In our very cardiac-conscious society, a child presenting with chest pain usually creates anxiety in his or her parents, who fear for the worst. Despite the family's worries, which can be considerable, the many causes of chest pain are usually benign. In rare cases, however, it can be the harbinger of significant cardiac disease. Pediatricians should therefore complete a preliminary evaluation for chest pain, decide on a differential diagnosis, and if not make a specific diagnosis, at least develop a diagnostic plan to learn its cause. Often a definite diagnosis calls for the aid of an appropriate consultation. With this assistance, a treatment plan can be established.
A variety of sources

There are many causes of chest pain in children (Table 1). Unlike in adults, where the risk of cardiac-based chest pain is considerable, cardiac etiologies of chest pain in children are uncommon. Despite a low prevalence of such occurrences, the consequences of misdiagnosis are nonetheless grave.

That said, pediatricians should be able to identify a child at risk, and recognize that although a specific anatomic cardiac diagnosis is the job of the cardiologist, that diagnosis can only be made if the patient is first referred on by his or her alert pediatrician.

By far the most common cause of chest pain among children is musculoskeletal injury. Children can easily injure their pectoral or intercostal muscles as well the cartilaginous structures of the immature chest wall in sports, heavy lifting, or even playground activity. In smaller children, this problem is often confounded by the child's inability to clearly state the nature of the problem. Similarly, vague complaints of chest pain are often difficult to separate from abdominal pain—especially in children under six years of age. (See "A hands-on approach to chest pain assessment" on page 50.) Less prevalent causes include those pulmonary in origin, typically a bronchospasm, either at rest or induced by exercise.

Finally, underlying cardiac problems, while usually rare, can also present as another source for chest pain among children. The focus of this article will be on the differential diagnosis of these cardiac-based etiologies.

Author's note: Non-cardiac causes including gastroesophageal reflux and asthma will not be discussed in this article. But they have been well covered by other authors.

Asking the right questions

As in all diagnostic evaluations, a thorough history is important, even in a young child. The pediatrician should first ask when the pain started, even though the answer is usually a vague "last month" or even "last year." In general, the longer the pain has been present without progression, the less likely it is life-threatening.

Once the pediatrician has established a time frame, the next questions should be about the most recent episode (hopefully, the last episode was in recent memory so
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Point Taken

Time descriptions are difficult in young children, so use a relationship they know, like the length of a TV ad, to see how long the pain lasted.

the child can describe it well). Ask how long the pain lasted, what made it better, and what made it worse. Was there a change in the pain with arm movement or respiration? Was there trouble breathing? Was the breathing noisy? Was there dizziness? Was the pain caused by any particular activity? If the pain comes at rest, ask whether it was like a pin or a pencil eraser pressing against one area of the chest. Time descriptions are difficult in young children, so using a relationship that they would know, i.e., the length of a TV commercial, can help determine how long the pain lasted.

In the history, the pediatrician should inquire about activities both current and in the recent past. Occurrences of pain with physical activities such as wrestling, weight lifting, gymnastics, dance, and swimming should be identified. In a chest wall injury (see Table 2 on page 53), the pain may not come during the activity but rather hours or even a full day later. If your patient plays a sport, it's important to ascertain whether or not the patient stretched and warmed up adequately before competing.

If a young child has been swinging from the monkey bars, question whether the pain is on the non-dominant side. Most individuals are right-handed, so the left side may be inherently weaker. Weight-lifting or monkey-bar type of play causes equal stress on both sides of the chest wall, and may lead to a strained pectoralis muscle or even a rib cage separation on the non-dominant side. There may be no pain during the specific activity, but after a cool-down period of up to a day or two,

A hands-on approach to chest pain assessment

Inspecting and palpating the chest wall is vital to identify the cause of chest pain; auscultation of the heart and lungs are less valuable. When palpating, check the rib spacings, muscular size, and consistency. Compare one side of the chest to the other, since a swollen pectoralis muscle that is also tender upon palpation means a chest wall injury. If the space between the ribs is uneven and the area is in pain, the diagnosis becomes clear. Often just pressing on the chest wall will elicit the same pain that brought the child to the office.
there can be sudden chest cramping. In general, pain that comes at rest is usually benign; pain brought out by exercise can be more significant.

Parents' assumptions can also be a factor in the early phases of chest pain. If the pain is emanating from the left side, the patient's family usually assumes that it is "heart pain," a warning sign for a heart attack. This erroneous conclusion, in turn, leads to an urgent call to the pediatrician. Questioning parents about family history also plays a crucial role. Pediatricians should take a careful family history, paying attention to any congenital heart disease, hypertrophic cardiomyopathy, or premature coronary artery disease. A family history of unexplained sudden death is an alarm bell for an extensive workup in a child with chest pain, especially if the pain comes with activity.4,6

The heart of the matter
While less prevalent than chest wall injuries, cardiac causes of chest pain are without question a reality. Hypertrophic cardiomyopathy, for its part, is the leading cause of sudden death during sports in children and adolescents in the US.7 In this cardiac muscle disease, the myocardium thickens and literally outgrows its own blood supply. The already compromised myocardium becomes more ischemic with activity, and chest pain can develop. If the ischemia persists, a fatal arrhythmia may occur as the myocardium becomes electrically unstable.

The resting physical examination in these patients often reveals no obvious abnormalities. There may be a grade 1/6 short ejection systolic murmur or no murmur at all. In order to further evaluate the murmur, have the patient hop or do jumping jacks to increase cardiac output and learn if this activity produces a more significant murmur. Squatting or changing body position may not have the same effect.

Similarly, a coronary artery could have an anomalous course that passes between the pulmonary artery and the aorta. That anomalous course could cause compression of the coronary artery during periods of activity when both the aortic and pulmonary artery pressures increase to meet the body's need for a higher cardiac output. Such compression could produce life-threatening ischemia, arrhythmia, and even sudden death.3,6

Murmurs are common in children, and most are usually innocent. A pathological

<table>
<thead>
<tr>
<th>Chest pain dialogue</th>
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<tbody>
<tr>
<td>1) When did the pain start?</td>
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<td>2) How long did the pain last? What has made it better/worse?</td>
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<tr>
<td>3) Was there a change in the pain with arm movement or respiration?</td>
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<tr>
<td>4) Was there trouble breathing? Was the breathing noisy?</td>
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<tr>
<td>5) Was there dizziness?</td>
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<tr>
<td>6) Was the pain caused by any particular activity?</td>
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<tr>
<td>7) Was the pain like a pin or a pencil eraser pressing against one area of the chest?</td>
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<tr>
<td>8) Ask about activities (dance, gymnastics, swimming, weight lifting, wrestling), both current and in the recent past. Did the patient stretch and warm up adequately before competing?</td>
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<tr>
<td>9) Is the pain on the non-dominant side?</td>
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<tr>
<td>10) Is there a family history of any congenital heart disease, such as hypertrophic cardiomyopathy, or premature coronary artery disease?</td>
</tr>
</tbody>
</table>

Table 2

A family history of unexplained sudden death is an alarm bell.
CHEST PAIN

Every full diagnostic workup should include an echocardiogram as well as an electrocardiogram.

murmur is a clear indication for a full cardiac workup, especially if associated with chest pain. Unfortunately, murmurs are usually absent or misdiagnosed as innocent in potentially lethal causes of chest pain. The pediatrician’s total evaluation decides if a cardiac referral is needed, not the presence or absence of a murmur.

Chest pain arising from rare etiologies must also be considered. One uncommon cause is chest pain from coronary stenosis from early atherosclerotic disease or Kawasaki disease. The role of Kawasaki disease in premature coronary atherosclerosis is the subject of much study. Myocarditis and pericarditis can lead to chest pain, but this is usually a more consistent discomfort and is not related to activity. Any child who has a paroxysmal arrhythmia, either atrial or ventricular in origin, can have inadequate coronary blood flow during the period of arrhythmia, leading to coronary insufficiency, ischemia, and chest pain. The patient should always be asked to identify any change in heart rate that may have preceded the onset of chest pain. Dizziness with chest pain can be a very ominous sign, with or without syncope, and deserves a full cardiac evaluation.

Tools of the trade

If one suspects that there is a cardiac etiology, the diagnostic workup by the cardiologist should include an electrocardiogram (ECG) and echocardiogram (echo). An ECG may reveal pre-excitation of the Wolff-Parkinson-White variety, which would predispose the child to an arrhythmia. There could also be a prolonged QT interval corrected for heart rate on the ECG, which could serve as a predictor for ventricular tachycardia of the torsades de pointes variety.

Signs of underlying congenital heart disease include atrial enlargement or ventricular hypertrophy. Detailed echocardiograms should, therefore, reveal the size and function of the left ventricle. In hypertrophic cardiomyopathy there is typically asymmetric septal hypertrophy with dynamic left ventricular outflow obstruction. A thin and dilated myocardium with poor function would be a sign for a dilated cardiomyopathy, which could also present with cardiac ischemia. The echo should also track the coronary artery origins from the aortic root, looking for an anomalous course.

Stress testing should be undertaken if the symptoms are induced by exercise and the ECG and echo are non-diagnostic. Stress testing may bring out an exercise-induced arrhythmia, such as ventricular tachycardia produced by an epinephrine surge. Event monitors and Holter monitors may also be used to look for paroxysmal arrhythmias.

Cardiac CT and/or contrast-enhanced MRI have been extremely helpful in identifying anomalous coronary arteries that
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are suspected from the echo. Cardiac catheterization could be used to define the anatomy further, but this is usually not necessary with an adequate cardiac CT and/or MRI. The child who has a completely normal ECG during exercise does not have ischemia. If there is a questionable exercise ECG or ongoing chest pain of unknown etiology, the child should have a coronary ischemia workup, including cardiac enzymes with special attention to troponin. You should obtain fasting lipid panel tests looking for hypercholesterolemia or other lipid disorders, and hemoglobin level tests looking for profound anemia.

Healing & outlook
In those cases where a chest wall injury is present, treatment should begin with reassuring the patient and the family that this is not a cardiac event. Recommend rest of the injured muscles, even if it means stopping a sport. Non-steroidal anti-inflammatory agents such as ibuprofen can relieve the pain and swelling of a chest wall injury. You should emphasize that this does not cure the injury, just lessens the acuity of the symptoms. Applying heat to the affected area sometimes helps. After no pain for a month, start range of motion exercises. If they do not cause pain, the patient can start strengthening the chest wall with very light weights and multiple repetitions. If the pain is still gone with the use of light weights, the child can return to playing sports. Be sure to explain to your patient that heavy or power weight lifting is never indicated.

While chest pain in children and adolescents is common, it's usually not a life-threatening malady. In most cases they have a chest wall injury, and treatment consists of general support and reassurance. Rarely, the pain will be a warning of a very serious problem. With a comprehensive history and physical examination, the pediatrician should be able to either diagnose and treat, or refer to the correct consultant. Atypical pain, initiated by activity, perhaps associated with dizzy spells or syncope, and especially if there is a family history of sudden death, is an indication for prompt referral. If there is doubt as to the diagnosis, it is always better to make a referral rather than risk a catastrophic outcome.

For more information on pediatric cardiology, see Contemporary Pediatrics Resources (CPR) on page 88.

References