Preoperative Assessment and Optimization of the Future Liver Remnant

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KEYWORDS

• Liver cancer • Liver metastases • Liver surgery • Steatosis
• Chemotherapy-associated hepatotoxicity • Portal vein embolization

KEY POINTS

- Patients who undergo liver resection and have an inadequate future liver remnant (FLR) volume are at increased risk for postoperative morbidity and mortality.
- The absolute volume of FLR required to avoid postoperative liver insufficiency depends on patient, disease, and anatomic factors.
- Rapid expansion of the FLR can be achieved with portal venous embolization (PVE) of the contralateral liver segments.
- PVE is a safe and effective procedure, when performed at high-volume hepatobiliary centers.
- Following PVE, the kinetic growth rate is the most reliable predictor of freedom from postoperative liver insufficiency.

The principle that guides curative treatment of both primary and secondary hepatobiliary malignancies is complete resection of all tumors. Anatomy and tumor factors, including tumor size and location, often mandate resection of several liver segments to obtain adequate margins. Patients who undergo liver resection and have an inadequate future liver remnant (FLR) volume are at increased risk for postoperative morbidity and mortality.[1] In patients who are anticipated to have a marginal or inadequate FLR volume, rapid expansion of the FLR can be achieved with portal venous embolization (PVE) of the contralateral liver segments.

MEASUREMENT OF PREOPERATIVE LIVER VOLUME AND FUNCTION

When evaluating a candidate for liver resection, history and physical examination are essential. It is important to detect any stigmata of hepatic dysfunction, including

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jaundice, scleral icterus, hepatomegaly, or ascites. It is also important to inquire about the existence of viral hepatitis or other predispositions to liver disease, including alcohol use.

When planning for major liver resection, it is also vital to assess baseline liver volume and function. There are several methods for evaluating liver volumes and function with both imaging modalities and biochemical markers. With baseline liver volumetry, it is possible to calculate the FLR volume based on the planned resection in order to predict the need for preoperative liver augmentation as well as to predict procedure-related morbidity and mortality.

Although ultrasound was the first modality used to calculate liver volumes, it has largely been replaced by cross-sectional imaging techniques. The technique of computed tomography (CT) volumetry was described and validated in 1979 by comparing CT volumetry with actual explanted liver volumes.[2] This initial report established CT scan as a noninvasive, accurate, and reproducible means of assessing liver volumes. Subsequently, CT-based liver volumetry was shown to correlate with clinical outcomes.[3] The advent of helical, multidetector, thin-slice CT scanning has made the rapid acquisition of high-resolution images increasingly available. This technique allows the images to be obtained during a single breath-hold, minimizing artifact and increasing quality and accuracy.

Once images are obtained from the CT scan, either manual or automated techniques are used for calculating liver volumes. The manual process involves a radiologist electronically tracing the contours of the liver. Hepatic and portal vein branch anatomy is used to delineate segments.[4] Manual techniques, although time consuming, provide the most accurate estimate of liver volume.[5] Increased accuracy is achieved through the exclusion of nearby structures, including the gallbladder, vasculature, and major fissures. Automated algorithms, which work from source images alone, have also been described. These automated methods take significantly less time to calculate and have had adequate correlation when compared with manual calculations. Despite these findings, software for fully automated techniques remains expensive, and most centers continue to use manual calculations.

Individuals who have underlying liver parenchymal disease, such as cirrhosis or steatosis, may benefit from functional as well as anatomic volumetric assessment. Indocyanine green and technetium-99m galactosyl serum albumin have both been used to estimate FLR function. When combined with CT volumetry, the clearance of these substances can help stratify patients into groups who will need PVE versus those who do not. However, these functional tests are not available in most Western centers, explaining the dependence of these centers on volumetry alone. In these centers, hypertrophic response to PVE is used as the marker for functional capacity of the FLR.

INDICATIONS FOR FUNCTIONAL LIVER REMNANT AUGMENTATION

Many factors have to be considered when deciding whether a patient will require PVE before resection. The first step is characterizing the patient's liver with regard to underlying parenchymal disease. This step is necessary to define what an acceptable FLR volume following resection for that individual will be. Other patient-centered characteristics, such as height and body surface area (BSA), also need to be considered. Tall individuals with larger BSA will require higher FLR volume than shorter patients having the same magnitude of hepatectomy. Vauthey and colleagues[6] have shown that total liver volume (TLV) is best estimated when controlling for BSA in Western adults; they developed a BSA-based formula that remains the most accurate method