UT SOUTHWESTERN MEDICAL CENTER

UNIVERSITY HOSPITALS & CLINICS

UNIVERSITY HOSPITAL – ST PAUL

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Liver Transplant Program

THE OPERATION

I. Purpose

The purpose of this section of the Protocol is to describe issues surrounding the transplant operation.

II. Policy

A. Assuring Match Between Donor and Recipient Blood Group

1. **ABO Matching**

This section outlines the steps necessary to ensure patient safety by correctly matching donated organs to recipients and to ensure policy compliance with UNOS and CMS regulations. This policy applies to both cadaveric and living donor solid organs.

2. **Organ Recovery**

a. *ABO Verification*. The ABO blood type will be verified by source documentation at each step of the transplant matching process and a final time immediately before transplantation.

b. *Organ Recovery*. Once the identity of an intended transplant recipient is known, and the transplant center sends a team to recover the organ(s), the recovery surgeon and another licensed healthcare professional **must** review and compare the donor data with the recipient's blood type and other vital data (i.e., medical record number, UNOS ID) **before** the organ(s) recovery takes place. A copy of the donor chart is provided by the OPO (organ procurement organization) coordinator and returned to UTSW Medical Center. This report will be filed in the transplant office and must include:

- Verification of brain death
- Consent to donate
- ABO confirmation
- Serology reports

2. **The Transplant Surgery**

a. *Living Donor Liver Transplant (LDLT).* The transplant surgeon and another licensed healthcare professional must verify that the living donor's blood type and other vital data are compatible with the recipient's prior to the removal of donor organs and prior to removal of recipient organs.

b. *Final Verification*. Final verification will be performed for both living donor and cadaveric transplants. In addition to the surgical time-out, the transplant surgeon and another licensed healthcare professional will verify the ABO blood type and other vital data prior to anesthetic induction. This confirmation will be documented on the Operative Data Form and will include incision time. This form will be kept in the patient's medical record.

3. **Incompatible ABO Type**

If the ABO blood type is **not** compatible between the donor and the recipient,

a. **Do not proceed** with the transplant.
b. **Immediately** contact the Southwest Transplant Alliance for further instructions (214-522-0255)

B. **Booking the Operating Room**

At the time of booking, the operating room is provided with the donor UNOS # and the recipient name. The OR then records these numbers on the "white board" in the OR so that they are clearly visible to the transplanting surgeons.

C. **Positioning**

The patient is positioned in a supine position. Both arms are extended 90°, to leave access for the anesthesiologist and veno-veno bypass (if needed). Thigh-high Ted hose are placed on the legs. The arms and legs are wrapped in space blankets. Protective foam booties are placed on the feet.

D. **Preparation**

The skin is shaved from clavicles to pubis, table to table. The left side will be used routinely for veno-veno bypass, if bypass is required. The left axilla is shaved to the elbow. Both groins are shaved. Prep is done with Betadine, followed by alcohol. A 3M drape is used for the groin. Cloth towels and paper drapes are used to drape. An Ioban drape is used to cover the field. A clear plastic pocketed drape is then placed on the field to catch fluid during the operation. A clear plastic pocketed drape is also placed below the axillary incision.

E. **Incision and Exposure**

1. **The Abdomen**

A bilateral subcostal incision is made in the patient's abdomen. This usually extends to the midaxillary line on the right and to the edge of the rectus on the left. It may be necessary to extend the incision in the midline to the xyphoid. Electrocautery is used

to incise the muscles and fascia. Large collaterals are ligated. The abdomen is entered, and ascites drained. The amount of ascites drained is recorded by the circulating nurse on the board.

The retractors are then placed. The Olivier retractor is placed subcostally, and pulled tight by the anesthesiologist. A 3/4 sheet is placed over this retractor at the top of the field. Two iron interns are used, one at the right upper quadrant and one at the left lower quadrant. Alternatively for larger patients, the Omni retractor is used. The bowel is left in the abdomen, and covered with a wet blue towel. Appropriate blades for the retractor are placed, and the exposure is complete. Care should be taken in placing the lower blades, padding them with the blue towel, to prevent damage to portal collaterals.

2. **Veno-Veno Bypass** (if needed)
   The right groin dissection is usually accomplished first. The sapheno-femoral junction is dissected out for use in the veno-veno bypass. Great care must be used in ligating lymphatics to prevent post-operative lymph leaks. An appropriate place for venous cannulation is selected, either the saphenous vein, or if too small, the sapheno-femoral junction. Vessel loops and a Rommel tourniquet are placed. Retractors are removed and the incision packed with an antibiotic soaked gauze.

   The left axilla is entered through a longitudinal incision. The axillary vein is located between the biceps and triceps. This is dissected out, and a vessel loop and Rommel tourniquet is placed. Retractors are removed, and the incision packed with an antibiotic soaked gauze.

F. **Dissection for the Hepatectomy**
   The cystic duct is dissected free. This is ligated and divided. The common bile duct is dissected as far into the liver hilum as reasonable, to maintain adequate recipient bile duct length. Extra dissection of the bile duct is avoided, so as to maintain the blood supply. The bile duct is ligated and divided. The hepatic artery is dissected in the hilum of the liver, usually past the bifurcation of the right and left hepatic branches. This is then dissected back toward the celiac axis, exposing the gastroduodenal artery and common hepatic artery. The rest of the tissue in the hepatoduodenal ligament is divided either between ligatures or with cautery, exposing the portal vein. The portal vein is dissected into the liver hilum, exposing the right and left branches. The portal vein is palpated to identify any thrombus.

   The lesser omentum is divided. The left lobe of the liver is mobilized. This exposes the vena cava on the patients left side. The vena cava dissection is begun on the right side of the porta hepatis, and crosses to the left side of the cava, on the other side of the porta. The vena cava is encircled with an umbilical tape between the renal veins and the caudate lobe of the liver.

   The right lobe of the liver is mobilized by dividing the right coronary ligament. The liver is separated from the diaphragm. This allows the right lobe of the liver to be elevated,

exposing the vena cava. The dissection is carried from above the right renal vein toward the heart. The right adrenal vein is identified, ligated, and divided. The rest of the vena caval dissection is accomplished.

G. **Preparation of the Donor Liver**

This portion of the operation is usually performed in the recipient operating room. In cases where the liver was procured by another team and shipped, examination and preparation of the donor liver is usually done prior to making an incision in the recipient. It can also be done at the same time as the dissection is being performed, or after the dissection is accomplished, depending on staffing.

The donor liver is removed from the packaging wrap and examined. The dissection is carried out with the donor liver immersed in Belzer's solution and ice. The hepatic arterial anatomy is defined. A thorough search for aberrant hepatic arteries is performed, and the hepatic arterial vessels are freed of their surrounding connective tissue. If an aberrant hepatic artery is found, the method for reconstruction will depend on the recipient hepatic arterial anatomy.

The infrahepatic cava is dissected out. The right adrenal vein is identified and ligated. The suprahepatic cava is dissected free. The diaphragm is removed, along with the pericardium. The suprahepatic vena caval cuff is examined. Coronary vein orifices are identified and suture ligated with 3-0 Prolene. The vena cava is examined for any remaining orifices, and all holes suture ligated. This is an important step, as exposure of the retro-hepatic cava after the liver is sewn in is extremely difficult. The portal vein is dissected free into the liver hilum. The common duct is examined, and shortened if necessary, so that there is a non-damaged edge for anastomosis. The liver is then placed in storage, in Belzer's solution and kept on ice.

H. **Excision of Recipient Liver**

A vena-cava clamp is placed on the suprahepatic cava at the level of the diaphragm. Care should be taken that the clamp is placed in a way so that the suprahepatic cava cannot slip through the jaws of the clamp and retract into the mediastinum. The scrub nurse has been instructed to save the largest Satinsky clamp, so that this "saved" clamp can be nested above the other clamp.

The recipient liver is then removed. The infrahepatic cava is dissected up the anterior surface, ligating branches to the caudate lobe. This preserves maximal length on the infrahepatic cava. The liver parenchyma is then incised approximately 3 cm from the suprahepatic caval clamp. This is carried down through the caudate lobe of the liver. This maneuver maximizes length of the suprahepatic cava. The recipient liver is then removed from the wound.

The liver bed is then examined for hemostasis. Suture ligatures are often necessary to achieve hemostasis, especially in the right adrenal bed. Meticulous hemostasis must be achieved, since exposure of this area will be nearly impossible when the donor liver is in place.

The suprahepatic vena cava cuff is prepared. The liver parenchyma is dissected from the vena cava and hepatic veins. The left and middle hepatic veins are closed with running 3-0 Prolene. The cuff is trimmed, and explored for any phrenic veins or hepatic veins not ligated. The field is then ready for revascularization of the donor liver.

I. **Revascularization of the Donor Liver**

The donor liver is brought into the field. The donor liver is given one final check for holes in the vena cava. The liver is insulated with lap pads soaked in slush. The time the donor liver is removed from cold storage is recorded.

The suprahepatic anastomosis is done first, using running 3-0 Prolene. The posterior wall is done from the inside, everting the caval edges. The anterior wall is then closed. A gauze pad is then placed at the tip of the Satinsky clamp, to protect the liver.

The infrahepatic caval anastomosis is accomplished with 3-0 Prolene. The excess cava, on either the donor or recipient, is trimmed. The posterior wall is done first, followed by the anterior wall. The last few stitches are not pulled tight, to allow a hole to vent the liver on reperfusion.

Occasionally, when a side clamp has been needed, or when a small liver is being transplanted, only one Coval anastomosis is performed. This is by a running 3-0 Prolene from end of lower suprahepatic to inferior vena cava to side vicinity of recipient's IVC.

The portal portion of the veno-veno bypass is interrupted. Tubing clamps are placed on the cannula. The Rommel tourniquet is freed. An angled vascular clamp is placed on the portal vein just above the pancreas. The Gott shunt is removed, and the clamp on the portal vein applied. The portal vein is then flushed, to push out any clot that may have formed around the cannula.

The donor portal vein is then cut to length. 5-0 Prolene is used for the anastomosis. The orientation of the anastomosis is maintained by placing sutures directly anteriorly and posteriorly. This allows both sides of the anastomosis to be done from the outside, everting the edges. "Growth factor" is left in the Prolene when tying the running suture, to allow for full expansion of the anastomosis. Before completing the anastomosis, the liver is flushed with room temperature Lactated Ringers and vented out the lower IVC anastomosis.

The liver is then ready for restoring perfusion. The anesthesiologist must be prepared for reperfusion, since electrolyte abnormalities and volume changes occur quickly during this phase. The portal clamp is removed, and the liver flushed of all the cold solution with portal blood. The vent is the infrahepatic caval anastomosis. Once the liver has been flushed, the infrahepatic suture is tied. The suprahepatic clamp is then released, followed by the infrahepatic clamp. Blood is now returning from the portal circulation through the liver to the heart. This time is recorded, as it ends the anhepatic phase of the operation.

The axillary cannula is clamped first, to prevent air embolus. The femoral cannula is clamped.

The anastomoses are checked for leaks. Appropriate sutures are placed. Once the surgeon is satisfied that there are no leaks, the liver is packed with laps. This allows the anesthesiologist to correct the coagulopathy associated with reperfusion of the liver.

J. **Arterial Anastomosis**

The donor and recipient arteries are prepared for anastomosis. The most common recipient site is the junction of the gastroduodenal artery and the proper hepatic artery. A clamp is placed on the common hepatic artery, and the bifurcation is opened, leaving a "fish mouth". The donor site is most commonly the splenic and common hepatic bifurcation. These vessels are also opened, creating another "fish mouth". The recipient artery clamp should be flashed open to flush any clots out of the recipient vessel prior to performing the anastomosis. Before the anastomosis the donor's hepatic artery is flushed with room temperature Lactated Ringers solution. The anastomosis is then performed end to end, using the "fish mouth" cuffs to prevent narrowing. 6-0 Prolene is used. A clamp often needs to be placed on the donor hepatic artery, since portal blood flow will back bleed out the hepatic artery. Clamps are removed, and the liver is arterialized. The liver is examined for arterial bleeding. Hemostasis is achieved.

K. **Post Revascularization Phase**

The surgical field is examined, and a thorough search performed for bleeding. It is important that the anesthesiologist not over-correct the coagulopathy. If there is a significant coagulopathy, the field is packed until the coagulopathy is corrected. All areas of the surgical field are checked, and the anastomoses are examined for any bleeding.

L. **Biliary Reconstruction**

The bile duct is reconstructed after satisfactory hemostasis is obtained. Choledocho-choledochostomy is the biliary reconstruction of choice unless there is a contraindication for its use, such as sclerosing cholangitis. The ends of both common ducts are trimmed if necessary. A "T" tube is inserted into the recipient common duct if there are ductal size differences. Two large CBD do not need to be drained with a T-tube. The back wall of the "T" tube is cut out. The exit site of the "T" tube is closed with interrupted 5-0 PDS. The choledochocholedochostomy is performed with running 5-0 Vicryl. The "T" tube is irrigated to check for leaks. An intra-operative cholangiogram is obtained.

In cases where the recipient common bile duct cannot be used, a roux-en-y loop of jejunum is used for biliary drainage. The roux loop should be 30 cm long, to prevent reflux up the roux loop into the biliary tree. The loop is usually placed retrocolic. The end is inverted with 3-0 silk Lembert sutures. The choledochojejunostomy is performed 2 cm from the end of the roux loop, on the anti-mesenteric side of the jejunum. Vicryl suture is used for this anastomosis. The anastomosis is stented with a 8F silastic tube.

M. **Closure**

The wound is examined for bleeding. Once hemostasis is adequate, 4 Hemovac drains are placed in the abdomen. Two are on the right, and two are on the left, one above and one below the liver. These are cut to length and secured. The "T" tube is brought out through the abdominal wall and secured.

The wound is closed in three layers. The posterior sheath, along with transversalis and internal oblique, is closed with a running suture of O Prolene. The anterior sheath is closed with interrupted suture of Dexor. The skin is closed with staples. The "T" tube is hooked up to gravity drainage. The hemovacs are placed on bulb suction. A gauze dressing is applied to all wounds.

N. **Use of Veno-Veno Bypass**

1. **Veno-Veno Bypass**

Veno-veno bypass shunts blood from the inferior vena cava and portal vein back to the heart via the axillary vein. The bypass circuit used is a Biomedicus™ centrifugal pump, attached to Gott shunts. The bypass equipment is placed on the patient's left.

The bypass tubing is primed with normal saline by the perfusionist prior to incision. The centrifugal pump chamber and the heat exchanger are handed off to the perfusionist just before bypass is initiated. The tubing is secured to the drapes with non-perforating clamps. The bypass circuit is then ready to be used.

Routine shunt sizes used will be a 9 mm Gott shunt for the portal cannula, and a 7 mm Gott shunt for the axillary and femoral cannulae. If the axillary vein is small, the perfusionists have alternate cannulae for the axillary vein. These are cardiac bypass catheters (Bard), 16F or smaller.

Once the patient is ready for veno-veno bypass, the lines are flushed. The venous line going to the pump from the patient is cut at the appropriate length from the "Y" connector. The Gott shunt cannulae are placed on the connectors, flushed, and tubing clamps are placed on the shunts. The same process is repeated for the axillary cannula, returning blood from the pump to the patient.

The vena cava cannula is placed first. A venotomy is made in the saphenous vein. The shunt tubing is back flushed by the perfusionist during insertion, and the cannula is placed into the femoral vein through the saphenous vein venotomy. It is secured with the Rommel tourniquet, a tubing clamp is placed on the cannula, and a #2 Tevdek is used to secure the Rommel to the cannula.

The same process is repeated with the axillary vein. The axillary cannula is introduced through a transverse venotomy. Care should be taken in making this venotomy, since it will need to be repaired at the completion of veno-veno bypass. A tubing clamp is placed on the cannula, and the Rommel is then secured with a #2 Tevdek. The shunt tubing should be examined at this time to ensure there are no bubbles in the system.

The portal vein cannula is then introduced. The portal vein is ligated in the liver hilum. This begins the anhepatic period, and the time should be recorded by the circulating nurse on the board. A venotomy is made, and the cannula introduced. It is secured with a Rommel tourniquet, maintaining as much portal venous length as possible. A tubing clamp is placed on the cannula, and the Rommel is then secured with a #2 Tevdek. The shunt tubing should be examined at this time to ensure there are no bubbles in the system. The bypass circuit is then completed, but no flow is yet occurring.

A Satinsky clamp is then placed on the infrahepatic cava above the level of the renal veins. The tubing clamp is removed from the axillary cannula. The tubing clamp is removed from the femoral cannula, and flow is observed in the tubing. If this seems adequate, no adjustments need to be made in the cannula positions. Finally, the portal tubing clamp is removed, and the patient is on veno-veno bypass.

Flow through the veno-veno bypass should be greater than 1.2 liters per minute, or else clotting will occur in the circuit. The flow in adults is approximately 2 to 3 liters per minute.

Occasionally in small patients when no short access is available, the IVC is partially clamped during the hepatectomy. Thus, the veno-veno bypass is not used. This must be correlated with the anesthesia team.

2. **Removal of Veno-veno Bypass**

The cannulae left in the saphenous vein and the axillary vein are removed. The saphenous vein cannula is removed. If the sapheno-femoral junction was used, this must be repaired with 5-0 or 6-0 Prolene. If not, the saphenous vein is ligated. The tubing is flushed by the perfusionist into the field, to be recycled by the cell saver.

The cannula in the axillary vein is then flushed by the perfusionist. The cannula is removed, and the axillary vein clamped. The perfusion tubing is passed off the field, and examined by the perfusionist for clots. The venotomy in the axillary vein is repaired with 6-0 Prolene.

The groin incision is closed in 3 or 4 layers. Running 2-0 Vicryl is used to close the femoral sheath. One or two layers of running 2-0 or 3-0 Vicryl are used to close the subcutaneous tissue. The skin is closed with a running 4-0 subcuticular Vicryl. Care should be taken in closure of this wound, as the area is prone to infection and lymphatic drainage. The axillary incision is closed in the same fashion, using running Vicryl.

O. **Intra-Operative Events**

1. **Dialysis**

There are occasions when hemodialysis is required throughout the liver transplant operation. Steps include:

a. *Surgeon*. The surgeon or their designee calls nephrologist (fellow or if fellow not on call, the attending) to alert them to the need for hemodialysis.

b. *Nephrologist*.
   1) calls technician with orders for set-up
   2) calls the ICU for a liver patient nurse request
   3) calls technician for pheresis if needed.

c. Surgeon places lines, attaches sterile tubing

d. Technician or nurse hooks up the non-sterile tubing.

e. Flush/prime for liver - 5000 u/IL NS

f. Due to anticoagulated states of liver and desire not to add to patient bleeding (which is the usual case) the filter and dialyzer will be flushed with another liter of NS without heparin.

g. Anticoagulation will be closely monitored.

h. Evaluation of citrate for UR/HD may be undertaken.

i. Plasmapheresis will be handled with citrate anticoagulation as before.

2. **Portopulmonary Hypertension**

Patients with portopulmonary hypertension (PPHTN) require careful monitoring during the operation. These patients will generally be known prior to the transplantation. However, there are situations in which a patient will have developed progressive PPHTN which may prevent successful transplantation. The following are intraoperative guidelines:

a. mPAP <35 mmHg – proceed with transplant
b. mPAP 35-40 mm Hg
   1) PVR <240 dynes – proceed with transplant
   2) PVR >240 dynes – perform transesophageal echocardiogram
      a) good RV function – proceed with transplant
      b) poor RV function – defer liver transplantation
c. mPAP >40 mmHg
   1) PVR <240 dynes – use diuretics and proceed with liver transplantation
   2) PVR >240 dynes – defer liver transplantation

3. **Use of Factor VII**.

Use of factor VII may be necessary for uncorrectable coagulopathy and will be used at the Transplant Surgeon's discretion.

III. Procedure/Intervention(s) – N/A

IV. Documentation (Documents & Forms) – N/A

V. Other Related Policies/Procedures

A. UTSW Policy No: 2.0 SOTP Clinical entitled "Verification of ABO blood type prior to kidney, liver and pancreas transplantation."
B. CMS – Condition of Participation; Reference Number 42 CFR 482.92
C. OPTN/UNOS Policy 3.1.4 and 3.1.4.2

VI. References – N/A