Liver Transplant Protocol

Loma Linda University Medical Center, Updated May 2021

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The Anesthesia Team

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The resident on cardiac call typically also covers liver call, unless there is a cardiac case going. In this case, the senior resident may cover the liver transplant case.

The cardiac rotation is a pre-requisite for doing a liver transplant, as the resident must be proficient in placing large bore lines and managing vasoactive drips.

One anesthesia technician is dedicated to the liver transplant room. Their many responsibilities include setting up lines/transducers, bringing necessary equipment to the OR, keeping a steady supply of blood products, and transporting blood samples.

Patient Selection and Preparation

Every patient on the transplant list has completed a comprehensive evaluation and deemed suitable for transplant by the liver selection committee. Prior to taking the patient to the OR a thorough pre-operative anesthesia evaluation must be done, summarizing the most recent labs and work-up that has been done.

In patients with altered mental status the results of a head CT must be reviewed as well as documentation for the need or lack thereof of an ICP monitoring device. However, ICP monitoring is uncommon. If no head CT is done, a discussion with the surgical team is highly recommended. A baseline pupillary exam should be done and documented.

Liver transplant recipients are notified by the transplant coordinator of the availability of an organ for transplantation and will come to the hospital the day of surgery. Some recipients are already admitted to the hospital.

Organ Procurement

The organ procurement process is strictly overseen by United Network for Organ Sharing (UNOS), based on the patient's MELD Score. Organs can be procured locally, within California, or even out of state. Considering the negative effects of ischemia time on outcomes, the OR as well as the anesthesia service director are notified ASAP when the surgical team is considering an organ. Effective coordination between the surgical team, the anesthesia team and OR staff is paramount in minimizing ischemia time.

As such, at times the patient can be brought to the OR even before the liver is deemed acceptable for transplantation. However, the patient should not be put to sleep unless the decision is made to transplant the organ procured. The surgical team is primarily responsible for this communication.

Operating Room Setup

Drugs/Infusions

1. Anesthetic drugs:
   a) Propofol or Etomidate dependent on hemodynamic status
   b) Rocuronium (modified rapid sequence dose, 1—1.2mg/kg)
   c) Fentanyl
   d) Lidocaine
2. Resuscitative drugs:
   a) Phenylephrine 100mcg/cc syringe x 4
   b) Epinephrine 10mcg/cc syringe x 4
   c) Epinephrine 100mcg/cc syringe
   d) Calcium chloride 1mg syringe x 4
   e) Sodium bicarbonate syringe x 4
   f) Dextrose 50% amp x 1
   g) Atropine syringe x 1
   h) Nitroglycerin syringe 40mcg/cc (diluted)
3. Infusions:
   a) Norepinephrine drip 8 mg in 250 ml NS (32mcg/ml) –inline
   b) Vasopressin drip 20 Units/100 mL NS typical rate 0.04 U/min –inline
   c) Octreotide drip 1250 mcg in 250 mL NS, running at 25—50 mcg/h –inline
   d) Epinephrine drip 8 mg in 250 NS (32mcg/ml) –inline
   e) Insulin drip 100 Units in 100 mL NS (1unit/mL) –available

Orders to place PRE-OP

1. Blood products: 10 pRBC, 10 FFP (prepared AND released)
2. Octreotide drip (call pharmacy once order is placed as a courtesy reminder)
3. TEE (ANES performed) Indication = liver transplant
4. ABG (PRN/Recurring)

Equipment/Supplies

1. Liver transplant drug cart, a.k.a. "crash cart" (anesthesia tech to bring)
2. Standard ASA cardiac setup
3. Arterial line (anesthesia tech to setup)
4. Central venous catheters with a CCO pulmonary artery catheter (anesthesia tech to setup)
    a. Typically "double stick" central access with placement of MAC and Cordis catheters
    b. MAC → connect to drips, hotline, and PA catheter
    c. Cordis → connect to rapid infuser
    d. Occasionally, a peripheral 14G or 16G IV may be secured and used for rapid infusion in place of the Cordis. Discuss this with the anesthesiologist attending for patient selection.
5. Rapid infuser device (anesthesia tech to setup and prime with albumin 5%)
6. Infusion pumps (see "Infusions" above for medication concentrations and rates)
    a) Carrier (N/S)
    b) Norepinephrine
    c) Vasopressin
    d) Epinephrine
    e) Octreotide (order from pharmacy)
    f) Available open infusion pumps x2 (for insulin, propofol, etc., as needed)
7. Blood warmer (anesthesia tech to setup)
8. SEDLINE & NIRS cerebral oximetry
9. TEE. *Avoid obtaining trans-gastric TEE views (attending dependent)
10. Ultrasound for line placement
11. Defibrillator in room with R2 pads applied on patient
12. Arterial blood gas syringes
13. Baer Hugger (upper and lower extremity), foil warming cap, gel donut (preferred to foam donut)
14. Cell Saver per surgeon request. Anesthesia tech to setup. *AVOIDED in hepatocellular carcinoma*.

Blood Bank

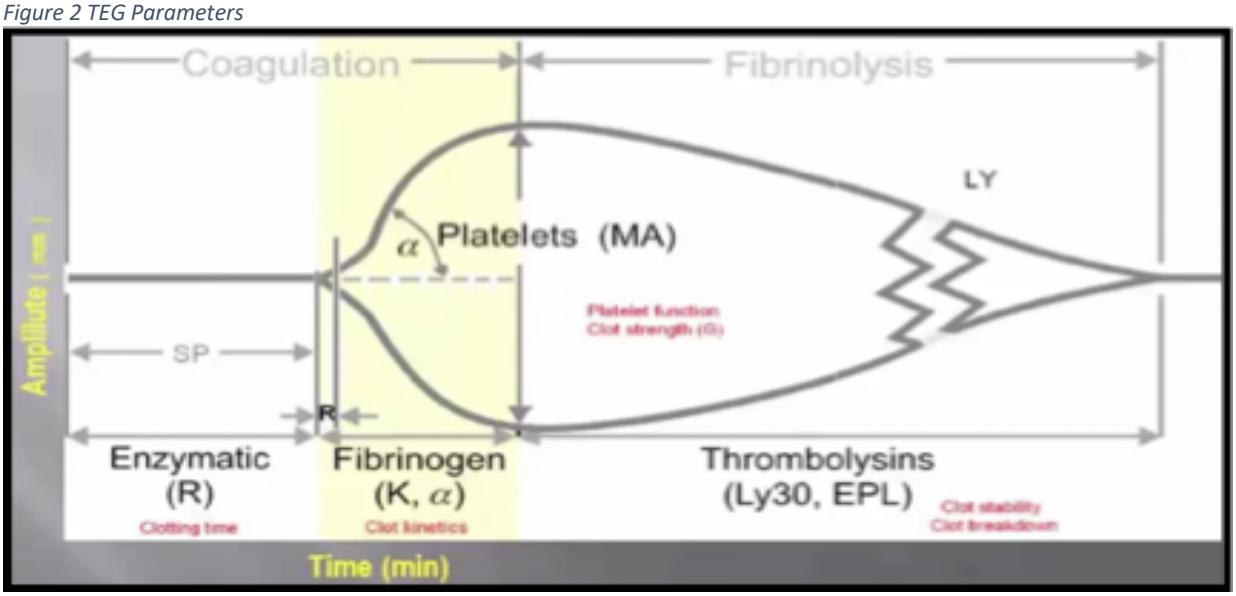
At the start of the case the anesthesia team should order blood products from the blood bank. The blood products brought to the OR should be:

1. PRBC x 10 - in room and checked, stay 10 ahead
2. FFP x 10 - in room and checked
3. Platelets – ordered later in case. Bring to room based on individual patient.
4. CRYO – ordered later in case. <u>Do not thaw</u> unless you have decided to transfuse
5. PRBC and FFP are to be kept in cooler under ice
6. Platelets and CRYO are to be kept in attached canvas bag (<u>do NOT put on ice</u>).

Thromboelastography/Rotational Thrombelastometry (TEG/ROTEM):

1. Clinical lab will be notified by the transplant team prior to operation.
2. The anesthesia tech dedicated to liver transplant will carry ROTEM samples to the clinical lab.
3. A dedicated computer will display virtual ROTEM graphs in the OR.
4. Although ROTEM is used intra-op, you will continue to be tested on TEG. Familiarize yourself with both. (*ROTEM interpretation guide available under transplant anesthesia materials*).
5. **WHEN TO DRAW ROTEM**:
    a) BASELINE (ASAP, before incision OK) –EXTEM, FIBTEM, INTEM & HEPTEM
    b) 60 MIN AFTER INCISION –EXTEM & FIBTEM (+APTEM if lysis is observed in any channel)
    c) 15-20 MIN POST-REPERFUSION –EXTEM, FIBTEM, INTEM, & HEPTEM (+/-APTEM)
    d) 1 HR POST-REPERFUSION –EXTEM & FIBTEM (+APTEM if lysis is observed in any channel)
    e) 2 HR POST-REPERFUSION –EXTEM & FIBTEM (+APTEM if lysis is observed in any channel)
    f) PRN any other time –EXTEM & FIBTEM (+APTEM if lysis is observed in any channel)

Figure 2 TEG Parameters



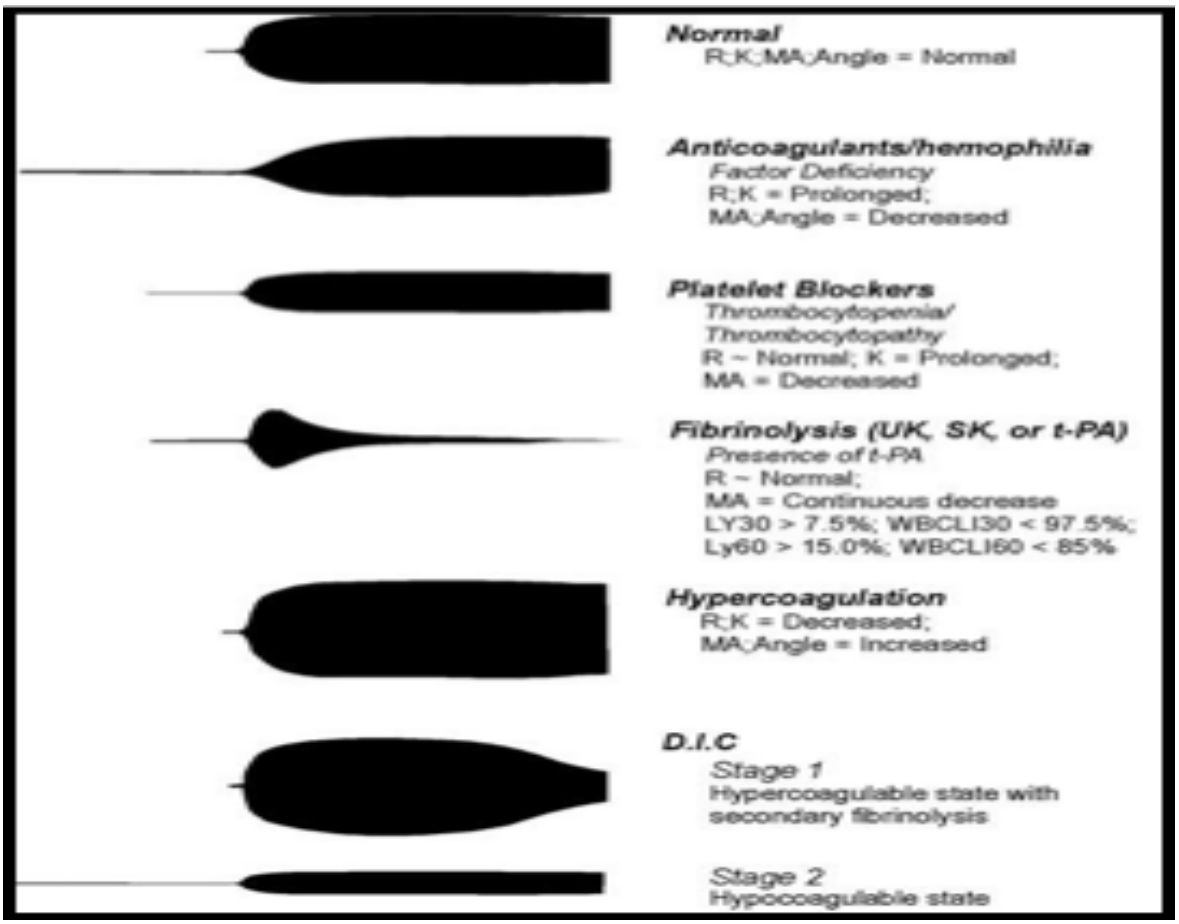


Figure 3 TEG Analysis

Anesthetic technique

Induction:

1. Liver transplantation is considered an emergency procedure. Generally, the patient should be treated as a full stomach with a **rapid sequence induction**.
2. Most recipients have good cardiac reserve with normal EF. Therefore, most patients will tolerate a propofol induction unless they come to the operating room on pressors already. Etomidate is an acceptable alternative.
3. Maintenance of general anesthesia is performed using a balanced anesthetic with inhalation agents, fentanyl, and muscle relaxants.

Vascular access:

Sterile precautions are paramount in transplant patients for any access as they are generally immunosuppressed and are at high risk for infection.

The following lines are usually placed after induction:

1. A radial arterial line.
2. A femoral artery line (discuss with surgeon about which side). This is generally placed by the surgery attending.

3. A central MAC venous catheter. Right IJ is preferred, although left IJ can be considered if venovenous line will be used (discuss with surgeon)
4. Continuous cardiac output pulmonary artery catheter.
5. A second large bore venous access is also needed. Options include:
   a) Venovenous cannula (placed by the surgical team)
   b) A second central line using a different location.
   c) A large bore peripheral access such as a 14-gauge or a peripherally inserted 7-Fr cannula if available.
   d) Existing dialysis catheter – must aspirate and discard 10cc from each port before use as dialysis lines are locked with Heparin. This is **used as a last resort**, for infectious reasons.

Miscellaneous

1. Insert an orogastric (OG) tube to decompress the stomach, to remain in place for surgery. Will need to remove if extubating patient at the end. If planning to extubate, discuss with surgeon if an NGT is necessary. NGT placement is rare as 1) patients resume bowel function quickly after surgery, and 2) coagulopathy may increase the risk of epistaxis
2. Place defibrillator pads
3. Place Baer huggers on the patient (upper and lower) as well as assure that the warming pad under the patient is turned on.

Monitoring

1. Standard ASA monitors
2. Continuous monitoring of CVP, PA pressures, CO, ScvO2, and SVV
3. SEDLINE, Cerebral Oximetry (NIRS)
4. Transesophageal echocardiography. It has been shown to be safe even in the presence of esophageal varices and has shown value in:
   a) Monitoring cardiac function and volume status
   b) The presence of pulmonary hypertension to measure the PVR
   c) Cases of intra-cardiac thromboembolic complications
   d) Presence of systolic anterior motion of the mitral valve (SAM)
5. Arterial Blood gases hourly or as needed to evaluate:
   a) Hemoglobin – in setting of clinical bleeding
   b) pH – in the anhepatic transplant phase as the liver is the primary organ to clear lactate. Bicarbonate supplementation may be needed.
   c) Potassium – in patients with concomitant renal disease or in the setting of massive transfusion
   d) Glucose – in the setting of steroids, vasopressors, or an acute liver failure patient
   e) Calcium – in the anhepatic transplant phase and ongoing blood transfusion as the liver is the organ primarily responsible to metabolize citrate.
   f) Critical times to obtain an ABG are 15 min prior to the anhepatic phase, 15 min after the anhepatic phase, and 10-15 minutes prior to reperfusion
6. Thromboelastography (ROTEM)
   a) The use of TEG/ROTEM has been associated with less transfusions
   b) Prolonged “R-time” (reaction time) – treat with FFP
   c) Decreased “MA” (maximum amplitude) or “alpha-angle” –treat with platelets
   d) Decreased “alpha-angle”and “K-time” not corrected with platelets should raise the suspicion of low fibrinogen –treat with CRYO

Operative stages:

1. **Pre-anhepatic**

Begins with surgical incision and ends with cross clamping of portal vein, supra and infra hepatic IVC, and the hepatic artery

a) Maintenance of anesthesia:

i) Balanced anesthetic utilizing volatile anesthetics, fentanyl and muscle relaxants.

ii) Colloid solutions are the fluid of choice, especially in patients with ascites. Crystalloids should be limited.

iii) Octreotide infusion should be started ASAP in cirrhotic patients as evidence suggests it decreases portal hypertension

b) Correction of coagulopathy:

i) No empiric correction based on abnormal coagulation parameters such as PT, INR.

ii) Evidence points to the fact that hemostasis in liver patients is still balanced although extremely fragile.

iii) Utilize TEG hourly with emphasis on critical times such as 15 min prior to the anhepatic phase 15 min after the anhepatic phase and 10-15 min prior to reperfusion

iv) Do not correct the TEG/ROTEM parameters unless associated with clinical coagulopathic bleeding. Communication with the surgical team is paramount.

v) Do not use a warmer for platelet transfusions

vi) In the setting massive bleeding, consider utilizing a 1 FFP: 1 PRBC ratio.

vii) Correct acidosis and hypothermia as they are common causes of coagulopathic bleeding.

c) Fluid Management

i) Goal Hgb ~ 8 g/dL.

ii) Evidence support targeting low CVP (<5) during the pre-anhepatic phase. Blood loss and utilization of blood and blood products is decreased utilizing this conservative fluid strategy. Consider using a nitroglycerin infusion to achieve this low CVP.

2. **Anhepatic Phase**

a) Begins with occlusion of vascular inflow to the liver and ends with reperfusion.

b) Octreotide infusion should be stopped.

c) Confirm with surgeon when to give steroids at this point in the case.

d) Be aware of surgical technique:

i) Total occlusion of IVC

ii) Partial occlusion “Piggy back” (most common at LLU)

iii) Veno-venous bypass

iv) The surgical technique chosen has major implications on the hemodynamics that are to be expected with clamping and unclamping.

v) Be aware of veno-venous complications such as air embolism, thromboembolism, and inadvertent decannulation which can be fatal or result in significant morbidity.

e) With the liver excluded from circulation, be aware of what the recipient is at risk for:

i) Worsening acidosis.

ii) Hypocalcemia especially with ongoing blood transfusion due to citrate toxicity. Replete with 1gm $CaCl_2$ as necessary with frequent ABG monitoring. Ionized calcium <1.08 should be replaced.

iii) Hypoglycemia – replete with dextrose as necessary

iv) Hyper- or hypokalemia. Treat hyperkalemia with bicarbonate, insulin, glucose. Treat hypokalemia only if symptomatic.

v) Worsening coagulopathy – Do not attempt to completely normalize coagulation parameters (TEG/ROTEM) before reperfusion, but do not allow severe abnormalities.

e) Prepare for Reperfusion:

i) Normalize pH, Ca2+, K+

ii) Volume load targeting normal filling pressures typically done with the albumin / PRBC mixture in the rapid infuser.

iii) Pressors / inotrope drips inline and infusing.

iv) Epinephrine, phenylephrine, bicarbonate, and calcium syringes available.

v) Close communication with the surgical team is required.

3. <u>Neo-hepatic "reperfusion" phase</u>

a) Starts with unclamping of the venous side of the hepatic blood supply until the conclusion of the operation

b) Post reperfusion syndrome (PRS)

i) Occurs usually within 5 minutes of reperfusion

ii) Typical symptoms: hypotension, bradycardia, and pulmonary hypertension

iii) Usual risk factors: long organ ischemia time (>6 hrs), or increased fat content in the donor organ

iv) Largely due to abrupt increases in potassium and hydrogen ion concentrations as well as changing preload and declining SVR due to vasoactive substances released with reperfusion.

v) Intra-cardiac thromboembolism should be excluded as the cause for hemodynamic decline using the TEE

c) Management of PRS:

i) Be ready for reperfusion with a normal pH, Ca2+, and K+. Adequately volume load prior to unclamping.

ii) Treat persistent acidosis and hyperkalemia.

iii) Epinephrine bolus as indicated.

iv) Volume loading if filling pressures are low. Avoid over filling as this leads to high CVP and liver congestion.

v) Continue inotropic / pressor drips until SVR normalized.

vi) Management of intracardiac thromboembolism:

(1) Serious complication that may lead to cardiac arrest.

(2) Massive transfusion of blood products is a risk factor.

(3) TEE is essential in diagnosis and monitoring of progression.

(4) Treatment is fluids and inotropes.

(5) Rarely heparin is required (5000 units, single dose).

(6) TPA can be considered.

d) Arterial anastomosis and biliary reconstruction:

i) Patient is typically much more stable at this point.

ii) Begin weaning pressors and inotropes.

iii) Monitor for signs of good graft function: improving acidosis with no assistance, normalizing Ca2+ with no repletion, formation of bile, increased core temperature, improvement of urine output

e) Monitor for fibrinolysis
   (1) Most commonly occurs after liver reperfusion
   (2) TEG/ROTEM is diagnostic
   (3) Consult with the attending anesthesiologist and attending liver transplant surgeon before using anti-fibrinolytic agents (ie. tranexamic acid or aminocaproic acid), as these can lead to very serious complications such as hepatic artery and portal vein thrombosis, and potentially graft loss.

f) Decrease frequency of ABG monitoring and TEG/ROTEM as the patient stabilizes and bleeding decreases.

Transport and Handoff to the ICU:

1. Patient will need the veno-venous cannula removed prior to exiting the OR. This is performed by the surgeon as the cannulation site needs to be sutured closed.
2. A verbal and written SBAR communication with the ICU team is imperative. Essential elements of communication are:
   i) Hemodynamic stability
   ii) Pressors being used
   iii) Coagulation status (drain output)
   iv) Anticipated extubation or ventilator settings
   v) Any inadvertent complications in the OR (anesthesia or surgical)
3. During transport, monitor: arterial blood pressure, EKG, pulse-oximetry and End-tidal CO2.
4. Some patients may be candidates for extubation in the OR. Discuss this possibility with the attending anesthesiologist.
   i) **Extubation considerations**: acceptable ABG, no severe acidosis, adequate respiratory mechanics, normothermia, minimal to no vasopressors, adequate pain control
   ii) **Exclusion criteria**: BMI >35, pre-op encephalopathy, mechanical ventilation prior to procedure, transfusing > 10 units of pRBC & FFP, re-transplant, multi-organ transplant, donor-graft dysfunction, living donor transplant, UNOS status 1