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LIVER TRANSPLANTS: A PRIMER FOR THE GENERAL SURGEON

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About Notable Grand Rounds

These assembled papers are edited transcripts of didactic lectures given by mainly senior residents, but also some distinguished attending and guests, at the Grand Rounds of the Michael and Marian Ilitch Department of Surgery at the Wayne State University School of Medicine.

Every week, approximately 50 faculty attending surgeons and surgical residents meet to conduct postmortems on cases that did not go well. That “Mortality and Morbidity” conference is followed immediately by Grand Rounds.

This collection is not intended as a scholarly journal, but in a significant way it is a peer reviewed publication by virtue of the fact that every presentation is examined in great detail by those 50 or so surgeons.

It serves to honor the presenters for their effort, to potentially serve as first draft for an article for submission to a medical journal, to let residents and potential residents see the high standard achieved by their peers and expected of them, and by no means least, to contribute to better patient care.

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Liver Transplants: A Primer for the General Surgeon

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by

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Introduction

Liver transplantation is a relatively new specialty, having existed for only two or three generations of surgeons.

All general surgeons need to be prepared to care for patients who have had a liver transplant or will undergo one in the future, so understanding the basics is essential.

Objectives

This paper aims:

1. To provide a basic understanding of the liver anatomy
2. To discuss technical aspects of donor and recipient surgery
3. To review the indications for liver transplant
4. To provide a basic review of immunosuppression

1. Liver Anatomy

Understanding anatomy is crucial, especially for liver and biliary tract surgeries. Standard liver anatomy applies to only about 35% of patients, so variations are to be expected. CT scans should be thoroughly reviewed before proceeding with any case; knowing the spatial relations

between anatomical structures is vital for a successful operation.

In every liver case, the first thing to consider is the ligaments. The liver must always be fully mobilized on the side to be worked on. This may seem unnecessary, but if bleeding is encountered and the surgeon has not prepared for it adequately, the situation can become disastrous. For example, performing a partial liver resection on the right side without having first mobilized the triangular, cardinal or falciform ligaments makes controlling bleeding near impossible.

My approach is to always mobilize the falciform ligament until it forms a triangle, showing that the hepatic veins will be posterior. From that point, the surgeon may operate on either the right or left side, being careful not to injure the diaphragm. A puncture of the diaphragm is easily repairable with a purse-string suture and suction underwater with the help of a red rubber catheter. The hole can be repaired using Prolene. This negates the need for a chest tube, and the patient's hemodynamics will indicate any issues.

By being thoroughly prepared and understanding the anatomy and surgical nuances, surgeons can increase the success rate and safety of liver transplant operations.

Liver Segmentation

The liver is divided into segments, and the most standard definition currently recognizes eight. Segment 1, also known as the caudate, is unique; it has its own blood supply and drainage system. The other segments are more conventional. When dividing the liver into left and right sections, the left comprises segments 2, 3, and 4, while the right includes segments 5, 6, 7, and 8. The caudate is posterior to all these.

In nearly 90% of cases, the hepatic vein comes into a common trunk. This common trunk can be accessed by lifting the left liver medially, then dissecting the umbilical ligament. Accessing the right side is more complex; you must fully mobilize the right liver, which will reveal numerous small vessels connecting to the inferior vena cava (IVC). While some suggest using the LigaSure™ device my personal preference is to individually tie all these vessels. The traditional practice is to tie, clamp, cut and tie these vessels, particularly on the IVC side. Liver bleeding is more easily manageable.

An important ligament that holds the liver to the IVC is either the Makuuchi ligament or the hepatocaval ligament. It must be transected to access the right hepatic vein. This ligament sometimes contains large blood vessels that must be clamped and sutured or stapled.

The anatomy of the portal vein is quite variable. Generally, the right portal vein has posterior and anterior branches, while the left has medial and lateral branches. These branches distribute to the different liver segments.

For test preparation, note that ultrasound images of the liver often show a white halo around the portal vein, serving as an identifier. Careful review of the CT scans, especially during the venous phase, will help to trace the portal vein and its anterior, posterior, medial, and lateral branches.

The hepatic arteries can be particularly tricky. The general rule is to avoid handling them unnecessarily, as they are prone to dissection, leading to significant complications. Understanding anatomy is crucial here. Arterial supply typically originates from the celiac trunk, which branches into the splenic, common hepatic, and left gastric arteries.

Most often, the common hepatic artery originates after the take-off of the splenic artery. The gastroduodenal artery (GDA) has collateral circulation with the superior mesenteric artery (SMA) system. Therefore, ligation in certain cases of the common hepatic artery usually will not compromise liver perfusion, as blood can still flow through the SMA system if patent.

One anatomical variation that can be problematic is when the left hepatic artery is replaced and originates from the left gastric artery. While some surgeons opt to ligate this in emergencies, caution is advised as it sometimes supplies the entire left liver. The replaced right hepatic artery can also be challenging, usually found lateral and posterior to the bile duct.

When reviewing CT scans, the surgeon should check the origin points of the celiac trunk and SMA for any replaced arteries. This is essential for planning procedures like the Whipple, where arterial involvement could be a concern. An "SMA-first approach" can be employed, dissecting the SMA a few centimeters from its aortic origin to separate it from the pancreas. If this is successful, the Whipple may proceed; otherwise, the operation should be aborted.

Bile ducts are another area where anatomical variation can cause complications. Always review MRCP scans to identify the origins of these ducts, particularly if planning a hepatectomy. An intraoperative cholangiogram can offer additional information if there is uncertainty. The left hepatic duct has a long extrahepatic portion which facilitates its dissection and use.

When discussing liver procedures, terms like "mobilizing the cystic or hilar plate" often come up. This refers to the peritoneal wrappings and attachments around the bile ducts that must be delicately peeled away layer by layer. Doing so enables exposure of the liver's hilum and mobilization of the parenchyma away from it. As for liver anatomy, variations abound, whether it's the right and left systems or the various segments defined by the Couinaud classification. For instance, segments 2 and 3 correspond to a left lateral section, while segments 5 and 8 define a right anterior section.

Blood flow in the liver is another important consideration. About 75-80% comes from the portal vein with a pressure of around 6-10 mmHg, while just 20% comes from the hepatic artery. However, the hepatic artery is crucial for bile duct health. If it's transected, the liver may survive but the bile ducts will not, leading to complications including abscesses and strictures.

The hepatic arterial buffer response is a vital mechanism that regulates blood flow to the liver. Essentially, if portal blood flow decreases, the hepatic artery dilates to increase its flow. This dilation is triggered by the accumulation of adenosine in the liver. This concept is especially important in living donor transplants where "small-for-size syndrome" can occur if the hepatic arterial flow is disproportionately high compared to the graft size.

Lastly, the hepatic venous pressure gradient is a useful measurement when dealing with cirrhosis. It is obtained by measuring the difference between portal and hepatic venous flows, and can range from 10 to 30. The value gives an indication of the severity of cirrhosis symptoms.

2. Liver Transplant Donors and Recipients

Criteria for organ allocation are stringent. Years ago, five-year survival rates for liver transplants hovered around 50%; now, they exceed 90%. This improvement is crucial because transplant centers need to meet national benchmarks for survival to stay active and provide best patient care.

The MELD (Model for End-Stage Liver Disease) score is the primary metric for liver transplant eligibility, eclipsing the previously used Child-Pugh score. A MELD score over 15 or the presence of certain symptoms qualifies a patient for a transplant. Liver allocation now prioritizes the highest MELD scores within geographic areas. However, exceptions exist; for example, patients with hepatocellular carcinoma might have lower MELD scores but can receive exception points to match the national average MELD score, facilitating their access to a transplant.

The old regional allocation system has been replaced by a “nautical mile” system, which has had both positive and negative impacts. It allows some centers to acquire organs more easily but can also create shortages, particularly in large cities with multiple transplant centers.

When assessing a donor, two key terms are relevant: DCD (donation after circulatory death) and DBD (donation after brain death). DBD refers to donors who have experienced irreversible cessation of brain activity, essentially meaning they are brain-dead. These donors are ideal for transplantation since the organs can be procured while still receiving blood flow, reducing warm ischemia time. On the other hand, DCD donors have died from irreversible cardiac causes. In these cases, warm ischemia time is longer, complicating the transplantation process. Cold ischemia time is essentially the time the liver has been on preservation solution and ice.

Expanded criteria are used to allocate organs to older recipients with low MELD scores, including

those from donors with histories of drug abuse or Hepatitis C. The recipient of a liver transplanted from a Hep C-positive donor can be treated at 6 months. With an approximately 95% cure rate, it is an effective approach.

The decision to declare a patient dead is typically not made by transplant or organ donor surgeons. They arrive at the OR only after other physicians have confirmed the patient's death. In Asia, living-donor transplants are common .

An important aspect to consider when evaluating a living donor is the Graft-to-Body Weight Ratio (GBWR); if it's below 0.8, the graft will likely be too small for that recipient.

Most liver donors are now managed using minimally invasive surgeries and robotic techniques. New technologies like normothermic perfusion allow for more precise assessment of the liver's condition, even making it possible to schedule transplants instead of performing them in emergency settings. This also reduces the risk of post-reperfusion complications.

In surgical techniques, there are various approaches for incisions and liver mobilization. For instance, a vertical incision from the sternum to the pubic symphysis may be made, or the surgeon may opt for a "cross" incision. Specialized retractors simplify the procedure, and careful mobilization of the liver is essential.

The Cattell–Braasch–Valdoni maneuver involves extensive mobilization of the colon and abdominal structures, enabling a clearer surgical field.

To begin, the entire right side of the colon is mobilized. Once the iliacs and ureter are visible, and the left renal vein and IMV are visible, mobilization can continue with electrocautery. All the bowel and colon are gathered into a towel to form a burrito which is then clamped and moved to the left upper quadrant for better exposure.

For liver transplants, extensive dissection of the IVC is generally not required. Cannulation involves one cannula for the portal system and another for the aortic system, IVC venting is usually performed by transecting the suprahepatic IVC immediately adjacent to the atrium.

The procedure involves coordination with cardiac surgeons, particularly when determining the length of the IVC to be used. The splenic artery is generally preserved for potential reconstruction.

Typically, duct-to-duct anastomosis is performed after a liver transplant, given that the blood supply to the bile duct is usually intact.

For aortic clamping usually, a supraceliac approach is preferred. This is achieved by dissecting next to the crus of the diaphragm and retracting the stomach laterally. Before clamping, 30,000 units of heparin and 25 grams of mannitol are administered.

For the cold preservation portion, either UW (University of Wisconsin) solution or HTK (histidine tryptophan ketogluterate) can be used. The back table work includes meticulous dissection of the arterial system from the aorta up to, but not beyond, the gastroduodenal artery (GDA).

3. Liver Transplant Indications

Acute decompensated liver failure and acute alcoholic hepatitis are liver transplant indications. They often receive a high MELD score and are categorized as Status 1A, which gives them priority in the national organ allocation system.

Liver tumors, hepatitis, and primary biliary cholangitis are also indications for transplant. Contraindications include significant hepatic malignancy and patients with severe other conditions like hemorrhagic strokes and active infection.

Transjugular Intrahepatic Portosystemic Shunt (TIPS) is not a technical impediment to transplantation. However, problems such as uncontrolled bleeding during surgery will arise if the surgeon forgets that the patient has TIPS. Acute viral hepatitis is another indication for transplant; the mortality rate without it is 80%.

Generally, you avoid transplants in patients with active infections. For acute liver disease, criteria like King's College are used to assess eligibility. High-risk patients often require living donor liver transplants. Conditions like Budd–Chiari syndrome present unique surgical challenges due to obstructed hepatic venous outflow.

TIPS alleviates portal hypertension by creating a pathway between hepatic and portal veins. For polycystic liver disease, hepatectomy is challenging.

Quality of life is a significant factor in considering transplants for chronic liver disease. Treatments like banding for bleeding varices and medications for encephalopathy often result in poor quality of life. Alcoholic hepatitis patients require high doses of steroids and strong family support for transplant eligibility. Unfortunately, many return to drinking post-transplant.

Hepatitis A and E may lead to transplants in rare cases, while Hepatitis B accounts for less than 5% of cases, primarily in Asian countries. Vaccination for Hepatitis B is available and crucial. Transplanted patients with Hepatitis B DNA positive require lifelong antiviral therapy. Hepatitis C used to be a leading cause and can lead to cancer, but hepatocellular carcinoma (HCC) may occur without cirrhosis.

Various treatments are available to stabilize patients before liver transplantation. Criteria such as UCSF and Milan guide eligibility. UCSF criteria, for example, are more expansive, allowing for larger tumor sizes.

For HC), the Barcelona Clinic criteria provide a helpful guideline for treatment.

Cholangiocarcinoma, once considered a poor candidate for transplantation, is now being treated with the Mayo Clinic protocol involving external beam radiation and chemotherapy.

Transplants for neuroendocrine tumors are rare, while those for unresectable colorectal metastases are a new trend, backed by promising research from centers like the one in Oslo. Toronto is also seeing good outcomes with this approach.

Hepatic artery infusion pumps are being increasingly used for chemotherapy delivery. These were popular in the 1980s and '90s, then fell out of favor; but are now making a comeback.

Lastly, non-alcoholic steatohepatitis (NASH) is becoming a common reason for liver transplantation, particularly among morbidly obese patients, although these cases present their own set of challenges due to the patients' size.

Liver Transplant Procedure Notes

Typically, a right upper quadrant incision is made, although some prefer a Legg Perthes incision. Studies have shown that this incision has less risk of tumor formation and hernias. But if preferred, an incision can also be made two finger breadths below the costal margin.

Begin by dissecting the hilar area with a right-angle instrument. Tie and clamp as needed. Always dissect as distally as possible on the hepatic arteries and portal veins. This allows for easier anastomosis later on. Preserve the cystic duct for potential trans-cystic stent placement.

Mobilize the liver carefully. Multiple small branches will be encountered, that can bleed profusely, so be prepared to tie or clamp them. For most cases, there is no need to put the patient on pump as the IVC is not clamped or only partially clamped and patient hemodynamics are unaffected.

For vascular anastomosis, secure both ends and perform a running suture for the posterior layer, which is crucial for preventing post-operative bleeding. If necessary, use a graft from the donor's iliac vein.

4. Complications and Immunosuppression

Complications: primary non-function occurs in 1-7% of cases and usually requires re-transplantation. Acute portal vein thrombosis mandates a trip back to the OR for a thrombectomy. Biliary complications and infections are fairly common but generally manageable with medical treatment.

Immunosuppression: Liver transplants do not usually require induction therapy. The liver is more tolerant to rejection compared to kidneys.

Maintenance therapy usually involves three agents: a calcineurin inhibitor (either cyclosporine or tacrolimus), an antiproliferative agent (mycophenolate mofetil or its alternative), and a short course of steroids.

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