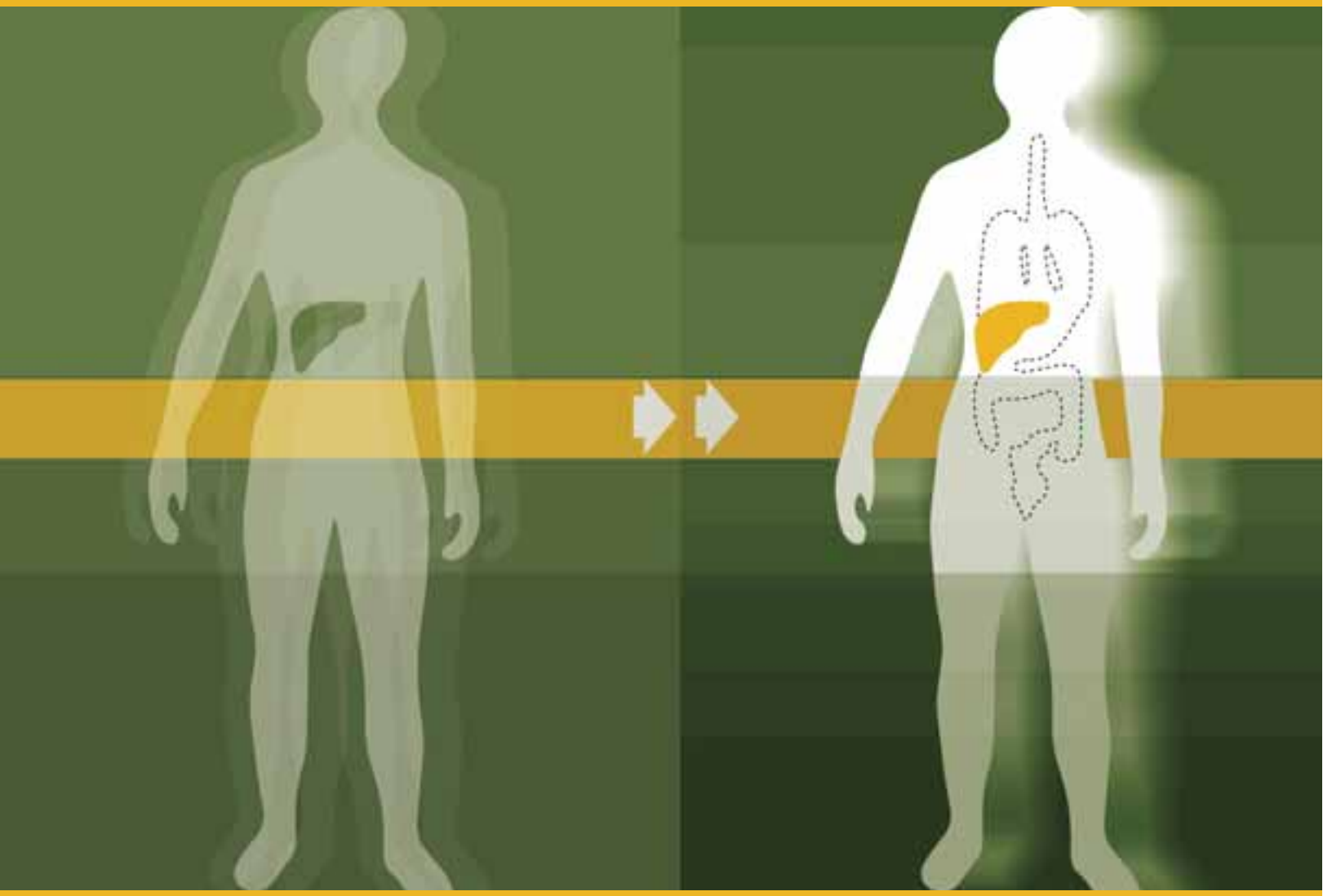

PEDIATRIC LIVER TRANSPLANT

Stuart Henry, CST/CFA, BS, Vanessa Gray, CST

Liver Transplant is an accepted form of treatment for end-stage liver disease, with more than 120 hospitals currently offering the procedure. A Certified Surgical Technologist (CST) should be familiar with the basics of the procedure to provide quality patient care. Liver transplants require the CST to have knowledge of vascular, general, and gastrointestinal (GI) instrumentation. Often transplant programs, such as the one at Children's Healthcare of Atlanta, require an on-call team, including an experienced CST familiar with the procedure, to ensure the best possible patient and graft outcome. This article will give an overview of the equipment, the three phases of the procedure, and the role of the CST during the transplant.

More than 100 liver diseases affect children.[1] Some of the most common include:

Autoimmune hepatitis: An autoimmune disease causing liver inflammation secondary to a virus.

Hemochromatosis: Iron overload, where a patient appears with cirrhosis due to excessive iron deposits in the liver and pancreas.

- *Hepatitis A, B, or C:* Inflammation of the liver due to a virus.
- *Biliary atresia:* A congenital absence or closure of the ducts that drain bile from the liver.
- *Byler's disease:* Intrahepatic cholestasis due to retention of bile salts resulting in hepatocyte injury.
- *Wilson's disease:* Liver disease due to copper depositing in hepatocytes.
- *Hepatopulmonary disease:* Liver disease secondary to arterial deoxygenating and intrapulmonary vasodilatation.[4]

Before the mid-1980s, patients with end stage liver disease (ESLD) had no curable treatment, and death was the usual outcome. As early as the 1900s, doctors had a vision of removing the diseased liver and replacing it with a healthy new one. In 1986, Dr Thomas Starzl performed the first orthotopic human liver transplant. Today liver transplant is an approved treatment for ESLD, and currently there are over 860 transplant programs in the US, 120 of which perform liver transplants. With the success of transplant therapy, more than 80,000 people nationwide now wait for a life-saving transplant. Of those 80,000, roughly 18,000 are waiting for a liver.[6]

Although orthotopic transplant will be the only type discussed in this article, surgeons have three options for liver transplantation:

1. Orthotopic transplant: Replacing the entire diseased liver with a whole healthy donor liver
2. Heterotopic transplant: Leaving the entire diseased liver intact and sewing in a new healthy liver in another location of the body
3. Reduced-size liver: Replacing the entire diseased liver with a part or portion of a healthy donor liver

Anatomy

The liver is the largest organ in the body, and is found in the right upper quadrant of the abdomen under the rib cage (Figure 1). The liver is divided into two main lobes: the right and the left. The right lobe is about six times the size of the left. The liver has more than 400 functions, but only the four major functions will be discussed in this article. The essential functions are:

Nutrition. The liver stores vitamins, iron, sugar, and carbohydrates for later use.

Clotting. Factors for clotting are made in the liver.

Bile Production. Bile is produced in the liver to aid breakdown of fatty foods during digestion. Bile also aids in mineral and vitamin absorption.

Filtration. The body's principal purification plant is the liver, and as the liver fails, toxins and waste products accumulate.[2]

The arterial supply to the liver is through the common hepatic artery, which branches from the celiac axis. When the common hepatic reaches the hilum of the liver, it divides into left and right branches. Of the two systems supplying blood to the liver, the hepatic artery supplies about 25%; the remaining 75% is supplied by the portal vein.

Bile produced in the liver drains into segmental ducts. The segmental ducts from each side of the liver combine to form the right and the left hepatic ducts, which join each other at the hilum to form the common hepatic duct.[7]

Diagnosis

Liver function tests are the first that physicians prescribe to evaluate the functional impairment of the liver. When a child has liver disease, the serum albumin will be lower than normal because the liver is responsible for synthesis of proteins. Albumin is the major protein that circulates in the bloodstream. Albumin is synthesized by the liver and secreted into the blood.

Low serum albumin concentrations indicate poor liver function. The serum albumin concentration is usually normal in chronic liver diseases until cirrhosis and significant liver damage is present. Albumin levels can be low in conditions other than liver diseases, including malnutrition, some kidney diseases and other rarer conditions.

The serum glutamic-oxaloacetic transaminase (SGOT), serum glutamic-pyruvic transaminase (SGPT), and ganna-glutamyl transpeptidase (GGT) will be elevated due to the cellular damage of liver disease. The prothrombin time (PT) will also become elevated due to a decrease in synthesis of prothrombin. The extent of abnormalities of the lab values will determine the severity of liver disease. There are not set values to determine liver failure or disease (Table 1).

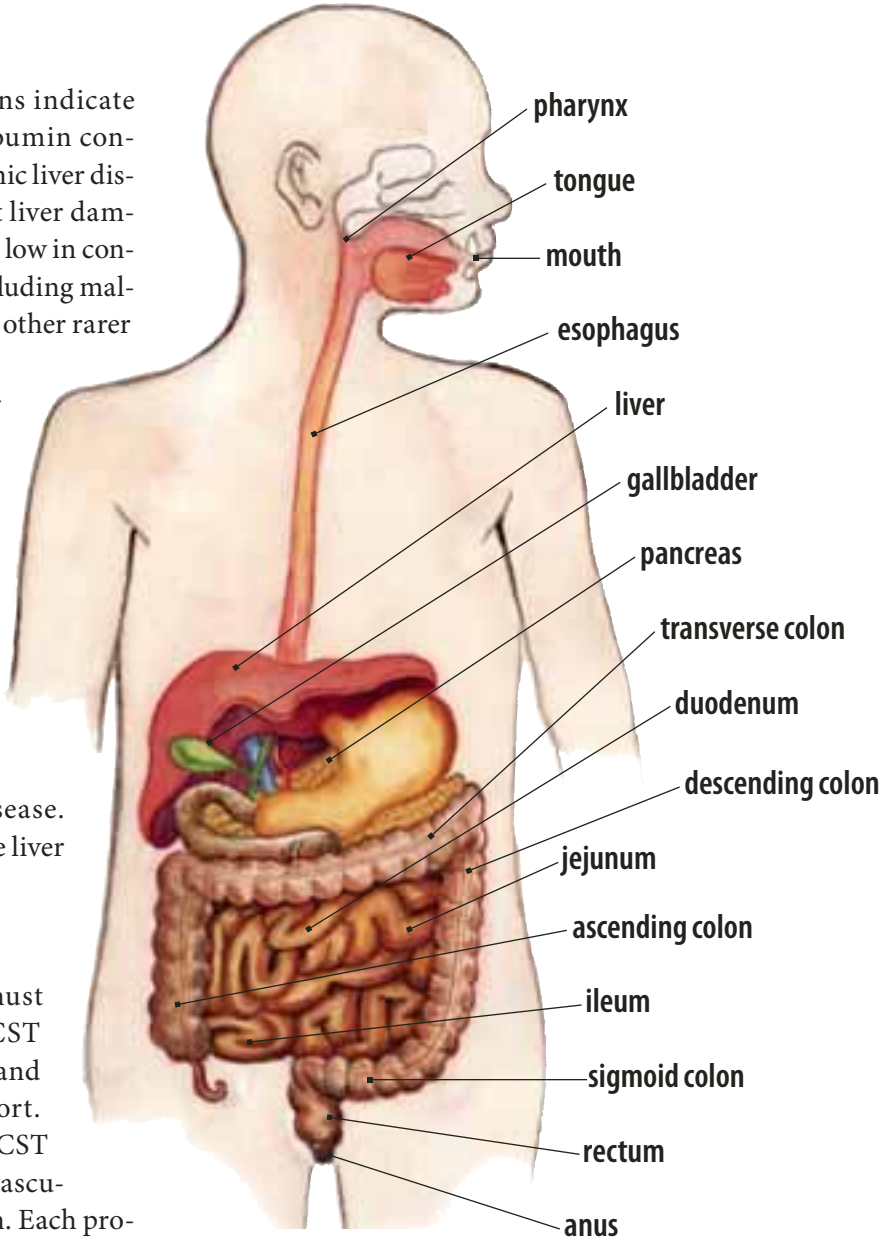

FIGURE 1

The liver is the largest organ in the human body.

Preoperative phase

In any major surgery, the room must be set up efficiently to allow the CST to reach all necessary instruments and equipment with a minimum of effort. Liver transplantation requires the CST to have a good basic knowledge of vascular, GI, and general instrumentation. Each program surgeon has his or her own preferences for instrumentation for a transplant, but Table 2 shows a general list that allows any CST to set up for a liver transplant case.

With the instruments, supplies and equipment assembled, the CST can begin opening and setting up for the case. Again each hospital is different, but Figure 3 shows the authors' set up for a liver transplant. Note that the CST has full access to all supplies and instrumentation with a minimum of effort. The CST has an excellent view of the field and can anticipate instrumentation and suture needed by the surgeon. A CST with experience in liver transplantation can keep the flow going smoothly by anticipating the next move and having the necessary instrument ready for the surgeon. An observant and alert CST can shorten the case by anticipating the next few steps of the procedure.

Intraoperative phase

An orthotopic liver transplant can be broken into three separate phases: removal of the diseased liver, antihepatic phase, and revascularization. This article will not go into depth of each step, but will highlight steps important for the CST.

The patient will be prepped with Dura Prep scrub and draped in the following sequence:

1. A green towel is left folded and used as a groin towel.

2. 6 paper drape towels
3. Two ¾ sheets are placed as "down" sheets, from the pubis to the foot of the table.
4. A large full sheet is used as an "up" sheet for the anesthesia barrier.
5. Two ¾ sheets (one on each side) are used as side sheets.
6. A large Ioban then covers the exposed surgical site.
7. A laparotomy drape with pockets covers the entire field.

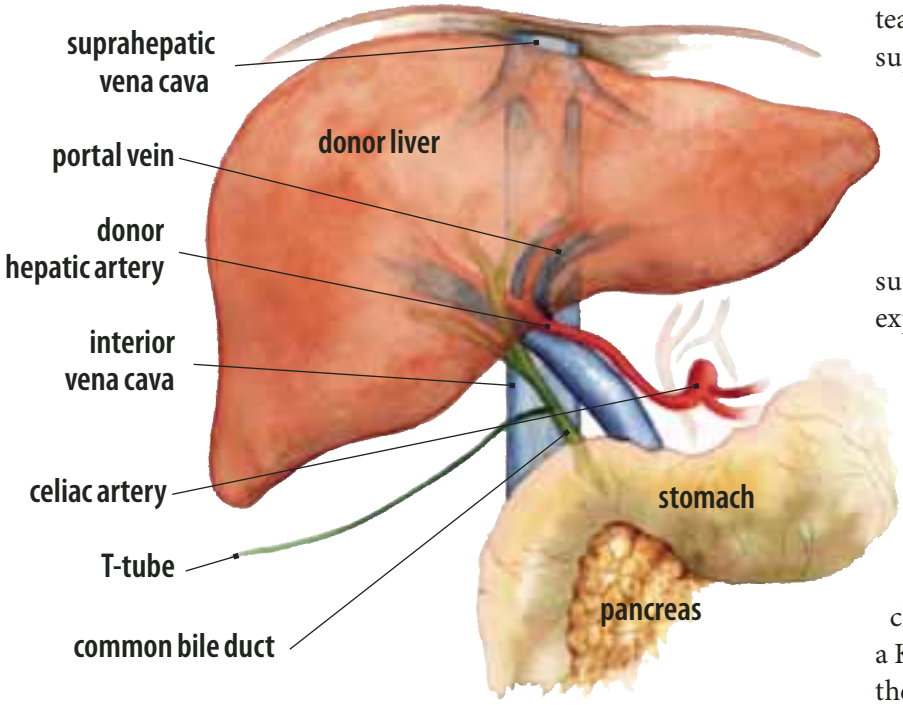

FIGURE 2
Attachment points of the donor liver.

Since the liver is such a large organ, exposure is important for a successful operation. The incision used is called a chevron incision or "Mercedes" incision. An incision is made just below the lower ribs on both right and left sides, and a midline incision is made up to the xiphoid. This will allow the best exposure of the liver and the abdominal cavity. The incision is usually made with a #10 blade followed by the electrosurgical pencil. The electrosurgical pencil has the advantage of coagulating tissue while cutting and helps maintain a bloodless field.

Once in the abdomen, the retractor is placed to offer the optimum view of the surgical site. A commonly used retractor, called the Thompson retractor, offers the surgeon multiple variations of placement of the components. Two bladder blade pieces are placed below the ribs to pull the chest upward and expose both the vena cava and the portal triad. The portal triad is an area where the hepatic artery, common bile duct, and portal vein are all located in close proximity. Bleeding is likely to occur in this area, and the CST must be ready with plenty of lap sponges and 5-0 prolene stitches. The CST may be asked to suction to keep the field free of fluid while the surgical team works.

Before the liver is removed, the surgical team must expose five important structures: the suprahepatic inferior vena cava, inferior vena cava, portal vein, the common hepatic artery, and the common bile duct. These five sites will be the attachment points of the donor liver (Figure 2).

When the diseased liver is freed from the surrounding tissue and all the structures are exposed, the next phase of the operation begins. This portion of the operation requires the CST to be knowledgeable of the vascular instruments available. The hepatic artery is ligated and cut high in the diseased liver to allow good length for the donor liver anastamosis. The portal vein is clamped first with a short straight DeBakey vascular clamp distal to the diseased liver followed by a Kelly clamp. The vessel between the clamps is then cut to expose the inferior vena cava. A long, angled DeBakey clamp is placed close to the diseased liver to allow good length of inferior vena cava for anastomosis. Finally, the suprahepatic inferior vena cava directly below the diaphragm is clamped with a large Satinsky clamp. Once all structures are cut, the diseased liver is removed from the field.

Before the donor liver is brought into the field, the abdominal cavity is checked for hemostasis. Removal of the diseased liver becomes the point of no return, since without a liver the patient will die. The donor liver is removed from the cold storage and the team begins the process of anastamosing the five structures. The surgeon's goal is to return blood flow to the

TABLE 1 **Normal values for hepatic tests[5]**

TEST	NORMAL VALUE
Serum albumin	3.5-4.6 g/dL
Total protein	6.0-7.4 g/dL
Cholesterol	135-300 mg/dL
Alkaline phos	24-100 IU/dL
AST	10-36 units/dL
ALT	10-48 units/dL
Gamma glutamyl transferase	
males	0-48 units/dL
females	4-26 units/dL
Prothrombin time	90-100% of lab control
Blood ammonia	10-63 ug/dL
Serum bilirubin	
total	less than 1.4 mg/dL
direct	less than 0.3 mg/dL

donor liver within 45 minutes of removal from cold storage. All sutures given to the surgeon are double armed and nonabsorbable. Prolene suture is used for this step. The order of anastomosis is:

1. Suprahepatic inferior vena cava. 5-0 prolene 36" c-1 taper needle double-armed suture x 3. The bottom wall is completed first followed by the upper wall.
2. Inferior vena cava (IVC). 4-0 prolene 36" SH taper needle double-armed x 2 is used again in a running fashion. The bottom wall of the lower cava is completed first followed by the upper wall.

TABLE 2 **Instrumentation, equipment and supplies**

INSTRUMENTATION
Major Dissecting Tray
General Vascular Tray
"Back table" pan
Thompson Abdominal Retractor Set
Retractor Pan

EQUIPMENT
ESUs
Upper and Lower Body Warmers
Multi suction set up
Cell-saver
If child is over 16, have Veno-veno bypass available

SUPPLIES
Pack: Custom pack
Gowns: Multi gown pack
Gloves: CST and surgeons
Blades: #10 and #15
Drapes: groin towel, 4-5 towels, 2 down (¾ sheets)—covers groin to feet, 1 large top drape, 2 side (¾ sheets), large loban, and major lap sheet with pockets
Suture: ties; silk 0, 2-0, 4-0; umbilical tape x 4
Suture; 3-0 on a SH taper, 4-0 on a SH taper, 5-0 on a C-1 taper, 7-0 on a BV-1 taper polypropylene for vascular anastomosis: 5-0 and 6-0 PDS on a RB-1 taper needle (bile duct anastomosis)
2-0 PDS (2-layer closing, lower fascia then upper fascia): 2-0 silk on a PS cutting needle (drain stitch)
Clips: medium, large ligating clips
Stapler: skin stapler
Drains: 15 French flat Blake drain
Dressing: 4x4 dressing and foam tape
Medications: heparin (1:1000) in 250 cc saline for heparin flush, no antibiotics on field
5% albumin to flush out preservation fluid before revascularization.
Prep solution: Dura Prep

3. Portal vein. 5-0 prolene 36" c-1 taper needle x 2 is used again double-armed. Again, the lower wall is completed first.
4. Hepatic artery. Again double-armed and using a 7-0 prolene 24" BV-1 taper needle x 2.
5. Common bile duct (CBD). The common bile duct is sewn with 5-0 polydioxanone (PDS) II, RB-1 taper needle, or 6-0 PDS II BV taper needle.

Before the clamps are removed from the vessels, the preservation solution must be removed from the liver. Viaspan, the solution used to maintain cell viability while the liver is being stored in ice, is a very high potassium solution. One-liter of Viaspan contains 125 mEq/L of potassium. If this solution is allowed to enter the blood stream of the recipient, the patient will cardiac arrest. To prevent this, a physiological solution, such as albumin, is used to flush out the Viaspan from the donor liver.

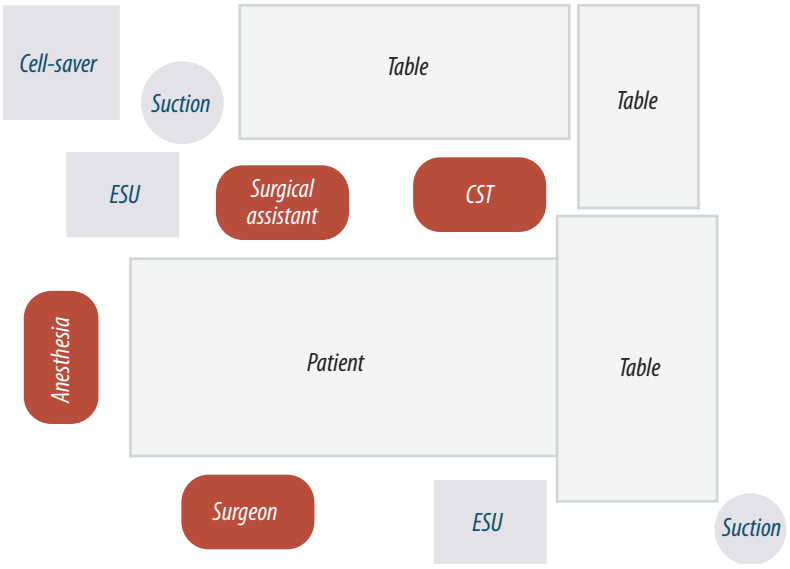

FIGURE 3
Operating room set up for liver transplant.

Once all anastomoses have been completed, the clamps are ready to be taken off and blood flow resumed. This stage has the most tension for the CST, as untied small vessels or holes in the vessels and tissue are common, and removal of clamps can cause a sudden loss of blood and a drop in the patient's blood pressure. The CST must be ready for rapid handling of suture to regain hemostasis. Often the bleeders will require stitches, as well as Gelfoam or Surgicel.

When the field is dry, the last anastamosis will be the common bile duct. The duct can either be sewn duct-duct or in the case of previous bile duct surgery a roux-en-y may be performed. Here 5-0 PDS 27" on a RB-1 taper needle is used and will be running or interrupted, depending on surgeon preference.

After all anastomoses are completed and hemostasis is achieved, the team performs a final inspection to ensure there are no small bleeders that can cause the patient to return to the OR. When satisfied, the surgeon will then place a 15 French flat Blake drain in the right upper quadrant below the dome of the donor liver. This will allow the patient care providers to monitor any bleeding postoperatively. The wound is irrigated with warm saline before the closing of the layers of the abdominal wall.

The final step is the closing of the wound, which is accomplished using a three-layer technique. It is important at this stage for the CST to begin the counts to ensure that no supplies are retained. The lower fascia is closed first to ensure there are no weak areas for hernias to occur later. The lower fascial layer can be closed in a running fashion using a 2-0 PDS II. The wound is closed in three directions, from the xiphoid down, and from the lateral wound edges to the middle. All three sutures meet in the middle and are tied tightly to ensure a good wound closure. The upper fascia of the side incisions is then closed. The last stage is approximating the skin edges with staples. Wet and dry laps are then used to clean the skin and around the surgical site. Sterile 4x4 dressing is then placed over the wound and drain site. Foam tape is used to secure the dressing.

Postoperative phase

The success of liver transplants has increased dramatically with the improvement of immunosuppressive drugs.

The more common regimes are:

- Cyclosporine or tacrolimus (Prograf, FK506)

- Azathioprine (Imuran)
- Prednisone

Cyclosporine and tacrolimus prevent rejection of the donor organ by preventing the growth and function of lymphocytes, which is part of the body's immune defense system. Azathioprine prevents lymphocyte proliferation. Prednisone, which is a glucocorticoid, inhibits the cells that would recognize the graft as a foreign object. Patients can expect to be on these medications for the life of their graft.

Postoperatively, patients can expect to be in the ICU for a day or two, and then be transferred to the transplant ward. The average hospital stay for liver transplant patients is seven to 10 days. Nationwide, the success of livers is currently about 90% graft-and-patient survival at one year and 75%-80% success at five years. The longest surviving liver recipient of a liver transplant is more than 29 years.[3] Once released from hospital, patients return to the outpatient clinic weekly for lab tests to ensure that the liver is functioning and the body is not rejecting the new organ. Visits progress to monthly, then annually.

Conclusion

CSTs play a vital role in the success of liver transplants. They must be familiar with a wide assortment of instruments and equipment and be able to adjust to every changing situation. No single liver transplant surgery is ever the same, and a good CST must be able to adapt to each situation. There must be a smooth transition between the three intraoperative phases. The antihepatic and revascularization phases are often the most intense and difficult stages for the CST to master. CSTs are vital members of a successful transplant team, and while the cases are long and difficult, the outcome of patients returning to a healthy life is well worth it.

About the authors

Stuart Henry, CST/CFA, BS, is currently in charge of organ donation for livers at both Childrens Health Care of Atlanta-Egleston and Emory Medical Center in Atlanta, Georgia. For the past 20 years, he has been a first assistant for both pediatric and adult liver transplantation at various transplant programs. He became certified last year.

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