

---

## CHEST PAIN IN PEDIATRICS

Keith C. Kocis, MD, MS

Chest pain is an alarming complaint in children, leading an often frightened and concerned family to a pediatrician or emergency room and commonly to a subsequent referral to a pediatric cardiologist. Because of the well-known association of chest pain with significant cardiovascular disease and sudden death in adult patients, medical personnel commonly share heightened concerns over pediatric patients presenting with chest pain. Although the differential diagnosis of chest pain is exhaustive, chest pain in children is least likely to be cardiac in origin. Organ systems responsible for causing chest pain in children include\*:

- Idiopathic (12%–85%)
- Musculoskeletal (15%–31%)
- Pulmonary (12%–21%)
- Other (4%–21%)
- Psychiatric (5%–17%)
- Gastrointestinal (4%–7%)
- Cardiac (4%–6%)

Furthermore, chest pain in the pediatric population is *rarely* associated with life-threatening disease; however, when present, prompt recognition, diagnostic evaluation, and intervention are necessary to prevent an adverse outcome. This article presents a comprehensive list of differential diagnostic possibilities of chest pain in pediatric patients, discusses the common causes in further detail, and outlines a rational diagnostic evaluation and treatment plan.

Chest pain, a common complaint of pediatric patients, is often idiopathic in etiology and commonly chronic in nature. In one study,<sup>67</sup> chest pain accounted for 6 in 1000 visits to an urban pediatric emergency room. In addition, chest pain is the second most common reason for referral to pediatric cardiologists.<sup>7, 23, 78</sup> Chest pain is found equally in male and female patients, with an average

\*References 13, 17, 23, 27, 32, 35, 44, 48, 49, 63–67, 74, and 78.

---

From the University of Southern California School of Medicine, Children's Hospital, Los Angeles, California

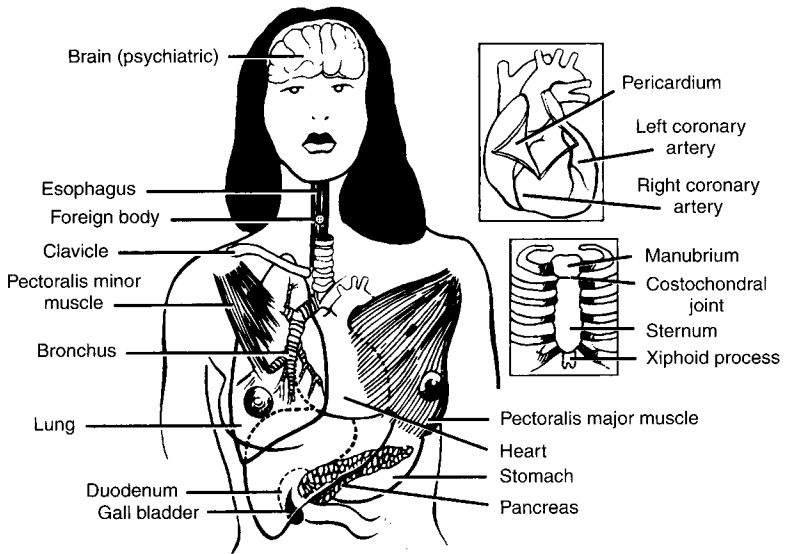
age of presentation of 13 years.<sup>67</sup> Chest pain in the pediatric population is most commonly idiopathic in etiology, representing 23% to 45% of all cases.<sup>17, 48, 63, 67</sup> Children fewer than 12 years of age are more likely to have a cardiorespiratory cause of their chest pain compared with children more than 12 years of age, who are more likely to have a psychogenic cause.<sup>63, 67</sup> In addition, patients diagnosed with psychogenic chest pain or costochondritis are more likely to be female.<sup>4, 9, 63</sup> Chest pain is a chronic condition in the pediatric population, with persistent symptoms in 45% to 69% of patients<sup>17, 57, 63</sup> and 19% of patients having symptoms lasting for more than 3 years.<sup>57</sup> The corollary, of course, is that in 81% of patients with persistent symptoms, the chest pain resolves with time. Clinically reassuring is that none of the patients followed over 3 years developed any severe disease process.<sup>57</sup> Because of the chronic nature and often unconfirmed cause of chest pain, pediatricians must develop a trusting, working relationship with these children and their families and be prepared to work jointly over time in diagnosing and treating patients with this very common and predominantly benign complaint.

## **ANATOMY OF MAJOR THORACIC STRUCTURES CAUSING CHEST PAIN**

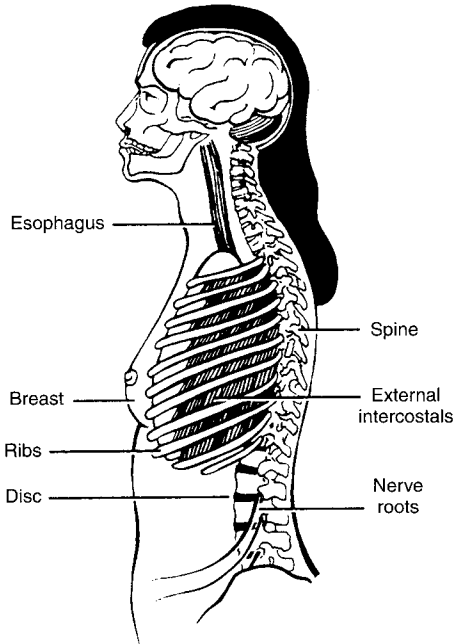
Figure 1 demonstrates the common sites of origin of chest pain in a schematic diagram of the major structures in the chest and abdomen in the antero-posterior and lateral planes.

## **HISTORY**

A thorough and complete history is essential for the accurate diagnosis of chest pain. One must methodically gather historical data and avoid a quick run to judgment or an exhaustive laboratory investigation when evaluating chest pain. A comprehensive time series of events leading up to, through, and after the episode of chest pain should be documented. The pain should be described with respect to time of onset, duration, frequency, nature, intensity, location, points of radiation, precipitants, and relieving factors. The relationship to meals and body position should be noted, as well as the impact the pain has had on the child's lifestyle and activity level. The patient's past medical and surgical history should be taken and specific inquiry made into any underlying cardiac disease or heart surgery. Medications the child is taking should be recorded, with attention to nonprescription medications, oral contraceptives, and those causing gastric irritation. A thorough family history must be elicited, particularly of sudden death or cardiovascular disease. A comprehensive social history, including use of alcohol, tobacco, intoxicants, stimulants, cocaine, or other drugs must be obtained. This is usually done in private with the patient separate from other family members. The type of work or play the child participates in, together with specific sports activity, should be recorded. Any recent family discord, family stressors, change in peer socialization, or change in the child's school performance should be noted. Finally, a complete review of systems should be assessed to elicit symptoms of chronic disease, such as fever, malaise, fatigue, weight loss, and night sweats.



A



B

**Figure 1.** Common sites of origin of chest pain in the major structures in chest and abdomen in anteroposterior (A) and lateral (B) planes.

## PHYSICAL EXAMINATION

A thorough and complete physical examination is fundamental to an accurate diagnosis of chest pain. During the physical examination, particular attention must be given to the child's vital signs (including blood pressure), general appearance and state (e.g., cyanotic, comfortable, distressed, panicked, anxious, or shock). The entire chest wall, musculature, breasts, sternum, xiphoid, and abdomen should be palpated in an attempt to identify the source and reproducibility of the pain. The examination should include cardiac findings (e.g., murmurs or gallop rhythm), pulmonary signs (e.g., depth and rate of breathing, use of accessory respiratory muscles, presence of rales, rhonchi, wheezes, or decreased breath sounds), abdominal examination (i.e., size of liver and points of tenderness), femoral pulses, and distal extremities (i.e., temperature, cyanosis, clubbing, and edema). Finally, the child's psychological state should be assessed.

Certain historical events, physical signs, and symptoms that should alert the clinician to one of the rare but potentially life-threatening causes of chest pain include:

### Cardiac

Underlying congenital or acquired cardiac disease

Arrhythmias

Crushing sternal chest pain with or without radiation to left arm or neck

Exercise-induced chest pain

Persistent tachycardia

Persistent hypertension

Hypotension

Gallop rhythm

Syncope

### Pulmonary

Hemoptysis

Dyspnea

Rales

Cyanosis

### Gastrointestinal

Hematemesis

Hematochezia

Melena

### Other

Febrile

Life-threatening psychiatric illness, such as psychosis or suicidal ideation

When present, prompt evaluation and intervention are necessary.

## DIFFERENTIAL DIAGNOSIS

A detailed list of differential diagnoses for chest pain in children includes:

### Cardiac (m = murmur present on auscultation)

Anatomic lesions

Aortic stenosis (m)

Aortic aneurysm with dissection ( $\pm$  m)

Subaortic stenosis (m)

Supravalvar aortic stenosis (m)

Ruptured sinus of Valsalva (m)

- Coarctation of the aorta (m)
- Anomalous left, right, or both coronary arteries from pulmonary artery ( $\pm$  m)
- Coronary artery ostia stenosis or atresia
- Intramural coronary artery
- Left coronary artery arising from anterior cusp
- Congenital coronary artery aneurysm
- Coronary artery fistula (m)
- Mitral valve prolapse (m)
- Severe pulmonary stenosis (m)
- Arrhythmogenic right ventricular dysplasia
- Acquired lesions
  - Cardiomyopathy—dilated, hypertrophic, restrictive (m)
  - Endocarditis ( $\pm$  m)
  - Myocarditis ( $\pm$  m)
  - Rheumatic fever ( $\pm$  m)
  - Myocardial infarction ( $\pm$  m)
  - Coronary vasospasm
  - Kawasaki disease ( $\pm$  m)
  - Accelerated atherosclerotic coronary artery disease (diabetes mellitus, familial dyslipoproteinemias)
  - Dissecting aortic aneurysm (Marfan syndrome) ( $\pm$  m)
  - Pericarditis—infectious, autoimmune, posttraumatic, constrictive (m)
  - Postpericardiotomy syndrome (m)
  - Partial absence of the pericardium
  - Pulmonary hypertension (primary or secondary) ( $\pm$  m)
  - Eisenmenger syndrome ( $\pm$  m)
  - Takayasu arteritis
  - Cardiac tumors ( $\pm$  m)
  - Pericardial neoplasm (primary or secondary) (m)
  - Cardiac transplant—rejection or accelerated coronary artery disease ( $\pm$  m)
- Arrhythmias
  - Premature atrial contractions
  - Atrial flutter
  - Atrial fibrillation
  - Supraventricular tachycardia (reentry or automatic)
  - Premature ventricular contractions
  - Ventricular tachycardia
- Pulmonary**
  - Reactive airway disease
  - Pneumothorax or pneumomediastinum
  - Pneumonia (viral, bacterial, mycobacterium, fungal, or parasitic)
  - Chronic cough
  - Pleural effusion
  - Pleurodynia
  - Pulmonary embolism
  - Foreign body aspiration
  - Cystic adenomatoid malformation
  - Primary or secondary adenoma or carcinoma
- Gastrointestinal**
  - Esophagitis
  - Esophageal diverticulum
  - Esophageal spasm

- Esophageal rupture (Boerhaave syndrome)
- Mallory-Weiss tear
- Achalasia
- Gastroesophageal reflux
- Gastritis
- Peptic ulcer disease
- Zollinger-Ellison syndrome
- Hiatal hernia
- Foreign body ingestion
- Cholecystitis
- Subdiaphragmatic abscess
- Fitz-Hugh-Curtis syndrome
- Pancreatitis

**Musculoskeletal**

- Muscle pain from overuse
  - Pectoralis major and minor muscle
  - Intercostal muscle
  - Latissimus dorsi muscle
  - Serratus muscle
  - Trapezius muscle
- Costochondritis
- Tietze syndrome
- Cervical ribs (C7)
- Slipping rib (8–10)
- Precordial catch syndrome
- Trauma
  - Child abuse
  - Fractured or contused clavicle or ribs
- Xiphoidalgia
- Osteomyelitis
- Rhabdomyosarcoma
- Myositis
- Thoracic outlet obstruction
- Ankylosing spondylitis
- Spondylolisthesis, spondylolysis
- Discitis
- Herniated disc
- Transverse myelitis

**Psychiatric**

- Somatoform disorder
- Stress
- Depression
- Hyperventilation syndrome
- Panic attacks
- Bulimia nervosa
- Munchhausen syndrome

**Ingestion**

- Cocaine
- Tobacco
- Methamphetamine
- Sympathomimetic decongestants

**Breast disease**

- Gynecomastia

Thelarche  
 Mastitis  
 Fibrocystic disease  
 Adenocarcinoma  
**Mediastinal tumors**  
 Hodgkin's disease  
 T-cell lymphoma  
 Thymoma  
 Thymolipoma  
 Teratoma  
 Germ cell tumor  
 Liposarcoma  
**Miscellaneous**  
 Diabetes mellitus  
 Hyperthyroidism  
 Cystic fibrosis  
 Neurofibromatosis  
 Marfan syndrome  
 Ehlers-Danlos syndrome  
 Homocysteinuria  
 SAPHO syndrome (synovitis, acne, pustulosis, hyperostosis, osteitis)  
 Sickle cell disease with vaso-occlusive crises  
 Sickle cell disease  
 Shingles (herpes zoster)  
 Echinococcosis  
 Mediterranean fever  
 Hypercoagulation syndromes (protein S/C deficiency, antithrombin 3 deficiency, heparin cofactor 2 deficiency, plasminogen deficiency, factor 5 Lieden, anticardiolipin antibodies, lupus anticoagulant)  
 Spinal cord meningioma  
 Spinal cord nerve root compression

Numerous review articles have been written on the topic,<sup>2, 5, 7, 13, 23, 27, 63-67, 74, 78, 83</sup> but very little new research on the topic has been published in recent years. Following is a brief discussion of the clinical features of several pertinent diagnoses.

### **Cardiac**

Although a rare cause of chest pain in pediatric patients (4-6%), this group remains the most concerning because an error in diagnosis may lead to significant morbidity or mortality. The three major etiologic categories are: (1) anatomic lesions, (2) acquired lesions, and (3) arrhythmias. Following are descriptions of the diagnostic features of many of the cardiac anomalies within each of the major categories.\*

#### **Anatomic Lesions**

Anatomic lesions frequently have a pathologic heart murmur present. However, one must be careful not to interpret commonly occurring innocent murmurs

---

\*References 1, 3, 8, 11, 14, 18, 20, 26, 30, 38, 39, 41, 49, 59-61, 68, 73, 76, and 77.

as pathologic. A resting 12-lead ECG should be obtained for all patients with anatomic lesions to evaluate for the expected lesion specific ECG changes and for evidence of ischemia. A chest radiograph may be helpful for comparison of the cardiac size to previous examinations. In most cases, the diagnosis is confirmed and specific features detailed by echocardiography. Cardiac catheterization is now rarely required for proper diagnosis. Consultation with a pediatric cardiologist is necessary because the chest pain may represent life-threatening myocardial ischemia. In the majority of cases, a discussion and review of the case with the pediatric cardiologist is all that is necessary. Occasionally, the cardiologist may want to see the patient immediately for further evaluation and testing. Chest pain is common in children with mitral valve prolapse (31%), although it is rarely life threatening.<sup>1, 3, 36, 56</sup> These patients have an increased incidence of arrhythmias (18%), some of which are life threatening and should be excluded.<sup>33, 34</sup>

### *Acquired Lesions*

Acquired cardiac lesions are diverse in their presentation. A dilated cardiomyopathy should be suspected when a patient presents with fatigue, decreased exercise tolerance, and palpitations. A gallop rhythm is heard on auscultation and may be accompanied by the murmur of mitral regurgitation. In contrast, hypertrophic cardiomyopathy presents with a systolic ejection murmur that becomes louder with an increase in heart rate (exercise) or decrease in preload (Valsalva maneuver). Patients with idiopathic hypertrophic subaortic stenosis often relate a family history of sudden death.

In patients with acquired cardiac lesions, ECG changes are found, cardiomegaly is seen by chest radiography, and an echocardiogram confirms the diagnosis. Patients with endocarditis are febrile and appear acutely ill. Serial blood cultures are positive in 92% of children with endocarditis. An echocardiogram, particularly via the transesophageal route, may assist in the diagnosis of endocarditis. Children with myocarditis present with fatigue, dyspnea, and frequently cardiovascular collapse. These patients commonly report a recent viral upper respiratory tract infection. Although an echocardiogram demonstrates the decreased cardiac function, cardiac catheterization with endomyocardial biopsy is often required. Rheumatic fever is diagnosed using the modified Jones' criteria. Although myocardial infarction is *extremely rare* in the pediatric population, it is diagnosed by the presence of classic symptoms (i.e., persistent crushing sternal chest pain with or without radiation to neck or arm, dyspnea, and diaphoresis). A chest radiograph, serial ECG, and cardiac enzymes (i.e., creatinine kinase with MB fraction or troponin T) are necessary for diagnosis. Coronary vasospasm or accelerated atherosclerotic coronary artery disease results in myocardial ischemia with symptoms of angina pectoralis. Patients with Kawasaki disease present acutely with the classic features of mucocutaneous lymph node syndrome and pancarditis. Later, they develop coronary aneurysms that may thrombose, resulting in myocardial infarction. Patients with Marfan syndrome who present with acute tearing chest pain must have dissection of the aorta excluded because it is a life-threatening emergency. MR imaging techniques or transesophageal echocardiography are the methods for rapid diagnosis of aortic dissection. Pericarditis is multifactorial in origin. On auscultation, distant heart sounds or a pericardial friction rub is typically heard. A pulsus paradoxicus is present. A chest radiograph reveals cardiomegaly, and an echocardiogram confirms the diagnosis. Postpericardiotomy syndrome is the development of a pericardial effusion days to months after cardiac surgery. Fatigue, decreased



exercise tolerance, palpitations, and syncope are common complaints of patients with pulmonary hypertension. Chronic pulmonary hypertension results in right ventricular dilatation and hypertrophy, with the resulting physical findings of a narrowed second heart sound, hepatomegaly, and cyanosis if an atrial or ventricular septal defect is present. A chest radiograph reveals cardiomegaly, and an echocardiogram confirms the diagnosis, but cardiac catheterization is frequently performed with a therapeutic trial of pulmonary vasodilating agents. Eisenmenger syndrome is severe pulmonary hypertension resulting from uncorrected congenital heart disease with left-to-right shunting and subsequent reversal of the shunt causing severe cyanosis. Takayasu arteritis is the "pulseless disease" affecting the aorta and great vessels in young women. Cardiac and pericardial tumors are extremely rare in children.

### *Arrhythmias*

Arrhythmias are not uncommon in children. Most are benign (e.g., premature atrial contractions and unifocal premature ventricular contractions), but a few (e.g., supraventricular tachycardia or ventricular tachycardia) are life threatening. Children with arrhythmias complain of palpitations and chest pain. If altered vital signs, shock, congestive heart failure, or syncope occur, immediate life-saving treatment should begin, together with consultation with a pediatric cardiologist. For stable patients, an electrocardiogram and 24-hour Holter monitor are diagnostically useful. For significant arrhythmias, referral should be made to a pediatric cardiologist. Patients with hyperthyroidism frequently have cardiac arrhythmias. Palpation of the thyroid gland should be included in the physical examination, and thyroid function tests may be ordered as part of the laboratory investigation.

### **Pulmonary**

Pulmonary causes of chest pain are common, occurring in 12% to 21% of cases, particularly in children fewer than 12 years of age. Reactive airway disease and pneumonia are principally diagnosed by auscultation and confirmed when necessary by chest radiography. Palpation of subcutaneous crepitations and crunching heart sounds (Hamman's sign) are suggestive of a pneumothorax or pneumomediastinum and confirmed by chest radiography. Decreased breath sounds coupled with dullness to percussion are indicative of a pleural effusion and posterior-anterior and decubitus chest radiographs or sonography are diagnostic. Pleurodynia, caused by Coxsackie virus, results in excruciating spasms of sharp chest pain, pleural friction rub, and fever. Pulmonary embolism in children is rare but should be suspected in female adolescents on oral contraceptives and children with hypercoagulation syndromes who present with dyspnea and cyanosis. The ECG reveals the typical pattern of right heart strain with ST changes, whereas chest radiography is usually nonspecific. A ventilation perfusion scan is usually diagnostic, although cardiac catheterization with angiography is sometimes necessary. Treatment with thrombolytic agents is life saving, although surgical thromboembolectomy is occasionally necessary. A foreign body should be suspected by history and physical examination. Inspiratory and expiratory chest radiographs can be helpful, although bronchoscopy is both diagnostic and therapeutic.<sup>10, 15, 19, 24, 37, 70-72, 80</sup>

## Gastrointestinal

Gastrointestinal causes of chest pain are relatively rare, accounting for only 4% to 7% of cases. Historical references to diet, relationship to meals, and body position are important diagnostically. Trials of antacids or hydrogen ion blockers are helpful diagnostically and therapeutically for patients with gastritis, gastrointestinal reflux, and peptic ulcer disease. If symptoms persist, referral may be made to a pediatric gastroenterologist for more intensive diagnostic procedures, such as endoscopy, pH probe, or esophageal manometry. Altered vital signs, hematemesis, hematochezia, melena, or esophageal rupture are life-threatening events, and immediate referral and intervention are indicated. A hiatal hernia is easily diagnosed when suspected clinically by a barium upper gastrointestinal series. A foreign body is suspected by history, possibly confirmed by plain radiograph, and is usually allowed to pass spontaneously. If the foreign body is lodged in the esophagus, endoscopy is necessary for removal. Cholecystitis presents with postprandial pain referred to the right upper quadrant, and an abdominal sonogram is diagnostic.<sup>6, 21, 22, 25, 29, 47, 52, 55</sup>

## Musculoskeletal

Musculoskeletal causes of chest pain are fairly common, representing 15% to 31% of pediatric patients with chest pain. A typical history is that of a deconditioned adolescent participating in sports activity and afterward complaining of chest pain. Palpation and contraction of the specific muscle group reproduces the pain, and treatment is symptomatic. Costochondritis is fairly common, particularly in girls. The chest pain is reproduced by palpation, and treatment is symptomatic. Tietze syndrome, characterized by swelling of the costochondral joints, is rare in children. Trauma, either accidental or intentional, can result in chest wall injury and chest pain. Examination localizes the source of pain, and radiographs are helpful in excluding fractures and pulmonary contusions. Slipping rib syndrome results from excess mobility of the 8th to 10th ribs, which do not directly insert into the sternum. Precordial catch syndrome is a positional change in the chest ("slouching"), resulting in acute sharp chest pain.<sup>40, 43, 45, 58, 75</sup>

## Psychiatric

Psychiatric reasons for chest pain are common and account for 5% to 17% of cases of chest pain. Patients frequently identify a life stressor (e.g., death in family, family discord, divorce of parents, poor school performance, or nonacceptance from peers) preceding the onset of chest pain. Symptoms of depression are common. Hyperventilation may be one of the presenting signs. A positive rapport and trusting working relationship with the family is essential for the diagnosis and treatment of these patients, and this will contribute to the eventual relief of the chest pain. Patients with bulimia nervosa can develop esophagitis or an esophageal tear from frequent bouts of emesis, resulting in chest pain. Rarely, disturbed parents inflict trauma to a child's chest area, resulting in chest pain.<sup>50, 51, 69</sup>

## Other

A whole host of other disease processes can result in chest pain. Cocaine use can result in palpitations, coronary vasospasm, or even myocardial infarction. Adolescents who smoke tobacco products have an increased incidence of chronic cough and chest pain. Male adolescents who develop gynecomastia can develop chest pain, as can female adolescents with fibrocystic breast disease. Mediastinal tumors are exceptionally rare. Young adults with advanced stages of diabetes mellitus can develop premature coronary artery disease. Children with sickle cell disease can develop vaso-occlusive crises, resulting in chest pain. The hypercoagulation syndromes result in thrombus formation, which can produce a pulmonary embolism or myocardial infarction.\*

## Laboratory Investigation

The potential laboratory tests available in evaluating and diagnosing even the most unusual causes of chest pain include:

**Cardiac:** ECG, chest radiograph, echocardiogram, Holter monitor, exercise stress test, dobutamine stress test, thallium scan, serum creatinine kinase with MB fraction, serum troponin T, fractionated serum lipid profile, pericardiocentesis, endomyocardial biopsy with polymerase chain reaction analysis, cardiac catheterization with or without selective coronary angiography

**Pulmonary:** Chest radiograph, CT scan of chest, MR imaging of chest, pulmonary function testing with and without methacholine challenge, bronchoscopy, ventilation perfusion scan, sweat test

**Gastrointestinal:** Gastric lavage; pH probe; upper gastrointestinal series; upper endoscopy; esophageal manometry; abdominal sonography, including liver, pancreas, and gallbladder; serum liver function tests; serum lipase and amylase; serum gastrin level; stool guaiac testing

**Musculoskeletal:** Skeletal radiographs, CT scan of spine, MR imaging of spine, nuclear bone scan, creatinine kinase with MM fraction

**Miscellaneous:** Urine and serum toxicology screen, serum complement levels, antinuclear antibodies, glycosylated hemoglobin A<sub>1c</sub>, hemoglobin electrophoresis, coagulation studies, mammography, breast sonography, breast biopsy, thyroid function tests, complete blood cell count, Westergren erythrocyte sedimentation rate, cultures (i.e., blood, pericardial fluid, and sputum), viral or bacterial antibody titers (i.e., IgM, and IgG), Tine testing, psychological testing

This list is given for reference only and should *not* be used as a checklist for evaluating routine chest pain in children. As mentioned previously, laboratory testing is most commonly *unnecessary* for appropriately diagnosing and treating chest pain in children.

## SUMMARY

Chest pain in the pediatric population is a common and mostly benign occurrence. A thorough history and physical examination are usually all that are necessary in excluding the *rare*, life-threatening causes of chest pain. These rare,

---

\*References 12, 16, 28, 31, 42, 46, 53, 54, 62, 79, 81, and 82.

life-threatening events require immediate evaluation, treatment, and subspecialty consultation. Idiopathic chest pain is the most common diagnosis, and the symptoms are typically chronic. Laboratory testing is usually nondiagnostic, costly, and burdensome to patients and therefore unnecessary. A long-term, trusting relationship with the patients and their families is needed to reassure them and allow symptoms to resolve.

## ACKNOWLEDGMENT

The author would like to acknowledge the expert medical illustrations prepared by Robert Amaral, MA, from the University of Southern California School of Medicine.

## References

1. Alpert MA, Mukerji V, Sabeti M: Mitral valve prolapse, panic disorder, and chest pain. *Med Clin North Am* 755:1119–1133, 1991
2. Anzai AK, Merkin TE: Adolescent chest pain. *Am Fam Physician* 535:1682–1690, 1996
3. Arfken CL, Lachman AS, McLaren MJ: Mitral valve prolapse: Association with symptoms and anxiety. *Pediatrics* 853:311–315, 1990
4. Asnes RS, Bemporad SRJ: Psychogenic chest pain in children. *Clin Pediatr* 2012:788–791, 1981
5. Bass C: Unexplained chest pain and breathlessness. *Med Clin North Am* 755:1157–1173, 1991
6. Berezin S, Medow MS, Glassman MS, et al: Esophageal chest pain in children with asthma. *J Pediatr Gastroenterol Nutr* 12:52–55, 1991
7. Brenner JI, Ringel RE, Berman MA: Cardiologic perspectives of chest pain in childhood: A referral problem? To whom? *Pediatr Clin North Am* 316:1241–1258, 1984
8. Brodwater BK, Queiroz R: Young male patient with atypical chest pain and cardiac mass on chest radiograph: Case from A3CR2 film panel [clinical conference]. *Acad Radiol* 51:69–71, 1998
9. Brown RT: Costochondritis in adolescents. *J Adolesc Health Care* 1:198–201, 1981
10. Buck JR, Connors RH, Coon W, et al: Pulmonary embolism in children. *J Pediatr Surg* 163:385–391, 1981
11. Burns JC, Shike H, Gordon JB, et al: Sequelae of Kawasaki disease in adolescents and young adults. *J Am Coll Cardiol* 281:253–257, 1996
12. Cohen M, Kelly K, Shaw KN: Chest pain and cardiomegaly without pulmonary involvement: An atypical presentation of pediatric mycobacterial disease. *Pediatr Emerg Care* 111:35–36, 1995
13. Coleman W: Recurrent chest pain in children. *Pediatr Clin North Am* 315:1007–1026, 1984
14. Declue TJ, Malone JI, Root AW: Coronary artery disease in diabetic adolescents. *Clin Pediatr* 2712:587–590, 1988
15. Dekel B, Paret G, Szeinberg A, et al: Spontaneous pneumomediastinum in children: Clinical and natural history. *Eur J Pediatr* 1558:695–697, 1996
16. Dolan AL, Mishra MB, Chambers JB, et al: Clinical and echocardiographic survey of the Ehlers-Danlos syndrome. *Br J Rheumatol* 364:459–462, 1997
17. Driscoll DJ, Glicklich LB, Gallen WJ: Chest pain in children: A prospective study. *Pediatrics* 57:648–651, 1976
18. Elliott PM, Kaski JC, Prasad K, et al: Chest pain during daily life in patients with hypertrophic cardiomyopathy: An ambulatory electrocardiographic study. *Eur Heart J* 177:1056–1064, 1996
19. Evans DA, Wilmott RW: Pulmonary embolism in children. *Pediatr Clin North Am* 413:569–584, 1994
20. Ferres-Sanchez P, Subirana-Domenech M, et al: Chest pain during exercise as first manifestation of Friedreich's ataxia. *Br Heart J* 744:464–467, 1995

21. Frobert O, Funch-Jensen P, Bagger JP: Diagnostic value of esophageal studies in patients with angina-like chest pain and normal coronary angiograms. *Ann Intern Med* 124:11:959-969, 1996
22. Frobert O, Funch-Jensen P, Jacobsen NO, et al: Upper endoscopy in patients with angina and normal coronary angiograms. *Endoscopy* 27:365-370, 1995
23. Fyfe MD: Chest pain in pediatric patients presenting to a cardiac clinic. *Clin Pediatr* 23:321-340, 1984
24. Goldsby RE, Saulys AJ, Helton JG: Pediatric pulmonary artery thromboembolism: An illustrative case. *Pediatr Emerg Care* 122:105-107, 1996
25. Goyal R: Changing focus on unexplained esophageal chest pain. *Ann Intern Med* 124:11:1008-1011, 1996
26. Graneto JW, Turnbull TL, Marciniak SA: An unusual cause of chest pain in an adolescent presenting to the emergency department. *Pediatr Emerg Care* 131:33-36, 1997
27. Gutesell HP, Barst RJ, Humes RA, et al: Common cardiovascular problems in the young: Part I. Murmurs, chest pain, syncope and irregular rhythms. *Am Fam Physician* 56:7:1825-1830, 1997
28. Hollander JE, Todd KH, Green G, et al: Chest pain associated with cocaine: An assessment of prevalence in suburban and urban emergency departments. *Ann Emerg Med* 26:6:671-676, 1995
29. Inculet R, Clark C, Girvan D: Boerhaave's syndrome and children: A rare and unexpected combination. *J Pediatr Surg* 31:9:1300-1301, 1996
30. Islam MN, Alimuzzaman M, Khan MN, et al: Ruptured aneurysm of the sinus of Valsalva. *Bangladesh Med Res Counc Bull* 22:1:19-26, 1996
31. Ivanov G: A study of pulmonary hydatid disease in children: 1. Epidemiological and clinical characteristics. *Ann Trop Med Parasitol* 90:2:167-171, 1996
32. Kaden GG, Shenker IR, Gootman N: Chest pain in adolescents. *J Adolesc Health* 12:251-255, 1991
33. Kavey REW, Blackman MS, Sondheimer HM, et al: Ventricular arrhythmias and mitral valve prolapse in childhood. *J Pediatr* 105:885, 1984
34. Kavey REW, Sondheimer HM, Blackman MS: Detection of dysrhythmias in pediatric patients with mitral valve prolapse. *Circulation* 62:582, 1980
35. Leung AK, Robson WL, Cho H: Chest pain in children. *Can Fam Physician* 42:1156-1160, 1163-1164, 1996
36. Lichodziejewska B, Klos J, Rezler J, et al: Clinical symptoms of mitral valve prolapse are related to hypomagnesemia and attenuated by magnesium supplementation [see comments]. *Am J Cardiol* 79:6:768-772, 1997
37. Lin MY, Wu MH, Chan CS, et al: Bronchial rupture caused by blunt chest injury. *Ann Emerg Med* 25:3:412-415, 1995
38. Liu CW, Hwang B, Lee BC, et al: Aortic stenosis in children: 19-year experience. *Chung Hua I Hsueh Tsa Chih (Taipei)* 59:2:107-113, 1997
39. Maeda M, Kobayashi M, Okamoto S, et al: Aortitis syndrome in children: Clinical observation of 35 cases in Japan. *Acta Paediatr Jpn* 39:2:280-284, 1997
40. Malleson PN, Al-Matar M, Petty RE: Idiopathic musculoskeletal pain syndromes in children. *J Rheumatol* 19:11:1786-1789, 1992
41. Maron BJ: Sudden death in young athletes. *N Engl J Med* 329:1:55-57, 1993
42. Marseglia GL, Savasta S, Ravelli A, et al: Recurrent chest pain as the presenting manifestation of spinal meningioma. *Acta Paediatr* 84:9:1086-1088, 1995
43. Mayberry JC, Trunkey DD: The fractured rib in chest wall trauma. *Chest Surg Clin North Am* 72:239-261, 1997
44. Milov DE, Kantor RJ: Chest pain in teenagers. *Postgrad Med* 88:5:145-154, 1990
45. Mooney DP, Shorter NA: Slipping rib syndrome in childhood. *J Pediatr Surg* 32:7:1081-1082, 1997
46. Moran CA, Rosado-de-Christenson M, Suster S: Thymolipoma: Clinicopathologic review of 33 cases [see comments]. *Mod Pathol* 8:7:741-744, 1995
47. Orenstein SR: Controversies in pediatric gastroesophageal reflux. *J Pediatr Gastroenterol Nutr* 14:3:338-348, 1992

48. Pantell RH, Goodman BW: Adolescent chest pain: A prospective study. *Pediatrics* 76:881-887, 1983
49. Perry RF, Garlisi AP, Allison EJ, et al: Acute myocardial infarction in a 16-year-old boy with no predisposing risk factors. *Pediatr Emerg Care* 136:413-416, 1997
50. Poikolainen K, Kanerva R, Lonnqvist J: Life events and other risk factors for somatic symptoms in adolescence. *Pediatrics* 96:59-63, 1995
51. Porter SC, Fein JA, Ginsburg KR: Depression screening in adolescents with somatic complaints presenting to the emergency department. *Ann Emerg Med* 291:141-145, 1997
52. Rao S, Gregersen H, Hayek B: Unexplained chest pain: The hypersensitive, hyperreactive, and poorly compliant esophagus. *Ann Intern Med* 12411:950-958, 1996
53. Ravilly S, Robinson W, Suresh S, et al: Chronic pain in cystic fibrosis. *Pediatrics* 984 (Pt 1):741-747, 1996
54. Reith JD, Bauer TW, Schils JP: Osseous manifestations of SAPHO (synovitis, acne, pustulosis, hyperostosis, osteitis) syndrome. *Am J Surg Pathol* 2011:1368-1377, 1996
55. Richter JE: Gastroesophageal reflux disease as a cause of chest pain. *Med Clin North Am* 755:1065-1080, 1991
56. Rokicki W, Krzystolik-Ladzinska J, Goc B: Clinical characteristics of primary mitral valve prolapse syndrome in children. *Acta Cardiol* 502:147-153, 1995
57. Rowland TW, Richards MM: The natural history of idiopathic chest pain in children. *Clin Pediatr* 2512:612-614, 1986
58. Saenz NC, Ghavimi F, Gerald W, et al: Chest wall rhabdomyosarcoma. *Cancer* 808:1513-1517, 1997
59. Said SA, el Gamal MI, van der Werf T: Coronary arteriovenous fistulas: Collective review and management of six new cases—changing etiology, presentation, and treatment strategy. *Clin Cardiol* 209:748-752, 1997
60. Said SA, Koetsveld-Baart JC, Den Hollander JC: Takayasu's arteritis: A rare cause of cardiac death in a Caucasian teenage female patient. *Neth J Med* 515:182-186, 1997
61. Schaffer MS, Nouri S, Chen S, et al: Fatal aortic rupture presenting as chest pain in an adolescent. *Clin Pediatr* 244:216-218, 1985
62. Schorry EK, Crawford AH, Egelhoff JC, et al: Thoracic tumors in children with neurofibromatosis-1. *Am J Med Genet* 745:533-537, 1997
63. Selbst S: Chest pain in children. *Pediatrics* 756:1068-1070, 1985
64. Selbst SM: Consultation with the specialist: Chest pain in children. *Pediatr Rev* 185:169-173, 1997
65. Selbst SM: Evaluation of chest pain in children. *Pediatr Rev* 82:56-62, 1986
66. Selbst SM, Ruddy RM, Clark BJ: Chest pain in children. *Clin Pediatr* 297:374-377, 1990
67. Selbst SM, Ruddy RM, Clark BJ: Pediatric chest pain: A prospective study. *Pediatrics* 823:319-323, 1988
68. Smith DR: Pericarditis following blunt thoracic trauma. *Ala Med* 649:6-8, 1995
69. Smith MS: Psychosomatic symptoms in adolescence. *Med Clin North Am* 74:1121-1134, 1990
70. Spence LD, Ahmed S, Keohane C, et al: Acute presentation of cystic adenomatoid malformation of the lung in a 9-year-old child. *Pediatr Radiol* 257:572-573, 1995
71. Stack AM, Caputo GL: Pneumomediastinum in childhood asthma. *Pediatr Emerg Care* 122:98-101, 1996
72. Stein PD, Henry JW: Clinical characteristics of patients with acute pulmonary embolism stratified according to their presenting syndromes. *Chest* 1124:974-979, 1997
73. Stiene HA, Black WS: Pericarditis in a collegiate basketball player. *Clin J Sport Med* 64:251-254, 1996
74. Swenson JM, Fischer DR, Miller SA, et al: Are chest radiographs and electrocardiograms still valuable in evaluating new pediatric patients with heart murmurs or chest pain? *Pediatrics* 991:1-3, 1997
75. Taubman B, Vetter VL: Slipping rib syndrome as a cause of chest pain in children. *Clin Pediatr (Phila)* 358:403-405, 1996
76. Trotter MC, Chung KC, Ochsner JL, et al: Pericardiectomy for pericardial constriction. *Am Surg* 624:304-307, 1996

77. Tsuji A, Nagashima M, Hasegawa S, et al: Long-term follow-up of idiopathic ventricular arrhythmias in otherwise normal children. *Jpn Circ J* 59:654-662, 1995
78. Tunaoglu FS, Olgunturk R, Akcabay S, et al: Chest pain in children referred to a cardiology clinic. *Pediatr Cardiol* 16:69-72, 1995
79. Unal M, Tuncer C, Serce K, et al: A cardiac giant hydatid cyst of the interventricular septum masquerading as ischemic heart disease: Role of MR imaging. *Acta Cardiol* 50:323-326, 1995
- 79a. van den Bergh AAH: Een Schijnbaar Havtgervisch. *Nederl, Tijdschr, Geneesk* 52:1104, 1908
80. Wiens L, Sabath R, Ewing L: Chest pain in otherwise healthy children and adolescents is frequently caused by exercise-induced asthma. *Pediatrics* 90:350-353, 1992
81. Wongsangiem M, Tangthangtham A: Primary tumors of the mediastinum: 190 cases analysis (1975-1995). *J Med Assoc Thai* 79:689-697, 1996
82. Woodward GA, Selbst SM: Chest pain secondary to cocaine use. *Pediatr Emerg Care* 33:153-154, 1987
83. Zavaras-Angelidou KA, Weinhouse E, Nelson DB: Review of 180 episodes of chest pain in 134 children. *Pediatr Emerg Care* 8:189-193, 1992

*Address reprint requests to*

Keith C. Kocis, MD, MS  
University of Southern California School of Medicine  
Childrens Hospital Los Angeles, MS 66  
4650 Sunset Boulevard  
Los Angeles, CA 90027