Technical Considerations in Liver Transplantation

Luis S. Marsano, MD
Professor of Medicine
U. of Louisville & Louisville VAMC
Types

- **OLTX**: Orthotopic liver Tx; placed in the anatomically correct position
- **ALTX**: Auxiliary liver Tx; placement of donor liver in the presence of native liver (part or all).
  - Orthotopic: in correct position after partial removal of native organ.
  - Heterotopic: in other place.
- **SLTX**: Segmental liver Tx; placement of portion of donor-liver.
- **Cadaveric** (whole or split) & **Living-donor**
- **Donor with Cardiac-Death (DCD)**
Technique

- Hepatectomy is the most difficult part of the procedure (bleeding, adhesions, reperfusion coagulopathy, risk of bowel violation); veno-venous bypass can help with bleeding by decompressing portal pressure.
- After [hepatectomy + retrohepatic IVC removal], a cadaveric [liver graft + donor IVC] is placed with a subdiaphragmatic end-to-end IVC interposition.
- Portal vein anastomosis: end-to-end
- Hepatic artery anastomosis: end-to-end
- Biliary reconstruction: duct-to-duct or hepatico-jejunostomy.
Hepatectomy
Technique
Hepatectomy

• Dissection of hilium is most important part.
• Preserve as much length of hepatic artery & portal vein as possible.
• Recipient’s Hepatic artery dissection:
  – starts at Rt & Lt branches, then
  – runs to the confluence,
  – then gastro-duodenal art,
  – finally to common hepatic artery;
  – avoid traction & intimal dissection
Technique
Hepatectomy

• Dissection of cystic duct & CBD:
  – with preservation of surrounding tissue to prevent ischemia/necrosis.

• Portal vein dissection:
  – is done after Hepatic artery and bile duct division;
  – all soft tissue around is removed from liver hilium until pancreas head.
Technique
Hepatectomy Precautions

• Avoid injury to Rt adrenal gland:
  – may cause massive bleed and need adrenalectomy.

• Avoid injury to Rt renal vein during IVC dissection.

• Avoid injury to Rt phrenic nerve:
  – may cause paralysis of Rt hemidiaphragm.
Anhepatic Phase
Technique
Anhepatic Phase

• **Veno-veno bypass:**
  - to decrease hemodynamic instability after clamp of IVC & PV,
  - bypass is done before hepatectomy, from IVC & PV to SVC,
  - heparin bonded cannulae and a motor.

• **Advantages of v-v bypass:**
  - 1. Avoids cardiovascular instability, specially in FHF & non-cirrhotics (no porto-systemic collateral circulation),
  - 2. Decompresses portal v. pressure, decreasing blood loss,
  - 3. Avoids mesenteric stasis/bowel edema, which may cause bacterial translocation,
  - 4. Protects renal function (no Renal vein stasis),
  - 5. Facilitates a safer & longer anhepatic phase, for proper dissection/hemostasis.
Technique
Anhepatic Phase

• Potential Indications for Veno-Venous bypass:
  – Fulminant hepatic failure.
  – Severe retroperitoneal collateralization.
  – Poor pre-operative renal function.
  – Hypotension after “test-clamp” of IVC, despite adequate volume loading.
  – Intestinal or mesenteric edema.
  – Inexperienced with the procedure.
Technique
Anhepatic Phase

• **Disadvantages of v-v bypass:**
  Complications in 10-30%
  – Lymphocoele in inguinal/axillary incision
  – Seroma in cannulae insertion site
  – Hematoma
  – Wound infection
  – DVT
  – Nerve injury
  – Air embolus with death (cannulae removal)

• **Possible alternative:** Piggyback technique.
Implantation
Technique
Implantation

• 1. IVC end-to-end anastomosis:
  – donor’s IVC is interposed into the severed recipient’s IVC (vs piggy-back into recipient’s supra-hepatic veins “common tunnel”)

• 2. Portal vein end-to-end anastomosis:
  – donor to recipient.
  – In PV thrombosis (0.6-64%), can do:
    • a) eversion thrombectomy,
    • b) interposition graft to SMV,
    • c) cavo-portal hemitransposition,
    • d) anastomosis to large venous collateral,
    • e) arterialization of Portal vein
Technique
Implantation

3. Reperfusion of liver with recipient’s blood;
   - unstable time with risk of arrhythmia, hypotension, pulmonary edema, hyperkalemia;
   - liver is pre-perfused with Lactate Ringer or albumin to decrease risk.

4. End-to-end hepatic artery anastomosis.
   - In celiac axis stenosis: use a “donor iliac artery conduit graft” from infrarenal or supra-ceeliac aorta, to the donor’s HA.
   - **Do not use artificial grafts** (high risk for thrombosis or infection).
Technique
Implantation

• 5. Biliary anastomosis ("Achilles tendon" of LTX):
  – a) Choledochocholedochostomy: frequently over T-tube,
  – b) Roux-en-Y Choledochojejunostomy
Standard Technique

Step 1
Step 2
Step 3 = Reperfusion
Step 4
Step 5
Technique
Anhepatic Phase

- **Piggy-back technique** can help to avoid venovenous bypass.
  - Dissection of recipient’s caudate & Rt lobe from retrohepatic IVC to expose Rt, middle & Lt suprahepatic veins.
  - Clamp at IVC junction, then cut of all 3 veins leaving as much afferent hepatic veins as possible.
  - All 3 afferent veins are interconnected to make a single hepatic vein tunnel cuff which opens into the recipient’s IVC.
  - Tunnel cuff will later be connected to the donor’s efferent IVC (afferent donor’s IVC will be ligated).
Technique
Anhepatic Phase

• **Advantages of “Piggy-back” technique:**
  – No need for lower IVC anastomosis
  – Less risk of adrenal gland injury
  – Less risk of renal v. injury
  – Less bleeding
  – Shorter anhepatic phase
  – Less hemodynamic instability; v-v bypass needed only if portal vein clamp causes instability
  – In FHF & non-cirrhotics, temporary porto-caval shunt may be needed to decompress the bowel (no porto-systemic collaterals)

• **Disadvantages of “Piggy-back” technique:**
  – Compression of IVC causing thrombosis (Budd-Chiari like)
Piggyback Technique #2

1a
Donor Middle Hepatic Vein
Donor Left Hepatic Vein
Caudate Lobe
Retrohepatic IVC

1b

1c
Triangulated Hepatic Vein Opening
Recipient IVC
IVC Anastomosis

3 = Reperfusion

1c Ligated
IVC

4
CBD
PV
2

5
HA
Indications for Choledochojejunostomy

- Donor-recipient duct size discrepancy
- Diseased recipient bile duct
  - Primary sclerosing cholangitis
  - Secondary biliary cirrhosis
  - Choledocholithiasis
- Biliary duct malignancy
- Poor blood supply to recipient’s bile duct.
- Inability to pass bile-probe through ampulla.
Post-Procedure
Intraoperative Signs of Hepatic Function

- Restoration of hemodynamic stability
- Adequate urine output
- Acid-base stabilization
- Normalization of coagulation
- Normalization of body temperature
- Maintenance of glycemia
- Adequate bile production
- Good texture & color of liver.
Early Post-operative Signs of Hepatic Function in ICU

- Hemodynamic stability
- Awakening from anesthesia
- Clearance of lactate
- Resolution of hypoglycemia
- Normalization of coagulation/ Factor V
- Resolution of elevated aminotransferases
- Good quantity of golden-brown bile.
Complications
Graft Complications

- **Primary Nonfunction:**
  - Occurs in 4-10% LTX.
  - **Features:** hepatocyte necrosis, *without* vascular complication
    - hepatic encephalopathy,
    - coagulopathy,
    - minimal bile output,
    - renal & multisystem failure,
    - persistent hypothermia,
    - hemodynamic instability,
    - high lactate & liver enzymes.
  - Those with hemodynamic instability or multiorgan failure need urgent retransplantation.
Graft Complications

• **Primary Nonfunction:**
  – Donor risk factors:
    • prolonged cold ischemia,
    • unstable donor,
    • high steatosis,
    • older age,
    • hypernatremia,
    • non-heartbeating donor
Graft Complications

• **Small-for-Size Syndrome**
  – Partial liver graft unable to meet functional demands of recipient: poor early graft function in absence of ischemia.
  – **Prevention**: in cirrhotic “Graft-Weight to Body-Weight Ratio” (GWBWR) must be $\geq 0.85\%$
  – **Manifestations**:
    • Poor bile production
    • Prolonged cholestasis
    • Significant ascites
    • Coagulopathy
Graft Complications

• **Small-for-Size Syndrome**
  - **Biochemical profile:**
    • Elevated Direct (& total) bili
    • Mild/moderate elevation of ALT & AST
    • Prolonged PT
  - **Histologic Features:**
    • Cholestasis with “bile plugs”
    • Areas of regeneration & ischemia with patchy necrosis.
  - **Prognosis:** 50% of recipients will die of sepsis within 4-6 weeks.
Graft Complications

• **Small-for-Size Syndrome**

• Recipient Factors Predictive of poor-outcome/SFSS
  – Graft total mass
  – Poor metabolic & physical recipient condition
  – Advanced chronic liver disease & severe portal hypertension
  – Impaired venous inflow and/or outflow.
Vascular Complications

**Hepatic Artery Stenosis**

- Caliber decrease of > 50%;
- Occurs in 5%.
  - Asymptomatic or elevated liver enzymes.
  - U/S doppler: resistive index < 0.5 with increase in focal peak velocity.

- Therapy:
  - early: surgical repair;
  - weeks later: angioplasty (90% success)
Vascular Complications

**Hepatic Artery Thrombosis**

- Pathogenesis: intimal dissection due to vigorous manipulation or clamping.
  - In children may be asymptomatic (rare in adults).
  - Manifestations:
    - acute, massive necrosis,
    - intrahepatic duct necrosis with central biloma,
    - multiple strictures, or
    - intermittent bacteremia.
Vascular Complications

**Hepatic Artery Thrombosis**

- HAT may be segmental;
  - Lt HAT is usually benign.
  - Rt HAT causes biliary strictures.
- **DX:** angiography.
- **Treatment:**
  - urgent revascularization;
  - may need retransplantation (biliary sepsis, intraabdominal infection)
Portal Vein Stenosis

- **Manifestations:** post-LTX ascites or elevated enzymes.
  - U/S doppler or CT angiography are diagnostic.
  - Confirmed by SMA angiography (late films).
- **Treatment:** Without therapy may evolve to thrombosis.
  - a) early: surgical,
  - b) late presentation: angioplasty or stenting.
Vascular Complications

**Portal Vein Thrombosis**

- Rare.
- May cause graft dysfunction or massive ascites.
- Due to:
  - kinked or redundant vein, or
  - anastomotic stricture/twist, or
  - poor mesentery flow due to “steal syndrome” from venous collaterals.
- **Treatment**: revascularization, +/- ligation of large collaterals.
Vascular Complications

**Hepatic Outflow Obstruction**

- More common after “piggy-back” technique.
- 2.5-6% have iatrogenic Budd-Chiari.
- High morbidity and mortality.
- Due to “rotation” of liver graft or to anastomotic stricture.
- Suprahepatic cava stenosis can cause:
  - liver dysfunction,
  - ascites, or
  - impaired renal function.
- Side-to-side cavo-cavoplasty may be protective.
- **DX:** cavagram with measurement of pressure gradient
- **Treatment:** angioplasty, stent, or surgical repair
Biliary Complications

- **Incidence**: 15-20%.
- **Mortality**: 10%.
- **Presentation**: nonspecific; elevation of bili, alk. phosph & GGT.

- **Biliary stenosis**:
  - Is the most common complication;
  - Due to imperfect anastomosis or ischemia.
  - May cause abnormal enzymes or recurrent cholangitis.

**Treatment**:
- Dilatation + stent (ERCP or PTC).
- May need creation of, or revision of choledochojejunostomy.
Biliary Complications

- **Ampullary dysfunction:**
  - Due to cut of hepatic branch of vagus?
  - Causes Donor+Recipient Bile Duct dilation.
- **Treatment:**
  - sphyncterotomy or conversion to choledochojejunostomy.
Biliary Complications

- **Multiple Intrahepatic Strictures:**
  - May be due to:
    - HA thrombosis/stenosis (more frequent in non-heart-beating donors),
    - Preservation damage,
    - Immune injury (lymphocytotoxic (+) cross-match),
    - Recurrent PSC,
    - CMV/ cryptosporidium/ microspora infection.
  - **Treatment:**
    - antibiotic prophylaxis;
    - may need retransplantation.
Biliary Complications

• **Bile leak:**
  – In c-c anastomosis:
    • usually at T-tube site & self-contained.
  – In c-j anastomosis:
    • may be lethal due to infection that makes repair difficult (friable & edematous)
    • high risk of mycotic rupture of hepatic artery anastomosis.
Biliary Complications

• **Roux-en-Y loop complications:**
  
  a) **Bleeding at jejunojejunostomy:**
     - self limited in half; need surgical hemostasis in other half.
  
  b) **Internal mesentery hernia at j-j anastomosis;**
     - Causes unexplained abdominal distention and vomiting, due to small bowel volvulus.
     - May be lethal due to bowel necrosis.
     - **DX:** CT scan showing “closed loop obstruction”.
     - **Treatment:** surgical closure of mesentery defect.
Live-Donor Adult Liver Tx

• 5% of transplants in USA. (learning curve = 20 cases)
• Only 30-45% of potential donors donate;
• Aborted hepatectomy in 5% of donors
• Donor relation:
  – 30% offspring, - 20% sibling,
  – 20% parent, - 20% unrelated,
  – 10% other relative/unknown.
• Donor age: 50% > 50 years old.
• Donor risk: (14 death, 1 vegetative state, 2 LT/ 6-7000 live-donors)
  – 0.4% mortality,
  – 0.4-0.6% catastrophic complication, &
  – 35% morbidity
• Patient survival: equal to cadaver-donor.
Live-Donor Adult Liver Tx
Disease-Specific Considerations

• HCC:
  – Must fulfill Milan Criteria

• HCV:
  – Is acceptable indication, but appropriate timing needs further investigation (not too early).

• FHF:
  – Acceptable indication for emergency transplantation.
Live-Donor Adult Liver Tx

Donor Evaluation

- Complete history & physical with “ideal & actual body weight”.
- No smoking.
- Stop BCPs before surgery.
- Laboratory:
  - CBC, - CMP,
  - serologic testing, - comprehensive coagulation profile,
  - markers of liver disease, - other tests as indicated by Hx & PE.
- Psychosocial evaluation.
Live-Donor Adult Liver Tx
Donor Evaluation

- **Radiology:**
  - liver volume & vascular anatomy;
  - biliary anatomy pre-op or intra-op.

- **Pre-op liver Bx is controversial. Do it if:**
  - abnormal enzymes, or
  - steatosis by imaging, or
  - BMI > 30,
  - donor genetically related to patient with AIH, PSC, or PBC
Live-Donor Adult Liver Tx

Donor Evaluation

• Donor age-limit of 60 is considered appropriate.
• BMI > 30 may increase risk to donor, but is not absolute contraindication.
• Volumetric imaging analysis may overestimate liver volume by 10%.
• Calculated donor-remnant should be at least 30% of original liver volume & with complete venous drainage.
• Graft-liver-volume to recipient-body-weight ratio (GWBWR) should be =/> 0.8%. (larger in portal-HTN)
• Later: Avoid excessive portal v. inflow and assure excellent hepatic vein outflow to prevent “graft flooding”.
Live-Donor Adult Liver Tx

Donor Evaluation

- ABO compatibility is recommended.
- ABO incompatible only in:
  - a) infants,
  - b) child < 1y/o without isoagglutinins,
  - c) emergency situation where no deceased-donor available

- Lab contraindications: HIV, HCV, HBsAg(+), anti-HBc(+)
- Thromboembolism & stress ulcer prophylaxis recommended.
- Autologous blood storage should be offered.