CHEST PAIN IN PEDIATRIC

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- **Nontraumatic chest pain is a common symptom in children and adolescents and is a frequent complaint in patients seeking primary, emergency, or subspecialty care.**
- **Although the etiology is benign in most cases, this symptom may lead to school absences, restriction of activities and causes considerable anxiety in patients and their families or caregivers.**

Different diagnosis of Chest Pain In children

MUSCULOSKELETAL (COMMON)
Trauma (accidental, abuse)
Exercise, overuse injury (strain, bursitis)
Costochondritis (Tietze syndrome)
Herpes zoster (cutaneous)
Pleurodynia
Fibrositis
Slipping rib
Precordial catch
Sickle cell anemia vasoocclusive crisis
Osteomyelitis (rare)
Primary or metastatic tumor (rare)

PULMONARY (COMMON)
Pneumonia
Pleurisy
Asthma
Chronic cough
Pneumothorax
Infarction (sickle cell anemia)
Foreign body
Embolism (rare)
Pulmonary hypertension (rare)
Tumor (rare)
Bronchiectasis

DIFFERENT DIAGNOSIS OF CHEST PAIN IN CHILDREN

GASTROINTESTINAL (LESS COMMON)
Esophagitis (gastroesophageal reflux, infectious, pill)
Esophageal foreign body
Esophageal spasm
Cholecystitis
Subdiaphragmatic abscess
Perihepatitis (Fitz-Hugh-Curtis syndrome)
Peptic ulcer disease
Pancreatitis

CARDIAC (LESS COMMON)
Pericarditis
Postpericardiotomy syndrome
Endocarditis
Cardiomyopathy
Mitral valve prolapse
Aortic or subaortic stenosis
Arrhythmias
Marfan syndrome (dissecting aortic aneurysm)
Kawasaki disease
Cocaine, sympathomimetic ingestion
Angina (familial hypercholesterolemia, anomalous coronary artery)

IDIOPATHIC (COMMON)
Anxiety, hyperventilation
Panic disorder

OTHER (LESS COMMON)
Spinal cord or nerve root compression
Breast-related pathologic condition (mastalgia)
Castleman disease (lymph node neoplasm)

CAUSES OF NONTRAUMATIC CHEST PAIN IN CHILDREN AND ADOLESCENTS

Common conditions (٩٤ to ٩٩% of patients)

Musculoskeletal conditions

- Muscle strain
- Costochondritis
- Slipping rib syndrome
- Precordial catch (Texidor twinge)
- Fibromyalgia
- Pectus excavatum or carinatum

Psychiatric

- Anxiety
- Panic disorder with or without hyperventilation syndrome
- Depression
- Hypochondriasis
- Somatization

Respiratory

- Pneumonia (can be life threatening)
- Asthma (can be life threatening)
- Chronic cough with muscle strain or, if severe, fractured rib
- Spontaneous pneumomediastinum

CAUSES OF NONTRAUMATIC CHEST PAIN IN CHILDREN AND ADOLESCENTS

Common conditions (٩٢ to ٩٩% of patients)

Gastrointestinal

- Gastroesophageal reflux disease
- Medication-induced ("pill") esophagitis
- Esophageal foreign body
- Esophageal spasm and achalasia
- Gastritis
- Peptic ulcer
- Irritable bowel disease
- Cholecystitis
- Pancreatitis

Breast

- Male adolescents: Gynecomastia
- Female adolescents: Pregnancy, thelarche, mastitis, or fibrocystic disease

Idiopathic

CAUSES OF NONTRAUMATIC CHEST PAIN IN CHILDREN AND ADOLESCENTS

Other conditions

Tietze syndrome

Pleurodynia

Herpes zoster

- A thorough history and physical examination usually can determine the cause and identify patients who require acute intervention and those who can be managed with reassurance and continued follow-up.
- Laboratory testing is necessary only in a small number of patients

- **Findings of life-threatening causes**
- **Pain description as follows:**
- **Classic anginal pain (ie, substernal, crushing, with radiation down the left arm or up into the jaw and associated with vomiting, diaphoresis, altered mental status, or dyspnea)**
- **Severe, tearing type pain often radiating to the back (aortic dissection)**
- **Pleuritic pain with difficulty breathing (pneumonia, pneumothorax, pulmonary embolus, or in patients with sickle cell disease, acute chest syndrome)**
- **Exertional pain or exercise intolerance due to tachypnea or fatigue caused by limitations in myocardial oxygen delivery (myocardial ischemia, coronary anomalies, cardiomyopathy)**
- **Sharp, retrosternal pain exacerbated by lying down, sometimes radiating to the left shoulder, and often associated with fever (pericarditis)**
- **Pain precipitated by the use of cocaine, amphetamines, bath salts, synthetic cannabinoids, marijuana or other vasoactive drugs (eg, cough and cold preparations) suggesting variant angina**

- **EVALUATION**

- **History** **Most children with nontraumatic chest pain appear well during acute evaluation. Thus, the history is of utmost importance for identifying serious underlying causes of pediatric chest pain.**

FINDINGS OF LIFE-THREATENING CAUSES

- **Symptoms occurring with pain as follows:**

١- Exertional syncope or dizziness (coronary anomalies, left ventricular outflow obstruction, cardiomyopathy)

٢- Palpitations

٣- Difficulty breathing

- Fever and heart failure symptoms (eg, DOE, orthopnea, or in infants, tachypnea with feedings) **suggestive of myocarditis**

FINDINGS OF LIFE-THREATENING CAUSES

- **Concerning past medical history such as:**
- •**Congenital or acquired heart disease**, Kawasaki disease, or sickle cell anemia
- Receipt of an mRNA **coronavirus disease ٢٠١٩ (COVID-١٩)** vaccine within the preceding ٣٠ days
- **Conditions that predispose to pericarditis**, for example, rheumatologic disease, malignancy, recent cardiac surgery, mediastinal radiation, renal failure or infections such as tuberculosis, human immunodeficiency virus
- **Risk factors for pulmonary embolism** including immobility, oral contraceptive use, pregnancy termination, ventriculo-atrial shunts for hydrocephalus, in-dwelling central venous catheters, solid tumors, heart disease, hypercoagulable states, and obesity
- **Previous aortic dissection**, particularly in a patient known to have Marfan, Loeys-Dietz, type IV Ehlers-Danlos, or Turner syndrome

FINDINGS OF LIFE-THREATENING CAUSES

- **Family history of:**
- **Hypertrophic cardiomyopathy** or of sudden death in first-degree relatives (eg, parents or siblings) younger than ٥٠ years of age
- **Marfan,** type IV Ehlers-Danlos, or Turner syndromes because of predisposition for aortic root dissection
- **Inherited hypercoagulable state** (factor V Leyden, protein C or protein S deficiency, and other conditions)

- **Other important features**
- **When history does not suggest a life-threatening cause, an accurate description of the chest pain can help establish a specific diagnosis as follows :**

- **Temporal elements – The duration and time course of the onset of chest pain may be a useful distinguishing feature. Chronic pain is unlikely to have a serious underlying cause and often is musculoskeletal, psychogenic, or idiopathic.**

- **Acute pain is more likely to be caused by a medical condition. As examples, pain caused by pulmonary conditions (eg, asthma or pneumothorax) or vascular events (eg, aortic dissection or acute pulmonary embolism) typically has an abrupt onset. However, ischemic myocardial pain, which is unusual in children and is described in greater detail above, may have a gradual onset with increasing intensity over time.**

- **Other important features**

- **Quality –** A description of the quality of the pain may be helpful. The pain associated with **costochondritis** typically is described as midsternal in location and sharp in quality with minimal radiation. It occurs mainly at rest and lasts for seconds to a few minutes. The pain may increase in intensity with deep inspiration because of stretching of the costochondral junctions or muscle fibers.

- Patients with **slipping rib syndrome** may describe "something slipping or giving away," "a popping sensation," or "hearing a clicking sound" . In that condition, pain frequently occurs with bending over or deep breathing

- **Location –** Pain that localizes to a small area on the chest more likely is of chest wall or pleural origin rather than visceral. Ischemic pain is a diffuse discomfort that may be difficult to localize.

- **Radiation** usually is associated with causes of pain that are uncommon in children. As an example, the pain of myocardial ischemia may radiate to the neck, throat, lower jaw, teeth, upper extremity, or shoulder.
- Other unusual causes include acute cholecystitis, which can present with right shoulder pain (although concomitant right upper quadrant or epigastric pain is more typical), aortic dissection, which may be radiates between the scapulae, or pericarditis that can radiate to the left shoulder.

- **Precipitating factors – The patient should be asked about factors that induce or make the pain worse:**
- **Deep breathing may exacerbate chest pain of musculoskeletal**
- **Pain made worse by swallowing likely is of esophageal origin. Discomfort that occurs with eating also may suggest upper gastrointestinal disease.**
- **History of a choking spell or witnessed warrants evaluation for an esophageal foreign body.**
- **Chest discomfort provoked by exertion often has a cardiac or respiratory cause.**
- **Pleuritic chest pain is worsened by inspiration.**
- **Chest pain that increases when lying supine and decreases when sitting suggests pericarditis.**
- **Pain associated with coronary artery anomalies typically occurs with exertion.**

ASSOCIATED SYMPTOMS

- **Dyspnea or cough**

- **May indicate pulmonary disorders or be a sign of cardiac disease.**

  In addition to chest pain, for example, patients with pulmonary embolism can develop dyspnea, hypoxemia, apprehension, cough, and diaphoresis

- **Patients with myocarditis may have dyspnea and fatigue.**

ASSOCIATED SYMPTOMS

- **Fever:**

  Respiratory infection.

  pericarditis

  Myocarditis

  Kawasaki disease

  multisystem inflammatory syndrome in children (MIS-C).

ASSOCIATED SYMPTOMS

- Vomiting or regurgitation, painful swallowing, or heartburn associated with eating suggest gastrointestinal disease, such as gastroesophageal reflux and esophagitis.
- Recurrent somatic complaints, including headache or abdominal or extremity pain, occur in most children with psychogenic chest pain
- Lightheadedness or paresthesia frequently accompany chest pain resulting from hyperventilation.
- Exertional syncope or palpitations suggest an underlying cardiac disorder.

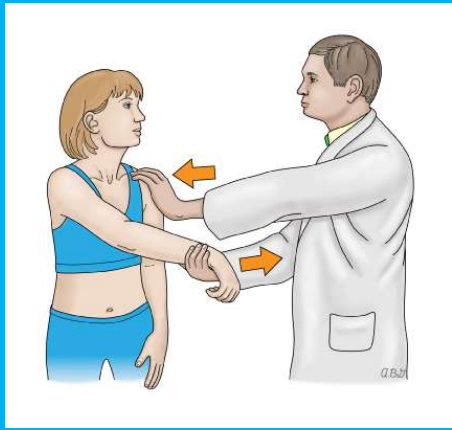
- **Physical examination**

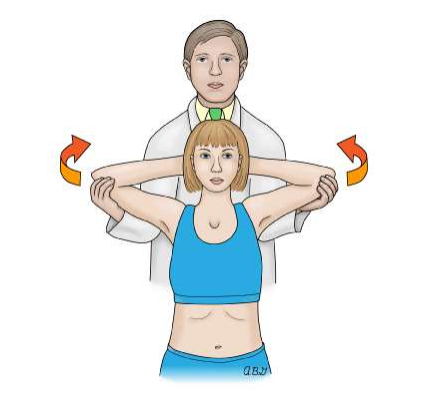
- Children and adolescents with chest pain are typically in no acute distress or have minimal discomfort during examination.
- **Fever** (associated with cardiac or pulmonary disease such as pericarditis, myocarditis, pneumonia, or a rheumatologic condition)
- **Tachycardia for age** (present in several common and life-threatening causes of pediatric chest pain and warrants evaluation of the patient's rhythm and cardiac function)
- **Tachypnea for age** (seen in patients with a variety of conditions but raises concerns for asthma, pneumonia, spontaneous pneumothorax, pulmonary embolism, pulmonary congestion from cardiac causes, and hyperventilation syndrome)
- **Hypertension** (frequently present in patients with aortic dissection)
- **Hypotension** (associated with serious cardiac, pulmonary, and infectious causes of chest pain)
- **Narrow pulse pressure or pulsus paradoxus >١٠ mmHg** (present in patients with a large pericardial effusion associated with cardiac tamponade)
- **Hypoxia** (eg, abnormal pulse oximetry; the threshold varies based on several factors, but, for normal individuals at sea level, many experts consider a resting oxygen saturation ≤٩٥ percent as abnormal.

- **General appearance may indicate the following:**
- **Presence of genetic conditions that are associated with congenital heart disease (eg, Turner syndrome) or aortic dissection (eg, Marfan or Ehlers-Danlos syndrome).**
- **Signs of chronic disease such as weight loss, fatigue, or pallor suggesting an underlying condition such as systemic lupus erythematosus, lymphoma, or a solid tumor.**
- **Tetany or carpopedal spasm indicating hyperventilation syndrome.**
- **Drooling associated with an esophageal foreign body**

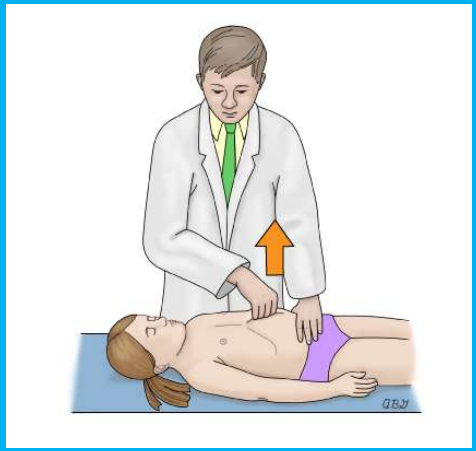
- **Next, the clinician should focus on the chest, lungs, and heart as follows:**
- **Chest wall –**

- **Chest wall deformity, such as pectus excavatum or carinatum (although uncommonly causes of chest pain), asymmetry of breathing (pneumothorax), rapid, shallow breathing with normal oxygenation (hyperventilation) or asymmetry of the breasts (gynecomastia) are important findings on inspection.**
- **Chest wall tenderness indicates a musculoskeletal cause of pain, typically costochondritis. Bruises associated with trauma sometimes are seen. However, serious underlying thoracic injury can occur without obvious chest wall bruising.**
- **Examination should also include palpation of the costochondral junctions, the insertion site of the pectoralis major muscle group (by grasping the head of the muscle between the examiner's fingers and thumb), the inframammary area, and other regions of the chest where pain is reported. In patients with costochondritis, involvement of the costochondral junctions often is asymmetric, with the left side more frequently affected. The diagnosis is confirmed when palpation reproduces the discomfort. Provocative maneuvers for costochondritis include horizontal arm traction and the "crowing rooster" maneuver .**





- Diagnosis of slipping rib syndrome can be confirmed by the "hooking" maneuver in which the examiner's fingers are curled around the lower costal margin. Lifting anteriorly will elicit a click and reproduce pain.



- Tenderness on palpation of breast tissue often can be elicited in patients who complain of breast pain. Tender subareolar masses may also be palpable.

- **Lungs**

- **Signs of a respiratory etiology may include tachypnea and respiratory distress. Patients with respiratory distress warrant urgent assessment of airway and breathing and administration of supplemental oxygen. Airway management in patients with signs of impending respiratory failure should be initiated prior to full evaluation.**
- **In addition to lung pathology, tachypnea with or without wheezing can also be an important sign of heart failure in children with myocarditis, dilated cardiomyopathy, or other cardiac causes of chest pain.**
- **Diminished breath sounds over affected areas of the lung raises suspicion for pneumothorax. Rales or tubular breath sounds suggest pneumonia whereas wheezing may be audible in patients with asthma.**

- **Lungs**

- **Pneumomediastinum or esophageal rupture may produce subcutaneous emphysema that is detected as crepitus on palpation of the supraclavicular or neck region.**
- **Hyperventilation, associated with chest pain of psychogenic origin, may be present at the time of the examination. Patients will display light, shallow breathing with normal lung sounds and oxygenation. If the patient is not actively hyperventilating, it may be possible to reproduce the chest pain by asking the patient to hyperventilate. However, hyperventilation for as long as ٢٠ minutes may be required to reproduce symptoms**
- **In patients with atypical angina due to coronary vasospasm, hyperventilation for six minutes can frequently reproduce symptoms**

- **Heart**

- **A cardiac cause of chest pain is identified by abnormal heart sounds on auscultation (eg, cardiac murmur, gallop, muffled heart sounds, or a pericardial friction rub) or by an abnormal pulse or blood pressure.**

- **Any new heart murmur or abnormal heart sound in association with chest pain should prompt additional evaluation and pediatric cardiology consultation.**

- **Findings associated with specific cardiac causes of chest pain:**
- **Hypertrophic cardiomyopathy (HCM)**
- **Dilated cardiomyopathy**
- **Coronary ischemia**
- **Left ventricular outflow obstruction**
- **Arrhythmia Pericarditis**
- **Myocarditis**
- **Pulmonary hypertension (pulmonary embolism)**

CAUSES OF NONTRAUMATIC CHEST PAIN IN CHILDREN AND ADOLESCENTS

- **Life-threatening conditions (١ to ٩% of patients)**
- Cardiac conditions
- Hypertrophic cardiomyopathy
- Aortic stenosis
- Coarctation of the aorta
- Coronary artery abnormalities (eg, Kawasaki , anomalous coronary arteries)
- Variant angina after recreational drug use (eg, cocaine, amphetamines, bath salts [methcanthinones], marijuana, and synthetic cannabinoids)
- Classic angina (early atherosclerotic disease from hyperlipidemias or diabetes)
- Pericarditis
- Myocarditis
- Dilated cardiomyopathy
- Tachyarrhythmias
- Aortic aneurysm or dissection
- Ruptured sinus of Valsalva aneurysm

CAUSES OF NONTRAUMATIC CHEST PAIN IN CHILDREN AND ADOLESCENTS

- **Life-threatening conditions (١ to ٢% of patients)**
- Airway foreign body
- Spontaneous pneumothorax
- Pulmonary embolism
- Pulmonary hypertension
- Sickle cell disease with acute chest syndrome
- Tumor (chest wall, pulmonary, or mediastinum)
- Nontraumatic esophageal rupture (Boerhaave syndrome)
- Spinal cord compression (tumor, vertebral collapse, or epidural abscess)

Serious causes of pediatric chest pain and key findings

Cause	History	Physical exam findings	ECG findings
Hypertrophic cardiomyopathy	Positive family history Exercise intolerance Exertional chest pain Syncope and/or arrhythmia	Dynamic systolic murmur	Left ventricular hypertrophy or left axis deviation ST segment or T wave changes Q waves Arrhythmias, ventricular premature beats Ventricular pre-excitation (Wolff-Parkinson-White)
Dilated cardiomyopathy	Family history Decreased exercise tolerance, syncope Heart failure symptoms	Gallop Mitral regurgitation murmur	Intraventricular conduction delay High or low QRS voltages Arrhythmia, premature beats
Anomalous coronary artery origin	Exertional chest pain Exertional syncope	Usually normal	Usually normal
Coronary ischemia	Predisposing conditions: ▪ History of Kawasaki disease ▪ Cardiac surgery or heart transplant ▪ Systemic arteriopathy (Williams syndrome) ▪ Severe familial hypercholesterolemia ▪ Drug use: Cocaine, sympathomimetics ▪ Anginal chest pain	Tachycardia Tachypnea New murmur or gallop	ST segment depressions or elevation T wave changes Q waves
Severe left ventricular outflow tract obstruction	Exertional symptoms Exertional syncope	Loud systolic murmur	Left ventricular hypertrophy Left ventricular strain pattern
Arrhythmia	Palpitations Syncope Positive family history	Irregular rhythm	Atrial arrhythmia Ventricular arrhythmia Premature contractions Ventricular pre-excitation (Wolff-Parkinson-White)
Pericarditis	Positional chest pain Predisposing factors: ▪ Rheumatologic conditions ▪ Malignancy ▪ Mediastinal radiation ▪ Infection (HIV, tuberculosis, viral) ▪ Renal failure ▪ Recent cardiac surgery	Cardiac rub Tachycardia/tachypnea Distant heart sounds, JVD	Diffuse ST segment changes T wave inversions
Myocarditis	Fever Viral prodrome Short duration of symptoms New onset heart failure symptoms	Tachycardia Tachypnea With or without gallop rhythm, ventricular ectopy Cardiovascular collapse	Diffuse ST segment changes T wave inversions PR depression Ventricular ectopy Low QRS voltages
Aortic dissection	Personal or family history of bicuspid aortic valve or connective tissue disorders (Marfan, Loey-Dietz, Ehlers-Danlos type IV, others) Acute onset sharp or tearing type of pain	Marfanoid body habitus	See coronary ischemia above
Pulmonary embolus	Pain description: Acute onset, pleuritic, associated dyspnea Personal or family risk factors (inherited thrombophilia, hypercoagulable states, immobilization, medications)	Right ventricular heave (elevated right ventricular pressure) Loud and/or unsplit S_2 (if right ventricular pressure elevated)	Right ventricular hypertrophy Right ventricular strain pattern

SERIOUS CAUSES OF PEDIATRIC CHEST PAIN AND KEY FINDINGS

Hypertrophic cardiomyopathy	Positive family history Exercise intolerance Exertional chest pain Syncope and/or arrhythmia	Dynamic systolic murmur	Left ventricular hypertrophy or left axis deviation ST segment or T wave changes Q waves Arrhythmias, ventricular premature beats Ventricular pre-excitation (Wolff-Parkinson-White)
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LIFE-THREATENING CONDITIONS

- **Cardiac disease**

- **Heart disease is more likely if chest pain occurs during exertion or is associated with palpitations, syncope with exertion, or decreased exercise tolerance**

- **Patients with known CHD, heart transplant, substance abuse, or prior KD are at heightened risk for myocardial ischemia.**

LIFE-THREATENING CONDITIONS

- **Cardiac disease**
- **A positive family history of cardiomyopathy, cardiac arrhythmia, or sudden death in close relatives before the age of ٥٠ years should also raise suspicion.**
- **In addition to a suggestive history, most patients with heart disease will have an abnormal cardiac examination or electrocardiogram**

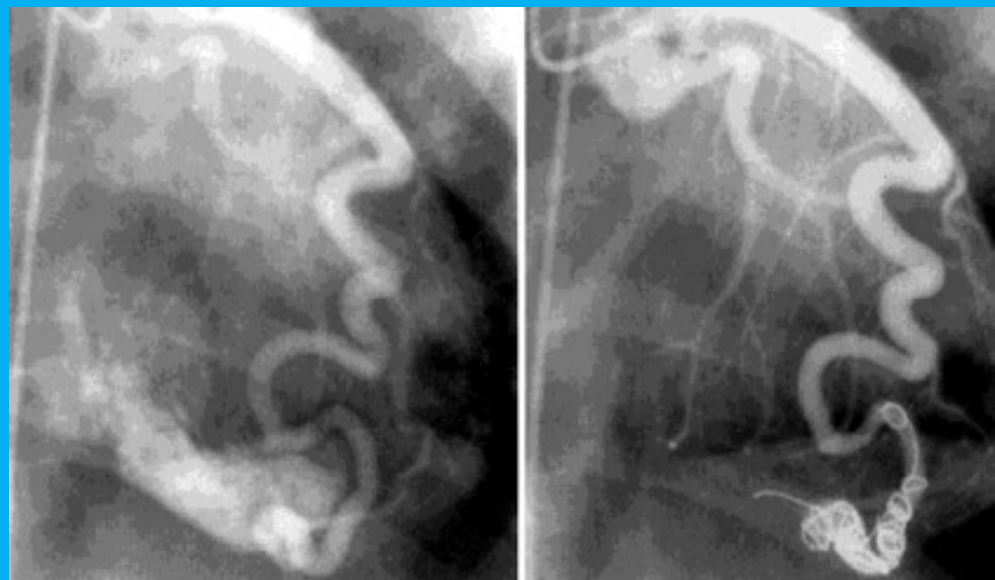
LIFE-THREATENING CONDITIONS

- Cardiac disease
- Congenital heart disease with left ventricular outflow tract obstruction Hypertrophic cardiomyopathy, aortic stenosis (subvalvar, valvar, or supravalvar), or coarctation of the aorta may cause decreased coronary blood flow and angina.

LIFE-THREATENING CONDITIONS

- Cardiac disease

- Coronary artery abnormalities — Although uncommon, a variety of coronary artery abnormalities occur in children, including congenital and acquired conditions (eg, coronary artery aneurysm or stenosis caused by Kawasaki disease) and may present with chest pain on exertion.



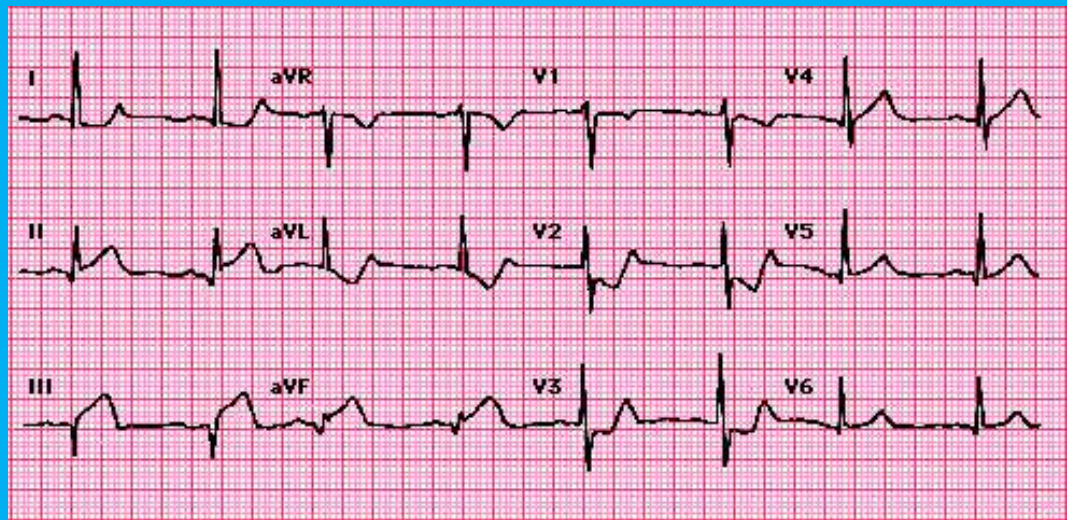
LIFE-THREATENING CONDITIONS

- **Cardiac disease**
- **Anomalous origin of the left coronary artery from the main pulmonary artery (ALCAPA)usually presents in infancy, but can become symptomatic later in childhood. In that disorder, left ventricular ischemia usually results in cardiomyopathy and mitral regurgitation.**
- **Origin of a coronary artery from the contralateral sinus of Valsalva and coursing of the anomalously positioned coronary artery between the aorta and pulmonary artery can be associated with exertional chest pain.**

LIFE-THREATENING CONDITIONS

- **Cardiac disease**

- **Classic angina —** Although uncommon, children and adolescents with predisposing conditions, such as hyperlipidemia, prior KD with coronary artery aneurysms or stenoses, or collagen vascular disease (eg, SLE) can develop classic angina consisting of crushing or squeezing substernal chest pain with radiation to the jaw or left arm and associated with diaphoresis, nausea and vomiting, difficulty breathing, or altered mental status. An (ECG) obtained while the patient has pain often shows ST wave elevation or depression



LIFE-THREATENING CONDITIONS

- **Cardiac disease**

- **Variant angina —** Coronary vasospasm (variant angina) and myocardial infarction are rare causes of chest pain in children and adolescents. Coronary vasospasm is associated with angina, transient ischemic changes on ECG during episodes of pain, cardiac enzyme elevation, and ST-segment elevation on ambulatory ECG monitoring. Variant angina with myocardial infarction has been described after recreational use of cocaine, amphetamines, bath salts (methcathinones), marijuana, and synthetic cannabinoids in adolescents.

LIFE-THREATENING CONDITIONS

- **Cardiac disease**
- **Pericarditis — The major clinical manifestations of acute pericarditis include :**
- **Chest pain that is typically sharp, increased with inspiration, improved by sitting up and leaning forward, worsened by lying down, and occasionally radiates to the left shoulder**
- **Pericardial friction rub described as a superficial scratchy or squeaking sound best heard with the diaphragm of the stethoscope over the left sternal border during the systolic, diastolic or both phases of the cardiac cycle**
- **Electrocardiographic (ECG) changes such as new widespread ST elevation or PR depression; later in the course there is T wave inversion**
- **Distant heart sounds and/or pulsus paradoxus suggesting pericardial effusion**

LIFE-THREATENING CONDITIONS

- **Cardiac disease**

- **Myocarditis** Viral myocarditis in children, which is usually painless, may occasionally cause chest pain when concomitant pericarditis is present. Children with myocarditis also may display tachycardia that is out of proportion to fever or persistent while quiet or asleep, respiratory distress, signs of heart failure, poor perfusion, and atrial or ventricular arrhythmias.

- In ٢٠٢٠, a new cause of myocarditis was associated with coronavirus disease ٢٠١٩ (COVID-١٩) as a finding in multisystem inflammatory syndrome in children (MIS-C)

LIFE-THREATENING CONDITIONS

- **Cardiac disease**
- **Dilated cardiomyopathy** Children with DCM can develop chest pain in association with syncope, decreased exercise tolerance, and heart failure symptoms (eg, orthopnea or DOE).
- From ٢٠ to ٥٠ percent of patients with DCM have an inherited form.

LIFE-THREATENING CONDITIONS

- **Cardiac disease**

- **Tachyarrhythmias** **Tachyarrhythmias (eg, PSVT with or without underlying WPW, V-tach) are usually painless, but, if sustained, may cause angina.**

LIFE-THREATENING CONDITIONS

- Cardiac disease

- Aortic root dissection — Aortic root dissection causes an abrupt onset of severe sharp or tearing pain that may be localized to the anterior chest (ascending aortic dissection) or posterior chest (descending aortic dissection) with radiation to other parts of the chest, back or abdomen. It is associated with Marfan syndrome, Turner syndrome, type IV Ehlers-Danlos syndrome, homocystinuria, rare familial aortopathies, or cystic medial necrosis.

LIFE-THREATENING CONDITIONS

- Cardiac disease

- Ruptured sinus of Valsalva aneurysm Ruptured sinus of Valsalva aneurysm is a rare condition caused by congenital absence of media in the aortic wall behind the sinus of Valsalva.

LIFE-THREATENING CONDITIONS

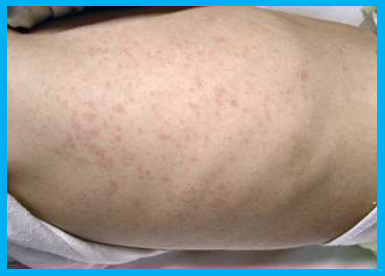
- Cardiac disease

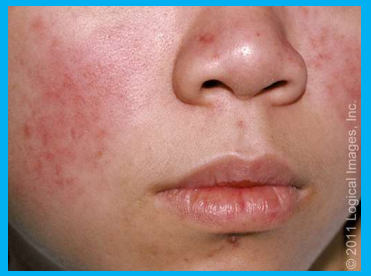
Pulmonary hypertension (pulmonary embolism) **Patients with pulmonary hypertension caused by a pulmonary embolus typically have a right ventricular heave and a single loud S٢. They may have a murmur consistent with tricuspid or pulmonary regurgitation.**

LIFE-THREATENING CONDITIONS

- Spontaneous pneumothorax Spontaneous pneumothorax typically occurs in older male adolescents and is associated with a tall, thin body habitus. Other important underlying causes include drug use (eg, snorting cocaine or methamphetamines, and smoking marijuana cigarettes) scuba diving, airway disease (eg, asthma or cystic fibrosis), congenital lung disease, foreign body aspiration, menstruation in postmenarcheal females (catamenial pneumothorax), and connective tissue disease (eg, Marfan syndrome or Ehlers-Danlos syndrome

- Additional findings that suggest specific diagnoses include:
- Epigastric abdominal tenderness associated with gastritis or, less commonly, pancreatitis
- Rashes (eg, evanescent salmon pink rash or malar rash characteristic of specific collagen vascular diseases



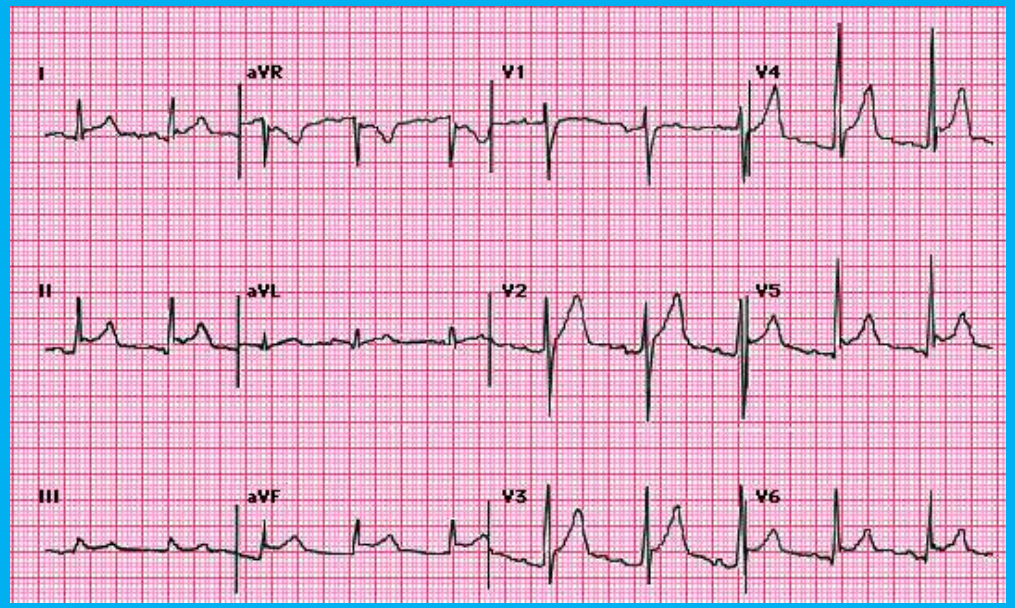


- Arthritis arising from underlying collagen vascular disease (eg,JRA or SLE)
- Posterior oral ulcers and rash on the palms and soles in associated with pleurodynia in patients with enterovirus infection (coxsackievirus B)

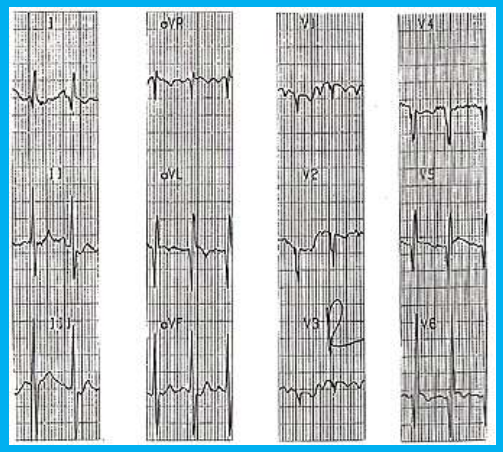
- **Ancillary studies**
- **Most children with chest pain have no history suggestive of life-threatening conditions and either a normal physical examination or findings consistent with a musculoskeletal etiology. Further investigations are not needed in patients for whom a clear etiology, other than cardiac disease, can be established**

- **Bedside ultrasonography** — When performed by properly trained and experienced clinicians, bedside ultrasound can rapidly confirm the presence of pneumothorax and pericardial effusions and guide emergent intervention
- **Electrocardiogram** — An electrocardiogram (ECG) should be obtained if cardiac disease is suspected based upon history or physical examination and when a noncardiac etiology (eg, costochondritis, pneumonia, gastroesophageal reflux, pill esophagitis, or esophageal foreign body) cannot be established.
- In patients with a rapid pulse rate or palpitations, an ECG can identify the type of arrhythmia (Holter monitor or event monitor recording may be needed)

- **Other ECG abnormalities**
- **Patients with hypertrophic cardiomyopathy may have evidence of left ventricular hypertrophy or strain.**
- **In pericarditis with effusion, the ECG changes during the clinical course. Generalized ST segment elevation involving limb and precordial leads is seen in the initial ١٠ to ١۴ days This is followed by T wave flattening or inversion that can persist for an additional two weeks.**
- **Voltages will be reduced in amplitude if the effusion is large.**
- **Abnormal Q waves typically are not seen in pericarditis. ST-T wave abnormalities occur in myocarditis.**



- In children with anomalous origin of the left coronary artery from the pulmonary artery (ALCAPA), the typical ECG pattern is of an anterolateral infarction with deep and wide Q waves and T wave inversions in leads I, aVL, V۵, and V۶



- Patients with PH typically have signs of RVH and RAD. The ECG may show right ventricular strain (abnormal T waves in the anterior leads).
- ECG findings in pulmonary embolism usually are nonspecific ST-T segment changes or sinus tachycardia.

- Chest radiograph
- Respiratory distress
- Pleuritic chest pain
- Pathologic cardiac murmur or heart sounds
- Pulmonary rales
- Hypoxia
- Persistent tachypnea
- History of choking or witnessed ingestion of a foreign body

- Signs of cardiac enlargement may be apparent in conditions causing LVOTO, HF, myocarditis, pericarditis, or PE.
- Patients with PH may have prominent PA. The peripheral lung fields may be dark if pulmonary vascular resistance is chronically elevated.
- In patients with suspected pulmonary disorders, a chest radiograph may show infiltrates caused by pneumonia or areas of atelectasis and air trapping caused by aspiration of a foreign body. Hyperinflation typically is seen in patients with asthma. In addition, pneumothorax, pneumomediastinum, or pleural effusions can be detected.
- An anteroposterior and lateral chest radiograph can localize and help identify the type of radio-opaque esophageal foreign body (eg, button battery, coin, or magnet)

- **Echocardiogram**
- **History of exertional chest pain or exertional syncope.**
- **Chest pain associated with fever (>۳۸.۵°C).**
- **Chest pain that radiates to the back, jaw, left arm or left shoulder, or that increases with supine position.**
- **Past medical history of CHD, heart transplant, Kawasaki syndrome, or diseases that raise cardiac risk (eg, malignancy, collagen vascular disease, hypercoagulable state, immobilization).**
- **Family history of cardiomyopathy, sudden death, or hypercoagulable state in first-degree relatives (eg, parents or siblings) younger than ۵۰ years of age.**
- **A new murmur, gallop, distant heart sounds, pericardial friction rub, increased intensity of the pulmonary component of S۲, or peripheral edema on cardiac examination.**
- **An abnormal ECG (eg, RVH or LVH, ST segment change >۲ mm, low QRS voltage, PR segment depression, S wave in lead ۱, Q wave in lead III, or an inverted T wave in lead III).**

- **The utility of echocardiography for such patients includes the following:**
- **Establish the diagnosis of pulmonary hypertension and evaluate ventricular function and associated structural abnormalities.**
- **Determine the severity and site of LVOTO.**
- **Determine LV function and assess for the presence of DCM or HCMP.**
- **Assess the size of a pericardial effusion and signs of tamponade,**
- **Identify coronary artery abnormalities, including abnormal origin or course, fistula, or aneurysm or stenosis caused by Kawasaki disease.**
- **Diagnose aortic root dissection**
- **Diagnose ruptured sinus of Valsalva aneurysm.**

- **Other tests**
- **Cardiac troponin** – Cardiac troponin testing may assist with diagnosis when myocardial infarction or ischemia is suspected. Troponin is a highly sensitive biomarker that aids in the detection of myocardial cell damage, which is often but not always, due to thrombotic obstruction of a coronary artery. Thus, while troponin may be useful to "rule out" a non-ST elevation myocardial infarction, the clinician must recognize the limitations of using troponin to "rule in" MI in patients with low clinical likelihood of an acute coronary syndrome (ACS) which includes most children and adolescents. While troponin is highly specific for myocardial injury, it is not specific for ACS as the cause. As a result, if troponin testing is applied indiscriminately in broad populations with a low pretest probability of thrombotic disease, the positive predictive value for ACS is greatly diminished.
- **Ambulatory cardiac rhythm monitoring**

Causes of elevated troponin

Myocardial ischemia
Acute coronary syndrome
STEMI
NSTEMI
Other coronary ischemia
Arrhythmia: tachy- or brady-
Cocaine/methamphetamine use
Coronary intervention (PCI or cardiothoracic surgery)
Coronary artery spasm (variant angina)
Stable coronary atherosclerotic disease in setting of increased O_2 demand (eg, tachycardia)
Severe hypertension
Coronary embolus
Aortic dissection
Coronary artery vasculitis (SLE, Kawasaki)
Noncoronary ischemia
Shock (hypotension)
Hypoxia
Hypoperfusion
Pulmonary embolism
Global ischemia
Cardiothoracic surgery
Myocardial injury with no ischemia
Comorbidities
Renal failure
Sepsis
Infiltrative diseases
Acute respiratory failure
Stroke
Subarachnoid hemorrhage
Specific identifiable precipitants
Extreme exertion
Cardiac contusion
Burns >30% BSA
Cardiotoxic meds: anthracyclines, herceptin
Electrical shock
Carbon monoxide exposure
Other
Stress (takotsubo) cardiomyopathy
Myocarditis
Myopericarditis
Rhabdomyolysis involving cardiac muscle
Hypertrophic cardiomyopathy
Peripartum cardiomyopathy
Heart failure, malignancy, stress cardiomyopathy

STEMI: ST elevation myocardial infarction; NSTEMI: non-ST elevation myocardial infarction; PCI: percutaneous coronary intervention; SLE: systemic lupus erythematosus; BSA: body surface area.

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- **APPROACH AND INITIAL MANAGEMENT**
- **Unstable**
- **١-Airway foreign body with obstruction**
- **٢-Tension pneumothorax**
- **٣-Severe status asthmaticus**
- **٤-Pulmonary embolism**
- **٥-Ischemia or infarction**
- **٦-Tachyarrhythmia**
- **٧-Heart failure with cardiogenic shock**

- **Acute chest pain with concerning findings** — Most children with a primary complaint of nontraumatic chest pain will be stable at initial evaluation. Patients with findings of a serious cardiac etiology on physical examination or ECG should have consultation with a pediatric cardiologist and treatment of the underlying abnormality. Patients with a normal physical examination and ECG but a concerning history deserve follow-up with a pediatric cardiologist within one to two weeks.
- A chest radiograph is helpful for patients with respiratory distress, pleuritic chest pain, abnormal murmur or heart sounds, or a suspected foreign body

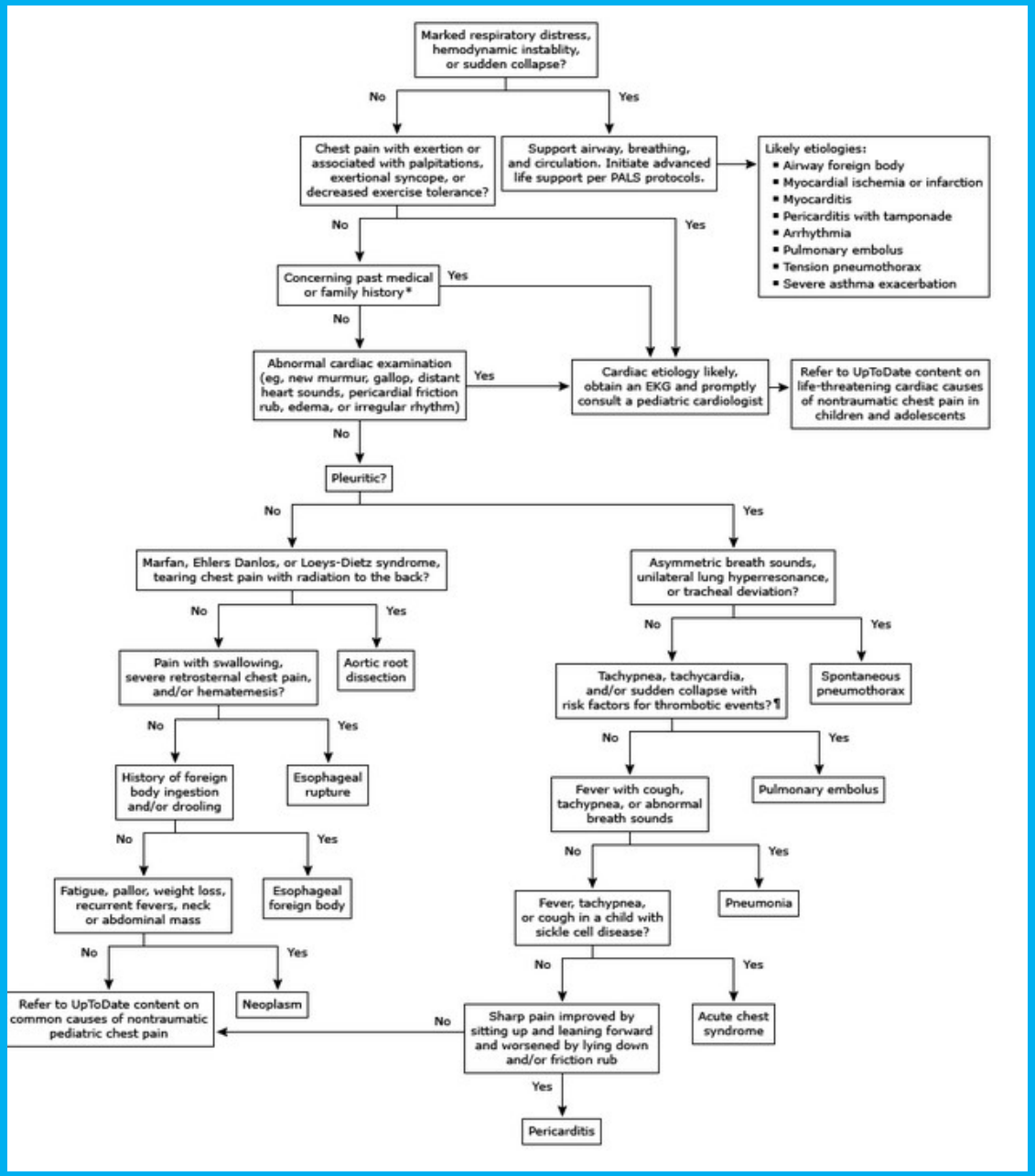
- Acute chest pain with concerning findings
- Pneumonia
- Pulmonary embolism
- Spontaneous pneumothorax
- Pericarditis
- Acute chest syndrome
- Aortic root dissection
- Esophageal foreign body
- Esophageal rupture Tumor

- **Important findings of common causes and initial management**
- **Chest wall pain** typically responds to analgesics
- **History of stressful event** with or without hyperventilation
- **Fever and cough**
- **Cough or dyspnea at night or with exercise** (exercise suggests exercise-induced or subclinical bronchospasm)
- **Heart burn** (after meals supports the diagnosis of gastroesophageal reflux)
- **Pain after taking medications**(eg, tetracycline, doxycycline, aspirin, or nonsteroidal antiinflammatory medications): antacids or histamine-٢ receptor blockers (eg, famotidine)
- **Breast pain** –Reassurance
- **Normal history and physical examination**

- **Urgent consultation with other pediatric specialists:**
- **Children with recurrent spontaneous pneumothorax or persistent large air leaks warrant pediatric surgical consultation.**
- **In addition to the involvement of a pediatric cardiologist, children with aortic root dissection require emergent involvement of a pediatric cardiothoracic surgeon.**
- **Children with pulmonary embolism should undergo evaluation by pediatric specialists with expertise in providing antithrombotic therapy to children and treating the underlying cause of venous thrombosis and thromboembolism (eg, systemic lupus erythematosus, inherited thrombophilia, heart valve disease, or structural venous anomalies).**
- **Patients with SCD complicated by acute chest syndrome warrant consultation and management by a pediatric hematologist.**
- **Patients with pulmonary hypertension require multidisciplinary consultation with a pediatric cardiologist and pulmonologist.**

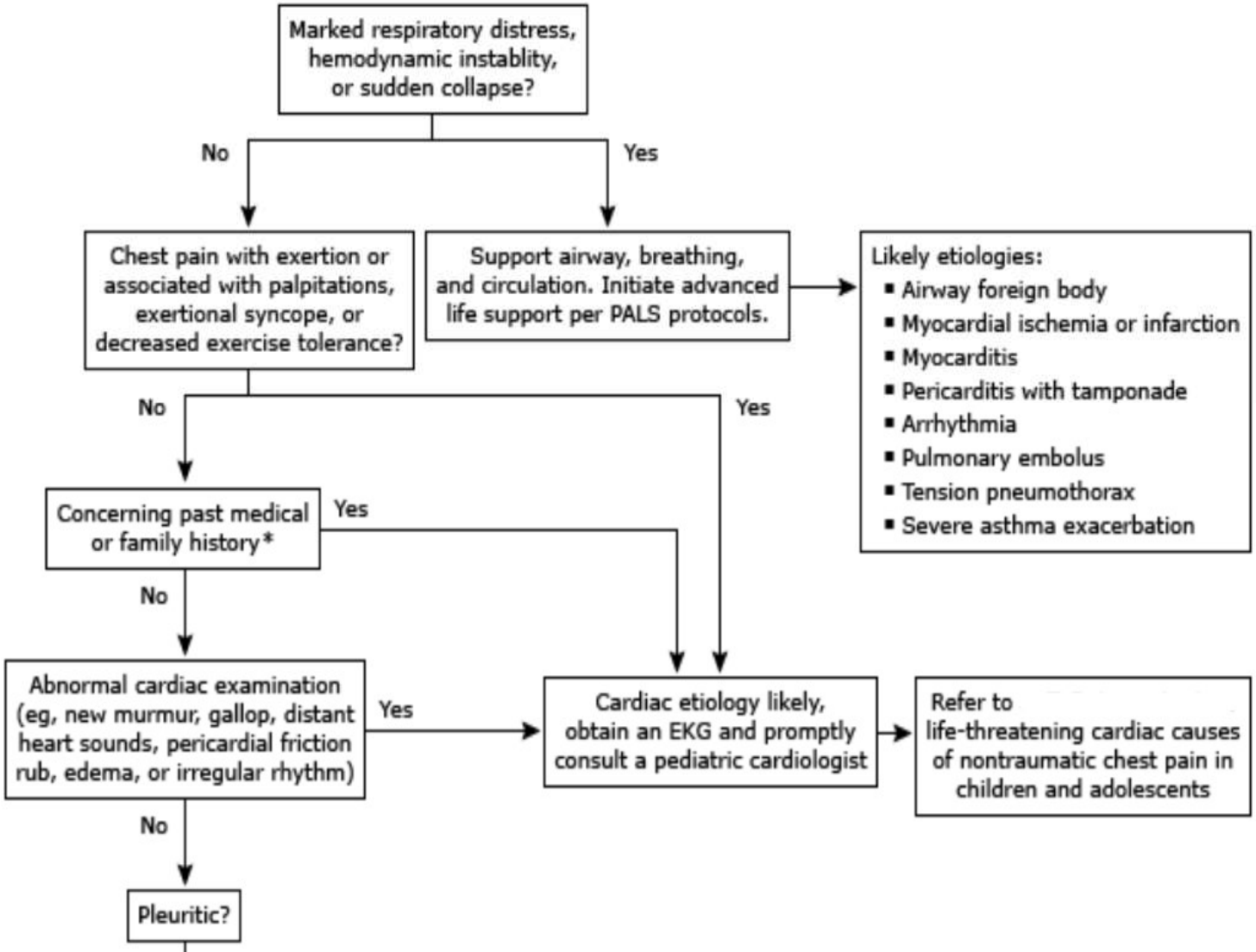
- **Disposition –**
- **Up to ٩٩ percent of children and adolescents with nontraumatic chest pain have a benign cause, most frequently musculoskeletal chest pain, and can be discharged with additional primary care or specialty follow-up determined by the underlying etiology.**

APPROACH TO PEDIATRIC NONTRAUMATIC CHEST PAIN



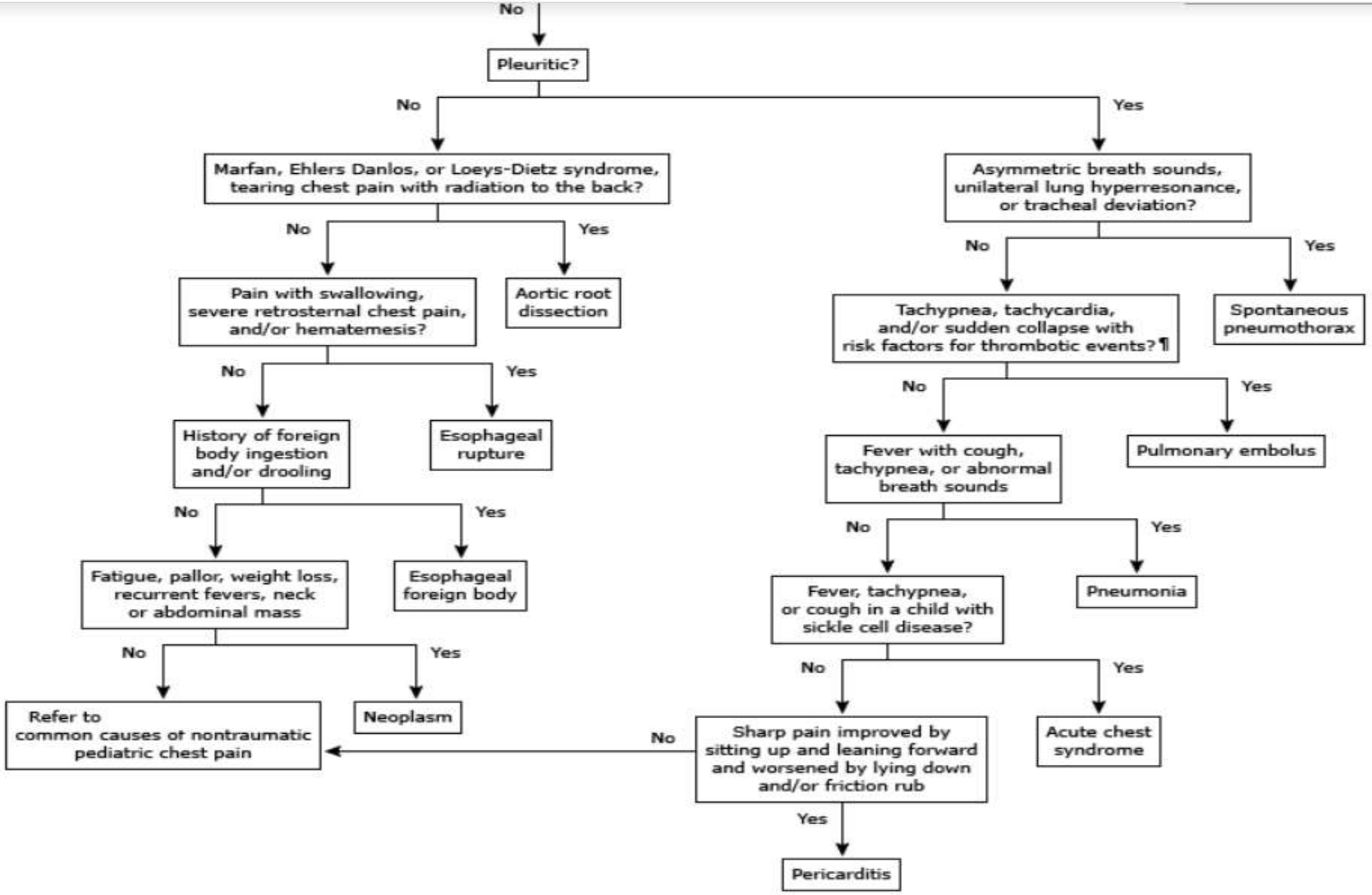
APPROACH TO PEDIATRIC NONTRAUMATIC CHEST PAIN

Approach to pediatric nontraumatic chest pain



APPROACH TO PEDIATRIC NONTRAUMATIC CHEST PAIN

Approach to pediatric nontraumatic chest pain



PALS: pediatric advanced life support; EKG: electrocardiogram.