

# Liver Transplant Surgical Protocol

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## Consent

The potential recipient will usually be able to participate in the consent process, unless fulminant liver failure or encephalopathy has supervened. Adults With Incapacity (Scotland) Act 2000 applies in such cases and the consultant surgeon should ensure that appropriate documentation has been completed.

The recipient should have had all of the relevant issues regarding transplant surgery explained in the assessment week. The pre-operative consent process is a review of relevant factors, including vascular anomalies (portal vein thrombosis, arterial jump graft) and a discussion of graft-specific issues (for example, DCD, steatosis, infection and malignancy risks). The consultant surgeon should confirm the recipient blood group (2 copies in the notes) in the light of the donor blood group communicated by the coordinators. There is a move towards consent being obtained during the assessment week which will require only to be countersigned pre-operatively. Guidelines issued by the British Transplantation Society provide clear direction as to best practice. SLTU does not yet fully comply with these guidelines, which are available through the following link.

[http://www.bts.org.uk/BTS/Guidelines\\_Standards/Current/BTS/Guidelines\\_Standards/Current/Guidelines.aspx?hkey=e285ca32-5920-4613-ac08-fa9fd90915b5](http://www.bts.org.uk/BTS/Guidelines_Standards/Current/BTS/Guidelines_Standards/Current/Guidelines.aspx?hkey=e285ca32-5920-4613-ac08-fa9fd90915b5)

The Human Tissue Authority now regulates organ donation and transplantation in the UK. The Royal Infirmary of Edinburgh holds an HTA licence for organ retrieval and transplantation. Current protocols in use for organ assessment, acceptance and transplantation have been passed by the HTA. Should there be incomplete information or uncertainty as regards graft history and quality, the implanting surgeon must carry out a risk assessment in discussion with the patient and record this in the notes. It is best practice to record this discussion on a routine basis.

## Back-Table Preparation

The liver is received in theatre by a senior member of the theatre team. The donor paperwork is checked to confirm the blood group and donor number match those on the theatre organ receipt form (white), confirming it is the correct liver for the correct recipient. The donor blood group must now be checked against the recipient blood group and entered on the pink form in the notes. Any discrepancy must be communicated to the coordinator and the consultant surgeon immediately.

Back table preparation is an important step in the liver transplant operation and usually takes one hour but may take longer depending on the need for back table reconstruction. Although it can be undertaken by one surgeon, as with any surgical procedure, an assistant is desirable. Any suspicion of vascular injury requires the consultant to be informed immediately. Split livers may require considerable back table preparation by a consultant prior to implantation.

The liver is removed from its containing bags, and the temperature of the organ is measured with the non-contact infra-red thermometer. If the temperature is above 4°C the consultant surgeon must be informed immediately. The liver is submerged in a slush/solution fluid. It is important to keep the liver well cooled at all times during the process and expose only the

relevant anatomy. Do not put ice directly over the liver. If additional UW is used in the back table procedure, the batch number and fluid type must be recorded.

The cut ends of the supra-hepatic and infra-hepatic IVC are stretched out between stay sutures. The posterior aspect of the IVC and the right lobe of the liver is dissected free of all extraneous tissue including pieces of diaphragm and the right adrenal. The right adrenal vein and the inferior phrenic veins need ligation. Great care should be taken in the region of the supra-hepatic IVC because the adventitia of the right and left hepatic veins are firmly adherent to the surrounding diaphragm. Inappropriate dissection can lead to injury of these veins which following repair may compromise hepatic venous outflow. The caudate lobe is partly dissected from the IVC by first dividing the hepato-caval ligament (Makuuchi's ligament) as it inserts into the edge of the caudate lobe. A number of short hepatic veins may need to be ligated and divided. The IVC should be inspected for defects that require oversewing with prolene. The IVC is confirmed to be watertight by applying a vascular clamp to one end of the IVC and flushing with UW from the other end using a catheter tipped syringe.

The portal vein is dissected free for an adequate length. Small tributaries are ligated. A cannula is tied in to allow the liver to be flushed prior to reperfusion.

The hepatic artery is cleared of adventitia. Aberrant hepatic arteries should be sought and if present dissected for an appropriate length. Back table reconstruction of hepatic arteries may be required.

No dissection on the bile duct should be performed.

Weighing the graft and obtaining a back-table liver biopsy are recommended as good practice and should be regarded as routine (specimen in formalin for routine processing).

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Depending on the delay from completion of the back-table to implantation, the liver should either be re-bagged as per the retrieval protocol or the liver is wrapped in a pack, kept well immersed in UW and slush packed all around it. The basin is kept in another container with ice and the liver left in a cool room until the time of re-implantation.

## **Recipient Procedure**

The purpose of this document is not to describe the recipient operation in detail but to highlight some of the surgical principles involved in successful implantation of a liver allograft. The cold ischaemia time should ideally not exceed 12 – 14 hours for DBD livers and 8 hours for DCD livers. In order to expedite implantation, the consultant may wish to commence the hepatectomy before the graft arrives. In this case, it is good practice to have the donor blood group faxed to the liver coordinators' office before commencing surgery.

### ***Recipient Hepatectomy -***

This step in the recipient operation can be the most difficult and time-consuming part especially in patients with severe portal hypertension or previous upper abdominal surgery.

## *Abdominal Incision*

Appropriate access is essential to enable liver transplantation. The following incisions are commonly used

- Bilateral subcostal with or without vertical extension (Mercedes-Benz).
- Hockey stick/J shaped/Makuuchi incision

Orthotopic liver transplantation may be undertaken with either caval preservation (Piggyback technique) or caval excision (Classical technique). Within SLTU, transplantation is usually undertaken with caval preservation. If a classical approach is required, consideration should be given, depending on experience, to enlisting additional surgical and anaesthetic help, as technical and physiological challenges may be significantly increased when this infrequently used approach is required. A clinical perfusionist may also be needed to provide veno-venous bypass.

## *Piggyback Liver Transplantation:*

In this technique the recipient inferior vena cava is preserved and used for the implantation of the liver allograft. A porto-caval shunt is usually created allowing mesenteric drainage and improved haemodynamic status.

Piggyback liver transplantation may be used for whole or partial liver allograft transplantation. It is the only technique that allows implantation of a liver allograft that does not contain the donor IVC.

The porta hepatis is initially dissected. The cystic duct and artery are ligated and divided. The hepatic arteries and the common hepatic duct is ligated and divided close to the liver. The portal vein is dissected along its length into the bifurcation. Following placement of a proximal vascular clamp the terminal branches of the portal vein are ligated and the portal vein transected. A length of infra-hepatic IVC is dissected free on the anterior surface allowing placement of a side-biting vascular clamp. An end to side portal vein to IVC anastomosis is created before removal of clamps.

The right and left lobes of the liver are mobilised. The liver is dissected free from the IVC with division of short hepatic veins. The right, and middle and left hepatic veins are controlled before division. The hepatic veins are clamped, divided and closed if the liver allograft is to be implanted using a side-to-side cava-cavostomy for venous outflow. Otherwise hepatic veins may be clamped and divided with the consequent venotomy being used for the venous outflow of the allograft.

During the anhepatic stage, the recipient arterial tree can be prepared for implantation.

If there is a large spontaneous spleno-renal shunt (SSRS), the left renal vein should be dissected and placed on a sling. Any other large porto-systemic shunt (such as the coronary vein) should be identified and may be placed on slings. The left renal vein or any other shunt may be ligated following reperfusion of the liver allograft if flow measurements suggest portal venous steal through the shunt rather than flow through the liver.

## *Implantation*

### *Hepatic Venous Outflow*

Two techniques are used to implant a liver allograft using the piggyback technique

#### 1. Side to side cava-cavostomy

This is the preferred outflow technique within SLTU.

The ends of the donor IVC are closed, either by suturing with prolene or using a vascular stapler. Care must be taken to ensure that the hepatic veins are not compromised. A longitudinal venotomy is made in the posterior wall of the donor IVC. This should be extended close to the supra-hepatic end of the cava, so the orifices of the hepatic veins are easily visible through the venotomy. A side-biting clamp is placed on the recipient IVC before making a longitudinal venotomy matching that on the donor IVC. When placing the IVC clamp care should be taken to ensure that the portocaval shunt can be disconnected without difficulty. If the portocaval shunt is in a position that would compromise the IVC anastomosis then this should be disconnected before the cava-cavostomy is undertaken.

A side-to-side cava-cavostomy is performed using a continuous 4/0 prolene suture. The anastomosis is usually undertaken by the surgeon on the patient's left hand side. Before completing the anastomosis the liver is flushed with 1 litre Hartmann's / 1% albumin/ 1% mannitol / 0.42% sodium bicarbonate solution at room temperature. The flush solution is made up thus:

1000ml of room temperature Hartmann's solution and withdraw 150ml from the bag. To the 850ml of Hartmann's solution the following is added:

50ml Human Albumin 20%  
50ml Mannitol 20%  
50ml Sodium Bicarbonate 8.4%

Alternatively a "blood flush" may be undertaken wherein the liver is reperfused through the portal vein and blood is allowed to drain from the donor infra-hepatic IVC prior to closure of the infra-hepatic IVC and release of the recipient IVC clamp. Similarly, the IVC anastomosis can be completed and the IVC clamp removed before completing the portal vein anastomosis allowing the liver to be "reverse" reperfused. This may be useful in the situation of an extended criteria (physiological) liver allograft.

#### 2. IVC to hepatic veins

In this method of implantation, a clamp is placed high on the hepatic veins, typically on middle and left hepatic vein, before the veins are divided. The liver is implanted with the donor IVC being anastomosed to a common orifice of MHV/LHV. To ensure a good outflow, the common orifice of the MHV/LHV can be extended into the anterior wall of the recipient cava. This can be done by hitching the anterior wall of the cava with a suture and re-placing the clamp to incorporate the MHV/LHV as well as the desired additional length of anterior caval wall. The infra-hepatic IVC is closed after creation of the upper anastomosis thereby allowing the liver flush effluent to drain prior to reperfusion.

### *Portal vein inflow*

The porto-caval shunt is disconnected and the IVC venotomy closed. An end-to-end, donor to recipient, portal vein to portal vein anastomosis is created using a continuous technique with 5/0 prolene. A growth factor is left.

### *Reperfusion*

Typically reperfusion will be through the portal vein. Controlled release of the portal vein will be undertaken in haemodynamically unstable recipients or in extended criteria (physiological) liver allografts in an attempt to minimize the physiological effects of reperfusion on the recipient. Initial hepatic arterial reperfusion may be undertaken in certain circumstances as determined by the lead surgeon.

### *Arterial Reconstruction And Reperfusion*

Arterial reconstruction is undertaken. The variability of hepatic arterial anatomy in both donor and recipient reduces the ability for a prescriptive description of arterial reconstruction. Arterial anastomosis is typically undertaken using a continuous technique with 6/0 prolene.

### *Flow measurements*

Hepatic vascular blood flows may be measured at various time points during the procedure. The following measurements may be recorded on the transplant audit form:

1. Native PV prior to division
2. Porto-caval shunt
3. Portal vein after 10 minutes after reperfusion
4. PV and HA after HA reperfusion 10 minutes after arterial reperfusion.
5. Final PV and HA measurement before closure.

### *Jump-grafts*

#### *Venous*

Donor iliac veins may be used as conduit between the recipient SMV and the donor portal vein when required. The recipient SMV is normally identified in the root of the small bowel mesentery within the infra-colic compartment.

#### *Arterial*

Donor iliac arteries may be used as a conduit between the recipient infrarenal aorta and the donor hepatic artery. Occasionally the right common/external iliac artery or the supra-renal aorta may be used for inflow to the conduit.

## *Biliary Reconstruction*

The gallbladder is dissected from the gallbladder bed with ligation and division of the cystic duct and artery. The donor bile duct is trimmed back. Standard biliary reconstruction is through an end to end duct to duct anastomosis using 5/0 PDS. The recipient bile duct should be flushed prior to undertaking the biliary anastomosis. Consideration should be given to the possibility of choledocholithiasis in the recipient if the recipient bile duct is dilated or if the recipient had gallstones. Choledochoscopy may be required to confirm that the recipient bile duct is clear. For patients with PSC and in re-transplantation an end to side hepatico-jejunostomy Roux-en-Y is used for reconstruction.

## *Classical (caval excision) Transplant*

The initial description of liver transplantation involved excision of the recipient IVC. This technique requires cross clamping of the IVC above and below the liver, and clamping of the portal vein. This results in a marked reduction in venous return and consequent haemodynamic instability. Anaesthetic techniques may ameliorate some of the haemodynamic changes but veno-venous bypass can be required.

Classical transplantation may allow for liver transplantation when caval preservation is not possible or practical.

Outflow reconstruction in the Classical transplant is through a supra-hepatic end to end, IVC to IVC anastomosis followed by an infra-hepatic end to end, IVC to IVC anastomosis. Flushing of the liver allograft prior to reperfusion may be undertaken with venting through the infra-hepatic IVC anastomosis before it is completed, or via the portal vein as previously described.

## *Veno-venous Bypass*

Veno-venous bypass is rarely required even in patients undergoing classical liver transplantation (caval excision). However, because of the infrequent need the procedure will be described in full so that when required a guide is available.

The cardiothoracic perfusionists are required when veno-venous bypass is to be used.

The left groin and left axilla should be prepared for surgical incision. A horizontal groin crease incision at the level of the sapheno-femoral junction is made. The termination of the long saphenous vein is dissected and tributaries ligated and divided. A 3cm length of the vein is isolated and slung. A transverse incision is made in the left axilla to expose the axillary vein. A length of this vein is mobilised and slung for control. An alternative vein for venous return is the large bore venous cannula placed in the internal jugular vein by the anaesthetists.

The distal ends of both the long saphenous and axillary veins are tied off. The appropriate sized Gott shunts are selected, filled with saline and clamped. The shunt with 2 holes is used in the groin (outflow) and one with one hole used in the axillary vein (inflow). The connecting tubes for both shunts are primed with saline attached and clamped. The portal line is similarly

primed with saline and clamped. All lines are secured with heavy vicryl ties and all visible air is expelled from the system. The portal vein is clamped proximally before distal division. The portal vein is then vented and subsequently flushed with heparin saline. With full control, the portal vein shunt is secured in place with a heavy vicryl ligature. The saphenous vein and portal vein lines are attached to a Y-connector and then to the axillary vein tubing. At all stages great care is taken to prevent air bubbles. After securing the Y-connection, the saphenous vein and portal vein line clamps are released. Flow will occur from the portal vein to the saphenous line. The axillary line clamp is then removed and bypass started. A flow more than 1 litre should be achieved to maintain blood flow. If the flow is less, check the angle of the portal line and adjust as necessary. When coming off bypass, the portal vein cannula is clamped and removed from the portal vein by dividing the securing ligature. A portal vein clamp should be applied with a 1-2cm length of portal vein available for anastomosis. The systemic bypass may be maintained while the portal vein anastomosis is being performed. At an appropriate time, the saphenous and axillary veins are clamped, the lines removed and both the saphenous and the axillary veins tied off. The groin and axillary wounds are closed at the end of the operation.

### *Abdominal Drainage*

The abdomen is usually drained with two 32F tube drains placed in the right subphrenic space (passing through right subhepatic space) and the left subhepatic space.

### *Abdominal Closure*

Loop 1 PDS to deep fascia. Clips to skin.

### *Documentation*

The green HTA A form, white liver receipt form, white liver implantation form, and donor blood group form must be returned to the liver coordinators for storage or return to NHSBT. These are legal requirements and registrars should post them under the coordinators' door before leaving the hospital.

## **Post-Operative Management**

Is documented in the SLTU 'Protocol For In-Patient Management Following Liver Transplantation'.



## **Back-table split liver transplant**

Liver allografts for patients on the elective liver transplant waiting list that meet the following criteria must be offered for splitting

- DBD donors
- Age < 40 years
- Weight > 50kg
- ITU stay < 5 days

The liver allograft offered by SLTU to other centres will usually consist of the left lateral section for paediatric use.

Throughout the offering sequence, retrieval process and the liver splitting procedure, appropriate communication will be had between the SLTU surgeon and the surgeon accepting the split liver allograft. Communication is key to providing an acceptable graft to the importing centre as well as minimising cold ischaemic time.

### *Liver splitting procedure*

The procedure will commence as soon as the liver arrives in the RIE. The back table procedure is undertaken with the liver submerged in a large bowl filled with slush. The liver must be kept cool at all times.

The liver is weighed.

The liver is inspected to confirm healthy parenchyma. Anatomical variants are noted especially with regard to hepatic arterial circulation.

Successful transplantation of both split liver allografts requires usable hepatic arterial inflow for both allografts. Satisfactory hepatic arterial inflow depends not only on donor liver hepatic arterial anatomy and the common variants but also on the requirements of both liver recipients. Therefore, a rigid approach to the management of the hepatic artery during liver splitting is not possible, rather the division and allocation of arteries will depend on the anatomical findings at back table dissection and discussions between all transplanting surgeons.

The following description of arterial dissection is provided as an illustration of the back table dissection. Standard hepatic arterial circulation will be considered with provision of the left hepatic artery only with the left lateral section. The hepatic artery is dissected from the coeliac axis into its terminal branches. The left hepatic artery is dissected up to the umbilical fissure. Where possible branches to segment IV are preserved with the main hepatic artery. This is most possible when there is a middle hepatic artery. Preservation of the artery to segment IV may allow this segment to remain viable following transection of the left branch of the portal vein. The left hepatic artery is ligated at its origin and divided distal to the ligature, or immediately after the segment IV artery if this allows for sufficient length on the artery to the left lateral section. The left hepatic artery is marked with a 6/0 prolene suture.

The portal vein is dissected along its length into its terminal branches. The bifurcation is dissected free. Caudate branches from the bifurcation and the left branch of the portal vein are ligated and divided. Once an adequate length of the left branch of the portal vein has been

dissected it is divided just after the bifurcation. This allows for further mobilisation of the left branch and this is dissected towards the base of the umbilical fissure with further ligation and division of any caudate branches.

Dissection is continued immediately to the right of the umbilical fissure. Structures entering segment 4 from the fissure are ligated and divided. If an arterial supply to segment 4 has already been preserved then this dissection should be undertaken with care in an attempt to protect this blood supply.

The left hepatic duct as it lies in the hilar plate to the right of the umbilical fissure is approached. A probe is passed from the transected common bile duct into the proximal biliary tree allowing identification of the right and left sided ducts. It should be possible to identify the ducts from segment 2,3 and 4. In this manner it is possible to identify the site of transection of the left hepatic duct. Back table cholangiography may also be undertaken to confirm the site of transection, and if this is considered necessary, it should be done at the beginning of the splitting process. Sharp transection of the left hepatic duct and hilar plate is undertaken with great care to preserve the ducts draining the right lobe of the liver.

The posterior surface of the IVC is cleared allowing an approach to the left hepatic vein. The supra-hepatic IVC is dissected allowing identification of the common trunk of the LHV and the MHV. The ligamentum venosum is divided allowing access to the space between the undersurface of the LHV and the IVC. It is then possible to dissect the space between the MHV and LHV allowing the LHV to be encircled. Inspection of the inside of the IVC may aid this manoeuvre. Once the LHV has been dissected it is transected at its insertion into the IVC. Care should be taken to ensure that the MHV is not injured.

The parenchymal transection line is marked. On the superior surface this lies to the right of the falciform ligament, which is preserved with the left lateral section allowing future fixation in the paediatric recipient. On the inferior surface the line of transection is to the right of the umbilical fissure, continuing through the site of the previously transected left hepatic duct and along the junction between the caudate lobe and the left lateral section at the site of the insertion of the lesser omentum. Parenchymal transection is undertaken with CUSA. A Penrose drain may be used to guide parenchymal transection. Internal structures may diathermied (bipolar), ligaclipped or ligated before division. Any large hepatic veins draining the left lateral section across to segment 4 should be marked allowing reconstruction by the paediatric centre.

Following completion of transection the left lateral section is weighed. Portal perfusion with 100-200ml of UW at this stage will help identifying any major leaking vessels on the cut surface that may require ligation. The allograft is then placed in a sterile bag and covered with UW solution. The bag is tied. The bag is then placed in a further sterile bag and with cold UW. The liver graft is then placed in a third bag with no fluid or ice. This bag is then placed in the travel box and covered in ice.

The NHSBT split liver paper work is completed and a copy of this and the blood group is sent with the allograft to the paediatric centre.

Donor iliac artery and veins will usually accompany the left lateral section but the decision will be made following discussion between adult and paediatric liver transplant surgeons.

### *Preparation Of The Extended Right Liver Allograft For Implantation.*

The defect in the portal vein at the site of the origin of the left branch portal vein is closed transversely using 6/0 prolene. A portal vein cannula is secured in the portal vein.

The left hepatic duct is closed with 5/0 PDS. The hilar plate may be oversewn with 5/0 PDS.

The IVC is dissected completely as for the whole liver allograft. The caudate lobe is partially mobilised from the IVC with ligation and division of any short hepatic veins. The defect at the site of the entry of the LHV into the IVC is closed transversely with 6/0 prolene. A vein patch may be required to if primary closure of this defect compromises the MHV.

## **Paperwork**

The following is the responsibility of the lead surgeon. The lead surgeon may delegate duties but remains responsible.

- Completion of pathology form for liver explant and liver allograft biopsy if taken
- Completion of SLTU audit form
- Documentation of operative details in case notes with any specific post-operative instructions especially if at variance from SLTU 'Protocol For In-Patient Management Following Liver Transplantation'.
- Dictation of transplant operation note
- Return of retrieval paperwork to liver transplant co-ordinators. This includes the 'A' form that accompanies the liver. If the liver has been split there will also be a copy of the NHSBT split liver form.
- Completion of the NHSBT 'B' form, thereby registering the transplant with NHSBT. The liver co-ordinators will provide the 'B' form for completion.