There are several types of liver tumors, ranging from benign to malignant or primary to metastatic (secondary). The type of tumor determines the appropriate treatment, and only a few types of liver tumors can be resected. Intraoperative management of liver tumors is challenging due to the inherent risks to the patient that may continue during the postoperative phase. Advances in surgical techniques and therapeutic management have improved survival rates and expanded the number of patients who may be able to have a tumor resection.

**Statistics**
According to the American Cancer Society, it’s estimated that in 2014, there will be 33,190 new cases of intrahepatic bile duct and liver cancer; of these, approximately 23,000 individuals will die from this disease. Unfortunately, based on Surveillance, Epidemiology and End Results data, the 5-year survival rate is only 16.1%.

**Anatomy and physiology**
The liver is the largest solid organ and the largest gland in the body. It’s located in the upper right quadrant of the abdomen, just behind the ribs and beneath the diaphragm. (See Anatomy of the liver and biliary system.)

It’s divided into the right and left lobes, which are further divided into segments. (See Hepatic segmentation.) The liver receives its blood from both the hepatic artery and the portal vein. The hepatic artery supplies the liver with oxygen-rich blood from the heart, and the portal vein supplies the liver with nutrient-rich blood from the intestines.

The liver has several important functions, including the breakdown and storage of various nutrients absorbed from the intestine. Some of these nutrients are metabolized in the liver before being used for energy or to repair or build body tissues. The liver is involved with most of the clotting factors in addition to the synthesis of glucose and glycogen storage. It secretes bile into the intestines to facilitate the absorption of nutrients—especially fats. Lastly, it breaks down and filters out toxic wastes in the blood, which are then removed from the body either in urine or feces.

The cells in the liver are mainly comprised of hepatocytes. There are other types of cells that line the blood vessels in the liver as well as the small bile duct tubes. All of these cells can form both malignant and benign tumors.

**Risk factors**
The causes of liver cancer are still not well understood today. However, scientists agree that there are several known risk factors for liver tumors, including male gender, ethnicity (Pacific Islanders and Asian Americans), individuals with a history of cirrhosis or viral hepatitis, or those who are obese. In 2014, the American Cancer Society estimated that the rate of newly diagnosed individuals—of both primary liver cancer and intrahepatic bile duct cancer—to be 24,600 (men) and 8,590 (women). In addition, 15,870 men and 7,130 women will die of these cancers. The lifetime risk for hepatic cancer is approximately 1 in 81 men and 1 in 196 women, with the average age of diagnosis at 63. In the United States, Pacific Islanders and Asian Americans
tumors
have the highest rates followed by American Indians, Alaska Natives, Hispanics, Blacks, and Whites. Worldwide, over 700,000 people are newly diagnosed with liver cancer each year with 600,000 associated deaths. Cirrhosis is another risk factor. In cirrhosis, liver cells are damaged and replaced with scar tissue. Nonalcoholic steatohepatitis or “fatty liver,” which is common in obese individuals, is another risk factor for liver cancer. An autoimmune disease such as primary biliary cirrhosis is yet another condition associated with higher rates of hepatic cancers.

Chronic viral hepatitis (hepatitis B [HBV] or hepatitis C [HCV]) is the most common risk factor for liver cancer worldwide. In the United States, HCV is the most common risk factor for hepatocellular carcinoma. Heavy alcohol use, obesity, type 2 diabetes, some inherited metabolic disorders (such as hereditary hemochromatosis), ingestion of aflatoxins (a fungal toxin in nuts, seeds, and legumes), chemical exposure (such as vinyl chloride), anabolic steroid use, arsenic exposure, infection with parasites (in rare cases), oral contraceptives, and tobacco use are other risk factors. All of these conditions may damage the liver and the DNA of the cells, therefore increasing the risk of hepatic tumors.

**Types of liver tumors**

Benign liver tumors are the first category of liver tumors. The most common liver tumor is a hemangiomma, which starts in the blood vessels and often doesn’t require any treatment. If bleeding occurs, surgical removal is necessary. In addition, there are also hepatic adenomas and focal nodular hyperplasia. Hepatic adenomas are typically asymptomatic and don’t require treatment. However, in some cases, they may cause pain or blood loss and will need surgical removal. There’s also a small risk that they may become malignant. Focal nodular hyperplasia may be difficult to differentiate from a malignancy, and in some instances, these cancers may be removed surgically.

There are two major types of primary liver cancer in adults: hepatocellular carcinoma, the most common type, and cholangiocarcinoma, also known as bile duct cancer. Rare types of primary liver cancer include angiosarcoma and hemangiosarcomas. These cancers are usually associated with exposure to toxic chemicals.
and start within the cells that line the blood vessels in the liver. These tumors tend to grow quickly and are too widespread for surgical resection. The last type of primary hepatic cancer is hepatoblastoma. This tumor is rare and typically develops in children who are under 4 years of age. Only two out of three children with these cancers have a successful treatment with surgery and chemotherapy.

Secondary liver cancer occurs from metastatic disease. Common sources where the tumors originate from include the colon, breasts, or lungs. In the United States, liver cancer from metastatic disease is more common than primary liver cancer unlike in Asia and Africa, where primary liver cancer is more common.

**Signs, symptoms, and diagnosis of liver cancer**

Liver cancer may present as symptomatic or asymptomatic masses in the liver. Clinical findings include the following: weight loss, loss of appetite, feeling full after a small meal, nausea, vomiting, abdominal or right shoulder blade pain, ascites, an enlarged liver or spleen on palpation, itching, and jaundice. Other findings include hypoglycemia, gynecomastia, erythrocytosis, hypercholesterolemia, and hypercalcemia (symptoms may include confusion, constipation, or muscle weakness).

Liver cancer is diagnosed through a medical history and physical exam, lab tests, abdominal ultrasound, computed tomography, magnetic resonance imaging, hepatic angiography, or laparoscopy with biopsy (a definitive diagnosis is made with a biopsy). Lab tests include the serum tumor marker, alpha-fetoprotein (AFP), a comprehensive metabolic panel, coagulation tests, a complete blood cell (CBC) count, and HBV/HCV tests.

**Staging liver cancer**

There are several systems for staging liver cancer. The American Joint Committee on Cancer (AJCC) TNM system has three key components: T describes the number and size of primary liver tumors, N
describes the extent of the cancer spread to nearby lymph nodes, and M is used to indicate whether the liver cancer has metastasized. The TNM categories are then combined with the four stages of liver cancer. Stage I involves only one tumor that hasn’t spread to any of the nearby lymph nodes or distant organs. In Stage II liver cancer, one of the following two conditions is present: Either the tumor has spread to nearby blood vessels, or there are multiple tumors, all of which are smaller than 5 cm in diameter. Stage III is subdivided into A, B, and C: In category A, there’s more than one tumor larger than 5 cm, but the tumor hasn’t spread to nearby lymph nodes or distant organs; in category B, at least one tumor is growing into a major vessel in the liver but has not spread to nearby lymph nodes or distant organs; in category C, one or more of the tumors, regardless of their size, has spread to nearby organs other than the gallbladder or have broken through the peritoneal cavity lining, but the tumor hasn’t spread to the nearby lymph nodes or distant organs. Stage IV is subdivided into A and B. In category A, one or more tumors have spread to nearby vessels or nearby organs and has spread to nearby lymph nodes. Category B occurs when the cancer has metastasized beyond the liver to other locations in the body.

The AJCC staging system described the extent of the cancer but doesn’t address liver function. Other staging systems, such as the Barcelona Clinic Liver Cancer system, take the extent of the disease and liver function into account.

**Treatment**

Once primary liver cancer has been diagnosed, the cancer is categorized into the following groups that are used to determine the treatment options: localized resectable, localized unresectable, and advanced liver cancer. Treatment options include surgery (cryosurgery, segmental resection, partial hepatectomy, total hepatectomy and liver transplantation, and radiofrequency ablation), chemotherapy, percutaneous ethanol injection, hyperthermia therapy, and biologic therapy. The last two treatments are being studied in clinical trials.

**Liver resection**

Surgical liver resection (also known as hepatectomy) is considered one of the most effective therapeutic treatments for certain patients with benign and malignant hepatic tumors (especially hepatocellular carcinomas, bile duct tumors, and liver metastasis). Treatment advances are associated with improvements in the operative and anesthesia technique, including more appropriate patient selection as well as the specialization of hepatobiliary surgery. Patients with chronic liver insufficiency may not be appropriate candidates for liver resection due to the prevalence of increased mortality and morbidity.

Liver resection, performed as an open procedure or laparoscopically for some procedures, is considered either minor or major depending on what part of the liver is being resected. Minor hepatic procedures are either wedge resections or segmentectomies, which occur in segments II, III, IVb, V, and VI, as it’s easier to approach and resect these segments. Bisegmentectomy, which is a resection of segments II and III, is also considered a minor procedure. However, hemihepatectomies (regular and extended) and right trisectionectomies, along with resections in segments I, IVa, VII, and VIII, are considered major procedures. These segments are considered the posterior aspect of the liver, are more technically difficult to resect, and require specialized laparoscopic skill to perform. Liver transplantation may be an option for patients who aren’t candidates for a resection.
Intraoperative concerns

From an intraoperative perspective, there are a variety of concerns for both liver resection and liver transplantation, which involve respiratory management, hemodynamics, medication management, and fluid management. Drug metabolism and clearance are considerations for general anesthesia, since different medications may cause either increased sensitivity which, in turn, accelerates biotransformation of the medication or increased half-lives of the drugs. This depends on the amount of liver blood flow as well as cytochrome P450 system activity in hepatocytes.

During the procedure, lower tidal volumes and avoiding the use of positive-end expiratory pressure are essential to lower preload and minimize the risk of bleeding.

Intraoperatively, significant blood loss, cardiac instability, electrolyte imbalances, and acid-based imbalances are common during liver surgery. The anesthesia provider needs to identify and treat any of these issues to prevent potential negative patient outcomes. Specifically, hemodynamic events are associated with poor outcomes.

An arterial line is typically placed for continuous BP monitoring, and a central venous catheter is placed in the patient to assist with hemodynamic and fluid balance monitoring.

As the procedure progresses (especially during the dissection and mobilization of the liver), fluid shifts may occur resulting from the drainage of ascitic fluid, transection or varices, and a temporary obstruction of venous return caused by surgical manipulation of the liver. Although these are important considerations, bleeding is the primary concern during liver resection. Strategies to reduce the risk of bleeding include preoperative autologous blood donation, intraoperative isovolemic hemodilution (a technique that removes approximately 450 to 500 mL of blood from the patient and replaces it with crystalloid and/or colloid replacement), normothermia, and maintaining a low central venous pressure (CVP). Maintaining normothermia assists in preventing coagulopathies induced from hypothermia, and maintaining a low CVP has been shown to decrease blood loss by 80%.

One important consideration is that fluid resuscitation results in decreased platelet counts and coagulation factors. Platelets and packed red blood cells should be available during the procedure if required. Intraoperative monitoring of coagulation parameters such as prothrombin time, fibrinogen, platelet counts, and international normalized ratio (INR) is performed throughout the procedure. Coagulopathy treatment isn’t recommended unless bleeding is extreme. Blood transfusions are not recommended, as they may cause fluid shifts, changes in electrolytes, such as hypocalcemia and hyperkalemia, hyperthermia, blood transfusion reactions, and acid-based disturbances.

The use of diuretics is another strategy in managing patients during hepatic surgery. Mannitol may be used to remove free water from the abdomen caused by the congestion of blood flow. It’s also used for its free radical scavenging and antioxidant properties. It’s especially beneficial if hepatorenal syndrome exists. Lastly, calcium chloride, if administered when there’s no hepatic function, will prevent citrate intoxication if blood products are administered.

There may be significant hemodynamic and electrolyte changes once the liver is partially resected or transplanted. If there are any coagulation concerns, they should be addressed during this time. Sodium levels and the extent of liver disease, such as cirrhosis prior to surgery, should be considered. Patients with cirrhosis may have low sodium levels, and it’s considered a predictor of death for patients in end-stage hepatic disease. In these patients, the brain adapts to the low sodium levels by losing its intracellular solutes, which limit brain edema. The anesthesia provider needs to be cognizant of the treatment for sodium imbalances. If the imbalance is corrected, it may prevent hepatic encephalopathy, but if it’s treated too quickly, osmotic demyelination syndrome (ODS) may occur. ODS is associated with neurologic morbidity and mortality.

Lastly, part of the intraoperative management of liver tumors involves managing the patient so that early extubation can occur. Early extubation improves patient comfort and satisfaction, lowers costs by decreasing the intensive care stay and hospital length of stay, enables the healthcare providers to perform an early neurologic assessment, improves pulmonary hygiene, and decreases the incidence of ventilator-associated pneumonia. However, some disadvantages of early extubation include respiratory failure and poor oxygenation to the liver and the potential for reintubation if the patient returns to the OR for early complications, such as a bile leak, thrombosis, or bleeding.

Postoperative care

When the surgery is finished and the patient is stable, the patient is usually transferred to the postanesthesia care unit. When the surgery is finished and the patient is stable, the patient is usually transferred to the postanesthesia care unit.
care unit. Once discharge criteria are met, the patient is transferred to the surgical intensive care unit. The postoperative management for a patient who has had hepatic surgery or transplantation includes airway management (with the potential for prolonged mechanical ventilation), pain management, and hypothermia management. The patient will have surgical drains in place to remove any fluid that may drain from the surgical site as well as to monitor for any bile leaks, a complication that may occur after hepatic surgery. Patients are also assessed for potential postoperative complications that may include bleeding, malnutrition, sepsis, anastomotic leaks, and rejection for those whose liver was transplanted. Postoperative treatment measures include the introduction of an enteral diet, judicious use of I.V. fluids, prompt removal of invasive monitoring devices, reduction in the use of opioid pain medication, and early mobilization.

After hepatic surgery, there’s a transient rise in serum hepatic transaminase levels. This occurs as a result of hepatocellular damage and typically peaks within 24 to 48 hours. Some hepatic ischemia may occur if the levels remain high. Biliary obstruction may occur if the rise of alkaline phosphatase is combined with a sustained elevation in bilirubin. This is more commonly seen with major hepatic surgery as opposed to minor hepatic surgery, since minor procedures don’t involve biliary reconstruction.

Platelet counts, activated partial thromboplastin time, and INR are liver function tests that should be monitored postoperatively. There may be a consumptive coagulopathy combined with decreased synthetic function if there’s a postoperative rise in INR that occurs in 1 to 5 days coupled with decreases in both fibrinogen levels and platelets. Postoperatively, patients should be assessed for bleeding and hemoglobin, and hematocrit levels should be monitored regularly. These levels should stabilize within the first 24 to 48 hours.

Fluid and electrolyte imbalances may be seen in postoperative patients who’ve had liver surgery. Albumin or colloids replacement fluids are preferred over crystalloids if the patient has a history of cirrhosis. Non-lactate solutions are recommended to help prevent an increase in lactate levels. Diuretic therapy and sodium restriction may also be initiated in the postoperative phase. Calcium, phosphate, and glucose levels are monitored, and any abnormalities require correction. It’s recognized that effective management of glucose levels has a direct correlation to improved patient outcomes. Phosphate impacts cell energy metabolism, and deficiencies may cause cardiac and neurologic dysfunctions, respiratory failure, and insulin resistance. Calcium gluconate or calcium chloride is used to correct low calcium levels, since calcium is important for coagulation and liver regeneration.

Venous thromboembolism (VTE) prophylaxis is initiated in the OR and continued in the postoperative phase, especially for oncology patients. This is accomplished through the use of compression devices and stockings. In addition, depending on the patient’s specific condition and the physician’s preference, low-molecular-weight heparin may be initiated on the day of surgery and continued postoperatively.

Pain control is imperative in the postoperative phase. Poor pain control leads to poor respiratory effort, longer recovery time, and loss of appetite. Opioids are typically used in the initial postoperative phase, and patients need to be monitored for respiratory depression. A transversus abdominis plane block may also be used to reduce the amount of opioids utilized and help decrease the risk of respiratory complications. Close monitoring of the patient is required to prevent adverse reactions when medications that are metabolized and detoxified by the liver are administered.

After hepatic surgery, the patient is in a catabolic state, and early nutritional interventions are required. If the patient has an adequate nutritional level, he or she is better able to fight off infection, promote hepatic healing, and have a better recovery. Probiotics are included in the feedings to promote the microbial flora and reduce any gut-mediated inflammatory responses as well as to help encourage liver regeneration.

Finally, it’s important to recognize any and all postoperative complications quickly. Patients over age 65, those who had larger resections, required transfusions, and have comorbid conditions are at a greater risk for complications. Liver failure occurs in approximately 3% to 5% of patients. Signs and symptoms of liver failure usually occur within 48 to 72 hours after the surgical procedure and occur more frequently in patients who’ve had larger resections. Once liver failure is identified, it’s categorized into the severity of failure, which determines the impact on the clinical management of the patient. Grade A failure, which is the mildest, doesn’t require any changes to the clinical management of the patient, whereas Grade B requires additional inter-
ventions but doesn’t involve any invasive therapy. Grade C, on the other hand, requires invasive therapies to be initiated.11

**A multisystem approach**

Hepatic surgery is a challenging surgical procedure due to the liver’s numerous functions. In addition, if a patient has a history of cirrhosis, the complications, which may occur along with the patients’ morbidity and mortality, rise. Aggressive measures to prevent complications and bleeding are implemented both intraoperatively and postoperatively to provide the patient with a better outcome. A multisystem approach that incorporates fluid and electrolyte management, prevention of bleeding, adequate nutrition, pain management, VTE prophylaxis, early recognition of complications, and a highly-skilled staff are required to provide the patient with a high standard of care. OR

**REFERENCES**


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