Kaiser patient 2002

- 16 y.o. Swimmer with chest pains and palpitations
- Normal Echo
- Normal ECG
- Normal exercise treadmill
- Seen in office with normal exam one February day and told OK to participate.

Later that same afternoon

Dead at bottom of pool
Abnormal coronary artery pattern found at autopsy

Sudden Death in Athletes

A work in progress
Kaiser Nurse Practitioner Education
April 17, 2008
An emergency-room doctor told Vincent and Wendy Stross that their son had died of a hidden heart defect that couldn't have been detected, the parents say. But two days later, they said, a nurse from the emergency room called and said her conscience required her to tell them. The defect probably could have been prevented if they had been informed. The nurses then got them to go to the nursing home to visit.

"I think Dr. Stross has it, as initial tests suggest," the nurse told them. "But a heart specialist can offer him a nearly normal life span.

"Heart disease, as it's called, is a genetic abnormality that makes the left ventricle, leading to sometimes-fatal disturbances of the heart rhythm. Young athletes suffer sudden cardiac death at a rate thought to be two to three times as high as that for their peers. The nurse said no doctor had suggested that their son, now named 'internal athlete,' undergo a heart scan. "I can still be active" if they had, says Mrs. Stross.

"American medicine is respected around the world for its all-out war on heart disease, with advanced drugs and procedures and campaigns that teach the public about the dangers of heart disease, and that's a great thing," the nurse said. "But this is the first time I've heard of such a problem."
How many die?

0.8-6.2 per 100,000
- 0.0008%–0.0062%
- Adult=0.1%
- 1/350,000 high school athletes/year

Studies
- Driscoll/Edwards, Minnesota ’50–’82
  - Age 1-22, 515 deaths
  - 12 were sudden cardiac (2.3%)
  - 1.3/100,000
More Studies

- Waller, Marion City, IN ’85-’90
  - 18 deaths, 0.04% incidence
- Do retrospective studies underestimate risk?

Diagnoses: Maron* 1985-95, 158 trained athletes

*Minneapolis Heart Institute, former NHLBI, chair ACC, ESC

Sudden Death in Athletes

- Entities
- Diagnosis and Treatment
- Prevention, Screening, Alternatives
- Legal issues
Hypertrophic cardiomyopathy

History: HCM

- Vulpian 1850: “rétrécissement de l’orifice ventriculoaortique”
- Or: “sub-aortic stricture”

Names
- Asymetrical hypertrophic cardiomyopathy
- Asymmetrical hypertrophy of the heart
- Brock’s disease
- Diffuse muscular subaortic stenosis
- Diffuse subvalvular aortic stenosis
- Dynamic hypertrophic subaortic sten.
And...
- Familial hypertrophic cardiomyopathy
- Familial hypertrophic subaortic stenosis
- Familial muscular subaortic stenosis
- Familial myocardial disease
- Functional aortic stenosis
- Functional hypertrophic subaortic stenosis
- Functional obstructive cardiomyopathy
- Functional obstructive subvalvular aortic stenosis
- Functional subaortic stenosis
- Hereditary cardiovascular dysplasia
- Hypertrophic cardiomyopathy
- Hypertrophic hyperkinetic cardiomyopathy

And also...
- Hypertrophic constrictive cardiomyopathy
- Hypertrophic infundibular aortic stenosis
- Hypertrophic restrictive cardiomyopathy
- Hypertrophic subaortic stenosis
- Idiopathic hypertrophic cardiomyopathy
- Idiopathic hypertrophic obstructive cardiomyopathy
- Idiopathic hypertrophic subaortic stenosis
- Idiopathic muscular hypertrophic subaortic stenosis
- Idiopathic muscular hypertrophic subvalvular stenosis
- Idiopathic muscular hypertrophic subvalvular stenosis of the left ventricle
- Idiopathic muscular hypertrophy
- Idiopathic ventricular septal hypertrophy
- Irregular hypertrophic cardiomyopathy
- Irregular hypertrophic obstructive cardiomyopathy
- Left subvalvular aortic stenosis
- Muscular left ventricle
- Muscular hypertrophic disease of the left ventricle

HCM incidence
- 1:500, worldwide
- 500,000 US citizens
- At risk for sudden death: maybe 50,000-100,000
Genetics

- Mendelian autosomal dominant
- Myosin proteins of sarcomere
- 10 mutations, variable penetrance

Hypertrophic cardiomyopathy

- Causes pathology with or without LV outflow tract obstruction.
- Sudden death risk: presumably arrhythmias
- Progressive CHF, not typically in pediatric patients.

HCM treatment

- CHF
  - Beta blockers
  - Ca channel blockers
  - Surgical resection of subaortic area
  - Mitral valve replacement
  - Pacing strategies
  - Ethanol septal ablation
HCM “Treatment”
- Sudden death risk in the asymptomatic patient
  - Only one study suggested medications play a role.
  - Restriction from competitive sports
  - ICD therapy for those who’ve experienced syncope

HCM diagnosis
- Only patients with outflow tract obstruction have murmurs (70%?)
- 75-90% have abnormal ECG
- Echocardiogram is 100% sensitive
- Not, unfortunately 100% specific
  - The “athlete’s heart”

ECG in Hypertrophic Cardiomyopathy
Hypertrophic Vs. Athlete’s heart

+ Unusual patterns LVH on ECG
+ LV cavity <45 mm
+ LV cavity > 55 mm
+ LA enlarged
+ Bizarre ECG patterns
+ Abnormal LV filling by echo
+ Female gender
  Decreases with deconditioning
+ Family history HCM
  Increased VO2-max

Screening relatives of HCM

- < age 12, ONLY if family history of young sudden death, symptoms, competitive athlete
- 12-21 yo Every 12 to 18 months
- Over 21 years, every 5 years
- May change with genetic testing availability

Feline hypertrophic cardiomyopathy

Feline hypertrophic cardiomyopathy (hcm) is a disease affecting cats in which the walls of the heart become increasingly enlarged. This is a compilation of information on the disease for veterinarians and pet owners, including a list of other HCM Internet resources. (Standard disclaimer applies: I’m not a vet and this is not medical advice.)

Diagnosis in early stages can be tricky, but here are the symptoms: lethargy, poor appetite, panting/troubled breathing. Often, a feline will develop a heart murmur along with HCM; while the HCM can be treated if detected early, the murmur will probably never go away (but it isn’t anything to worry about). Even after treatment, weakness or paralysis of the back legs should be watched for — blood clots can be developed and lodged in each leg (“saddle
Hypertrophic cardiomyopathy in the neonate

- Glycogen storage disease—Pompe disease
- Noonan syndrome
- Fabry’s disease
- Mitochondrial disorder
- Infant of diabetic mother

Arrhythmias: The “Channelopathies”

- Long QT
- Brugada syndrome
- Short QT

Long QT History

- 1856: Meissner, Germany
  - Deaf girl collapses in school
  - Siblings died previously
- 1953: First ecg features in deaf child with “seizures”
- 1957: Jervell and Lange-Nielsen (6/million)
- 1963-4: Romano and Ward, separately describe a non-deaf syndrome (1/7000)
- 1998 Chicago Hope
Long QT

Long QT presentation

A previously well 8-year-old girl was swimming with several friends in a neighbor’s pool. Suddenly, she sank to the bottom of the pool and remained motionless. Initially thought to be at play, she was soon rescued from the pool and found to be unresponsive. She received bystander CPR and regained consciousness rapidly.

Long QT: Genetics

- Romano-Ward: Autosomal dominant
  - KCNQ1, LQT1 K channel chr. 11
  - KCNH2, LQT2 K channel chr 7 drugs
  - SCN5A LQT3 Na channel chr 3
  - Ank2 LQT4 chr 4 (not an ion channel)
  - KCNE1 LQT5 chr 21
  - KCNE2 LQT6 K channel chr 21
- Jervell and Lange-Nielsen:
  - Autosomal recessive, KCNQ1, KCNE1
LQT scoring system of Schwartz

<1=Low, 2-3= Probable, >4=High

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Syncope with stress</td>
</tr>
<tr>
<td>1</td>
<td>Without stress</td>
</tr>
<tr>
<td>0.5</td>
<td>Congenital deafness</td>
</tr>
<tr>
<td>1</td>
<td>Family history LQTS</td>
</tr>
<tr>
<td>0.5</td>
<td>Unexplained sudden death &lt;30</td>
</tr>
<tr>
<td>3</td>
<td>QTc&gt;480ms</td>
</tr>
<tr>
<td>2</td>
<td>460-470</td>
</tr>
<tr>
<td>1</td>
<td>450 males only</td>
</tr>
<tr>
<td>2</td>
<td>Torsades des pointes</td>
</tr>
<tr>
<td>1</td>
<td>T-wave alternans</td>
</tr>
<tr>
<td>1</td>
<td>“notched” t-waves 3 leads</td>
</tr>
<tr>
<td>0.5</td>
<td>Bradycardia</td>
</tr>
</tbody>
</table>

Long QT therapy

- **First line**
  - Exercise prohibition
  - Beta blockers
  - Medication avoidance (www.qtdrugs.org)

- **Second line**
  - ICD

- **Uncommon**
  - Stellate ganglion ablation

Long QT/controversies/the future

- **Mutation specific therapy**
  - More aggressive therapy for LQT3
  - Primary Mexilitine for LQT3
  - Routine genetic testing
  - ICD for primary prevention
Brugada (SUDS)

- Named for Pedro, Josep and Ramon Brugada in 1992
- First described 1989 in a 3 yo polish boy whose sister had died suddenly
- Autosomal Dominant 1:2000 (?) M>F 10:1
- SCN5A mutation (Same gene as LQT3)
- Worst survival of all entities
ARVD

- Familial, mostly male
- Leads to VT sudden death
- Most common cause of sudden cardiac death in young in Italian studies
ARVD--Diagnosis

- ECG/Echo/Treadmill or Holter
- Cardiac MRI, sometimes CT
- Endomyocardial biopsy (rarely done)
- EPS
- Pitfalls
  - RV outflow tachycardia
    - Much more common, benign, often curable
  - Overzealous workup
ARVD

- 8 genetic types identified
- Up to 1:5000 incidence
- Treatment of symptomatic individuals: antiarrhythmics, ICD
- Relation to Brugada?

Congenital Coronary artery anomalies

Coros: clinical

- May present with chest pain with exercise or shortly afterwards
- Most commonly have no symptoms
- ECG is normal
- Exam is normal
- Rare: 0.03-0.05%
- Probably risky
Anomalous origin of LCA from PA (ALCAPA)

Bland White Garland syndrome

ALCAPA

- May present as CHF or MR in infants, or as dilated cardiomyopathy
- Rarely survives to teen or adult years and can present as sudden death, primary arrhythmia.

Coros: diagnostic

- Echo
- MRI
- Angio
Coros: Identification

- Mostly not symptomatic
- ? Treadmill
- Stress Echo?

Sudden Death in Athletes

- Prevention
- Detection
- Treatment/Bail out

Population screening

Cardiovascular Preparticipation Screening of Competitive Athletes

A Statement for Health Professionals From the Task Force on Cardiovascular Disease and Exercise of the American Heart Association and American College of Cardiology. Circulation. 2007;116(11):1265-1275

Key Points:
- Cardiac risk assessment
- Electrocardiogram
- Exercise stress test
- Echocardiography
AHA 1996, revised ‘05

- a complete and careful personal and family history and physical examination designed to identify (or raise suspicion of) those cardiovascular lesions known to cause sudden death or disease progression in young athletes is the best available and most practical approach to screening populations of competitive sports participants, regardless of age. Such cardiovascular screening is an obtainable objective and should be mandatory for all athletes.

Noninvasive tests: ECG, Echo

- Noninvasive testing can enhance the diagnostic power of the standard history and physical examination; however, it is not prudent to recommend routine use of such tests as 12-lead electrocardiography, echocardiography, or graded exercise testing for detection of cardiovascular disease in large populations of young or older athletes.

Echo: AHA position paper

- the costs are probably prohibitive, ranging from $400 to $2000 per echocardiographic study (average $600). For example, if the occurrence of hypertrophic cardiomyopathy in a young athletic population is assumed to be 1:500, even at $500 per study it would theoretically cost $250,000 to detect even one previously undiagnosed case.
But...in Europe

February 2, 2005

The document takes note of the 25-year Italian experience on systematic pre-participation screening of competitive athletes and focuses on relevant issues, mostly regarding the relative risk, causes, and prevalence of sudden death in athletes; the efficacy, feasibility, and cost-effectiveness of population-based pre-participation cardiovascular screening; the key role of 12-lead ECG for identification of cardiovascular diseases such as cardiomyopathies and channelopathies at risk of sudden death during sports; and the potential of preventing fatal events.
Veneto section of Italy

Deaths in US V. Italy

PreParticipationExam
- Family History
  - Premature Sudden Cardiac Death
  - Heart disease <50 y.o.
- Personal History
  - Murmur
  - Hypertension
  - Fatigue
  - Syncope/Near Syncope
  - Excessive/Unexplained exertional dyspnea
  - Exertional Chest Pain
Physical Exam

- Murmur
- Femoral Pulses
- Marfan Stigmata
- BP sitting

Veneto, ECG

Results: Italian program 1979-2004

- 42,386 athletes screened (population 385,600)
  - 3900 were referred for work up (9%)
  - 879 disqualified (2%)
    - 30 Hypertrophic cardiomyopathy
    - 16 ARVD
    - 205 "systemic hypertension"
    - 345 arrhythmias (only 5 LQTS)
    - 11 coronary artery (9/11 since 1993)
Italian study—work up

- All 879 had echocardiograms
- 44% echo+tmill
- 38% echo+tmill+holter
- 3% echo+holter
- 5% MRI in addition to any other test

---

Italian study—effects of screening

![Graph showing deaths per 100,000 for Italian athletes and non-athletes over years 79 to 1999.]

Deaths per 100,000

- Italian athletes
- Italian non-athletes
Italian study—effects of screening

Deaths per 100,000

US data: Driscoll, Edwards ‘50–’82

Deaths in the United States

2,400,000

Deaths by diagnosis
Deaths in late teens

13,812 total deaths yearly 15-24 yo

Deaths in late teens

400 of 13,000 deaths sudden in athletes

Other diseases with screening tests

- Breast Cancer 40,970 deaths yearly
  - 200,000 new cases yearly
- Colon Cancer 55,170
  - 106,000 new cases
- ALL 1,490
  - 3,930 new cases
PKU
- Approx. 1:15,000

Lead
- 450,000 to 900,000 is prevalence
- Death extremely rare
- Case report

ECG in US
- 1989 Manhassat NY
  - 1424 students screening ECG
    - 88.8% normal
    - 5.1% abnormal with no Hx (72)
    - No hypertrophs identified, no one excluded
Echo

- 1992 Indiana college athletes
  - 2997 echos, 64 abnormalities
  - Seriousness not described
  - $7.34 per echo (!)
- Maron Howard Univ.
  - 265 athletes
  - 28 abnormalities none serious
- Maron U Maryland
  - 501 athletes
  - 3 borderline studies

Standard screening

  - Standard questionnaire and PE protocol
  - “Targeted” ECG and Echo
Sudden Death in Athletes
- Prevention
- Detection
- Treatment/Bail out

The AED

Wisconsin’s project Adam
- Goal to place AEDs in all public and private high schools
- As of ’04 143/400 had AEDs without legislation
- Cost $8000 startup, or $3065/year
Diagnoses=saved lives?

“Pistol” Pete Maravich, 1947-1988

“Pistol” Pete

☐ 3 years at LSU, set all-time career scoring record
☐ Drafted third in 1971, played 10 NBA seasons, 82 games each
☐ Died at age 40 in a pickup game in a gym in Pasadena
☐ Single Coronary artery found at autopsy
Legal Decisions

☐ This should clear things up

☐ Or not.

1996 Knapp v N’western Univ

☐ HCM athlete tried to sue under ADA to play despite diagnosis.
☐ He had an ICD already placed.
☐ Court found medical grounds valid.

☐ You can be sued for excluding athlete, if you follow guidelines you’ll likely prevail.

2003 Izador v Knight

☐ Consent signed, but patient referred to cardiologist.
☐ HCM found, athlete told not to compete.
☐ Competed anyway and died.

☐ Don’t sign consent until work up done.
1990 Gathers v Loyola Marymount

- Gathers was diagnosed with myocarditis-related cardiomyopathy
- He continued to play on beta blockers
- His dose was lowered at his request because of symptoms.

- Do not allow personal feelings to alter course of treatment

What is the Physician-Athlete relationship?

- Team MD
- Private MD hired by School
- Private MD in office
- What about waivers/disclaimers

My advice to you

- Utilize screening questions
- ECG
  - Patients who fail screen but are at low suspicion can be screened “out” by ECG
- Consult/Echo
  - For higher risk patients
Future directions

- Standardize screening
- Enforce 2 year screening
- Pilot an ECG protocol in a study group
- Follow up on Oregon data
- Follow European data closely
- Think about AEDs

The ICD in pediatrics
HCM in Veneto

- 33,735 screened
  - 22 HCM found

- At $400/work up this is $600K/Dx
- At $20, $30,000/Dx

Genetics
Long QT: Genetics

- Romano-Ward: Autosomal dominant
  - KCNQ1, LQT1 K channel chr. 11
  - HERG, LQT2 K channel chr 7 drugs
  - SCN5A LQT3 Na channel chr 3
  - Ankyrin-B LQT4 chr 4
  - minK LQT5 chr 21
  - MiRP1 LQT6 K channel
- Jervell and Lange-Nielsen
  - Autosomal recessive

ICD in peds: Silka, et. al. 1993

- Multicenter registry n=128
- 96% secondary prevention
- 59% appropriate shock within 3 y.
- But...20% inappropriate shocks
  - 51% Cardiomyopathy
  - 32% Arrhythmia
  - 16% CHD
  - 1% Marfan

Veneto prospective study

- 2.1 deaths/100,000
  - 1979-1999 Prospective cohort of 1.4M
  - 10:1 male
  - About 2:1 relative risk for exercise
So......

- Is sudden death in young athletes underestimated in the US?
- Or, are Italians dying from different diseases?

---

Diagnoses: Veneto

<table>
<thead>
<tr>
<th>HCM</th>
<th>ARVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
</tr>
</tbody>
</table>

- HCM
- Coro
- Marfan
- AS
- Myocard
- Dilated
- ARVD
- MVP
- CAD
- "other"

---

Explanation:

- US: “Your patients are different.”
- Italy: “We screened out our HCM’s and Congenital coros and saved them.”
- US: “Then why is your death incidence higher?”
Brugada syndrome

Add’l family history
- Hypertrophic Cardiomyopathy
- Dilated Cardiomyopathy
- Marfan
- Ehlers-Danlos
- ARVD
- Early Coronary artery disease
- LQTS/Brugada
- Pulmonary Hypertension

PPE continued
- Family History
  - Died for no reason (young person)
  - Heart Problem
  - Died of heart problem <50
  - Syncope
  - Unexplained seizures
  - Arrhythmias/pacemaker
- Genetic Disorders:
Veneto, Italy 1979-2004