clearance

New AAP Guidelines; Heat

- Risk reduction training: coaches, trainers others
- Trained staff on site to monitor and treat
- Educate children
- Allow gradual acclimation
- Hydrate before, during and after exercise
- Modify activity or cancel; based on weather, individuals
- Limit those with recent illness
- Develop Emergency Action Plans
Arkansas Activities Association
Arkansas Athletic Trainers Association
Sports Medicine Advisory Committee

- Secondary School Coaches education; conferences
- Online training: AETN Ideas library; House Bill, video
- http://ideas.aetn.org/web/search?mode=results&queries keywords query=heat
- AAA Website for forms, heat resources, concussion
- http://www.ahsaa.org/activity/73/sports-medicine

HOUSE BILL 1743
State of Arkansas 88th General Assembly
By: Representatives Ingram, Perry

- AN ACT TO PROMOTE THE HEALTH AND SAFETY OF STUDENTS IN PUBLIC SCHOOL ATHLETIC ACTIVITIES THROUGH THE USE OF ATHLETIC TRAINERS AND PROFESSIONAL DEVELOPMENT FOR COACHES; AND OTHER PURPOSES

» Approved 04/06/2011
**HOUSE BILL 1743**

6-18-708  Health and Safety in Public Schools

School districts must develop procedures for student physical activity in public schools, for recognition and management of:

- Concussion, dehydration, other emergencies
- Environmental issues threatening health
- A communicable disease

Every 3 years coaches complete best practices training in these areas.

### AAA/AATA Exertional Heat Illness

**Symptom progression:**

- Cramps
- Syncope
- Exhaustion
- Stroke

**Prevention:**

- Acclimate
- Heat Index charts
- Weight checks
- Urine color charts
AAA/AATA Exertional Heat Illness

Fluid replacement guides
Exertional hyponatremia
Golden Hour concept
Cold Water Immersion guide
12 ice-towel substitute method
Cooling methods comparison
“Cool First, Transport Second”
EMS & Hospital initiative
Emergency Action Planning
• zeemaps

AAA/AATA Exertional Heat Illness
Practice Guidelines

• 3 hour limit in single practice
• No consecutive days of 2-a-day practices
• Max of 5 hours practice in a 2-a-day with one hour min cool break
• Acclimate
• Limit risk
• Promote recovery
Korey Stringer Institute

Dr. Doug Casa
Heat Illness expert
University of Connecticut

http://ksi.uconn.edu/

What do you want Docs to know?

Cool first, transport second; EMS protocols
ED cooling techniques, protocols and practice
On field cooling techniques
Dr Casa as resource; guides for all states
Families who have suffered want to help
Need help getting message to parents

100 percent of Heat illness is preventable
Exercise and Heat

- Heat
- Cooling mechanisms
- Heat stroke
- Prevention of heat illness
- Rehydration
Heat

- A high temperature;
- The sensation produced by proximity to fire or an incandescent object, as opposed to cold.
- The basis of heat is the kinetic energy of atoms and molecules which becomes zero at absolute zero.
- Enthalpy.

Heat Stroke

- A severe and often fatal illness caused by exposure to excessive temperatures, especially when accompanied by marked exertion;
- characterized by headache, vertigo, confusion, hot dry skin and a slight rise in body temperature;
- in severe cases very high body temperature, vascular collapse, and coma develop.
Heat Production

- Heat load increases 10-20 fold in exercise
- Maximal efficiency is 25%; 75% of energy goes to heat production
- Body functions in narrow range of temperature (5-6 degrees C)
- Heat management critical: uncontrolled temperature can lead to catastrophe

Heat transfer and dissipation

- Heat production exceeds loss early in exercise*
- Body core temperature increases
- Thermodetectors then begin to regulate heat dissipation processes
- Skin blood flow transfers heat by convection to the skin
- Heat dissipation is not limitless
Arkansas is HOT

- Weather in Little Rock
- Tuesday August 19th, 2003
- High Temperature 99 degrees F
- Winds 10 mph from South
- Relative Humidity 56%, Dew Point 70 degrees
- Heat Index 110, Heat Advisory issued

Skin transfers heat by

- Radiation
- Convection
- Conduction
- Evaporation
Conflict in Heat Exercise
Cardiac Output and Plasma Volume:

- Muscle demands intra-vascular fluid
- Skin demands blood flow for cooling (25% of CO)
- Sweating costs 1-2 liters/hr of plasma volume loss
- Plasma volume falls
- CO and Stroke volume fall
- Regulatory mechanisms reduce peripheral flow to preserve vital function

Hubbard’s Energy Depletion Model

- Thermal metabolic events drain energy.
- ...even in euhydration

- muscle metabolic rate increases
- cell membranes leak ions
- intracellular lactic acidosis occurs
Heat illness

- All athletes will suffer some degree of heat illness in Arkansas
- Prime symptom of heat illness: fatigue, subtle changes in pace

Cooling mechanisms

- All cooling processes depend on water
- Cooling is a complicated and critical process
- Arkansas’ heat and humidity work against cooling
Heat Illnesses

- Heat edema
- Heat syncope
- Heat exhaustion
- Heat cramps
- Heat stroke
- Hyponatremic collapse

Heat Cramps

- Muscle spasm tightening and pain
- Lower extremities most common, abdominals and intercostals too
- Caused by lack of acclimation, or excessive endurance work
- Long standing sodium depletion; diuretics and water replacement, caffeine!
- Rest, cool, massage, give hypotonic salt solution
Heat Exhaustion

- Hyperthermia, dehydration, hyponatremia core temp elevated <103
- Sodium depletion and water depletion types
- Fatigue, weakness, lightheadedness, cramps, flu like sx, GI sx, thirst, headache, anxiety, agitation, incoordination, fever, tachycardia, hypotension.
- Immediate cooling, IV fluids

Radiation of heat

- Person becomes red faced, shunting blood to surface
- Like water carrying heat to an old steam radiator
- Feeling sun’s direct warmth
- If ambient temp is more than skin temp...then you gain heat
Evaporation & convection of heat

- Sweating, feeling sticky; phase change from water to gas, releases the energy of heat and cools
- Profuse sweating, soaking clothes
- Relative humidity is high for most of the summer and fall here, making a narrow gradient of relative humidity for evaporation.

Exertional heat stroke

- Extreme hyperthermia:
- Muscular exercise
- Generates heat
- Exceeds body’s ability to dissipate it.
Exertional heat stroke

- Sporadic
- Single predisposition
- Combo of factors increases risk
- Common in young athletes
- Preventable

Acclimation

- Sweating: earlier, faster rate, greater capacity, lower salt concentration
- Plasma volume greater
- Heart rate lower at work load and heat stress
- Aldosterone, urine sodium excretion, muscle mitochondrial density, myoglobin, glycogen, all increased
- Heat shock proteins are made that extend temp range.
Exertional heat stroke risk factors

- Lack of acclimatization
- Overweight (reduced skin area to body mass ratio)
- Low physical fitness
- Infectious disease
- Sweat gland dysfunction
- Drugs, over motivation

Exertional heat stroke prevention

- Proper health education
- Regulations (h2o breaks q 15-20 min)
- Acclimatization to prevailing environment
- Fitness matched to activity
- Schedules to avoid highest risk hours
- Proper hydration and rest
Heat exhaustion
signs and symptoms

Nonspecific...dx missed often!

- Headache
- Nausea and vomiting
- Thirst with anorexia
- Chills and paraesthesias
- Dizziness and ataxia

Exertional heat stroke; diagnosis

- Collapse
- Extreme hyperthermia (t>104f, 40c)
- Cns disturbances (coma, delirium, seizure)
- Heme and enzyme changes (dic and rhabdomyolysis)
- Shock and brain edema
Learning from history

- The crusaders lost their final battle of the holy land in July 1187 because of exertional heat illness.

Exertional heat stroke series; military

- Summer 65%, spring 34%
- Morning 44%, night 15%, mid-day 17%
- Basic training 57%, screening 21%
- Aerobic training 80%
- Endurance runs 21%
- Short events (5k) 57%!
Exertional heat stroke; underdiagnosed

- Stereotype is misleading
  - Long exertion
  - Warm climate
  - Very high body temp.
- Symptoms nonspecific
- Higher index of suspicion needed
- Treatment initiation urgent to improve outcome

Exertional heat stroke treatment

- Cooling: tepid water and fan
- Fluids
- Systemic support: dic/sz/rhabdo
- Immunotherapy
Prevention of overheating

- Seek shade; reduce radiant gain
- Light colored clothing reflects radiant heat
- Moving air improves relative humidity at skin & evaporation

Prevention of overheating

- Change when clothes begin to soak
- Dry clothing wicks away sweat and improves evaporation
- Plan ahead; acclimate over 4 weeks
- Train; training regimen will help
**Water**

- Regulated by kidneys, pressure/osmol sensors, brain
- Adults may need 4 liters water/day if exercising in heat
- Can’t guzzle 4 liters before practice and expect success
- Water needs time to seep into appropriate places

---

**Water**

- Water must equilibrate with body fluid salts
- Thirst is not enough; push yourself to hydrate
- Drink water the day and night before, as well as during meals
- Make bottled or filtered water available
Water

- Pitcher of ice-water at all meals, liquids with salt retained
- Sugar & electrolyte sport drinks are absorbed faster than ice water and are retained for longer
- Clear looking urine is the goal!

Caffeine

- Makes kidneys act dumb
- Acts as drug/diuretic
- Causes kidney to loss of water and electrolytes, despite needs of metabolic balance
- Ever have to urinate after a large drink?
- Thirst only temporarily quenched...ever felt thirsty after?
Caffeine

- Junior high athletes drank 3.8 caffeine pops/day at avg of \( \frac{1}{2} \) the weight of adults...equal to nearly 8 caffeine drinks
- You never get ahead drinking only caffeine drinks
- Suggest 1 or 2 soft drinks per day limit, lots of water instead

Alcohol

- Although most athletes don't drink, some experiment. !?!
- Acts through aldosterone making the kidney lose water.
- (Ever have to urinate after drinking alcohol?)
- Limit alcohol use, replenish water and salt losses before exercise.
Sugared/sport drinks

- Increase time to empty stomach
- Move fluids to bloodstream faster however
- They replenish cellular fluids better than water.
- Try to avoid sugars at least 1 hour before exercise

Salt supplements can be dangerous

- Enough in american diet
- Free water needed.
- Salt tablets “never!”
- Sport drinks are “low salt” and considered safe
- High salt solutions best for rapid rehydration
What’s your favorite drink?

- Coke, Pepsi, diets, Dr. Pepper, Mtn Dew/Mello Yellow, Surge (2x caffeine), tea, coffee, water, lemonade, sport drinks?

Drink enough water

- Minimize water losses
- Manage heat-gain situations
- Optimize cooling
- Transport and cool early!!!!
- Lead by your example in athleticism and hydration!