THE PIVOTAL ROLE OF MULTIDETECTOR COMPUTED TOMOGRAPHY IN LIVER TRANSPLANTATION

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Abstract: Liver transplantation is often the only lifesaving option for patients with end-stage liver disease. Because deceased donor organs are extremely scarce, living donor liver transplantation has become increasingly common. This requires perfect anatomical precision to keep the donor safe and ensure the recipient's survival. A review of the current literature was conducted to explore how multidetector computed tomography (MDCT) is used throughout the liver transplant process, from screening to post-op care. MDCT is highly accurate across the board. For recipients, it helps predict survival in acute-on-chronic liver failure. For donors, unenhanced CT accurately measures liver fat (steatosis), while multiphasic scans map out complex blood vessel anatomy. MDCT volumetry is the standard for estimating graft weight, though raw data usually overestimates the actual weight, meaning a correction factor is often needed to prevent small-for-size syndrome.

Postoperatively, CT is over 90% sensitive in catching dangerous clots and biliary leaks.

Keywords: Liver Transplantation, Computed Tomography, Living Donor, CT Volumetry, Hepatic Steatosis, Graft-to-Recipient Weight Ratio.

Introduction: Orthotopic liver transplantation is a massive surgical undertaking and the definitive treatment for irreversible liver failure, advanced cirrhosis, and certain liver cancers. To decide who needs a transplant, we use scoring systems like the Model for End-Stage Liver Disease (MELD). A MELD score over 12 generally indicates that a patient will definitively benefit from a transplant.

In the past, figuring out a patient's liver anatomy required invasive procedures like catheter angiography or endoscopic retrograde cholangiopancreatography, which carried significant risks of bleeding, infection, and high radiation exposure. Today, multidetector computed tomography (MDCT) has completely changed the game. It gives us a rapid, non-invasive, 3D look at the entire liver in just one breath-hold.

Because there just aren't enough deceased donors, living donor liver transplantation (LDLT) has stepped in to fill the gap. This is a highly complex surgery where a healthy person donates a large portion of their liver. Preoperative imaging isn't just about getting a surgical map; it's the primary way we ensure the donor will survive the surgery with enough functional liver left, and that the recipient gets a big enough piece to survive.

Methods: This review looks at clinical guidelines and retrospective studies to understand how MDCT is actually used in the clinic for liver transplants.

To get good images, patients usually drink about 750 mL of water before the scan to distend the stomach without causing the bright artifacts you get from barium contrast. Then, around 120 mL of iodine-based IV contrast is injected rapidly.

Timing is everything. Using automated tracking, the arterial phase is snapped about 25 seconds after injection to catch the peak enhancement of the hepatic arteries. The portal venous phase is taken at 55 to 60 seconds to get the best look at the liver tissue and veins, which is the data we use to calculate liver volume. Recently, a lot of hospitals have switched to lower-voltage (100-kVp) protocols with iterative reconstruction for healthy donors. This neat trick uses the physical properties of iodine to let us cut the radiation dose by over 40% and the contrast dose by 20% without losing image quality.

Results

Recipient Evaluation

For the person receiving the liver, the CT scan is about mapping out the damage caused by cirrhosis and making sure the surgery is actually possible. We look for shrunken right lobes, massively overgrown caudate lobes (which can wrap around the vena cava and make surgery bloody), and signs of portal hypertension like severe varices. CT is also crucial for spotting hidden liver cancers.

Interestingly, CT can actually predict how likely a critically ill patient with acute-on-chronic liver failure is to survive the first year after a transplant. By looking at three things—massive splenomegaly, liver atrophy, and a shrunken inferior vena cava—doctors can calculate a risk score. Patients with a high CT risk score have a dismal 1-year survival rate of 27%, compared to 67% for low-risk patients.

Donor Evaluation and Steatosis

Evaluating a healthy donor is incredibly strict. In fact, studies show that about 42.3% of potential donors who get a CT scan are rejected because their anatomy just isn't suitable.

One of the biggest reasons for rejection is a fatty liver (steatosis). If you transplant a fatty liver, it might fail in the recipient, and the donor's remaining liver won't regenerate properly. We measure fat using a non-contrast CT by calculating the Liver Attenuation Index (LAI), which compares the density of the liver to the spleen. If the LAI is greater than 5 Hounsfield Units (HU), the liver has very little fat and is safe to use. If the LAI drops below -10 HU, the liver is more than 30% fat, and the donor is absolutely rejected.

We also use MDCT to map out the blood vessels. The liver's plumbing is incredibly variable, and MDCT catches portal vein variants with 100% sensitivity and arterial variants with up to 93.7% sensitivity. Missing a variant, like a segment IV artery branching off the right hepatic artery, could mean accidentally cutting off the blood supply to the donor's remaining liver.

CT Volumetry

Calculating liver volume is the math that keeps both patients alive. The donor needs to keep at least 30% to 35% of their original liver volume, and the recipient needs a graft that is at least 0.8% of their body weight to avoid fatal small-for-size syndrome.

While automated software is great at tracing the liver, there is a known glitch: it consistently overestimates how much the graft will actually weigh in the operating room. Across mixed grafts, there is a mean error ratio of about 6.59%, and the raw CT data overestimates the true weight in 61% of cases. This is mostly because the liver is full of blood on the scan, but shrinks when it is flushed with cold fluid during surgery. To fix this, researchers found that multiplying the software's estimated volume by a correlation coefficient of 0.71 gives a much more accurate real-world weight.

Postoperative Complications

After the surgery, things can still go wrong, primarily with blood clots or bile leaks. MDCT is excellent for catching these early. In the first three months, it has an overall accuracy of 92% for finding abdominal complications. It catches devastating hepatic artery clots (which kill the bile ducts) with 97.1% sensitivity, and spots biliary strictures with 90.6% sensitivity. It is also 100% sensitive for finding bile leaks and bile lakes (bilomas).

Discussion: Moving away from invasive angiograms and relying entirely on MDCT has made liver transplants far safer. For medical students and future surgeons, the main takeaway is that while CT is an incredible tool, we have to know its physical and mathematical limitations.

The fact that CT volumetry generally overestimates graft weight is a huge clinical trap. If a surgical team blindly trusts the computer's output for a borderline left-lobe graft, they might accidentally give the recipient a liver that is too small, triggering lethal small-for-size syndrome. Applying physiological math corrections, like the 0.71 coefficient, bridges the gap between digital imaging and real-world surgery.

From a practical standpoint, starting the donor evaluation with a CT scan just makes sense. Because so many donors are anatomically unsuitable (often due to small remnant sizes or low LAI scores indicating fat), getting a fast, relatively cheap CT scan first saves the patient from going through the grueling, expensive process of an MRI workup unnecessarily.

Conclusion: Multidetector computed tomography is the backbone of modern liver transplantation. For sick recipients, it helps predict survival and maps out advanced disease. For healthy donors, it calculates liver volume and screens out fatty livers, ensuring they aren't put at undue risk. By turning complex anatomy into precise, 3D surgical roadmaps and adjusting for known volumetric errors, MDCT prevents intraoperative disasters and remains the best tool we have for managing patients safely after they leave the OR.

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