Pediatric Liver: Focal Masses

Marilyn J. Siegel, MD[a,*], Ellen M. Chung, MD[b], Richard M. Conran, MD, PhD, JD[c]

KEYWORDS

• Liver tumors • Children • MR imaging

Imaging is a standard part of the evaluation of pediatric liver disease. Advances in magnetic resonance imaging have improved detection, characterization, and staging of hepatic lesions. This article addresses the MR imaging appearances of various focal hepatic lesions that can present in children. Techniques for performing hepatic MR imaging are also reviewed.

HEPATIC MR IMAGING TECHNIQUES

Coils

MR imaging examinations should be performed with the smallest coil that fits tightly around the body part being studied.[1,2] A head coil often is adequate in infants and small children, whereas a phased-array coil should be used in larger children and adolescents.

Imaging Sequences

The routine imaging technique for liver masses includes unenhanced coronal and axial T1-weighted images, unenhanced axial fast spin echo T2-weighted images, unenhanced axial gradient echo images, and contrast-enhanced images following intravenous injection of gadolinium chelate.

Unenhanced spin-echo images

T1-weighted images, obtained with either spin-echo or gradient echo techniques, are useful for lesion detection and characterization of blood and fat. On T1-weighted images, most focal lesions appear hypointense to normal hepatic parenchyma. Exceptions are hemorrhagic and fatty lesions, which appear hyperintense. T2-weighted spin-echo sequences, obtained with fat suppression techniques, improve the contrast differentiation between normal and abnormal soft tissue. On T2-weighted images, most hepatic tumors appear hyperintense to normal parenchyma.

Unenhanced gradient-echo sequences

Unenhanced gradient-echo imaging (short repetition time or TR, short echo time or TE, small flip angle) results in high signal in flowing blood and is used to assess patency of vascular structures.

Contrast-enhanced images

Gadolinium-enhanced imaging is performed in combination with dynamic gradient echo sequences. After contrast agent injection, images are obtained through the liver during the arterial phase (20–30 seconds after the injection), portal venous phase (60–80 seconds after the injection), and at equilibrium (3–5 minutes after the injection). Delayed images can be obtained if needed for further lesion characterization.

Optional imaging sequences

By varying the TE of T1-weighted gradient echo sequences, in-phase and out-of-phase (opposed phase) images can be acquired. In-phase and out-of-phase images provide information on fat content. Fat has an increased signal intensity on in-phase images and decreased signal intensity on out-of-phase images.

[a] Mallinckrodt Institute of Radiology, Washington University School of Medicine, 510 South Kingshighway Boulevard, St. Louis, MO 63110, USA
[b] Department of Radiologic Pathology, Armed Forces Institute of Pathology, 6825 16th Street NW, Washington, DC 20306-6000, USA
[c] Department of Pathology, Uniformed Services University of the Health Sciences, Bethesda, MD 20814, USA
* Corresponding author.
E-mail address: siegelm@mir.wustl.edu (M.J. Siegel).

Magn Reson Imaging Clin N Am 16 (2008) 437–452
doi:10.1016/j.mric.2008.04.001
1064-9689/08/$ – see front matter

Other Technical Factors

MR images are usually obtained with 3-mm to 6-mm interval sections and slice thickness, depending on patient size, and with 128 to 192 phase-encoding steps. Spatial resolution can be improved larger phase-encoding steps, but this approach will prolong imaging time. Imaging is performed with a breath-hold technique when possible. However, useful information can still be obtained in sedated children or younger children who are unable to suspend respiration.

IMAGING STRATEGIES FOR EVALUATION OF HEPATIC TUMORS

The role of imaging is to determine the organ of origin, character, and extent of the lesion.[3–8] Ultrasonography (US) is readily available, fast, and relatively inexpensive, and can usually reveal the location, extent, and solid or cystic nature of a mass and assess vascular invasion. Because of these advantages, US is considered the screening technique of choice for evaluation of a suspected liver mass. If the sonogram is normal, further radiographic evaluation generally is not required. If US cannot yield adequate information or if it suggests a mass, further evaluation with either CT or MR imaging is needed. Whether CT scan or MR imaging should follow sonography is usually based on personal expertise and availability of the equipment. CT scanning is generally used more often than MR imaging because it is more widely available and can provide excellent anatomic detail of a hepatic mass and also extrahepatic abdominal and pulmonary disease. However, CT requires exposure to ionizing radiation. MR imaging has the advantages of not requiring ionizing radiation exposure and providing superb tissue contrast. Thus it can play an important role in evaluating the liver as a primary study and a problem-solving technique.

MR IMAGING OF NORMAL LIVER

The signal intensity of normal hepatic parenchyma is slightly greater than that of muscle on both T1- and T2-weighted images. The normal liver enhances after the administration of gadolinium-chelate agents.

Traditionally, the liver had been divided into right and left lobes by the middle hepatic vein superiorly and by the gallbladder fossa inferiorly. The right lobe was then divided into anterior and posterior segments by the right hepatic vein. The left lobe was divided into medial and lateral segments by the left hepatic vein superiorly and by the fissure for the ligamentum teres inferiorly. The traditional classification made no distinction between the superior and inferior divisions of each major segment.

In the classification system of Couinaud, the hepatic segments are divided not only by three vertical planes along the hepatic veins, but also by a transverse plane defined by the portal venous supply.[9] Eight segments are defined by this system. Each segment has separate afferent and efferent vessels and biliary channels. This classification is widely used because it divides the liver into segments that are surgically resectable.[10]

HEPATIC TUMORS

Hepatic tumors are the third most frequent abdominal neoplasms in children after Wilms tumor and neuroblastoma. Malignant hepatic neoplasms are twice as frequent as benign neoplasms and most of these are hepatoblastomas.[11–14] Hepatocellular carcinoma, including the fibrolamellar variant, undifferentiated (embryonal) sarcoma, and angiosarcoma are less common malignant tumors. The common benign hepatic tumors are hemangioendothelioma, hemangioma, and mesenchymal hamartoma, with focal nodular hyperplasia and adenoma encountered less often.[3–6,11–14]

Patient age, clinical signs and symptoms, and alpha-fetoprotein levels are critical discriminators in the evaluation of hepatic tumors. Hemangioendothelioma is the most common mass in the first 6 months of life. Hepatoblastoma, mesenchymal hamartoma, and metastatic disease from neuroblastoma or Wilms tumor usually present in the first 3 years of life. Undifferentiated (embryonal) sarcoma typically presents between 6 and 10 years of age, and hepatocellular carcinoma, focal nodular hyperplasia, and hepatic adenoma usually occur in older children and adolescents.

The clinical presentation also can suggest a specific diagnosis. Congestive heart failure in a neonate with a liver mass suggests the diagnosis of hemangioendothelioma, whereas a history of immunosuppression in a transplant patient suggests lymphoproliferative disorder or fungal abscesses. Laboratory findings, particularly serum alpha-fetoprotein levels, can be important in making a diagnosis. Certain tumors, such as hepatoblastoma and hepatocellular carcinoma, excluding the fibrolamellar variant, are associated with elevated serum alpha-fetoprotein levels.[11]

PRIMARY MALIGNANT NEOPLASMS

Hepatoblastoma

Hepatoblastoma is the most common liver tumor in children, and 90% are seen in infants and young children under 5 years of age, with approximately