Imaging of Liver Transplantation.

By

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• Liver transplantation is a successful therapeutic option for patients with multiple irreversible acute and chronic diseases
Common indications for liver transplantation:

A- Chronic liver disease:

-----> Primary biliary cirrhosis.

-----> Primary sclerosing cholangitis.

-----> Biliary atresia.

-----> HBV or HCV cirrhosis.

-----> Alcoholic cirrhosis.

-----> Autoimmune chronic active hepatitis.

-----> Haemochromatosis.

-----> Budd-Chiari.
B- Malignancy:

-----> Stage I or II HCC in cirrhosis.

-----> Non-resectable, chemosensitive hepatoblastoma.

-----> Epithelioid haemangioendothelioma.

C- Inborn errors of metabolism:

-----> Primary oxalosis.

-----> Crigler-Najjar type 1.

-----> Urea cycle defects.

-----> Familial amyloid polyneuropathy.

D- Fulminant liver failure:

-----> Viral hepatitis.

-----> Drugs.

-----> Toxins unknown.
Contra-indications of liver transplantation:

1- AIDS.

2- Advanced & extra-hepatic malignant tumors.

3- Alcohol abuse.

4- Presence of any active, untreated bacterial, fungal or viral infection at the time of transplantation.
Types of Liver Transplantation

- Cadaveric
- Living donor.
The major advantage of living donor liver transplantation:-

1- Increases the number of organs available.

2- Allows performance of surgery on an elective basis.

3- Frees the recipient from awaiting the availability of a cadaveric organ.

4- Reduction in cold ischaemia time.

5- Use of healthy donor.

** These factors leading to:

A- Reduce morbidity.

B- " mortality.

C- " cost.
Figure 38-7  Living donor liver transplant procedures. A. The left lateral segment of the donor is divided at the falciform ligament. The left hepatic vein and short segments of the left portal vein (or branch) and the left hepatic artery (or branch) are transected. B. To provide tension-free vascular anastomoses, parental or cryopreserved donor veins are used as the portal vein and hepatic artery. Orientation of the grafts with choledochojejunostomy on the right is similar to cadaveric segmental implants.
Imaging of Liver Transplantation

Timing of imaging.

Preoperative:
- 1-Donor.
- 2-Recipient.

Intraoperative US in donor.

Post-operative:
- 1-Donor.
- 2-Recipient.
Imaging modalities

1. Ultrasonography + CCDI.
2. Non enhanced CT scan.
3. Dual phase spiral CT + CTA.
4. Abdominal MR imaging, MRA & MRCP
5. DSA.
Donor Selection Criteria

A good donor is:

• a person in good mental and physical health.

• Age: 21 – 60 years.

• Free from HIV infection, viral hepatitis, active alcoholism, DM, Psychiatric illness, malignancy, heart and lung diseases (Marcos et al, 2000)
Pre-operative

Donor
imaging of donor

- parenchymal
- vascular
- biliary
Preoperative evaluation of the donor:

1- Detection of focal & diffuse liver disease.
2- Calculation of liver volume.
3- Depiction of the biliary tracts & ductal anomalies.
4- Depiction of the liver vasculature & vascular anomalies.
Image Analysis

1. Assessment of the study.
2. Exclusion of focal or diffuse liver lesions.
3. Size of hepatic lobes.
4. Morphology of the hepatic arterial system.
5. Morphology of hepatic and portal veins.
7. Creation of hepatectomy plane.
Fatty liver transplantation results in:

1. Correction of graft to recipient body weight (GRBW) ratio.
2. Impaired graft function.
3. Increase blood loss during parenchymal transection in the donor.
Volumetric liver analysis:

** Before transplantation, it is important to determine:-

--- > the volumes of the RT. Hepatic lobe that will be resected.

--- > the volume of the left hepatic lobe that remain.

- Sufficient liver parenchyma must be present to sustain adequate liver function in both the recipient & donor.
• Minimum Graft volume is at least 50% of the ideal liver mass (2-2.7% of recipient body weight).

• Safety limits for remnant liver ratio:
  
  > 35%  safe
  
  30-35%  marginal
  
  < 30%  risky
Hepatic Artery Variations

• Michel’s described 10 variants of hepatic arteries.

• It ‘s better to describe the variant than to try to classify them.

• The most common variant is abberant LHA (Prokop& Van Der Molen, 2003).

• Accessory vessels require more arterial anastemoses.
Portal vein variants
Normal P.V. anatomy
Portal Vein Anomalies

• Trifurcation

• Quadrifurcation
• Right anterior segmental vein from the left PV.

• Right posterior segmental vein from main PV.
Hepatic vein variations:

• Accessory hepatic veins.
• Inferior right hepatic veins.
• Different ramification pattern of the right, middle and left hepatic veins.
Biliary Tree Anomalies:

• Right posterior duct draining into left HD.
• Trifurcation of CHD.
• Multiple ducts forming CHD.
Donor Radiological Exclusion Criteria

1. Focal or diffuse liver diseases.
2. Fatty infiltration of the liver.
3. Insufficient liver volume.
4. Some portal Venous Anomalies.
5. Some biliary Tree Anomalies.
6. Atherosclerotic disease in the celiac artery.
Fatty liver
Liver Volume
CT Portography
CT Portovenography
CT Portovenography
Normal
CTA at the celiac trunk
MR Portography
MR Portography shows I.M.V. drains into S.M.V.

Note branches of S.M. & I.M.V.
MR Portography shows branches of I.M.V. & its drains into S.M.V.
MR Portography
Normal
Quadrifurcation P.V.
Trifurcation of P.V.
MR Portovenography
MR Portovenography
MR Portovenogram
MR Portovenogram
RT. Anterior branch from Left P.V.
MR Angiography
MRA at the level of celiac trunk
MRA
RT. H. artery from S.M.A.
Lt. H. artery from celiac trunk
MRA
MRA: Stenosed origin of celiac art.
MRA shows hepatic artery arise from S.M.A.
MRI: RT. Inferior hepatic vein.
Biliary systems
The intrahepatic biliary tree and its relation to the hepatic segments
Extra-hepatic bile ducts.
Normal MRCP.
MRCP (from posterior)

Normal
MRCP
Normal
MRCP
RT. Posterior duct into LHD.
(MRCP)
RT. posterior duct draining into left HD.
MRCP

Trifurcation of HD.
MRCP: Trifurcated hepatic ducts
Pre-operative

Recipient
Pre-operative assessment of recipients include:

1- Evaluation of the liver parenchyma and vasculature.

2- Exclusion of intrahepatic and extrahepatic malignancy.

3- Evaluation of venous thrombosis, extensive perihepatic varices, celiac stenosis, splenic artery aneurysm, and incorrect location of a transjugular portosystemic shunt is clinically helpful.

4- The gallbladder is removed in all cases; therefore, identification of abnormalities in it usually does not alter the surgical plan.
Evaluation of Liver Parenchyma:

The liver can appear normal in 25% of patients with cirrhosis.

**CT signs of cirrhosis:**

1- The contour of the cirrhotic liver is usually nodular.

2- Atrophy of the right lobe.

3- Hypertrophy of the lateral segment and caudate lobe.
Nodular liver and enlargement of the left lobe in a 49-year-old female liver transplantation candidate with cryptogenic cirrhosis. CT scan of the abdomen obtained with intravenous administration of contrast material shows that the left lobe of the liver (solid arrow) is enlarged and the right lobe (open arrow) is atrophied. The contour of both lobes is nodular. The spleen is also enlarged.
Enlarged caudate lobe in a 54-year-old female liver transplantation candidate with cirrhosis secondary to alcohol use. CT scan of the abdomen obtained with intravenous contrast material shows that the caudate lobe (*) is hypertrophied and wrapped around the inferior vena cava (arrow). There is also relative atrophy of the right lobe, and the liver contour is nodular.
Hepatic tumour:

Aim of tumour imaging:

1- Selecting the appropriate patient for transplantation.

2- Assessing prognosis.

3- Calculating the cost effectiveness of the procedure.
Role of tumour imaging:

1- Detection of the tumour.

2- Evaluation of the size.

3- Evaluation of the number.

4- Staging of HCC.
Presence & extent of HCC:

Liver transplantation is feasible in patients with stage I or II disease, since it can be curative.

- **Stage I tumors** are those with one tumor nodule less than 1.9 cm in diameter.

- **Stage II tumors** are those with either one nodule 2–5 cm in diameter or up to three nodules each less than 3 cm in diameter. Therefore, if one mass less than 5 cm in diameter or up to three masses each less than 3 cm in diameter are present in the liver without evidence of extrahepatic metastases, transplantation can be performed.
Exclusion criteria for transplantation in HCC generally include:

1- Single HCC large than 5 cm in maximum diameter.
2- More than 3 HCCs of 3 cm or greater.
3- Invasion of P.V. or H.V.
4- Extra-hepatic metastasis.
Hepatocellular carcinoma confined to the liver—not a contraindication to transplantation—in a 47-year-old female transplantation candidate with cirrhosis secondary to hepatitis.
Presence of Cholangiocarcinoma and Other Malignancies

1- Known **cholangiocarcinoma**, especially a hilar tumor, is an absolute contraindication to liver transplantation due to a high recurrence rate of 44%.

2- Detection of a **primary tumor outside the liver**, with or without hepatic metastases, is also an absolute contraindication to transplantation.
Intrahepatic cholangiocarcinoma—a contraindication to transplantation—in a 46-year-old female liver transplantation candidate with sclerosing cholangitis and end-stage liver disease. CT scan of the abdomen obtained with intravenous and oral contrast material shows a hypoattenuating mass in the left lobe of the liver (arrow) that is compatible with tumor. Cholangiocarcinoma was diagnosed by means of percutaneous biopsy. Although the patient was previously considered for transplantation,
Evaluation of portal hypertension & porto-systemic shunts
Cavernous transformation of the portal vein.: multiple collateral vessels (arrow) in the porta hepatis and the absence of the main portal vein, findings compatible with previous portal venous thrombosis. The stomach wall is thickened and enhanced due to gastric varices.
MR Portography shows dilated tortuous short gastric veins with lineorenal shunt
MR Portography shows dilated tortuous short gastric veins with lineorenal shunt
The umbilical vein (arrow) is recanalized and dilated.
MR Portography shows recanalized umbilical vein
Intra-operative of the donor.
The usual surgical procedure involves resecting the RT. Lobe for donation & retaining the left lobe in the donor.

The amount of donated liver about 1% of the recipient’s body mass should be sufficient.
The resection plane is approximately 1cm into the RT. Lobe from the middle hepatic vein & extends inferiorly to the bifurcation between the RT. & left P.V., so that the donor retains the middle H.V.
Illustration A demonstrates intraoperative US performed to map the plane of dissection 1 cm lateral to the middle hepatic vein. Diagram B depicts the argon laser as it scores the liver surface.
Delineation of dissection plane. Color Doppler US scan demonstrates an artifact (arrow) created by scoring of the liver that is 1 cm lateral to the middle hepatic vein (MHV). IVC = inferior vena cava, RHV = right
Post-operative observation & complications

1- Donor.

2- Recipient.
Post-operative observation & Complications:

For donor:

1-- Liver volume.

2- Complication includes:-

A- abscess.

B- bile leakage.

C- liver dysfunction owing to ligation of a major bile duct branch, hepatic artery injury, and duodenal ulcer.
Regeneration of hepatic volume:

A- **In the early phase** (first 2 postoperative weeks), there was rapid regeneration with associated vascular engorgement and tissue edema.

B- **In the second phase** (1–2 months after resection), the volume actually decreased, probably secondary to reduced vascular engorgement and edema.

C- **In the third phase**; there was a continued slow increase in liver volume, which eventually reached a plateau.
Postoperative day 7 in a recipient and donor.
Postoperative day 7 in a recipient MR image shows the transplanted **right** hepatic lobe \( (TP) \) resting in the orthotopic position in the **right** upper quadrant.
Postoperative day 7 in a donor. T1-weighted fat-suppressed axial MR image (200/4.4) demonstrates a perihepatic biloma (B) without associated biliary obstruction. The biloma is depicted as a low-signal-intensity collection that is inseparable from the cut surface of the liver (arrows).
Postoperative day 7 in a donor.
Postoperative day 30 in a **donor**. (a) MRCP shows biliary obstruction due to a hematoma. Dilated ducts (arrows) are depicted in the residual left hepatic **lobe**. The intrapancreatic portion of the extrahepatic bile duct (arrowhead) is normal caliber (1 mm). (b) Gadolinium-enhanced MR image of the **liver** demonstrates that the dilated left hepatic duct (arrows) is obstructed at the cut surface of the **liver**. A hematoma \((H)\) that is nearly isointense relative to the **liver** lies at the cut surface of the **liver**.
Post-operative observation & complications:

For recipient:

1- Liver volume.

2- Major complications include:-
Major complications of the recipient include:-

a- H.A. thrombosis or stenosis.
B- P.V. stenosis of thrombosis.
C- stenosis of the biliary-enteric anastomosis.
D- outflow obstruction of the hepatic vein anastomosis.
F- bile leakage

g- abscess.

H- rejection.
I- Others.
Postoperative day 7 in a recipient. Gadolinium-enhanced T1-weighted axial fat-suppressed MR image (200/4.4) shows the transplanted right hepatic lobe (*), which has undergone hypertrophy.
Hepatic artery complications
Hepatic angiography revealed server stenosed segment at the site of stenosis. Angiogram after PTA.
Portal vein complications
Extrahepatic portal venous stenosis. Balloon dilation of the stenosis was performed.
* CT scan of post-operative recipient liver

Partially thrombosed P.V. ostium.
Transhepatic portal venogram revealed localized segment of stenosis. PTA was done.
Biliary complications
Postoperative day 15 in a recipient. (a) Coronal US scan demonstrates segmental biliary obstruction with a dilated branch of the **right** hepatic duct (arrows). (b) Percutaneous transhepatic cholangiogram shows segmental dilation of the **right** hepatic duct (arrows) due to obstruction at the biliary-enteric anastomosis (arrowhead)
Intrahepatic biloma in a 16-year-old girl 2 months after living related transplantation to treat biliary atresia. Contrast-enhanced CT image shows multiple round low-attenuation areas (arrows) and intrahepatic bile duct dilatation (arrowheads).
Systemic Complications
Posttransplantation lymphoproliferative disorder in a 9-year-old boy 2 years after living related transplantation to treat cryptogenic liver cirrhosis. The patient presented with sudden gastrointestinal tract bleeding. (a) Contrast-enhanced CT image shows a low-attenuation lymph node mass (arrows) that invades the duodenum. The node was proved to be Epstein-Barr virus lymphoma.
(b) Contrast-enhanced CT image was obtained 10 months after a. After chemotherapy, abdominal lymphadenopathy is no longer seen.
Thank You