Sudden Cardiac Death in Endurance Events

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Objectives

- Understand the risks of cardiovascular collapse during the marathon
- Recognize the causes of potentially fatal collapse in runners
- Develop a triage and treatment system for collapsed runners with sudden cardiac arrest

I. Introduction
- A. Is moderate to high intensity, long term athletic training and competition associated with enhanced coronary artery disease?
  1. Few studies available examining coronary atherosclerosis in endurance athletes
  2. Data suggest that coronary artery calcification and soft plaque may be paradoxically increased in this group
     a. Possibly due to increased sheer stress on the arteries
  3. Möhlenkamp, AHA 2006 Chicago –
     a. Healthy men over 50 finished ≥ 5 marathons in last 5 yrs
        (1) More likely to have major calcium deposits in their arteries than healthy men who did not run as much
        (2) Possibly a sign of increased cardiovascular risk
     b. 36% of 108 male marathon runners had coronary artery calcium scores > 100
     c. 22% of 216 men with similar heart disease risk factors who did not run had scores > 100
  4. Is marathon running cardioprotective for most participants?
     a. How do you control for variations in training volume, total number of marathons, cardiac risk factors, and lifestyle issues?
- B. Marathon runners compared to active controls (Zoneraich, 1997)
  1. Echocardiogram abnormalities related to the overload type of heart
  2. "Early repolarization syndrome"
     a. Abnormal RS-T segment elevation and notched T waves in ECG
  3. 3 athletes met ECG criteria and 1 met vectrocardiography (VCG) criteria of LVH.
- C. What are the common causes of fatal and near fatal medical collapse during and after the marathon?
  1. Cardiac arrest and sudden cardiac death
     a. Leading cause of death
  2. Exertional hyponatremia
  3. Hyperthermia and exertional heat stroke
  4. Subarachnoid hemorrhage
- D. Sudden cardiac arrest (SCA) and especially sudden cardiac death (SCD) are high visibility incidents that can overshadow the event
  1. Sensational coverage in media

2. May inadvertently promote inactivity

II. 2006 TCM and MCM experience
   A. 4 SCA with 2 SCD
      1. Poisson distribution
         a. An event that occurs rarely but has many opportunities to do so
         b. Occasionally crop up in small clusters after many years with no occurrences
      2. Nearly 1/3 of total SCA for this data set
   B. 2006 cases newspaper accounts
      1. Marathon runner has heart attack, dies
         a. 49 yo Mpls experienced male with no history of heart disease
         b. Loved to run and taught that love to his sons
         c. Collapsed from heart attack near 6-mile mark near Lake Calhoun
         d. Ran 1st TCM in 1987 and had completed 10 marathons
         e. No known health problems
         f. Just had a physical exam
         g. CPR started immediately by runners
         h. Treated on site within minutes by emergency technicians
      2. Second TCM male runner collapsed at 11:30 AM 400m short of finish line
         a. Resuscitated with an automatic external defibrillator
         b. Doing well and back to previous job
      3. 60 yo male runner went into cardiac arrest at about 8:30 AM just after start of Marine Corps Marathon in Arlington
         a. Collapsed close to several trained medical personnel
            (1) Including fellow marathoner Frederick C. Lough
               (a) Director of cardiac surgery at GW Univ Hospital
            (2) Rapid response with defibrillator.
            (3) Transferred to GWU directly to cardiac catheterization lab
            (4) Doing well
      4. 56 yo MCM male runner died Sunday afternoon after collapsing during the race at mile 17

III. What are the risks of sudden cardiac arrest and sudden cardiac death associated with marathon?
   A. Death risk low in racing
      1. Training statistics not known or tracked
         a. 1 TCM trainee died of MI last year (2006) 2 weeks before the race
      2. Training deaths are a part of “down on street” stats with 5-15% chance of survival
   B. In competition statistics
      1. Sudden cardiac arrest
         a. Twin Cities & Marine Corps Marathons (unpublished data – Roberts)
            (1) 1 in 49,100 finishers
         b. TCM (unpublished data – Roberts)
            (1) 1 in 27,600 finishers
            (2) 1 in 17,000 male finishers
         c. London Marathon
            (1) 14 in 709,500 completed runs
            (2) 1 in 50,700 finishers
            (3) Coronary artery disease most common cause of SCA
               (a) 5 deaths and 6 resuscitations,

(4) Hypertrophic cardiomyopathy or idiopathic left ventricular hypertrophy diagnosed at autopsy on 3 occasions
(a) HCM deaths had the same average age as the runners with ischemic heart disease deaths

2. Sudden cardiac death
a. 2006 USA stats
(1) 6 deaths in 450,000 finishes (may contain repeat finishers)
(2) 1 in 75,000 finishers
b. TCM/MCM since 1976 (unpublished data – Roberts)
(1) 1in 88,400 finishers
c. TCM since 1982 (unpublished data – Roberts)
(1) 1 in 69,000 finishers
(2) 1 in 42,000 male finishers
d. London Marathon since 1981 (Unpublished data – Tunstall Pedoe)
(1) 1 in 88,700 finishers
e. Chicago Marathon
(1) 3 cardiac related deaths in 350,696 finishers
(a) 1 was hyperthermic at 107 ºF and young (EHS?)
(2) 1 in 117,000 finishers

IV. Where do cardiac arrests occur during and after the marathon?
A. Race Experience
1. London Marathon collapse sites
a. Finish line and post finish - 4
b. Between 6 and 26 miles - 10
(1) Average 16 miles
2. TCM/MCM collapse sites
a. Finish line and post finish – 2 (SCA, SCD)
b. Mile 26.1 – 2 (SCA)
c. Mile 24 – 1 (SCD)
d. Mile 23 – 1 (SCD)
e. Mile 21 – 1 (SCA) [in aid station]
f. Mile 17 – 1 (SCD)
g. Mile 15 – 2 (SCD)
h. Mile 8 – 1 (SCA)
i. Mile 6 – 1 (SCD)
j. Mile 2 – 1 (SCD)
k. Mile 0.1 – 1 (SCA)
B. Most frequent location is finish area defined as 26 miles thru finish complex

V. Who is most affected by SCA?
A. Cardiac arrests occur even in experienced runners
1. 47 yo running 38th marathon
2. 52 yo running 11th marathon
3. 50 yo running 19th marathon
4. 52 yo running 4th marathon
5. 32 yo running 4th marathon
6. 58 yo running 4th marathon
B. Male runners more frequently involved
1. Unexpected collapse due to soft plaque rupture?
2. Ignored symptoms?
a. Occasional history consistent with “angina” prior to arrest

b. Only one of the eight London runners who died had reported symptoms to his family or physician suggestive of cardiac disease.
(1) negative exercise stress test prior to the marathon and despite this died with an LAD stenosis
c. One of 2 TCM runners who died had reported epigastric discomfort to his physician 2 days prior to his SCD

3. Negative stress tests prior to marathon
a. Above
b. TCM SCA had normal GXT 3 weeks prior to marathon
4. TCM/MCM male SCA rate is 1:27,400 male finishers

C. Death in women runners
1. London Marathon - no female deaths in 680,000 finishes
2. TCM / MCM 1 female death in 498,000 finishes (unpublished data, Roberts)
a. Age 19 – anomalous coronary artery
b. TCM/MCM female SCA rate is 1:135,400 women finishers
3. Chicago 1 female death in 350,696 finishes
a. Age 29 – "mitral valve prolapse"

D. Older (≥ 40)
1. TCM/MCM database
a. 10/13 SCA
b. 77%
2. London database
a. 6/8 SCD
b. 75%
c. 1990 age 39 HCM, 1993 47 IHD, 1994 52 IHD, 1995 49 IHD, 1997 44 IHD, 2001 34 HCM, 2003 52 IHD, 2005 59 Idiopath LVH (?HCM.)

VI. What happens to cause SCA in runners
A. Mechanism of onset in CAD
1. Soft plaque rupture
a. Sudden occlusion without collaterals
b. Usually no warning
2. Obstruction ischemia from large calcified plaque
a. Prodromal symptoms before and during race
b. Arrhythmia
3. Arrhythmia

B. Congenital heart disease (HCM, anomalous coronary artery, long QT)
1. Arrhythmia
2. Often no warning

C. What does the pathology look like?
1. Case 1 – 40 yo male;100% occlusion of LAD and ≥80% of every other coronary artery and major body artery
2. Case 2 – 52 yo male; acute plaque rupture and progressive occlusion of LAD
3. Case 3 – 28 yo male; nearly absent flow in R coronary artery with normal repeat study; mitochondrial defect on muscle biopsy
4. Case 4 - HCM

VII. Recognition and on site planning to reduce SCD
A. Sudden collapse common marathon presentation of SCA
1. Immediate LOC with no protective reflex

2. Facial and tooth fractures common

B. History chest pain, chest pressure, loss of exercise capacity, epigastric distress is less common but often ignored in runners
   1. Education
   2. Pre screening symptomatic participants

C. Preparation for SCA on course and in finish area
   1. Rapid response times by teams equipped with external defibrillators
      a. Ambulances staffed with paramedics
      b. Bicycle (or motorcycle) pairs or trios with AEDs
      c. Defibrillators at stationary medical stations
      d. Combination of manual and automatic defibrillators in finish area
   2. Automatic external defibrillators have improved response times
      a. Easy to carry
      b. Easy to apply and use
   3. Communication system with backups and overlap
      a. Cell phone and line of sight
      b. Ham radio operators
      c. Short wave radios
   4. Communicating location and problem
      a. Volunteer training
      b. Exact location for 911 calls
      c. Use runner number for rig assignments so ambulance is not "hijacked" by another emergency
   5. CPR trained volunteers along course
   6. Another runner is most likely first responder
      a. TCM "Runners treating runners" program – Runners who help are given complimentary entry into next race

D. Treatment
   1. CPR with modifications
      a. Increased compressions & decreased mouth to mouth
      b. "Plunger"
      c. "Air flow block"
   2. Rapid defibrillator application and use seems to decrease SCD
      a. 2 minutes of chest compressions if AED is not immediately available
   3. New protocol employs a single shock followed by 2 minutes of CPR

E. Disposition
   1. Hospital transfer

F. Public relations plan
   1. Limit discussion to "need to know"
   2. Single source for press release preferably as a single press conference
   3. Stress safety of event and intervention plan

VIII. How much training to protect the heart?

A. Bassler's hypothesis that a marathon runner could not get coronary artery disease disproven

B. Recent work suggests cardiac strain in marathon finishers
   1. Möhlenkamp, Herz 2006
      a. Coronary artery calcium counts elevated in male masters marathon runners
      b. No account of risk factors and lifestyle issues
   2. Neilan, Circulation 2006

a. Studied 60 nonelite 2004 and 2005 Boston Marathon finishers before and after the race
b. Echocardiography
    (1) Conventional measures
    (2) Tissue Doppler-derived strain and strain rate imaging
c. Biomarkers
    (1) Cardiac troponin T (cTnT)
        (a) At baseline all had unmeasurable troponin
    (2) N-terminal pro-brain natriuretic peptide (NT-proBNP)
d. Echocardiographic abnormalities after the race
    (1) Altered diastolic filling
    (2) Increased pulmonary pressures
    (3) Increased right ventricular dimensions
    (4) Decreased right ventricular systolic function
e. Biomarker abnormalities after the race
    (1) cTnT
        (a) >60% increased >99th percentile of normal (>0.01 ng/mL)
        (b) 40% at or above the decision limit for acute myocardial necrosis (>/=0.03 ng/mL)
    (2) NT-proBNP concentrations
        (a) Increased from 63 pg/mL to 131 pg/mL (P<0.001)
f. Increase in biomarkers correlated with post-race
    (1) Diastolic dysfunction
    (2) Increased pulmonary pressures
    (3) Right ventricular dysfunction (right ventricular mid strain, r=-0.70, P<0.001)
    (4) Inversely with training mileage (r=-0.71, P<0.001)
g. Athletes who trained <35 miles/wk compared to >45 miles/wk demonstrated
    (1) Increased pulmonary pressures
    (2) Right ventricular dysfunction (mid strain 16±5% versus 25±4%, P<0.001),
    (3) Myocyte injury (cTnT 0.09 versus <0.01 ng/mL,P<0.001)
    (4) stress (NT-proBNP 182 versus 106 pg/mL, P<0.001)
h. Malissa Wood (Senior Author)
    (1) Does not suggest a long term detrimental effect from running
    (2) No evidence to suggest that there are *substantial* long term sequelae to this

C. Less cardiac strain and stress post race with more miles of preparation
    1. >40-45 miles per week going into marathon races
D. Lifestyle, health habits, and family history probably play a role in cardiac risk that is lessened buy regular exercise

IX. Should we screen marathon runners with exercise testing?
A. Marathoners should be screened like the rest of the population
B. More intensive screening if they have risk factors

X. Summary
A. SCA occurs in marathon runners during races and presumably during training and at rest
B. Risk is less at rest than sedentary counterparts

C. SCA occurs along the course basically from start to finish
D. SCA is occuring primarily in men at this time
E. SCD can be prevented by early intervention with defibrillation but early intervention does not ensure survival
F. SCA survival seems to be more likely near the finish and start areas.
G. Increased cardiac strain occurs in marathon racers who are not well trained coming into the race
H. Prepare protocols and equipment in advance
I. Educate volunteers and runners

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