

**Technique**

**Computed Tomography**

In a solid organ such as the liver, computed tomography (CT) reveals characteristic attenuation alterations and morphologic changes of diffuse disorders such as cirrhosis and fatty infiltration. Similar changes are also detected with magnetic resonance imaging (MRI). Currently the primary limitation of both CT and MRI is that a number of liver disorders have overlapping imaging findings, thus limiting specificity.

The terms *helical CT* and *spiral CT* are used interchangeably. In helical CT the patient table moves at a constant speed while the x-ray tube and detectors rotate continuously, and thus scanning is in a helix rather than a circle as with conventional CT. Images obtained with helical CT do not define a specific circular body slice and are not identical to those obtained with conventional CT. There is little argument that in evaluating abdominal disease in general, and liver disorders in particular, helical CT is preferred over conventional CT.

Initial helical CT scanners could cover either large body parts or thin sections of a limited volume, but not both, a limitation largely overcome by the introduction of multidetector CT (also known as *multirow CT* and *multislice CT*) in the late 1990s. As a basic concept, multidetector CT generates more than one slice per x-ray tube rotation. Multidetector CT, with 16 detectors being readily available, 32 detectors being tested, and 64 or more detectors on the drawing boards, offers several advantages: a larger volume scanned during a given time, reduced time required to scan a given volume, narrower collimation and thus increased resolution, and shorter enhancement intervals after contrast. Multidetector helical CT allows simultaneous acquisition of multiple slices, and complex, single breath-hold techniques are thus feasible (a breath-hold is typically defined as 20 sec or less). Three-dimensional (3D) CT arteriograms without venous overlay are readily obtained by using first-pass data from a multirow detector CT scanner. One by-product of multidetector CT is a considerable increase in the number of images available for review, thus adding to study complexity. Simply decreasing the number of images evaluated is not a viable option because overlapping images at various phases of contrast flow improve disease detection.

In general, precontrast CT scanning identifies fewer liver lesions than postcontrast images. In many institutions precontrast CT is limited to specific indications such as in detecting calcifications or hemorrhage.

Correct arterial phase timing is obtained by using an initial test dose. Automatic bolus tracking initiates scanning after injection of contrast by monitoring a region-of-interest cursor placed in the abdominal aorta; a typical scenario is to set a threshold level at 100 Hounsfield units (HU) over the aortic baseline.
CT level and initiate scanning about 10 seconds later. A similar approach is to start arterial phase imaging when splenic enhancement reaches a certain HU value above baseline.

On average, CT arterial phase begins to enhance about 15 to 20 seconds after the start of intravenous (IV) contrast injection, followed by portal venous enhancement about 30 seconds later and parenchymal enhancement shortly after that. Images during the arterial phase map the major hepatic artery branches, and portal phase images outline portal and hepatic venous systems. Such a biphasic or dual-phase CT technique refers to the two discrete imaging sequences obtained and not to a biphasic contrast injection. For some indications, a liver parenchyma enhancement phase, also called an equilibrium phase, obtained several minutes after the start of contrast injection, is useful.

The literature is inconsistent about defining biphasic and triphasic CT imaging. Some authors include a precontrast phase as part of these terms, but others do not. In this book a precontrast phase is not included as part of either biphasic or triphasic imaging, and the use of these terms refers to postcontrast phases only. Even here confusion exists; does “biphasic” refer to the arterial, portal venous or equilibrium phases (or any other phase for that matter)? The term double arterial phase imaging signifies that early and late arterial phase images are obtained during a single breath-hold study. Some use quadruple phase to mean that images are obtained precontrast and at three times after the start of contrast injection. No sharp boundary exists between various phases. Ideally, authors should include the specific times after the start of injection when scanning is initiated.

Computed tomography CT data are viewed either as traditional transverse images or displayed in coronal, sagittal, or 3D projections. The latter allows a direct estimate of tumor size, information at times useful to the oncologist or surgeon.

**Computed Tomography Angiography**

Computed tomography angiography (CTA) is a general term used in a sense similar to conventional angiography but is often applied to a technique of injecting IV contrast and obtaining images during the arterial phase. Use of multidetector CT is especially well suited for such vascular studies.

Computed tomography angiography can also be performed with contrast injected through a catheter advanced into a major abdominal artery; whether one obtains CT arterial portography or CT hepatic arteriography (or any other specific vessel angiography) depends on the artery used and image timing.

**Computed Tomography Arterial Portography**

Computed tomography arterial portography consists of angiographic placement of a catheter in the superior mesenteric artery or splenic artery, transfer of the patient to a CT suite, injection of a contrast bolus through the intraarterial catheter, followed by liver imaging during the portal venous phase. This technique maximizes attenuation differences between a neoplasm having a primarily arterial blood supply and normal liver parenchyma primarily supplied by the portal vein. It is superior to the usual intravenous contrast-enhanced CT imaging; over 80% of tumors <1 cm in diameter are imaged.

It is used in some centers preoperatively for anatomic localization of lesions and in evaluating whether a patient is indeed a surgical candidate. A refinement of this technique consists of a dual-phase study: during the first phase images are obtained about 30 seconds after the start of the contrast injection, and second-phase images are obtained at 70 seconds.

In general, there is no difference in hepatic enhancement whether CT arterial portography is performed via the superior mesenteric artery or the splenic artery. In the presence of an anomalous right hepatic artery originating from the superior mesenteric artery, the catheter needs to be positioned distal to this site. Computed tomography arterial portography is of limited use in patients with portal hypertension and collateral portal blood flow away from the liver.

Altered blood flow anomalies result in a number of artifacts during arterial portography. Inhomogeneous perfusion is most common near the porta hepatis, falciform ligament, and gallbladder. Perfusion defects can either resemble a neoplasm or even mask the presence of one. A liver zebra pattern, consisting of alternating regions of hyper- and hypoperfusion,