Anesthesia for Liver Transplantation Guidelines: Recipient

**Transplant Team**

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<th>Email</th>
</tr>
</thead>
<tbody>
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</tbody>
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**CPT Codes:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Code</th>
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<tbody>
<tr>
<td>Liver Transplantation (Recipient) Anesthesia</td>
<td>00796</td>
</tr>
<tr>
<td>Liver Transplantation Surgery</td>
<td>47135</td>
</tr>
</tbody>
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**Useful Numbers:**

<table>
<thead>
<tr>
<th>Service</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab</td>
<td>Satellite Lab: x88700, Main Lab: x86224</td>
</tr>
<tr>
<td>Blood</td>
<td>Transfusion Support: x86240, University District Lab: 522-2462</td>
</tr>
<tr>
<td>Drugs</td>
<td>Pharmacy Main OR: x84194, Main Hospital Pharmacy: x84088 or x84999</td>
</tr>
<tr>
<td>OR</td>
<td>OR Charge RN: x87914, Main OR Front desk: x89608 or x84270</td>
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**Pretransplant considerations**

**Room set-up**

**Medications:**

- Transplant / cardiac anesthesia cart
- Orange liver transplant medication box

**Resuscitation medications:**

- Calcium Chloride, 1000 mg, 10 ml syringe(s)
- Epinephrine, 10 μg/ml, 2 x 10 ml syringes
- Phenylephrine, 100 μg/ml, 2 x 10 ml syringes
- Vasopressin, 1 unit/ml, 1 x 20 ml syringe

**Other medications:**

- Midazolam 2 mg, 1 vial
- Cisatracurium 20 mg, 4 vials
- Fentanyl 250 μg, 1 vial
- Fentanyl 1000 μg (20 ml), 1 vial
- Propofol, 100 ml bottle, 1 bottle (Sedation for post-op transfer to ICU)
- Furosemide – 100 mg vial
Infusion solutions for Alaris 4-channel infusion pumps:

- Carrier: NACL, 1000 ml; 50 ml/hour
- Vasoactive agents:

<table>
<thead>
<tr>
<th>Name</th>
<th>Solution</th>
<th>Baseline Infusion Rate Setting</th>
<th>Minimum – Maximum dose (µg/kg/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Epinephrine</td>
<td>5 mg in 250 ml D5W</td>
<td>0.01 µg/kg/min</td>
<td>0.05 – 0.1*</td>
</tr>
<tr>
<td>2. Norepinephrine</td>
<td>20 mg in 250 ml D5W</td>
<td>0.1 µg/kg/min</td>
<td>0.1 – 1.0*</td>
</tr>
<tr>
<td>3. Phenylephrine</td>
<td>50 mg in 250 ml D5W</td>
<td>0.1 µg/kg/min</td>
<td>0.2 – 1.0*</td>
</tr>
<tr>
<td>4. Nitroglycerine</td>
<td>50 mg in 250 ml D5W</td>
<td>0.5 -1 µg/kg/min</td>
<td>0.5 – 3.0*</td>
</tr>
</tbody>
</table>

- Insulin, regular 1 unit/ml

Infusion solutions for Alaris 2-channel syringe driver pump:

<table>
<thead>
<tr>
<th>Name</th>
<th>Infusion Solution</th>
<th>Baseline Infusion Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisatracurium</td>
<td>40 mg, 20 ml syringe</td>
<td>1.0 µg/kg/min</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>1000 µg, 20 ml syringe</td>
<td>1.0 – 5.0 µg/kg/hr</td>
</tr>
</tbody>
</table>

Check with the Transplant Anesthesia Attending before setting up the infusions

Fluids and blood products:

- Colloids: 1000 ml 5% Albumin in OR (500 ml in orange transplant box)
- Crystalloid solutions:
  Plasmalyte is the crystalloid IV solution of choice.
  0.9% Saline may be used for filling the Bellmont canister and as a vehicle/carrier fluid for all infusions only. Avoid using Lactate Ringer.
- Blood products: 10 units of packed cells in the portable blood refrigerator in the OR; 10 units and more are always available.10 units unthawed FFP + 2 units unthawed Cryoprecipitate should be available.

Induction of Anesthesia

- Patients for liver transplants are often called in from home and may not have had sufficient NPO time. Modified rapid sequence induction of anesthesia should be performed.

Medications at this phase:

- Ceftriaxone, 2000 mg, i.v. (or other antibiotic), in the OR around induction time.
- Methylprednisolone, 1000 mg, I.V., Administer around induction or shortly thereafter.

Monitors: Standard ASA monitors, Defibrillator, CO monitor.

- Advanced cardiac monitoring is a standard of care. PA catheter is the most commonly used; TEE can be used as an alternative method.

Standard Lines:

- 1 - 2 Arterial line(s)
- Triple-Cordis with PA catheter
Line Connections:

- Belmont rapid infusion pump tubing - directly to the 9 Fr (brown) port of the Triple-Cordis line
- Hotline - to the 12 G (white) port of the Triple Cordis line
- Infusion pump tubing through 2 consequently connected T-quad tubes - to the white port of PA-line. Connect inotrope infusion tubs close to the patient’s end (first T-quad), and all the rest (Fentanyl, Cis-atracurium, Insulin, Amicar, etc.) – to the second T-quad tube

Naso-gastric tube insertion:

- Apply vasoconstrictive nasal spray (Phenylephrine, located in orange transplant box) to both nostrils before naso-gastric tube is inserted to avoid epistaxis

Heating devices:

- Lower body bear Hugger with Thermo-regulation mattress underneath

Events/Times to be documented

- Portal vein clamp (anhepatic start)
- IVC clamp
- Reperfusion

Labs:

- Baseline: ABG with lactate, Emergency hemostasis panel (PT/aPTT, Fibrinogen), and TEG, (two blue-cap, 1 purple cap tubes for TEG and emergency hemostasis panel). Repeat as indicated.

Intraoperative management

1. Pre-anhepatic phase (Stage I):

   - During this stage, removal of the recipient’s liver is performed. Approximately 50% of overall estimated blood loss occurs during dissection stage.

2. Anhepatic phase (Stage II):

   - Started when portal vein is clamped. IVC full (total) or only partial clamp may be used.
   - Alprostadil infusion: To surgeons’ request, start Alprostadil infusion at 0.2mcg/kg/h, increase to 0.6-0.8 mcg/kg/h as tolerated.

3. Reperfusion (Stage III)

   - Hemodynamic instability during recirculation of the liver graft range from mild, transient hypotension and bradycardia to cardiac arrest, requiring full CPR. The usual problem is rapid decrease of SVR, less contractility.
   - Definition of Post-reperfusion syndrome (PRS) (Aggarwal, 1986): MAP > 30% depression of MAP from baseline, occurs within 5 minutes, and lasting more than 1 minutes.
   - Medications to use for resuscitation: Phenylephrine, 100-300 mcg, Ephedrine, 5-15 mg, Vasopressin, 1-5 units, Epinephrine, 10-100mcg, Methylene blue 1.0-1.5mg/kg, Calcium Chloride 1g, etc.
   - Acid-base status disturbances treated as outlined below (See: Additional considerations, 3. Acid-Base status management)
4. **Neo-hepatic phase (Stage IV):**

- During this stage, hepatic artery anastomosis, cholecystectomy, bile duct anastomosis and wound closure are performed.
- Common problem: Increase of PA and CVP pressures, along with liver graft congestion. Goal of treatment: keep systolic PA pressure lower than 35 mmHg, CVP lower than 12-15 mmHg.

**Management:**
- Decrease Belmont flow rates
- NTG infusion start at 0.5 mcg/kg/min, increasing to 1 – 1.5 mcg/kg/min
- Decrease phenylephrine or norepinephrine rates to necessary minimum
- Furosemide, IV bolus
- Decrease PEEP

**Additional Considerations:**

1. **Estimated Blood Loss calculation**

   \[ EBL \sim \text{Volume of Cell Saver return} \times 3.5 \]

2. **Coagulation deficit management**

   - For coagulation deficit correction, Thrombo-Elastogram (TEG) should be used to guide the treatment, as outlined in the laminated manual in OR-13.
   - Only if fibrinolysis is present, Aminocaproic acid administration may be considered.

3. **Acid-Base status management**

   - Moderate-to severe lactic acidosis is a common event in liver transplantation.
   - **Tromethamin (THAM) Dosage calculation:**
     \[ \text{THAM Solution} (\text{mL of 0.3 M}) = \text{Body Weight} (kg) \times \text{Base Deficit} (\text{mEq/L}) \times 1.1 \]
   - Sodium Bicarbonate is indicated as acute treatment of severe intractable metabolic acidosis after reperfusion or following CPR. Dosage: \[ 0.2 \times \text{weight} (kg) \times \text{base deficit}, \text{or } \text{HCO}_3 (\text{mEq}) \text{ required} = 0.5 \times \text{weight} (kg) \times [24 - \text{serum HCO}_3 \text{ (mEq/L)}]. \]
   - Acute dialysis may be considered for severe lactic acidosis

4. **Intra-operative dialysis**

   - In cases, where intra-operative dialysis is indicated and planned, anesthesiologist may be asked to insert MAHURKAR™™ 11.5Fr Dual Lumen Acute Dialysis Catheter. It is preferable to insert Triple-lumen MAC and flow PA catheter in the left internal jugular vein, and then Dialysis catheter in the right internal jugular vein. It is possible to insert both catheters in the RIJ; in this case, CVP measurement may be inaccurate.
   - Fluid extraction rates may vary in the range of 0 to 500 ml/h, usually 250-500ml/hr .Mean BP lower than 70, increasing requirement for vasopressors dosage require extraction rate adjustments.

5. **Pulmonary hypertension and porto-pulmonary syndrome management**

   - Definition: Pulmonary hypertension: an elevation of Mean PAP>25mmHg at rest; mild 25-35mmHg, moderate >35 and <45 mmHg, and severe >45mmHg
   - **Epoprostenol IV continuous Infusion:** 4 ng/kg/min less than the maximum tolerated infusion rate, through dedicated central line.
   - **Nitric Oxide inhalation,** 5-20 ppm. Requires special equipment and setup, presence of RT
   - Keep infusion rates to necessary minimum
- NTG infusion, 0.5-1.2mcg/kg/min, as tolerated
- Furosemide, 40-100 mg

**Postoperative management:**

- All blood products transfusions should be completed, unless their continuation is indicated by clinical necessity
- For patient sedation during transfer, Propofol, 50-75 mg/kg/min is recommended, as tolerated; Etomidate, 0.1-0.2 mg/kg may be used for unstable patients
- Typical set of infusions for transfer may include:
  - Carrier fluid, 50-100ml/h
  - Phenylephrine infusion
  - Insulin infusion
  - Propofol infusion
- Unless necessary, defibrillator pads wires are disconnected from defibrillator cable and will be used for ECG monitoring during transfer.
- After surgery is completed, patient remains sedated, intubated and ventilated, and will be directly transferred to the ICU by anesthesia team. Anesthesia Resident and Attending both are present throughout transfer and handover in the ICU.

**References:**