of an appendicolith increases the specificity. In cases of appendiceal perforation, the appendix itself may be difficult, if not impossible, to visualize. A pericecal loculated fluid collection suggests perforation, whereas free intraperitoneal fluid is not a predictor of perforation.

With color Doppler ultrasonography, increased blood flow can be seen in areas of inflammation. Although this technique can increase observer confidence, it does not increase the sensitivity in detecting acute appendicitis. Recent studies have shown the use of sonography for the diagnosis of appendicitis to have a sensitivity of 76% to 100%, a specificity of 89% to 97%, and an accuracy of 83% to 97%. The ultrasound diagnosis of appendicitis is somewhat limited by the presence of obesity, ascites, and severe abdominal pain and can be more difficult if an appendix is retrocecal. Ultrasonography, however, is useful in evaluating the abdomen and pelvis for other disease if scanning of the right lower quadrant is not diagnostic for appendicitis. In children, other possible disorders that can be revealed with ultrasonography include mesenteric adenitis, ileitis, intussusception, Crohn's disease, Burkitt's lymphoma, foreign body, and neutropenic colitis.

Computed tomography has also been used to evaluate atypical clinical findings of appendicitis and can be highly specific even without the use of intravenous or oral contrast media. Computed tomographic criteria include the visualization of an abnormal appendix with fat stranding in the pericecal area or an appendicolith with a right lower quadrant abscess or phlegmon. The sensitivity, specificity, and accuracy for the CT diagnosis of acute appendicitis range from 87% to 98%, 83% to 97%, and 83% to 97%, respectively. Computed tomography can be used to detect complications of appendicitis such as hepatic abscess, small bowel obstruction, and mesenteric venous thrombosis and to evaluate concurrent disorders. It is also useful in the guidance of percutaneous appendiceal abscess drainage procedures.

Although there is a small false-negative and false-positive rate for the diagnosis of appendicitis using either ultrasonography or CT, both modalities can be extremely useful. Ultrasonography may be most beneficial in children and young women because of the lack of ionizing irradiation, lower cost, and positive predictive value. Equipment is portable if necessary. In women of childbearing age, graded compression ultrasonography in conjunction with an endovaginal ultrasonogram is useful for evaluating acute gynecologic disorders. Computed tomography is advantageous in that it is tolerated by sick patients, is not operator-dependent, and the results are not affected by the amount of bowel gas or abdominal pain.

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Spiral and Ultrafast Computed Tomography for Noninvasive Cardiac Imaging in Children

CONGENITAL HEART DISEASE is a serious health problem in the United States, affecting about 8 of 1,000 newborns. With the recent dramatic improvements in postoperative survival of infants with even the most serious and complex congenital cardiac malformations, emphasis has been placed on improving cardiac function, neurologic outcome, and the quality of life. Imaging studies play an important role in the management of these patients.

During the past decade, the need for cardiac catheterization with projectional angiocardiography has decreased with the use of less invasive cross-sectional imaging techniques such as echocardiography and magnetic resonance imaging. Computed tomography (CT) combines high spatial and contrast resolution with tomographic imaging, eliminating the superimposition of complex cardiac anatomy and surrounding lung and bony chest wall. The recent development of spiral and ultrafast (electron beam) CT techniques has extended its application to cardiovascular imaging (CT angiocardiography) with less motion artifact due to heartbeat and respirations. In adult abdominal and peripheral vascular disease, CT angiography has yielded results comparable to those of projectional angiography, with less radiation exposure, reduced requirements for contrast material, and no need for invasive catheterization of the vascular system. In the chest, CT angiography is most useful in the diagnosis of pulmonary embolism and in congenital heart disease, where there is a need for exactly delineating complex cardiovascular anatomy.

In infants and children, because of their small size, the entire thorax can be covered with spiral CT in 20 to 30 seconds during peak contrast enhancement given through a peripheral vein. Motion is further reduced by having older cooperative children hold their breath during the scan. Young children can be scanned successfully during quiet respiration, and sedation is less frequently needed because of the rapid acquisition time of the CT data. Imaging data are initially reconstructed as axial slices, familiar from conventional CT. Because the data are collected from a large volume of tissue rather than a slice at a time, they can be subsequently reconstructed and viewed on a computer work station from different angles in user-selected cross-sectional planes and three-dimensional renditions best suited to display complex cardiovascular relationships, without the need to administer additional contrast media.

Respiratory and cardiac motion can be further suppressed by means of ultrafast (electron beam) scanning. Slice acquisition time is about 100 milliseconds, and, when using the dynamic imaging mode, the images are virtually motion-free even in dyspneic or crying children. Multislice bolus tracking (flow) techniques can be used to visualize hemodynamic events in real time and to calculate shunt fractions. Cardiac gating is used to link image acquisition to events in the cardiac cycle, allowing the reconstruction of multislice cine sequences, which are used to evaluate regional ventricular wall motion and to calculate

functional indices—systolic and diastolic ventricular volumes, cardiac output, and ejection fraction.

Computed tomographic angiocardiography provides valuable anatomic information in three dimensions regarding the size and structure of cardiac chambers, the caliber of pulmonary arteries and aorta, septal defects, the connection between ventricles and great vessels, the compression of airways by vascular structures, and position and patency of shunts and stents. In most cases, the image information is analogous or even superior to that provided by conventional projectional angiocardiography. Computed tomography uses less contrast material and radiation dose than angiography, which often requires administering multiple doses and biplane filming in various projections.

Although cardiac catheterization is still required for percutaneous interventions—balloon dilatation, stent placement, and embolization—and it is the only test to measure intracardiac and intravascular pressure curves and oxygen saturation, electron-beam CT can also provide detailed functional information, as mentioned earlier.

Emerging indications for cardiac CT are as follows: possible aortic coarctation; preoperative evaluation of pulmonary vascularity in patients with cyanotic heart disease who are being considered for palliative shunt placement; unifocalization of aortopulmonary collaterals or complete repair; assessment of complex postoperative anatomy; and the visualization of airway compression by vascular rings, slings, dilated vessels, and shunts. If cardiac catheterization is still required to further assess cardiac function and to guide endovascular intervention, the performance of cardiac CT on the day before catheterization substantially reduces the number of administrations and projections, the amount of contrast material required, and the procedure time, which should lead to savings in radiation dose and costs. Close cooperation between radiologists and pediatric cardiologists is required, especially in the user-interactive three-dimensional rendering and interpretation of the CT data. Noninvasive high-resolution "four-dimensional" cardiac imaging with CT has now become a reality, and its more general application in multidisciplinary cardiovascular research and treatment centers should have an important influence on patient management and outcome.

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Doppler Ultrasonography of Transjugular Intrahepatic Portosystemic Shunts

THE TRANSJUGULAR INTRAHEPATIC portosystemic shunt (TIPS) procedure is a nonoperative treatment option for managing variceal hemorrhage from portal hypertension. In this percutaneous procedure, an expandable metallic stent is placed in the liver to create a channel between a hepatic vein and a portal vein. Its creation has been shown to be feasible and effective, and it has become an accepted method for treating patients with portal hypertension and acute variceal bleeding. These shunts can become stenotic or occluded, however. Because the likelihood of shunt complications increases with length of time since insertion and the risk of recurrent variceal bleeding is directly related to shunt patency, a noninvasive, widely available, and relatively inexpensive means for assessing shunt function is of great importance.

Sonography is a valuable diagnostic tool in the noninvasive evaluation of hepatic parenchymal disease and hepatic vasculature. With the use of Doppler sonography, functional hemodynamic information regarding vascular patency, flow direction, and flow patterns can be obtained. Doppler sonography has been used to evaluate conventional, surgically created portosystemic shunts, and recent reports have shown this technique to be of value in demonstrating changes in hepatic hemodynamics after TIPS placement. The intrahepatic location of the TIPS makes it amenable to sonographic assessment. On gray-scale sonographic imaging, the walls of the stent are seen as highly echogenic parallel lines. Sonographic protocol includes spectral and color Doppler insonation of the main and intraparenchymal right and left portal veins, the TIPS stent, and the hepatic veins. The shunt is imaged along its long axis, and the maximum flow velocity within the TIPS is measured. The peak flow velocity by Doppler ultrasonography within a patent TIPS ranges from 50 to 270 cm per second.

Doppler sonography demonstrates TIPS flow and detects thrombosis. The absence of detectable flow within a TIPS indicates shunt thrombosis. Several Doppler sonographic variables have been studied in an effort to investigate which changes are most indicative of shunt dysfunction and, in particular, of TIPS stenosis. The variables that have been used include portal vein flow velocity and portal blood flow, maximum flow velocity within the shunt, the direction of flow within the intrahepatic portal venous branches, temporal change in peak stent velocity, and the direction of flow in the draining hepatic vein.

Reduced maximum flow velocities within a TIPS, measured in the intrahepatic portion of the stent, suggest stenoses that most often occur downstream, at the hepatic venous end of the shunt, or in the draining hepatic vein. Doppler measurement of a maximum flow velocity within the TIPS of 50 cm per second or less is a useful and suggestive indication of shunt stenosis.

Routinely doing baseline postprocedure and follow-up Doppler sonographic studies in patients with TIPS aids in screening for shunt complications and in selecting patients who will benefit from therapeutic intervention, including revising stenotic shunts. Although long-term complications are known to occur, TIPS function can be