Sports Cardiology In Endurance Athletes
AKOMA CME Conference
5-10-14 Anchorage AK

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Outline
- Numbers of athletes are increasing
- Exercise physiology of endurance sports
- Interpreting cardiac tests in endurance athletes
- Risks of endurance sports
- How sports cardiologists minimize risk

Many Health Benefits of exercise for all ages
- Current United States (US) physical activity guidelines:
  - Healthy adults: 2.5 hours of moderate activity/wk
  - Children: 60 minutes of daily physical activity, with 20-30 minutes of vigorous activity 3 days per week for both age groups
- Ref: Swift, Fletcher, Thompson, Pate, Jansen, Thorpe and US DHHS website

Numbers of athletes in USA—INCREASING
- Participation doubled in all demographic groups over past 10 yrs
- Established heart disease: Living longer; may contemplate sports and exercise

Over age 35 years—drawn to endurance exercise
- Marathon finishers up from 353,000 in 2000 to over 500,000 in 2011
- USA Triathlon memberships up from 21,341 to more than 146,000 during the same period

Risks of exercise
- Paradoxically, despite its favorable effects on well-being and survival, exercise can acutely be associated with:
  - risk of myocardial infarction
  - aortic dissection
  - arrhythmias
  - Sudden cardiac arrest (SCA) and/or death (SCD)
Exercise physiology

**Acute Exercise Response**

\[ VO_2 \text{max} = CO \times A-V O_2 \text{ diff} \]

\[ VO_2 \text{max} = (HR \times SV) \times A-V O_2 \text{ diff} \]

**Effects Exercise Training**

\[ \uparrow VO_2 \text{ max} \]

*Primarily SV*

*Reduced HR*

**Any Part Equation can Reduce Performance**

- Heart Rate
- Stroke Volume
- Arterial \(O_2\) Content
- Venous \(O_2\) Content

Cross country skiing: Lesson in sports cardiology, and evaluating an athlete

- CV Demands:
  - Endurance
  - Altitude (interaction w/ external athletic environment)
  - \(O_2\) desaturation - worse with altitude, as low as 80%
  - Use of both arms and legs

Cross country skiing: Lesson in sports cardiology, and evaluating an athlete

- CV Adaptations
  - \(VO_2\) max 87ml/kg/min (highest recorded 96ml/kg/min - B. Daehlie)
  - Max HR of 185 bpm
  - SV 200ml
  - CO 40 L/min
  - Up to 40% increases in all chamber measurements in ECHO/MRI
Interpreting cardiac tests

ECG findings/adaptation
Enhanced Parasympathetic Tone

- Resting Bradycardia
- Sinus Arrhythmia
- AV Conduction Delay
  1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}
- Early Repolarization
- T Wave Changes

28 year old 2:17 marathoner - chest discomfort

16 year old miler

WPW Pattern is More Common in Endurance Athletes

- Large Venous Capacity
- High Vagal Tone
- Reduced Sympathetic Tone

Be Careful of + Tilt Tables in Athletes-Up to 66% can be positive

Huston NEJM 1985

Vaso-Vagal Syncope is More Common in Endurance Athletes
Cardiac Enlargement

- Global (LV, RV, LA, RA)
- Mild
- Marked Enlargement → Disease

The Limits of LV Cavity

- 1300 Elite Italian Athletes
- LVID Increased
  - 45% > 55 mm
  - 14% > 60 mm
- Largest LVID
  - Female = 66 mm
  - Male = 70 mm
- HR r = 0.37; BSA r = 0.76

Pelliccia Annals IM 1999

Distribution of Left Atrial Dimensions in 1,823 Elite Athletes

- 20% (≥40mm)
- 71% (≥45mm)

The Limits of Normal Wall Thickness

- 947 Italian Athletes
- 209 Women
- 16 Athletes LVWT > 12 mm
- Rowing + Canoeing - 7% of Those Athletes
  - 1 Athlete > 16 mm
  - All Women < 11 mm

Pelliccia NEJM 1991

Distribution of max. LV wall thickness in 738 male and 600 female elite athletes

(Pelliccia, NEJM 91 and JAMA 95)

Left Ventricular Ejection Fraction: ? Normal

Tour De France Cyclists - 11% have LVEF less than 52%
Weight lifting: Pressure overload

- LV cavity not increased
- Wall thickness not increased, but out of proportion to cavity dimension

Risks of exercise

- Paradoxically, despite its favorable effects on well-being and survival, exercise can acutely be associated with:
  - risk of myocardial infarction +/- SCA/SCD
  - aortic dissection
  - arrhythmias
  - Sudden cardiac arrest (SCA) and/or death (SCD)

How Dangerous Is Exercise For Healthy Adults?

1 Death/Year/Per

<table>
<thead>
<tr>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School 0.12</td>
<td>High School 0.66</td>
</tr>
<tr>
<td>College 0.28</td>
<td>College 1.45</td>
</tr>
</tbody>
</table>

(1 / 133,333 men & 1/769,230 women)

Van Camp 1995
Incidence and etiology of SCD in athletes

- SCD rare (Swiss Engadine Ski Marathon, 1:120,000 skiing hours)
- Swedish Vasaloppet racers showed more than 7 X greater risk of SCD acutely
- Over a 10 year period, standardized mortality ratios of 0.48 [95% confidence interval (CI) 0.44-0.53]
- Acute increase in SCD outweighed by long term benefit
- Higher incidence of atrial fibrillation

Medical perspective - XC skiing

Exercise Also Increases the Risk of Myocardial Infarction

Most MIs Are Caused by Lesions of Minimal Stenosis

Screening Exercise Tests

- May Be Falsely Positive
- Because of Left Ventricular Enlargement ??
- Can Be Dismissed if Good Exercise Tolerance, No Symptoms, Good Heart Rate Response, Rapid Resolution in Recovery
- Nuclear Imaging May Show Inferior Defect
- Due to Large Hearts & Diaphragmatic Attenuation ??
Screening Exercise Tests

Are Not Good Predictors of Sudden Death or Acute MI in Asymptomatic Individuals

Exercise Testing for Asymptomatic Persons Without Known CAD

- Class 2 - Conflict or Divergence of Opinion
- Evidence/Opinion Favors - Diabetes Pre Vigorous Exercise
- Usefulness Less Established - Men >45, Women >55 Pre Vigorous Exercise

Exercise Advice?

- 36th Bethesda Conference 2005 Determining Athletic Eligibility in Athletes with Heart Disease Are Very Restrictive
- Prohibit Competitive Athletics with High Risk Lesions (CAD, HCM, Marfan)
- Flexibility Depending on the Perceived Risk For the Athlete…but
- The "I Gotta Sleep Too Rule"

The Most Frequent Problem

- High Powered, Exercise – Addicted Lawyers, Bankers, Stock Brokers
- Wanting to Return to Climbing, Competition, Whatever
- After an ACS

Typical baby boomer athlete

- Born post WWII between 1946 and 1964
- A weekend warrior
- Or, an athlete who resumes sports after years of no training or the athlete who starts a sport late in life

Return to previous activity after event???

- 60 y/o male attending cardiac rehab after CX stent for MI
- Asymptomatic, MVO2 32.4ml/kg/min, max HR 134 bpm (10:15 min Bruce protocol)
- LVET 52%, nuclear stress- small fixed defect lateral wall, no evidence of reversible ischemia
- His question: Is it OK to return to competitive open wheel race car driving at 145mph?
Patient Information

- 21-year-old male
- Six years prior – diagnosed with mild aortic insufficiency
- Otherwise a healthy individual.
- No history of:
  - Hypertension
  - Diabetes
  - Dyslipidemia
  - COPD
  - Smoking
- Weight: 201 lb (91 kg), Height: 72 in (184 cm)

Clinical Presentation

In June, 1999:

- Presented to an outside institution with acute severe substernal chest pain with shortness of breath
- The pain developed during strenuous exercise (lifting weights)

Weight Lifting Exercise

- Weightlifter
- Exercises daily
- Primarily anaerobic exercise
- Lifts up to 75-100% of body weight

Computed Tomography

- Dilated ascending aorta from the sinuses to the proximal arch,
- Maximal size 5.2 cm
- Aortic dissection was suspected, but a clear dissection flap was not visible
**Transesophageal Echocardiography**

- Dilatation of the ascending aorta from the sinuses to the proximal arch
- Maximal size 5.3 cm
- Bicuspid aortic valve
- Moderate aortic insufficiency, no stenosis
- Normal left ventricular ejection fraction
- Fluid in the pericardium
- No signs of aortic dissection

**Intraoperative findings**

- Bloody fluid in the pericardium – moderate amount (no hemodynamic effect)
- Ascending aorta appeared severely dilated
- Tubular type aneurysm
- Severe ecchymosis in the wall of the aorta
- Upon entry of the aorta – a large stellate laceration (3 cm) of the internal surface of the aorta was found in the right lateral location.

**Evidence of Intramural Hematoma of the Ascending Aorta**

**Intramural Hematoma**

**Surgical procedure**

- Composite graft replacement of the ascending aorta, aortic valve, and hemiarch on cardiopulmonary bypass and deep hypothermic circulatory arrest

- Cardiopulmonary bypass time – 174 min
- Aortic cross-clamp time – 108 min
- DHCA time at 18 degrees Celsius – 31 min

**Postoperative Course**

- Early:
  - Benign, diuresing well, hemodynamically stable.
  - No atrial fibrillation
  - Discharged home on 5th postoperative day
- Late:
  - 15 years postoperatively the patient is doing well
  - Continues physical training and weight lifting

**Patient wants to return to weightlifting**

- What advice to give to patient?
  - Restrict anaerobic physical exercise to less than 50% of body weight.
  - Allow complete return to preoperative levels of physical activity.
  - Allow complete return to preoperative levels of physical activity and screen the size of arch/descending/thoracoabdominal aorta.
Five years postoperatively

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Thanks to Dr. Paul Thompson (Hartford Hospital, CT) for use of some slides

Thank you!