Objectives

- Review common non-cardiac etiologies of chest pain in pediatrics
- Discuss cardiac etiologies of chest pain in pediatrics
- Review a clinical approach to these patients
- Discuss the causes of and appropriate evaluation of syncope and palpitations
Chest pain

- Chest pain common complaint in children in office and emergency department
- 6 of 1000 patients presenting to urban ED
- Mean age ~12 years
- High level of patient and familial anxiety
## Family Perception

<table>
<thead>
<tr>
<th>Cause</th>
<th>Family estimate %</th>
<th>Medical Diagnosis prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>52-56</td>
<td>1-6</td>
</tr>
<tr>
<td>Musculoskeletal</td>
<td>13</td>
<td>15-31</td>
</tr>
<tr>
<td>Respiratory Tract</td>
<td>10</td>
<td>2-11</td>
</tr>
<tr>
<td>Psychiatric</td>
<td>0</td>
<td>0-30</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>0</td>
<td>2-8</td>
</tr>
<tr>
<td>Cancer</td>
<td>0-12</td>
<td>0</td>
</tr>
<tr>
<td>Skin infection</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Unsure/idiopathic</td>
<td>10-19</td>
<td>21-45</td>
</tr>
<tr>
<td>Misc: neurologic, toxic substance, PE</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>

*Table adapted from Newburger, “Outpatient Cardiology Chest pain, hyperlipidemia and hypertension” 7/5/10*
Common etiologies

- Three most common causes in pediatrics:
  - Costochondritis
  - Musculoskeletal (trauma or muscle strain)
  - Respiratory
Costochondritis

- Anterior chest pain, usually unilateral and sharp
- Pain exaggerated by exercise, activity, positioning, breathing
- May persist for months
- More common in females
- Reproducible tenderness over chondrosternal or costochondral junction
- Treatment: reassurance, NSAIDs
Musculoskeletal

- Strains of pectoral, shoulder or back muscles after exercise
- Chest wall muscle strains from coughing
- Trauma
- New vigorous exercise, weightlifting
Respiratory etiologies

- Prolonged cough
- Pneumonia
- Pleural effusion
  - Pain worse with deep inspiration
- Asthma
- Exercise induced asthma
- Spontaneous pneumothorax
Other non-cardiac causes

- Psychogenic
  - Often can elicit stressful situation with history

- Gastroesophageal reflux/esophagitis

- Precordial catch (Texidor’s twinge)
  - Unilateral, few seconds, associated with bending torso
Other non-cardiac causes (cont)

- Pleurodynia
  - Sharp pain, usually unilateral over lower ribs, febrile

- Herpes Zoster

- Pulmonary Embolism
Cardiac etiologies of chest pain

- Disease of the coronary arteries - ischemia/infarction
  - Anomalous coronary arteries
  - Coronary arteritis (Kawasaki disease)
  - Long-standing diabetes mellitus
- Arrhythmia
  - Supraventricular tachycardia
  - Ventricular tachycardia
- Structural abnormalities
  - Hypertrophic cardiomyopathy
  - Severe pulmonary stenosis
  - Aortic valve stenosis
- Infectious
  - Pericarditis
  - Myocarditis

Percentage of patients presenting with chest pain (10 year time period in Boston)

<table>
<thead>
<tr>
<th>Disease</th>
<th>Patients</th>
<th>Patients with Chest pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic dissection</td>
<td>1</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Coronary anomalies</td>
<td>131</td>
<td>34 (26%)</td>
</tr>
<tr>
<td>Dilated cardiomyopathy</td>
<td>61</td>
<td>5 (8%)</td>
</tr>
<tr>
<td>Hypertrophic cardiomyopathy</td>
<td>100</td>
<td>5 (5%)</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>62</td>
<td>46 (74%)</td>
</tr>
<tr>
<td>Pericarditis</td>
<td>65</td>
<td>62 (95%)</td>
</tr>
<tr>
<td>Pulmonary embolus</td>
<td>19</td>
<td>13 (68%)</td>
</tr>
<tr>
<td>Pulmonary artery hypertension</td>
<td>37</td>
<td>6 (16%)</td>
</tr>
<tr>
<td>Takayasu arteritis</td>
<td>8</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Total</td>
<td>484</td>
<td>171 (35%)</td>
</tr>
</tbody>
</table>

Hypertrophic Cardiomyopathy

- Genetic disorder with heterogeneous expression
  - Autosomal Dominant
  - Most common B-myosin heavy chain
- Most common cause of sudden cardiac death in pediatrics
- Thickened non-dilated left ventricle
- With or without obstruction
Hypertrophic Cardiomyopathy-
physical exam

- Variable
- If obstruction:
  - Loud, systolic ejection murmur along LLSB
  - May be holosystolic
  - Increased palpation of apical impulse

- No obstruction:
  - Typically have normal exam
  - May be able to elicit dynamic obstruction with maneuvers

- Murmur increased with standing (after squatting) or Valsalva
HCM - ECG

- Typically abnormal (90-95%)
- LVH, ST-T wave abnormalities, left atrial enlargement, deep Q waves
Hypertrophic Cardiomyopathy - Echo
Hypertrophic Cardiomyopathy - Echo
Anomalous coronary arteries

- Abnormal origin of right or left coronary artery from the inappropriate sinus
  - Higher risk if passes between aorta and RV infundibulum
  - If asymptomatic, controversial treatment
- History of angina type chest pain or syncope with strenuous exercise
- First sign may be sudden death
LCA from right cusp coursing between great arteries
Anomalous coronary arteries (cont)

- Anomalous LCA from pulmonary artery (ALCAPA)
- More commonly presents with cardiomyopathy in first few months of life
- May present with dyspnea, syncope or angina with exertion
- Classic ECG of anterolateral infarct:
  - Q waves in I, aVL, V4-V6
Kawasaki Disease with coronary involvement

- Aneurysms form during subacute phase
- Scarring, stenosis, calcification can occur over next several years
- Most frequent location
  - Left main coronary artery
  - Proximal left anterior descending
  - Right coronary
- >50% regress in 1-2 years
- ? Long term implications
Case of 12 year old with chest pain while playing basketball
Case of missed Kawasaki in past, presenting in 12 year old with chest pain while playing basketball
Case of missed Kawasaki in past, presenting in 12 year old with chest pain while playing basketball
Pericarditis

- Inflammation of the pericardium
- Numerous causes
  - Viral
  - Bacterial - high mortality
  - Rheumatic disease – Acute rheumatic fever, JRA, SLE
  - Drug induced
  - Postpericardiotomy Syndrome
  - Uremic
Pericarditis

- Chest pain
  - Sharp, stabbing pain
  - Worsens with lying flat
  - Pain improves with sitting and leaning forward
- Febrile
- Exam
  - Friction rub
  - Muffled heart sounds
  - Jugular venous distension
- Pulses paradoxus
  - Exaggerated (>10 mmHg) decrease in systolic BP with inspiration
Pericarditis- ECG

- Diffuse ST elevation and PR depression
- May evolve to ST normalization and T wave depression
- Low voltage with large effusion
- Electrical alternans
  - Cyclical variation QRS amplitude
Case 13 year old with chest and abdominal pain
ECG

[ECG tracing with annotations]
Echo- pericardial effusion
Clinical approach for Chest pain

- History of present illness
  - Pain
    - Duration
    - Location
    - Radiation
    - Precipitating factors: exercise, breathing, position
    - Relieving factors
  - Associated symptoms
Additional History

- Recent trauma, new exercise routine
- Recent fever
- Exposure to medications or drugs (cocaine)

Past Medical History
- Kawasaki
- Congenital heart disease
- Past operations
Clinical approach (cont)

- Family history
  - History of heart disease (congenital or acquired)
  - Medications
  - Sudden cardiac death
  - Connective tissue disease, aortic aneurysm
Physical exam

- Observation:
  - ? Distress, evidence of trauma
- Cardiac exam:
  - Inspection, palpation, auscultation
- Pulmonary exam
- Abdominal exam (referred pain)
- Palpation of costochondral and chondrosternal junctions
- Concerns on history and physical?
  - ECG +/- chest xray
Management of Pediatric Chest Pain Using a Standardized Assessment and Management Plan

Kevin G. Friedman, David A. Kane, Rahul H. Rathod, Ashley Renaud, Michael Farias, Robert Geggel, David R. Fulton, James E. Lock and Susan F. Saleeb

Pediatrics 2011;128:239; originally published online July 11, 2011;

FIGURE 1
SCAMP algorithm to guide testing in patients with chest pain. * Diagnoses that lead to increased risk of cardiac chest pain (ie, inflammatory disorders, malignancy, thrombophilia). † Family history was considered positive if any of the following were present in a first-degree relative: sudden or unexplained death, aborted sudden death, cardiomyopathy, or pulmonary hypertension. Six patients had an abnormal ECG result and an abnormal past medical history, family history, or physical examination. Patients with more than 1 abnormality (ie, ECG, past medical history, family history, and/or physical examination) were counted in only 1 category in this figure. CP indicates chest pain; PMHx, past medical history; echo, echocardiogram.
Regional Implementation of a Pediatric Cardiology Chest Pain Guideline Using SCAMPs Methodology


- 1016 patients
- 61% at Boston Children’s
- Average age 13.1
### TABLE 2 Indications for Echocardiography

<table>
<thead>
<tr>
<th>Historical Factors</th>
<th>Examination Findings</th>
<th>ECG Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest pain early in exercise</td>
<td>RR &gt; 40</td>
<td>Right ventricular hypertrophy</td>
</tr>
<tr>
<td>Chest pain at peak exercise</td>
<td>Temperature &gt;38.4°C</td>
<td>Left ventricular hypertrophy</td>
</tr>
<tr>
<td>Exertional syncope</td>
<td>Ill-appearing</td>
<td>ST-T segment change &gt; 2 mm</td>
</tr>
<tr>
<td>Radiation* or increase with supine position</td>
<td>Painful/swollen extremities</td>
<td>Low QRS voltage</td>
</tr>
<tr>
<td>Chest pain associated with fever (&gt;38.4°C)</td>
<td>Noninnocent murmur</td>
<td>PR segment depression</td>
</tr>
<tr>
<td>History hypercoagulable state</td>
<td>Distant heart sounds</td>
<td>S1, Q3, inverted T3</td>
</tr>
<tr>
<td>History arthritis/vasculitis</td>
<td>Gallop</td>
<td>Q1c &gt; 470 ms</td>
</tr>
<tr>
<td>History immobilization?</td>
<td>↑ Pulmonic component of S2</td>
<td></td>
</tr>
<tr>
<td>Familial sudden unexplained death</td>
<td>Pericardial friction rub</td>
<td></td>
</tr>
<tr>
<td>Familial cardiomyopathy</td>
<td>Peripheral edema</td>
<td></td>
</tr>
<tr>
<td>Familial hypercoagulable state</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a To back, jaw, left arm or left shoulder.*
SCAMP Echo findings

**TABLE 5 Echocardiogram Findings**

<table>
<thead>
<tr>
<th>Results</th>
<th>Test Recommended</th>
<th>Test Not Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>390 (92.2)</td>
<td>66 (81.5)</td>
</tr>
<tr>
<td>Explaining chest pain (pericarditis, anomalous origin of the RCA from the left sinus of Valsalva)</td>
<td>2 (0.5)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Incidental abnormality</td>
<td>31 (7.3)</td>
<td>15 (18.5)</td>
</tr>
<tr>
<td>Timing of echo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before appointment</td>
<td>71 (16.8)</td>
<td>19 (23.5)</td>
</tr>
<tr>
<td>On/After appointment</td>
<td>276 (65.2)</td>
<td>43 (53.1)</td>
</tr>
<tr>
<td>Unavailable</td>
<td>76 (18.0)</td>
<td>19 (23.5)</td>
</tr>
<tr>
<td>Incidental findings (n = 46)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitral valve prolapse</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Patent foramen ovale</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Left ventricular hypertrophy</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Borderline left ventricular function</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Insignificant coronary anomaly</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Bicuspid aortic valve</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Trivial/Mild mitral or tricuspid regurgitation</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Atrial septal defect</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Trivial aortic regurgitation</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Aortic dilatation</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Situs inversus totals</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Left ventricular noncompaction</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pulmonary artery dilatation</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Not specified</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Incidental totals</td>
<td>31 (7.3)</td>
<td>15 (18.5)</td>
</tr>
</tbody>
</table>

* P < .002

b 5 BCH, 88 NECCA
* 2 BCH, 17 NECCA
### TABLE 4: Testing Deviation

<table>
<thead>
<tr>
<th>Stated Reasons for Deviation from Echo Recommendations (a)</th>
<th>Echo Done When Not Recommended n = 81 (%)</th>
<th>Echo Not Done When Recommended n = 85 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parental anxiety or preference</td>
<td>2 (2.5%)</td>
<td>43 (50.6%)</td>
</tr>
<tr>
<td>Abnormal ECG</td>
<td>5 (6.2%)</td>
<td>6 (7.1%)</td>
</tr>
<tr>
<td>Other symptoms with chest pain</td>
<td>9 (11.1%)</td>
<td>18 (21.4%)</td>
</tr>
<tr>
<td>Family history prompted echo</td>
<td>8 (9.9%)</td>
<td>3 (3.5%)</td>
</tr>
<tr>
<td>Exam or history finding for cardiac disease unrelated to chest pain</td>
<td>21 (25.9%)</td>
<td>8 (9.4%)</td>
</tr>
<tr>
<td>Done before visit</td>
<td>7 (8.6%)</td>
<td>3 (3.5%)</td>
</tr>
<tr>
<td>No clear explanation given</td>
<td>12 (14.8%)</td>
<td>3 (3.5%)</td>
</tr>
<tr>
<td>Missing</td>
<td>17 (21.0%)</td>
<td>2 (2.4%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Added Cardiac Tests (b)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test</td>
<td>n = 129 (%)</td>
<td></td>
</tr>
<tr>
<td>Stress MBI</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
<tr>
<td>Exercise stress test</td>
<td>41 (31.8%)</td>
<td></td>
</tr>
<tr>
<td>Ambulatory monitoring</td>
<td>59 (45.8%)</td>
<td></td>
</tr>
<tr>
<td>Metabolic cart</td>
<td>2 (1.6%)</td>
<td></td>
</tr>
<tr>
<td>Blood test (eg, CBC, liver function)</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
<tr>
<td>Fasting lipid profile</td>
<td>3 (2.3%)</td>
<td></td>
</tr>
<tr>
<td>Chest radiograph</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
<tr>
<td>Urinalysis</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
<tr>
<td>CRP</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>11 (8.5%)</td>
<td></td>
</tr>
<tr>
<td>Cardiac MRI</td>
<td>4 (3.1%)</td>
<td></td>
</tr>
<tr>
<td>Stress echocardiogram</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
<tr>
<td>Nonfasting total cholesterol and HDL</td>
<td>3 (2.3%)</td>
<td></td>
</tr>
</tbody>
</table>

CBC: complete blood count; CRP, C-reactive protein; HDL, high density lipoprotein; MBI, Technetium \(^{99m}\) Tc sestamibi scan; MRI, magnetic resonance imaging.
Take home points

- **Good history** most important tool distinguishing cardiac vs non-cardiac etiology
- Chest pain rarely due to cardiac disease
- Cardiac etiology unlikely if:
  - Unrelated to exercise or supine position
  - Unassociated with symptoms of illness
  - Not anginal in nature
  - Normal cardiac exam and ECG
- Chest pain that only occurs with exertion, or associated with dizziness/syncope, requires further evaluation
Syncope in Children

Syncope: transient and sudden loss of consciousness and postural tone that results from inadequate cerebral perfusion

Presyncope: the sensation of impending loss of consciousness and postural tone

Dizziness: less specific, may include lightheadedness, vertigo, disequilibrium
Syncope in Children

- Common in children 8-18 years of age
- History and Physical Exam +/- ECG are often adequate in evaluation of first event
- Causes:
  - Neurocardiogenic ("vasovagal")—common
  - Non cardiac (e.g. seizure)
  - Cardiac—least common
Neurocardiogenic (Vasodepressor Syncope)

- All types precipitated by decreased venous return to the heart
  - Upright posture
  - Dehydration
  - Peripheral vasodilatation from
    - Sudden pain or fright
    - Ambient heat
    - Immediately POST exercise
Vasodepressor Syncope - Predisposing Factors

- Ambient warmth
- Poor ventilation
- Sudden fear
- Sudden pain or surprise
- Dehydration
- Self-imposed salt restriction
Vasodepressor Syncope

- History before faint is crucial
- Before
  - Nausea
  - Vision changes
  - Sweatiness
  - Tachycardia
  - Abrupt change in posture
  - Hunger, thirst, pain
  - Exertion during pain
Vasodepressor Syncope

- History after faint is crucial
- After
  - Sensorium is usually intact
  - Loss of bowel/bladder control unusual
  - Post-episode paralysis, neuro findings unusual
Neurocardiogenic Syncope

- Previous history of dizziness with quick standing is common
- Symptoms of dizziness are similar to symptoms before faint
- Physical exam may reveal low blood pressure or drop of > 20 mm Hg systolic blood pressure after standing for 3 minutes
- Physical exam is otherwise normal
Treatment

- Liberalize fluid and salt intake
- Recognize signs and symptoms
- Lay down to abort episodes
- Medical therapy in fluid resistant cases
Syncope in Children—Cardiac Causes

- Obstruction of Outflow
  - Hypertrophic cardiomyopathy, Aortic stenosis, Pulmonary hypertension
- Myocardial dysfunction
  - Dilated cardiomyopathy, myocarditis, coronary anomalies
- Arrhythmias
  - Ventricular tachycardia (long QT syndrome)
  - Supraventricular tachycardia (rare)
  - Heart block
Non-cardiac Syncope

- Seizures
  - tonic-clonic motions before loss of consciousness
  - loss of bladder/bowel control
- Migraine/CNS pathology
  - faint often preceded by headache
- Drug ingestion
- Metabolic (hypoglycemia with ketosis)
  - ketotic odor may be noted
- Hyperventilation
  - paresthesias may be present
- Carotid sinus hypersentivity
  - rare, related to neck pressure, manipulation, tight collar, neck tumors
Syncope in Childhood—Evaluation

- **Good history** of events before and after episode
- Family history of SIDS, sudden death or deafness, seizures, HCM
- Complete Physical Exam with blood pressures supine and standing
- ECG with attention to QT interval, PR interval or delta waves, LVH, heart block
Syncope in Children—Indications for Referral

- Exercise-induced syncope
- Chest pain preceding the faint
- Seizure activity before the faint or prolonged activity during/after the faint
- Atypical symptoms (palpitations, headache)
- Recurrent episodes (? > 2-3)
- Abnormal cardiac exam or ECG
Palpitations in Children

- Increasingly common reason for referral to a pediatric cardiologist
- Side-effect of many ADHD medications
- Usually benign (sinus tachycardia)
- History and physical exam remain extremely helpful in identifying abnormal cases
- ECG helps to exclude underlying causes of arrhythmias
- Event recorder helpful in cases with episodic significant symptoms
Palpitations

- History
  - Sensation of “fast”, “hard beating” or both
  - Did anyone count heart rate
  - Duration, resolved suddenly or gradually?
  - Aggravating factors?
  - Only with exercise, excitement or anxiety?
  - Caffeine intake?
  - Medications, including OTC medications?
  - Emotional, exhausted, thin, heat intolerant?
Palpitations

- Physical Exam
  - Usually normal
  - Check for thyromegaly
  - Premature extrasystoles?
Palpitations

- ECG
  - Premature atrial or ventricular contractions
    - May be benign
    - May be associated with intermittent SVT or VT
  - short PR interval +/- delta wave
    - Wolff-Parkinson-White syndrome
  - long QT interval (QTc = QT/RR^{1/2})
    - Congenital long QT syndrome
  - Ventricular hypertrophy
    - Cardiomyopathy

- If concerns, event recorder to document rhythm during episode
Event recorder example
Questions?