## REFERENCES

For references, please visit **www.TheAnesthesiaGuide.com**.

# CHAPTER 81
# Liver Transplant

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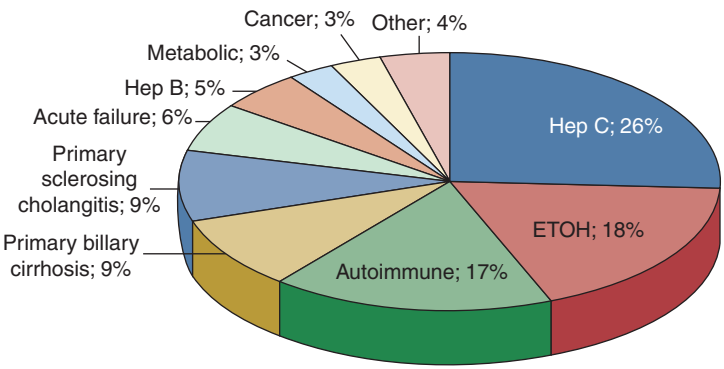
## PREOPERATIVE

**FIGURE 81-1. Indications for liver transplant**




*4000–600 liver transplants in the US/year over the last 10 years. Only 300–400 of these are living donor transplants.*

## CONTRAINDICATIONS

### Absolute

Pulmonary hypertension: mean pulmonary artery pressure > 45 mm Hg
- Recidivism to alcohol and drug abuse
- Extrahepatic malignancies
- Systemic sepsis

### Relative

- Pulmonary hypertension: mean pulmonary artery pressure > 35 mm Hg
- Significant cardiopulmonary disease
- Poor psychosocial support or compliance
- In the case of hepatocellular carcinoma ("Milan criteria")
  - 1 tumor > 5 cm
  - >3 tumors < 3 cm
  - Presence of extrahepatic tumors
  - Presence of vascular invasion

| TABLE 81-1 Liver Failure and Associated Morbidities | |
|---|---|
| Neuro | • Encephalopathy<br>• Increased intracranial pressure (with fulminant liver failure)<br>• Coma |
| Respiratory | • Hepatopulmonary syndrome<br>▸ Transpulmonary shunts with paradoxical improvement of $SaO_2$ in supine position (orthodeoxia)<br>• Atelectasis from ascites<br>• Aspiration risk |
| Cardiac | • Hyperdynamic state of cirrhosis<br>▸ Low SVR, high cardiac output, splanchnic vasodilation<br>• Portopulmonary hypertension<br>• Mean PAP >35 mm Hg relative contraindication for liver transplantation |
| GI | • Delayed gastric emptying and increased intra-abdominal pressure (ascites)<br>▸ Rapid sequence induction<br>• Esophageal varices |
| Renal | • Hepatorenal syndrome<br>▸ Type I: doubling of serum creatinine within 2 weeks<br>▪ Mean survival: 1 month<br>▸ Type II: increase of serum creatinine > 1.5 mg/dL<br>▪ Mean survival: 6 months<br>• Relative hypovolemia<br>• Hyponatremia |
| ID | • Immunosuppression<br>• Spontaneous bacterial peritonitis |
| Hematology | • Myelosupression<br>▸ Anemia<br>▸ Leukopenia<br>• Thrombocytopenia from hypersplenism<br>• Coagulopathy of liver disease<br>▸ Frequently hypo-/hypercoagulable disease |

## ANESTHESIA

Routine setup of liver room at Columbia University Medical Center (courtesy of Dr. Tricia Brentjens)

### Drugs

#### Induction and maintenance

- Propofol
- Etomidate
- Midazolam (have 10 mg available)
- Fentanyl (have 3 mg available)
- Succinylcholine
- Cisatracurium (have 200 mg available)
- Isoflurane (have 2 full bottles available)

#### Vasoactive drugs

- Epinephrine 100 mcg/mL, 10 mL
- Epinephrine 10 mcg/mL, 10 mL
- Calcium chloride 1 g in 10 mL (have 10 vials available)
- Phenylephrine 40 mcg/mL, 10 mL syringe, and 250 mL bag

- Ephedrine 5 mg/mL, 10 mL
- Atropine 100 mcg/mL, 10 mL
- Sodium bicarbonate 50 mEq (have 10 vials available)

### Others

- Magnesium sulfate 2 g (4 mL of the 0.5 g/mL solution): Not drawn up!
- Methylprednisolone sodium 500 mg
- Mannitol 12.5 g/20 mL: Not drawn up
- Acetylcysteine: discuss with your attending physician
  - Load: 150 mg/kg in 200 cc over 1 hour
  - Maintenance: 50 mg/kg in 500c c D5W over 4 hours
  - Then 100 mg/kg in 1 L D5W over 16 hours

### Mandatory infusions

- Norepinephrine 4 mg/250 mL N saline
- Vasopressin 100 U/100 mL N saline
- Furosemide 100 mg/100 mL N saline

### Have available

- Dopamine 200 mg/250 mL premix bag
- Dobutamine 250 mg/250 mL premix bag
- Nitroglycerin 50 mg/250 mL premix bottle
- Aminocaproic acid (Amicar) — antifibrinolytic: various protocols

## Monitors

### Routine monitors

- EKG 3 channels: I, II, V
- $SpO_2$
- NIBP cuff of medium, large, extra large sizes

### Hemodynamic monitoring

- Do not heparinize pressure lines/bags!
- Three pressure transducers on the right: for right femoral artery, PA, CVP
- One pressure transducer on the left: for left radial artery
- Pediatric CVL kit [20 g] for femoral arterial line
- Assorted 20 G cannulas for radial arterial line placement
- Double lumen Cordis for IJ placement
- Oximetric PA catheter (needs to be calibrated prior to insertion)

## IV setup

- All IVs are primed with PlasmaLyte except when otherwise indicated
- Rapid transfuser FMS2000 primed
- Two IV lines on warmers
- Venous infusion port (VIP) on microdrip with six ports for IV drips
- Call the blood bank and check on available products:
  - 10 PRBCs, 10 FFP, and 12 platelets

## Others

- Point of care arterial blood gas (ABG) analyzer with at least 20 cartridges
- Multiple test tubes for complete blood count (CBC) and coagulation studies
- Two forced air warming machines with upper and lower body blankets
- For CVVHD: high-flow set for the blood warmer on the left side of the OR table to warm the returning limb of CVVH

## MONITORING

- Arterial catheter (femoral and radial)
  - Radial artery catheter often dampens during anhepatic phase
- PA catheter
  - Maximize cardiac output
  - Measure PA pressures
- Pulse pressure variation (PPV)
  - Allows estimate of volume responsiveness
- Point of care arterial blood gas analyzer
  - Measure pH, acidemia, hematocrit, potassium
- Point of care coagulation test: thrombelastography or rotational thromboelastometry (ROTEM®)
  - Allows estimation of global *in vivo* hemostasis including coagulation factor defects, platelet function, abnormal fibrinogen polymerization, anticoagulant defects and hyperfibrinolysis

## INDUCTION

- Rapid sequence induction for almost all patients (ascites)
- Patients are hyperdynamic with low SVR and maintain cardiac output with increased endogenous catecholamines: beware of hypotension after induction
- Most induction drugs will need a higher dose and have a delayed onset (larger volume of distribution) but have a prolonged half-life time (decreased hepatic metabolism)

## MAINTENANCE

### Surgical technique

#### Complete caval clamping

Vena cava is clamped completely above and below the liver and the donor cava is anastomosed end-end to the recipient.

*Advantages:*
- Fast
- Simpler (and possibly better) caval anastomosis

*Disadvantages:*
- Severe hypotension due to loss of preload during anhepatic phase
- Renal outflow obstruction and renal injury

### Veno-venous bypass

Cannulation of portal vein and femoral vein with return of blood through a bypass pump either to a cannula in the axillary vein or the internal jugular vein. Anticoagulation is rarely required if heparin coated circuits are used.

*Advantages:*
- Hemodynamic stability during anhepatic phase
- Adequate renal venous drainage
- Less intestinal engorgement from portal occlusion

*Disadvantages:*
- Cumbersome
- Technical complications from access

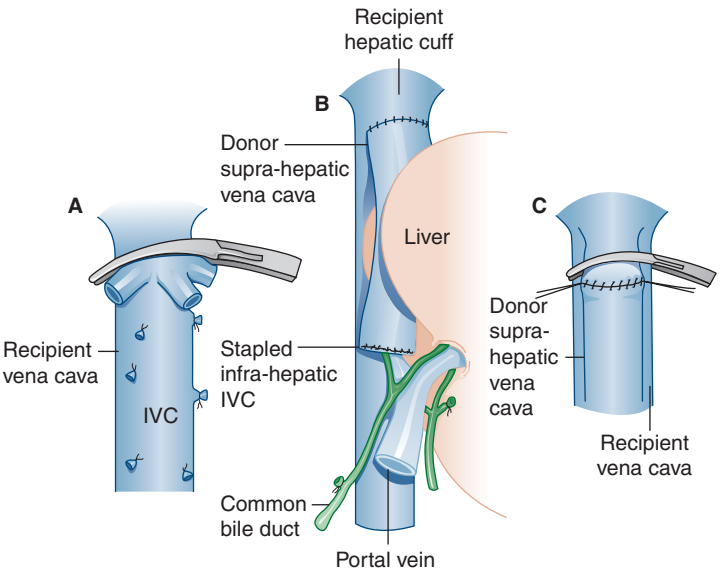
### Piggyback technique

Instead of replacing the vena cava with a typical bicaval approach, the recipient vena cava is preserved, and an anastomosis is created between the donor suprahepatic cava and a cuff of the recipient hepatic veins. Partial occlusion of the vena cava at the level of the hepatic veins. Partial caval blood flow is maintained throughout.

*Advantages:*
- Less hemodynamic instability
- Renal venous drainage is maintained

*Disadvantages:*
- Caval anastomosis is technically more difficult
- Portal occlusion may still cause intestinal engorgement (may be alleviated with temporal portocaval shunt)

**FIGURE 81-2. Piggyback technique of liver transplantation**




*The recipient vena cava is preserved, and an anastomosis is created between the donor suprahepatic vena cava and a cuff of the recipient hepatic veins.* Reproduced from Minter RM: *Current Procedures: Surgery*. Figure 32–7A–C. Available at: www.accesssurgery.com. Copyright © The McGraw-Hill Companies, Inc. All rights reserved.

**TABLE 81-2** Four Phases of Liver Transplantation

| | |
|---|---|
| **Pre-anhepatic/ dissection phase** | • Bleeding due to dissection in area of portal hypertension<br>• Correct coagulopathy, anemia, and optimize volume status |
| **Anhepatic** | • Low preload and cardiac output despite low SVR<br>• Acidosis: unable to metabolize lactate |
| **Reperfusion** | • Possibly sudden<br>▸ Acidosis<br>▸ Hyperkalemia<br>▸ Pulmonary hypertension<br>▸ Right ventricular distension and failure<br>▸ Cardiac arrest |
| **Neohepatic phase** | • If the liver functions well: within hours improvement of<br>▸ Acidosis<br>▸ Coagulopathy<br>▸ Vasodilatory state |

## PRE-ANHEPATIC/DISSECTION PHASE

### Bleeding due to dissection in area of portal hypertension

- Treat only clinical bleeding, not laboratory numbers:
  - Increased INR can be associated with hypercoagulability (deficiency of liver derived protein C and S and other anticoagulant factors)
  - Thrombelastography/rotational thrombolastography (ROTEM) may detect specific coagulation defects
- Maintain isovolemia and optimize fluid status:
  - Occult blood loss from retroperitoneal dissection or bleeding from collateral veins
  - Acute fluid loss when ascites is drained
- Do not transfuse platelets unless platelet count low, clinical bleeding evident and after consultation with the surgery team
  - Platelets sequester in the spleen and platelet transfusion is associated with increased thrombotic complications
- Often furosemide is required to maintain urine output and create intravascular "room" for transfusion of coagulation factors (plasma)

## ANHEPATIC

### Low preload and cardiac output despite low SVR

- Requires adequate preload especially with caval cross-clamping
  - Goal CVP 12–15
- The anesthesiologist needs to be confident that he/she will be able to maintain adequate hemodynamics during the anhepatic phase before the liver is removed
- Often requires high doses of vasopressors
  - Norepinephrine 2–10 mcg/min
  - Vasopressin 1–4 units/h
  - Goal: MAP 60 mm Hg or within 20% of preoperative BP
  - No urine output during anhepatic phase may indicate worse renal outcome
- Acidosis: unable to clear lactate during anhepatic phase
  - Treat aggressively with sodium bicarbonate (50–100 mEq over 20 minutes) as acidosis will worsen with reperfusion
- Large fluid administration during the anhepatic phase will cause volume overload and possible right heart failure with reperfusion
  - Use preferentially vasopressors to maintain blood pressure
- We routinely give 2 g magnesium sulfate IV over 10 minutes during anhepatic phase to prevent arrhythmias during reperfusion
- Check arterial blood gas 20 minutes prior to reperfusion to detect treatable abnormalities: acidosis, hyperkalemia, hypocalcemia

## REPERFUSION

Washout of graft often associated with sudden:

- Acidosis
- Hyperkalemia: closely watch T waves
- Pulmonary hypertension
- Right ventricular distension and failure
- Cardiac arrest
  - Reperfusion will be worse with prolonged cold or warm ischemic time, steatotic grafts or with organs after donation after cardiac death (DCD)
  - Consider requesting from surgeon to flush the graft with portal vein blood prior to finishing the caval anastomosis, or slow reopening of portal vein
  - Aggressively treat:
    - Hyperkalemia: Insulin/glucose, bicarbonate, $CaCl_2$
    - Hypocalcemia
    - Acidosis: bicarbonate and hyperventilation
    - Hypotension: vasopressors, epinephrine in 10–30 mcg intravenous boluses

## NEO-HEPATIC

*If the liver functions well: within hours, improvement of*

- Acidosis
- Coagulopathy
- Vasodilatory state
  - Excessive fibrinolysis possible due to graft reperfusion and release of tissue plasminogen activator (tPA): consider transfusion of cryoprecipitate
  - Avoid platelet transfusions especially if hepatic artery or portal vein anastomosis is precarious. Discuss with surgical team

## POSTOPERATIVE

Extubation in the operating room is possible but little benefit

**TABLE 81-3 Early Complications after Liver Transplant**

| | |
|---|---|
| 0–24 h | • Bleeding<br>• Graft failure<br>  ▸ Hepatic artery thrombosis<br>  ▸ Portal vein thrombosis<br>  ▸ Early graft failure/delayed graft function<br>• Vasodilatory shock |
| 1–5 days | • Acute kidney injury<br>• Infection<br>• Bile leak<br>• Prolonged respiratory failure |
| >5 days | • Rejection<br>• Malnutrition<br>• Prolonged hepatic failure<br>• "Failure to thrive" |

*Diagnostic features and therapy of early complications*

### Bleeding

*Diagnosis:*

- Increased drain output (consider checking drain fluid hematocrit)
- Increased abdominal girth (measure hourly)
- Increased intra-abdominal pressure (measure hourly)

*Rx:*

Correction of coagulopathy

If bleeding persists or substantial bleeding: re-exploration

### Hepatic artery or portal vein thrombosis

*Diagnosis*

- Persistent
  - Metabolic (lactate) acidosis
  - Elevated total bilirubin
  - Coagulopathy
  - Ascites
  - Vasodilatory state and high vasopressor requirements
  - Low urine output and worsening acute kidney injury

- Late and severe cases:
  - Persistent hypoglycemia
  - Depressed mental status/encephalopathy
  - Hypothermia
- Diagnosis confirmed by Doppler ultrasound
- Elevated transaminases are due to (ischemic) injury to the liver and not necessarily a sign of dysfunction

*Differential diagnosis*
- Early allograft dysfunction due to
  - Primary non-function
  - Small for size syndrome

*Rx:*
- Re-exploration
- Rarely amenable to endovascular intervention

### Bile leak

*Diagnosis*
- Persistent
  - Bilous fluid from drains
  - Increased total bilirubin, alkaline phosphatase (AP) and gamma-glutamyltranspeptidase (γ-GT)
  - Fever, malaise
- Diagnosis confirmed by ultrasound (intra-abdominal fluid) and drain fluid total bilirubin concentration

*Rx:*
- Re-exploration (breakdown of biliary anastomosis often due to ischemic injury to the bile) and possibly Roux-en-Y revision
- Percutaneous drainage
- Endoscopic biliary stent placement

Acute rejection

*Diagnosis*
- Days after surgery
  - Worsening liver function
  - Increasing total bilirubin and transaminases
  - Malaise and fever
- Diagnosis confirmed by biopsy

*Rx:*
- Increased immunosuppression
- Pulse steroids
- OKT-3 (muromonab-CD3 antibody)

## PEARLS AND TIPS

- Magnesium (2g IV over 20 minutes) during the anhepatic phase may stabilize membranes and ameliorate cardiac arrhythmias of reperfusion
- Avoid platelet transfusion postoperative if there is concern about the patency of the hepatic artery anastomosis

## REFERENCES

For references, please visit **www.TheAnesthesiaGuide.com**.