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Review Article

Role of Doppler studies in monitoring patients after living-related liver transplant

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INTRODUCTION

After its introduction in late 1980s living-related living transplant (LRLT) has now become the treatment of choice for end-stage liver disease. This is especially true in eastern countries, where the incidence of type B and type C viral hepatitis is high. The persistent shortage of cadaveric liver for transplantation has caused LRLT to emerge as a strong alternative.

In LRLT, a portion of liver from an immunologically compatible donor is used to replace the entire diseased liver of recipient. The donor is left with enough liver to maintain normal hepatic function and recipient is given enough liver to restore function. The donor and recipient benefit from significant hyperplasia that begins within 12 hours of surgery. The transplant surgery requires vascular anastomosis of hepatic vein, hepatic artery and portal vein. Technically, satisfactory vascular anastomosis, to allow adequate blood supply to the graft, is essential for successful liver transplantation and long-term graft survival.

Imaging has contributed to monitoring, detection, evaluation and management of post transplant complications. Ultrasound has become the imaging modality of choice throughout the perisurgical period because grey scale sonography permits optimal assessment of morphological changes in parenchyma, while colour and spectral Doppler permits evaluation of both parenchymal perfusion and spectral waveform of major transplanted artery and veins. Unlike cross-sectional modalities such as CT and MRI, sonography is inexpensive; available both intraoperatively and at bedside, and it requires no ionizing radiation or intravascular contrast media. Impeccable knowledge of the anatomy and surgical technique of liver transplantation, as well as awareness of normal and abnormal US and Doppler findings is of utmost importance in being able to detect complications and prevent misdiagnosis in the case of transplanted liver.

ROLE OF ULTRASOUND

Role of ultrasound with Grey Scales and Colour Doppler in the Transplant programme is three fold:

1. Pre Surgery Assessment
2. Intra Operative Assessment
3. Post Operative Assessment

Preoperative ultrasound is used for assessment of donors and recipients for any associated abnormalities of liver, gall bladder, kidneys and also for patency of vessels (mainly extra hepatic) just prior to surgery.

Intraoperative ultrasound is useful for documenting patency, flow direction and waveform pattern with optimal velocities in surgically-created vascular system for the graft and generally guiding transplant procedure. It helps to detect abnormal hepatic haemodynamics, allowing immediate intervention to ensure better patient outcome.

Postoperative ultrasound is done as per institutional protocol for the recipient and donor, for monitoring adequacy of graft and identifying acute and subacute post transplant complications. In patients with abnormal findings, more complex imaging is performed to confirm the findings.

ULTRASOUND PROTOCOL-CLBS

Day 1	Evening before transplant: to check for patency of the vessels
Day 0	Intraoperative: to check the patency of Porto systemic shunt
Day 1 to 5	Twice a day: to monitor adequate vascular inflow and outflow
Day 6 and 7	Once a day: to monitor adequate vascular inflow and outflow

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NORMAL FINDINGS

The normal liver transplant has a homogenous echo texture on grey scale ultrasound with no intrahepatic biliary radical dilation. Vascular patency is assessed by colour and spectral Doppler evaluation of the hepatic arteries, portal veins, and hepatic veins. Doppler sonograms assess the resistive index of the hepatic artery, the peak flow velocity of the portal vein in the pre-anastomotic and anastomotic segment, the portal vein flow pattern and volume, presence of thrombus in the vessel lumen and the hepatic vein flow pattern.

The *normal hepatic artery* shows rapid systolic peak and continuous diastole. The *resistive index* (systolic–diastolic/systolic) and *systolic acceleration time* are most commonly used parameter in hepatic artery evaluation. The *resistive index* allows semi quantitative assessment of resistance to arterial flow into the liver and its normal value ranges from 0.55 to 0.80.

According to the degree of resistance high RI has been classified in four types by Garcia-Criado et al.

- Type I-RI > 0.80 with continuous blood flow in the diastole
- Type II-complete absence of diastole and preserved systolic velocity
- Type III-absence of diastole and diminished systolic velocity
- Type IV-undetectable Doppler flow of resistance.

The *systolic acceleration time* is time from end diastole to first systolic peak and its normal value is <.080 ms.

The *normal portal vein* has continuous hepatopedal flow with mild respiratory variations. The *Portal vein velocity ratio* measures the ratio of portal vein peak anastomotic velocity to the pre-anastomotic velocity. The *Portal Volume* is calculated in the extrahepatic component of the portal vein and an average of three readings is taken, of the ratio of the lumen calibre and peak velocity.

The *normal hepatic veins and IVC (inferior vena cava)* shows triphasic flow pattern, reflecting the transmit flow from the atrium during the cardiac cycle.

POST TRANSPLANT COMPLICATIONS

Post transplant complications are generally classified into three categories:

- Vascular
- Biliary
- Collection

Though biliary complication are most common (25%) in LRLT, vascular complications especially hepatic artery thrombosis and stenosis are one of the most frequent cause of morbidity and graft loss in immediate post-operative period.

(A) Vascular Complications

(1) *Early hepatic artery thrombosis* (within 15 days) is the most serious complication after liver transplant and has an incidence of 5–7% in adults. However, hepatic artery thrombosis can be diagnosed by colour Doppler ultrasound in the pre-symptomatic phase, allowing early reperfusion that obviates the need for retransplantation. Patients with hepatic artery thrombosis who are treated by revascularization before the development of clinical or lab alterations have lower incidence of late biliary complications, which emphasizes the importance of performing close Doppler monitoring after liver transplantations. In hepatic artery thrombosis, colour and spectral Doppler imaging may demonstrate absent flow (type IV curve). A tardus-parvus waveform (RI < 0.50) may be demonstrated in the intrahepatic branches distal to occlusion. However, it is important to interpret imaging findings within the context of other clinical information, as a similar pattern may result from low-flow non-occlusive states, including systemic hypotension. A tardus-parvus spectral pattern is a potentially normal finding for 72 hours post transplantation, perhaps due to oedema at the anastomotic site. These changes must be distinguished from true complications (Figure 1).

Absent diastole and diminishing peak systolic velocity (Type III waveform) in immediate post-operative period can be secondary to arterial complication as in pre-occlusive state proximal to thrombus. When associated with clinical and lab parameter (LFT) derangement, it is an indicator of impending arterial thrombosis and patient should put on an anticoagulant and closely followed-up. This emphasizes the role of CDUS in monitoring the transplant patient and modulating the outcome of impending arterial complication.

The appearance of type I and type II waveform in post-operative period was observed to be transient and not indicative of primarily an arterial occlusion.

Dodd et al. (1994): SAT ≥ 80 ms or RI < 0.05 (for > 50% stenosis) (Table 1).

(2) *Hepatic artery stenosis* occurs most frequently at the anastomotic site due to clamp injury or intimal trauma at the time of surgery. Doppler spectral waveform demonstrates a velocity of 2 m/s or greater at the site of stenosis and turbulent flow, a tardus-parvus spectral waveform (RI < 0.5) is identified distal to the stenosis. Absent diastole and diminishing peak systolic velocity can also be seen in hepatic artery stenosis. Routine CDUS monitoring helps in early diagnosis allowing reexploration and prevention of biliary ischaemia, hepatic dysfunction, and eventual hepatic failure.