Adolescent Syncope

Brett Goudie, M.D.
Pediatric Cardiology

Syncope

- From the Greek word *synkoptein*, which means “to cut short”
- Syncope – “temporary loss of consciousness and postural tone resulting from an abrupt, transient, and diffuse cerebral dysfunction (hypoperfusion), and followed by spontaneous recovery” – cerebral blood flow ↓ 30-50%
- Syncopized???? Syncopated?
- Pre-syncopize? Syncopal
- Pre-syncope – prodromal dizziness and lightheadedness that precedes LOC – aka near-syncope
- Sadly I have no financial disclosures related to this topic

Syncope – why talk about it?

- Common - 15-25% of children experience at least one episode (peak ages 15-19) ♀ > ♂
- Expensive clinical problem / testing / Up to 3 % of ER visits / treatable
- Most typically totally benign
- 80-90% is vasodepressor (vs cardioinhibitory) ANGST!!!!!!!
- Only 1% of time due to arrhythmia or structural cardiac disease / sudden death
Vasovagal Syncope Terminology

- Vasodepressor (Vaso)
- Cardioinhibitory (Vagal)
- Neurocardiogenic
- POTS – postural orthostatic tachycardia syndrome
- Orthostatic Hypotension or Intolerance
- Situational
- Reflex
- Neural mediated
“Fainting Goat”

Myotonia Congenita
Syncope, at the Carotid Sinus

- Upright posture, 25% of blood redistributed to lower extremities
- Preload diminished, leads to diminished stroke volume by as much as 40%, $CO = HR \times SV$
- Baroreceptors activated (Carotid sinus)
- Increased sympathetic activity increases HR, contractility, and SVR
- Failure of this response leads to syncope

Causes of Syncope

- Primary cardiac arrhythmia
- Congenital or acquired structural heart disease
- CNS (seizure, atypical migraine)
- Behavioral/psychiatric
- Orthostatic Issue and/or Neurally mediated reflexive syncope

History

- What are the circumstances leading to events? Sick with URI or other illness pre or post? Preceding mono or viral illness weeks or months prior? Growth spurt?
- Is the syncope abrupt or is there a prodrome? Exercise?
- Are there palpitations, visual changes, chest pain, shortness of breath, parasthesias? When?
- Injury? Seizure? Loss of bowel/bladder control?
- Which way did he/she fall?
- Is there a history of caffeine use? Is his/her urine concentrated or clear? 2nd daily void timing?
- Does the patient get light headed at other times?
**Syncope History – Red Flags**

- Syncope after surprise, loud noises, anger
- Prodrome of palpitations/tachycardia/CP
- Syncope with exercise
- Syncope with exercise
- Prolonged down time, CPR
- Other red flags
  - Abnormal exam or EKG
  - Hx of sudden death / SIDS
  - Hx of CHD

**Family History**

- Sudden death
- SIDS
- Pacemakers
- Defibrillators
- Deafness
- Fainters
Historical Findings That May Need Clarification

• Syncope with exercise – Really?
• Seizure activity – Before, during, or after?
• Dizziness – Vertigo or lightheadedness
• Syncope following trauma – Concussion?

Physical Exam

• Heart rate and blood pressure, both supine and standing, then standing again in a few minutes
• Are the first and second heart sounds normal?
• Is there a murmur? Does it get louder with standing?
• Are there any clicks, gallops, or rumbles?

Diagnostic tests

• ECG
• Head Up Tilt Test - usually not necessary
• Exercise stress test
• 24 hour Holter
• Echocardiogram with emphasis on chamber size, obstructive lesions, coronary arteries
• Electrophysiology study
Important Considerations in Structural Heart Disease Causing Syncope

- Syncope with exercise
- Syncope with chest pain
- Family history of structural heart disease, “enlarged heart”, or sudden death
- Murmur that gets louder when standing
- Hypertrophy or strain on ECG
- Echo should be done by a pediatric facility
Causes of Syncope

- Primary cardiac arrhythmia
- Structural heart disease
- Neurally mediated reflexive syncope
- Orthostasis
- CNS
- Behavioral/psychiatric

Neurally Mediated Reflexive Syncope (Vasovagal Syncope)

- Vasodepressor
  - Common faint
  - Lover’s swoon
  - Cough syncope
  - Micturition syncope
  - Hair grooming syncope
  - Weight lifter’s syncope
- Cardioinhibitory
  - Neurocardiogenic Syncope
- Combined
Bezold-Jarisch Reflex

- Increase HR, contractility, and BP
- Catecholamines

Albert von Bezold (1836-1868)

- "Bezold-Jarisch reflex" is a triad of responses (bradycardia, hypotension, and apnea) from paradoxical stimulation of vagal mediated ventricular C fiber receptors.
- "Reflex is involved with "Vasodepressor" as well as the "Cardioinhibitory" or "Neurocardiogenic" Syncope
- Bezold - intravenous injection of veratrum alkaloids, +/- vagal nerve ligation. Bezold - Munich, then in Univ of Berlin under du Bois-Reymond (nerve action potential)
- Adolf Jarisch Jr (1891–1965)

Veratrum viride or album

- Potent alkaloids, antagonism of adrenergic receptors
- Highly toxic – nausea / vomiting, cold sweat and vertigo, slowing of respiration, bradycardia, hypotension, death
- 1950-1960s extract known as alkavervir – antihypertensive
- Some Native American nations – historical use for elections of new leader
Neurocardiogenic Syncope

• Occurs with prolonged standing or sitting
• Does not occur with exercise (but frequently occurs during cool down)
• Prodrome of lightheadedness, visual changes, hot flashes, pallor, racing heart
• Aborts with lying down
• Typical body habitus
• Chronically fatigued

The Tilt Lab

A “Positive” Tilt Test
Neurally-Mediated Syncope
Tilt Table Response

Tilt Test-Onset of Symptoms

Tilt Test-Syncope
Syncope Treatment - acute

- Lay down
- Legs up
- Give them air
- Get them a drink

Neurocardiogenic Syncope
Nonpharmacologic Interventions

- Hydration
  - 64 fluid oz of fluid/day (4-6 ½L waters/day)
  - 32 oz by noon
  - Urine should be clear, void every 2-3 hrs.
- Avoid caffeine
- Increase salt intake (if not hypertensive)
- Support hose
- Tilt training – leg strengthening
- Time -
Pharmacologic Interventions

- Florinef acetate 0.1 mg po q.d.
  - Avoid if hypertensive, or glaucoma
  - Recent study suggests no more effective than placebo, and placebo very effective.
    - (Salim M, et al. 2005)
- Beta blocker therapy (Atenolol or Nadolol) 1 mg/kg div. b.i.d. or q.d.
  - Lack of controlled studies
- Midodrine (ProAmatine)
  - Shown to be effective in acute setting
    - (Kaufmann H, et al. 2002)
  - Side effects often intolerable
- SSRI (Prozac, Zoloft)

Causes of Syncope

- Primary cardiac arrhythmia
- Structural heart disease
- Neuromediated reflexive syncope
- Orthostasis
- CNS
- Behavioral/psychiatric

Orthostatic Syncope

- Hypovolemia
- Vasodilated states (fever, sepsis, anaphylaxis)
- Orthostatic intolerance
  - Postural Orthostatic Tachycardia Syndrome (POTS)
- Dysautonomias
  - Riley-Day syndrome
  - Adolescence
Causes of Syncope

- Primary cardiac arrhythmia
- Structural heart disease
- Neurally mediated reflexive syncope
- Orthostasis
- CNS
- Behavioral/psychiatric

Clues that Syncope is Seizure

- No prodrome (except CPS)
- Tonic clonic activity at onset of event
- Typically not assoc w/ pallor or clammy skin
- Post-ictal or confused state prolonged
Hyperventilation Syndrome

- Typically provoked by anxiety
- Subjective SOB (inability to fill lungs)
- Paresthesias of hands and lips
- Visual changes-tunneled vision
- Lightheadedness
- Chest pain (tightness) very common
- Treatment: Breath into a paper bag!

Breath Holding Spells

- Pallid
  - Usually provoked by pain
  - Child becomes pale and limp
  - Caused by reflex asystole
- Cyanotic
  - Usually provoked by anger
  - Infant holds breath and becomes cyanotic
- In both cases, the child may have tonic or tonic-clonic activity
Pallid Breath Holding Spell
18 month old

How to Approach the Patient With Syncope

• History, History, History
• Family history
• Physical exam including orthostatic BP and auscultation in prone and upright position
• All patients deserve an ECG
• The remainder of tests (echo, tilt, EST, EP study, cardiac MRI) should be confirmatory, not exploratory

! When to Worry!

• Syncope during exertion
• Family history of sudden death
• Abrupt syncope without a prodrome
• Sustained seizure activity
• Apnea requiring CPR
• Prior cardiac surgery or CHD
**! When to Be Suspicious !**

- Frequent absence from school
- Selective loss of neurological function
- Risky social or sexual behavior
  - SEXUAL ABUSE
- Multiple episodes daily
- Vague changing character of symptoms

---

**Who to refer to the Cardiologist**

- Syncope with exertion, swimming, palpitations, or chest pain
- Abnormal ECG
- Abnormal cardiac exam
- Family history of sudden cardiac death
- Congenital heart disease or prior heart surgery
- Anyone who’s syncope is not obviously neurally mediated, orthostatic, CNS, or psychogenic

---

**Causes of Syncope**

- Primary cardiac arrhythmia
- Structural heart disease
- Neurally mediated reflexive syncope
- Orthostasis
- CNS
- Behavioral/psychiatric
Arrhythmias Causing Syncope

- Bradycardia
  - Sinus Node Dysfunction
  - AV Block
- Tachycardias
  - Wolff-Parkinson-White Syndrome
  - Long QT Syndrome
  - Brugada Syndrome
  - Arrhythmogenic RV Dysplasia (ARVD)
  - Catecholaminergic Polymorphic VT (CPVT)

What to look for on ECG

- Is the rhythm SINUS?
- Is the rate appropriate?
- Is there AV block?
- Is there evidence of hypertrophy or strain?
- Is there pre-excitation (short PR or delta)?
- Is the QTc normal?
Sinus Node Dysfunction

- Inappropriately slow (or fast) heart rate
- SA node origin
- Frequently seen in post-op hearts
- <3 years old: <100
- 3-9 years old: <60
- 9-16 years old: <50
- >16 years old: <40

Complete AV Block

Left Ventricular Hypertrophy
Wolff-Parkinson-White Syndrome

Not-so-subtle WPW

Subtle WPW
The Long QT Syndrome

- LQTS is present in 1:5,000 persons (over 50,000 people) in the USA.
- Estimated to cause as many as 3000 deaths (mostly in children and young adults) in the USA each year.
- It is present in all races and ethnic groups.
Some Disturbing Facts

- In as many as 30-40%, sudden death is the first event (8-40% of asymptomatic patients have SCD as first event)
- 57% of patients who die will die by age 20
- Events rates are 5%/yr. for syncope and 0.9-2.5%/yr. for cardiac death

Corrected QT (QTc)

\[ QTc = \frac{QT}{\sqrt{RR}} \]

- Include U wave if > 50% of T wave height
- Upper limits of normal 450

<table>
<thead>
<tr>
<th></th>
<th>PPV 100%</th>
<th>Male</th>
<th>&gt;470</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>&gt;480</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PPV 93%</td>
<td>&gt;460</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NPV 100%</td>
<td>Male</td>
<td>&lt;400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>&lt;420</td>
</tr>
</tbody>
</table>
**Torsades de Pointes**

**ECG Phenotype of LQT3, 2, and 1**

- **LQT 1** - Tend to have events at times of exertion or excitement.
- **LQT 2** - Tend to have events when startled or with swimming.
- **LQT 3** - Tend to have events when asleep.

**Varieties of LQTS**

- LQT 1 - Tend to have events at times of exertion or excitement.
- LQT 2 - Tend to have events when startled or with swimming.
- LQT 3 - Tend to have events when asleep.
- LQT 1 and 2 account for 85% of total. LQT 3 accounts for about 10%. 

TdP following a sudden arousal (alarm clock) in a patient with a HERG defect.

Wilde et al. JACC. 1999;33:327-32

Treatment of LQTS

- Avoid all strenuous exercise, esp. swimming
- Avoid startling (alarm clocks etc.)
- Beta blocker therapy (Propranolol, Nadolol) w/ or w/o bradycardia pacing
- ICD (QTc>550, noncompliant, FHx SCD)
- Left Stellate ganglionectomy

Drugs Known to prolong QT
Drugs “to be avoided” in patients with the LQTS

- Albuterol
- Amantadine
- Cocaine
- Dobutamine
- Dopamine
- Ephedrine
- Epinephrine
- Fenfluramine
- Isoproterenol
- Metaproterenol
- Midodrine
- Nor-epinephrine
- Phenetermine
- Phenylephrine
- Nesuprphenine
- Phenylephanolamine
- Pseudoephedrine
- Riludrine
- Salmeterol
- Sibutramine
- Terbutaline

Long QT Syndrome
web sites

www.sads.org
The Sudden Arrhythmia Death Syndromes (SADS) Foundation

www.longqt.org
The Cardiac Arrhythmia Research and Education (CARE) Foundation

www.familion.com

Brugada Syndrome

- **AKA: Lai Tai** ("died during sleep") in northeast Thailand
- **Bangungut** ("moaning and dying during sleep") in the Philippines
- **Pokkuri** ("sudden unexpected death at night") in Japan
Brugada Syndrome

- Leading cause of death in young Asian males
- Arrhythmias tend to occur during febrile periods (exercise) and during sleep
- Defect is in cardiac sodium channel

Wilde A, et al., 2002

Catecholaminergic Polymorphic Ventricular Tachycardia (CPVT)

- aka Syncopeal paroxysmal tachycardia, malignant paroxysmal VT, multifocal ventricular premature beats, paroxysmal VF; bidirectional tachycardia, Familial Polymorphic VT
- Defect identified in the ryanodine receptor (RyR2) and Calsequestrin genes
- Rarely symptomatic before 3 years. Mean age of presentation 8 yrs for RYR2 defect, later for others.
- Male predominance in RYR2 variety
Catecholaminergic Polymorphic Ventricular Tachycardia (CPVT)

- There is resting bradycardia (mean 60).
- Sx’s appear with sinus rates > 120-130 bpm (window zone).
- 6% of referrals for LQT were found to have CPVT instead*
- CPVT found in 7/49 unexplained deaths and 2/2 unexplained drownings**

*Tester DJ et al, Mayo Clin Proc, 2004
**Ackerman MJ et al, Mayo Clin Proc 2005

Bidirectional VT in CPVT

Priori S, et al, 2002

History Findings Suspicious Arrhythmias

- Syncope preceded by palpitations
- Syncope with exertion or excitement
- Abrupt syncope without a prodrome
- Syncope while swimming
- Family history of syncope, seizures, SIDS, sudden death, or deafness
Causes of Syncope

- Primary cardiac arrhythmia
- Structural heart disease
- Neuromediates reflexive syncope
- Orthostasis
- CNS
- Behavioral/psychiatric

Syncope and Structural Heart Disease

- Hypertrophic Cardiomyopathy
- Coronary artery anomalies
  - Abnormal take-off
  - Single coronary
- Marfan syndrome
- Arrhythmogenic RV Dysplasia
- AS, PS, TOF, pulmonary hypertension, MVP (0.5% risk of sudden death annually)

Hypertrophic Cardiomyopathy

- Leading cause of sudden death in healthy young athletes
- Typically die of arrhythmias (V fib)
- Prevalence as high as 1/500
- At least 50% are inherited
- Family history is prognostic
Hypertrophic Obstructive Cardiomyopathy (HOCM)

From: Moss and Adams, Heart Disease in Infants, Children, and Adolescents, 1995

Hypertrophic Cardiomyopathy

Myocyte Disarray and Fibrosis

Hughs SE, 2004
**Hypertrophic Cardiomyopathy**

- Often don’t develop hypertrophy until 14-17 years old
- ECG changes often precede echo findings
- MRI and echo tissue Doppler imaging (TDI) can be helpful
- Commercially available Genetic testing (50-60% yield)

---

**Coronary Artery Anomalies**

---

**Coronary Artery Anomalies**

---
Coronary Artery Anomalies

- Study of 27 patients (Basso C, et al., 2000)
  - 23 had anomalous LCA
  - 4 had anomalous RCA
- 41% HS students, 44% JHS, college 2%
- Sports included
  - Basketball 8
  - Soccer 7
  - Football 3
  - Distance running 3
  - Track 2
  - Hockey, rugby, softball, swimming one each

Coronary Artery Anomalies

- 16 died during training, 11 during competition
- 10/12 patients with clinical history available
  - 5 chest pain (3 with exertion)
  - 4 syncope (3 with exertion)
  - 2 palpitations unrelated to exercise
  - 1 palpitations and presyncope with exercise
- ECG normal 9/9
- EST normal 6/6
- Echo normal in 2/2

Arrhythmogenic RV Dysplasia

- Second leading cause of sports related death in parts of Europe
- Occurs in 1 in 5000 individuals
- Defect in cardiac ryanodine receptor (calcium release protein)
- Arrhythmias occur during times of stress
- Associated with fibrosis and fatty infiltrates of the RV free wall, best detected by MRI
- ECG may show classic “epsilon” waves
Marfan Syndrome

- Tall thin with disproportionately long arms
- Long lower body
- Arachnodactyly
- Hypermobility (thumb sign, wrist sign)
- Scoliosis
- Pectus deformity
- Lens dislocation
- Aortic root dilatation

- In one study (Fornes P, et al, 2003) 3/11 sports related SCD were due to ruptures aortic aneurysm

THE END