Marathon Medicine:
Exercise Associated Collapse in Endurance Sports

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Overview

- Epidemiology / Demographics of Runners
- Emergency Preparedness
- Exercise Associated Collapse
  - Exercise Associated Hyponatremia
  - Cardiac Arrest
- Heat-related Illness
Exercise Associated Collapse

Extensive Differential:

- EAC
- Heat related illness
- Hypothermia
- Hypoglycemia
- Hyponatremia
- Muscle cramps
- Cardiac arrest
- Other medical / neurologic conditions
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“Benign” Exercise Associated Collapse

AFTER the finish line

“postural hypotension”

Not simply the result of dehydration  (Holzhausen 1994, Med Sci Sports Exer)
“Benign” Exercise Associated Collapse

Pathophysiology:

- Leg muscles venous pump
- Venous pooling
- Collapse

As temperature increases, blood flow is shunted from core to skin
Exercise Associated Collapse

Assessment:
- Level of responsiveness
- ABC’s
- When? - during the race vs. after finish
- Blood glucose, Na, Rectal temp, cardiac rhythm, orthostatics

Treatment:
- Treat the underlying cause
- Elevate legs and pelvis
- Oral rehydration
- Not clearing within 15-30 minutes: IVF
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Exercise Associated Hyponatremia

Hypervolemic hyponatremia

First reported in the 1981 Comrades Run (90km) in South Africa

International media attention after a 28yo female runner died after the 2002 Boston Marathon

The Boston Globe: “MARATHON RUNNER’S DEATH LINKED TO EXCESSIVE FLUID INTAKE”

488 runners had a usable blood sample at the finish
- 13% (63) Na < 135
- 0.6% (3) Na < 120

Risk Factors after Multivariate Analysis
- Weight gain
- Race time > 4 hours
- BMI extremes
Pathophysiology:
(similar to SIADH)

Overconsumption of fluids exacerbated by AVP secretion

Sources of AVP during exercise:
- Plasma volume contraction
- Muscle breakdown (rhabdo)
- Nausea/vomiting
- Hypoglycemia
- Stress
- Hyperthermia
Exercise Associated Hyponatremia

Cerebral Edema and Pulmonary Edema

Signs and Symptoms:

Early: Lightheaded, dizzy, nauseated

Middle: Severe and progressive HA, vomiting, puffiness, cramps, confusion, “impending doom”

Late: Ashen, obtundation, seizures
**Treatment**

**Na < 135, fluid overloaded, symptomatic with progressive encephalopathy**
- high flow O2
- 100cc of 3% NaCl over 10 min x 2
- (+/- 50-70cc/hour)
- (+/- diuretic)
- Transfer to E.D.
- Start Rx of hyponatremia before head CT

**Na < 135, fluid overloaded, minimal symptoms**
- allow natural diuresis
- close observation
- ? hospitalization
- fluid restriction

**Na < 135, dehydrated**
- rehydrate with NS
- if encephalopathic: use 3%NS
- check lytes after each liter
- consider transfer to E.D.
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Prevention

Emphasize Individual Differences

Replace what you need (sweat losses)

Drink when you are thirsty
(very safe for slower and at risk runners)

Salty sweaters (or if competition > 6hrs):
use Na / electrolyte replacement
Prevention

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General Guidelines:

Average fluid replacement in a marathon:
400-800 cc / hour  (14-27 ounces)
Diagnosis and Prevention of Hyponatremia at an Ultradistance Triathlon

Ironman New Zealand

1997
- 3.8% (25) received care for EAH
- 14 were hospitalized
- 2 were admitted to ICU

1998
- 0.6% (4) received care for EAH
- none were critical
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Intervention:
Education on fluid intake
(500-1000cc/hour)
Limited the number of aid stations
- bike: from q 12km to q 20km
- run: from q 1.8 km to q 2.5 km
Exercise Associated Hyponatremia: Summary

Risk Factors
- Finish time > 4 hrs
- Weight gain / high fluid intake
- Smaller runners
- Hot & humid conditions

Treatment
- Oxygen
- 3% NaCl on site
- Transfer to Emergency Facility
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SCD in Marathons

Often quoted risk of SCD in marathons due to CV disease: 1:50,000
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The rate has improved over the last 10-15 years (potentially due to earlier recognition, better preparation, AED use)

1976-1994 Twin Cities & Marine Corp: 1:55,000
1995-2004 Twin Cities & Marine Corp: 1:220,000
1981-2006 London: 1:130,000

Twin Cities & Marine Corp
1976-2004
~442,000 finishers
9 cardiac arrests
5 died (1:88,000)
4 resuscitated (45%),
(75% in last decade):
  - 3 VFib, 1 asystole
  - all had AED within 5 minutes

7/9 (age 32-58): CAD
19yo female: anomalous coronary artery origin
28yo male: mitochondrial myopathy
6/9 completed one prior marathon

London
1981-2006
~650,000 finishers
11 cardiac arrests
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6 resuscitated (55%),
(50% in last decade)

8/11: CAD
3/11: HCM
1/3rd presented at finish
2/3rd btwn Miles 6-26
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Toronto
2001-2008

2,500 - 4,000 entrants / year

4 cardiac deaths

2001: 54yo multi-marathoner in marathon
2004: 42yo male near end of half-marathon
2005: 37yo male after the half-marathon
2006: 41yo male 800m from finish of marathon
Berlin
September 2008

40,000 entrants

Danny Kassup
25yo Canadian Olympic hopeful

Collapsed at the 5K mark
CPR started immediately
AED within 2 minutes
V Fib arrest from myocarditis
(had a recent URI)
Seattle
November 2007

~ 11,000 entrants

37yo software engineer

1st marathon, multiple half-marathon finishes
Collapsed 30 yards before finish
CPR started immediately
Successfully resuscitated

Cath: 70%mid LAD lesion--> stented
Sept 2009: Virginia Beach RnR HM, 23 yo male
during race, near finish
Oct 2009: San Jose RnR HM, 34yo female, 35yo male
within last mile
Oct 2009: Baltimore Marathon, 23yo male
25th mile, heat stroke (temp 107-108 in ED)
Oct 2009: Detroit HM, 26, 36, 65 yo males
26yo: after finish, others btwn 11-12 miles, all cardiac (65yo CAD)
Dec 2009: Memphis HM, 32yo female
after finish, h/o AFib s/p ablation
Jan 2010: Mississippi Blues Marathon relay, 40yo male
died in the initial mile of the anchor leg
Mar 2010: Dallas RnR HM, 32yo male
after finish, myocarditis
May 2010: Orange County HM, 46yo male
100yds before finish, heat stroke, h/o sz disorder,
June 2010: Duluth Grandma’s HM, 64yo male
after finish, CAD s/p MI
Sept 2010: Virginia Beach RnR HM, 27yo male
at finish
Sept 2010: Nashville Women’s HM, 54yo female
after finish, CAD s/p MI
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14 Race Related Deaths in 2009-10

Marathon: 2
Half Marathon: 12

cardiac: 7
heat stroke: 2
unknown: 5

males: 11
females: 3

7 < 35yo
7 > 35yo
(3 > 50yo)
Risk of SCD in Marathon Running vs. Dying in an MVA

(that might otherwise have taken place if the roads had not been closed)

DA Redelmeier, 2009 BMJ
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Retrospectively studied 26 US marathons 1975-2004:
  26 SCD
Due to road closures, 46 MV fatalities were prevented
  (35% risk reduction)
  1.8 crash deaths saved for each case of SCD

From a societal perspective, organized marathons decrease the death rate
Exercise Associated Collapse

Extensive Differential:

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Heat Exhaustion

Inability to continue to exercise in the heat
Represents a failure of the CV responses to workload, high env. temps, and dehydration
No known chronic or harmful effects
Heat Stroke

Hyperthermia: core temp > 39C/102.2F with CNS dysfunction
Rectal temperature
Medical Emergency!
Causes multi-organ system failure.
Treatment: Immediate cooling!
Whole Body Cooling

“Golden half-hour”
- cool within 30 minutes
- <40C/104F
- d/c water immersion when at 101-102F

Fastest: cold water immersion

Whatever method is utilized, it should be:
- simple and safe
- provide adequate cooling
- not restrict other forms of rx (CPR, defibrillation, IV cannulation)

Methods
- Ice bath/cold water immersion
- Burrito method with sheets and ice
- Ice to head, neck, axilla, and groin

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Etiology of Heat Stroke

- High ambient temperature
  - but does occur in cool environments

- Metabolic heat production from exercise exceeds heat loss / inadequate heat losing mechanisms
  - but does occur in slower runners whose metabolic rate is lower and thus heat production is lower

- Excessive endothermy (endogenous heat production)
  - ? form of malignant hyperthermia
  - excessive sympathetic activation in the presence of a metabolic myopathy

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Pathophysiology of Heat Stroke

- **Systemic Inflammatory Response System (SIRS)**
  - a “cytokine storm,” similar to sepsis:
  - organ hypoperfusion --> gut ischemia --> endotoxin release --> pyrogenic cytokines --> worsening hyperthermia
  - primed by prior viral exposure (URI?)

- **Multi-organ system failure**
  - CNS involvement: cerebellum and BBB breakdown
  - Associated with rhabdomyolysis, renal failure, liver damage, hyperkalemia, hypercalcemia, and hypoglycemia

Bouchama: NEJM 2002
Sonna: Prog Brain Res 2007
O’Connor: Curr Sports Med Rep 2010
Summary

1. Prevention of benign EAC:
   - keep the runner walking after the finish
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   - check rectal temperature
   - Rx: immediate whole body cooling