Hepatic resection is appropriate treatment for a variety of benign and primary or secondary malignant hepatic lesions. In appropriate patients with malignant disease, resection generally offers the best opportunity for long-term survival or cure. In patients with benign tumors, resection is safe and effective when carried out for symptoms directly related to the tumor.

In patients with malignant tumors submitted to a potentially curative operation, complete resection requires a negative histologic margin. Previously, a margin of 1 cm of normal parenchyma was considered essential, but recent studies have suggested that this is not necessarily the case, and margins of less than 1 cm are adequate. In many cases, tumor proximity to major vascular structures will preclude a resection margin of more than a few millimeters, which is generally sufficient. Regardless, anatomically based partial hepatectomy is the best means of achieving a negative margin. Wedge resections are usually inadequate and potentially dangerous, especially for large tumors, and are often associated with greater blood loss and a greater incidence of positive histologic margins. Anatomic segmental resections are much more controlled and are generally superior to wedge resections.

Hepatic resection for benign hepatic tumors may be indicated for relief of symptoms (such as pain or early satiety), for uncertainty in diagnosis, or for lesions with malignant potential. In contrast to the situation with malignant tumors, however, most benign tumors can be removed with maximal sparing of normal parenchyma. Consequently, lesions such as hemangiomas, adenomas, complex cysts, or fibronodular hyperplasia are often excised by enucleation (Fig. 8–1) or anatomic resections with limited margins.

The fear of uncontrolled hemorrhage was a major impediment to the evolution of hepatic resection as an effective form of therapy. While bleeding remains a concern, operative technique has improved greatly, and experienced centers have realized significant reductions in blood loss and transfusion requirements, even after major resections. Portal-triad clamping reduces hepatic arterial and portal venous bleeding but does not address the hepatic veins, which are usually the major source of blood loss. Our approach to hepatic resection, developed by the senior author, involves inflow and outflow vascular control before parenchymal transection, low central venous pressure anesthesia to minimize hepatic venous bleeding, and anatomically based resections. Using this approach, we have reduced the median blood loss to less than 1 L and the number of patients requiring transfusion to less than half. Some authors use the technique of total vascular isolation routinely for all resections. This is a fundamentally different approach that may be useful in a handful of cases. Moreover, Belghiti and colleagues, in a prospective study, found that total vascular isolation offered little advantage to the approach described above and was actually associated with greater blood loss. In our experience of approximately 1,700 hepatic resections since 1992, we have not found it necessary to use vascular isolation.
Figure 8–1. Enucleation of a giant hemangioma from the right liver. The hemangioma is being progressively elevated as vessels are dissected and controlled. The middle hepatic vein is seen lying exposed in the floor of the cavity (arrow).

In this chapter, we describe the techniques of liver resection, including anatomic, anesthetic, and technical considerations, as well as preoperative and postoperative care.

ANATOMY

A thorough understanding of the anatomy of the liver is necessary for any surgeon contemplating hepatic resection. The nomenclature is from the descriptions of Couinaud,6,7 which divides the liver into eight segments based on the branches of the portal triad and hepatic veins (Fig. 8–2).

Surface Anatomy, Relationships, and Peritoneal Attachments

The surface of the liver is related to the diaphragm and to the viscera (Fig. 8–3). The hepatic flexure and transverse colon extend from the right side of the liver to the medial aspect of the left lobe. Posterior to the colon are the adrenal gland and right kidney.

The falciform, round, and coronary ligaments attach the liver to the anterior abdominal wall and to the diaphragm. The triangular ligaments attach the right and left edges of the liver. The coronary ligament, a reflection of the peritoneum of the liver reflected onto the diaphragm, has an anterior and posterior leaf. Between these two leaves lies the bare area where the liver is in contact with the diaphragm directly. The anterior leaf extending over the superior aspect of the liver becomes the falciform ligament as it folds over and attaches to the anterior abdominal wall. Within the fold of the falciform lies the ligamentum teres (round ligament), the left umbilical vein remnant, which enters the liver in the umbilical fissure. The ligamentum venosum (the obliterated umbilical vein) runs within the ligamentum teres, courses along the anterior surface of the caudate lobe, and attaches to the left hepatic vein. The umbilical fissure divides the liver into right and left lobes (Fig. 8–4). The transverse hilar fissure lies at the visceral...
surface of the right lobe. The quadrate lobe (segment IV) lies anterior to the fissure and is limited by the gallbladder fossa on the right and the umbilical fissure on the left. Posterior to the transverse fissure and anterior to the inferior vena cava is the caudate lobe.

A layer of peritoneum from the liver to the stomach forms the lesser omentum, extending to the lesser curvature of the stomach as the hepatogastric ligament and as the hepatoduodenal ligament at the proximal duodenum. The hepatic artery, portal vein, and common bile duct are contained within the hepatoduodenal ligament.

**Sectors and Segments**

Within the substance of the liver is a complex segmental organization that belies the simple lobar divisions evident on the surface. The structures of the portal triad (hepatic artery, portal vein, and biliary duct) are separate extrahepatically but enter the hepatic hilus afterward, ensheathed within a thickened layer of Glisson’s capsule. The three main hepatic veins divide the liver into four sectors, each of which is supplied by a portal pedicle. The caudate lobe is an exception since its venous drainage is directly into the vena cava and therefore independent of the major hepatic veins. The four sectors delimited by the hepatic veins are called the portal sectors, and these portions of the parenchyma are supplied by independent portal pedicles that arise from the right or left main pedicles. The divisions separating the sectors are called portal scissurae, within each of which runs a hepatic vein. Further branching of the pedicles subdivide the sectors into segments. The liver is thus subdivided into segments, numbered I through VIII, with the caudate lobe designated as segment I. At operation, each segmental pedicle can be identified and occluded or clamped to delineate its precise parenchymal distribution.

The right and left liver are separated anatomically by an imaginary line running from the medial aspect of the gallbladder fossa anteriorly to the inferior vena cava (IVC), running parallel with the fissure of the round ligament. This is known as Cantlie’s line or the principal plane and contains the middle hepatic vein. The left liver consists of the medial and lateral sectors or segments. Segments II and III make up the left lobe (also referred to as the left lateral segment). Segments III and IV (the quadrate lobe), separated by the umbilical fissure, together constitute the medial sector of the left liver, being themselves delineated from the right liver by the main scissura containing the middle hepatic vein. Segments I to IV thus make up the left liver. Similarly, the right liver is further divided into anterior and posterior sectors by the plane of the right hepatic vein. Thus, the right liver consists of segments V and VIII (anterior sector) and segments VI and VII (posterior sector).

The caudate lobe is considered separately since its blood supply and biliary drainage arise from both the right and left sides; however, the main pedicle to the caudate lobe originates from the left (Fig. 8–5). The caudate lobe lies between the left portal vein and the IVC and extends to the hepatic venous confluence. Some authors consider the caudate lobe to consist of three parts: (1) the Spigel lobe, which extends to the left of the IVC (Fig. 8–6); (2) the paracaval portion anterior to the IVC; and (3) the caudate process, which attaches the caudate lobe to the right liver. The medial border of the caudate lobe, within the substance of the liver, is poorly

---

**Figure 8–5.** Vascular inflow of the caudate lobe (I). The caudate receives its main inflow from branches of the left portal vein. IVC = inferior vena cava; MHV = middle hepatic vein; LHV = left hepatic vein; PV = portal vein; RPV = right portal vein; LPV = left portal vein. Reprinted with permission from Blumgart LH. Liver resection for benign disease and for liver and biliary tumors. In: Blumgart LH, Fong Y, editors. Surgery of the liver and biliary tract, 3rd ed. Edinburgh [UK]: Churchill Livingstone; 2000.
defined (Fig. 8–7). A ligamentous band from the Spigel lobe often passes posterior to the IVC and attaches to segment VII (Fig. 8–8); in some patients, this band consists of hepatic parenchyma. Venous drainage from the caudate lobe occurs through multiple branches directly into the IVC and is independent of the major hepatic veins (Fig. 8–9).

**Pedicles**

Outside the liver, in the hilum, the major branches of the portal vein and hepatic artery and tributaries of the bile ducts can be individually dissected after dividing the peritoneum. They divide into major right and left branches. The right portal vein often

---

**Figure 8–6.** The caudate lobe as seen by computed tomography. A, The caudate lobe lies between the left portal vein (LPV) and the inferior vena cava (IVC). The Spigel lobe (S) extends to the left of the IVC. B, The caudate process (thick arrow) lies between the right portal vein (RPV) (thin arrow) and the IVC and is part of segment VI.

The anatomy of the caudate lobe. A ligamentous band from the Spigel lobe passes posterior to the inferior vena cava, attaching to segment VII (arrowhead). The principal inflow blood supply arises from the left (small arrow). IVC = inferior vena cava; LHV = left hepatic vein; LV = left ventricle; RL = right lobe. (Reprinted with permission from Yanaga K, Matsumata T, Hayashi H, et al. Isolated hepatic caudate lobectomy. Surgery 1994;115:759.)

Hepatic Artery

Typically, the common hepatic artery arises from the celiac axis, giving rise to the gastroduodenal and proper hepatic arteries. The proper hepatic artery divides into right and left branches before entering the liver; the point at which the proper hepatic artery gives rise to left and right hepatic arteries is quite variable. The right hepatic artery passes beneath the common bile duct in most cases. A variety of anatomic anomalies are possible, however, although only a few are seen frequently. A replaced or accessory right hepatic artery arises from the superior mesenteric artery and courses posterolateral to the bile duct within the porta hepatis. This variation is seen in 25 percent of patients. An accessory or replaced left hepatic artery, arising from the left gas-
Triartery and entering the liver within the gastro-hepatic omentum, is seen in about 20 percent of the population. Other variations that may be encountered include a completely replaced hepatic artery arising from the superior mesenteric artery and the anomalous origin of a left medial (segment IV) branch such that the left hepatic artery supplies only segments II and III.

Figure 8–9. The anatomy of the left portal system. The left ductal system has a horizontal course below the quadrate lobe. A, The hilar plate (arrow) is formed by the fusion of connective tissue enclosing the biliary and vascular elements and Glisson’s capsule. B, The hilar plate is lowered, and the quadrate lobe is retracted upward to expose the left hepatic duct and left portal vein. This technique is useful for exposing the bile duct above an iatrogenic injury of a proximal bile duct cancer. (Reprinted with permission from Smadja C, Blumgart LH. The biliary tract and the anatomy of biliary exposure. In: Blumgart LH, editor. Surgery of the liver and biliary tract. 2nd ed. Edinburgh [UK]: Churchill Livingstone; 1994. p. 14)
Hepatic Veins

The hepatic veins course between the sectors, providing venous drainage for the adjacent segments. The main hepatic venous trunks have a short extrahepatic course before joining the IVC. The right hepatic vein runs within the right scissura and enters the cava separately. The right vein drains both the anterior and posterior sectors. The left hepatic vein runs in the left scissura (between segments II and III) and commonly joins the middle hepatic vein (from the principal scissura) prior to entering the cava. The left vein may also enter the cava independently. The left hepatic vein drains the lateral segment as well as the medial superior segment. An umbilical vein (within the umbilical fissure and of variable size) often enters the left hepatic vein near its confluence with the middle hepatic vein. This vein can maintain drainage of segment IV if the middle hepatic vein is sacrificed at operation. The middle hepatic vein drains the anteroinferior segment and the medial inferior segment. A variable number of small, unnamed veins, some of which may be quite substantial in size, drain from the posterior surface of the liver directly into the vena cava; from 2 to as many as 10 venous branches enter the IVC directly from the caudate lobe. Occasionally, a large inferior right hepatic vein (see below) is present, which may assume importance during resection.

Portal Vein

The portal vein is formed from the merger of the splenic vein with the superior mesenteric vein posterior to the pancreas. The inferior mesenteric usually enters the splenic vein or the confluence of the splenic and superior mesenteric veins. Several smaller veins, including the left gastric (coronary) vein and often one or two jejunal branches, join the portal vein prior to its entry into the liver. The portal vein usually divides into right and left branches outside the liver. Typically, the right vein has a short extrahepatic course before dividing into anterior and posterior sectoral branches. The smaller left portal vein divides into medial and lateral branches, supplying segment IV and segments II and III, respectively. The main portal venous trunks usually have few branches outside the liver. However, a small branch from the right vein to the caudate process and a branch from the portal venous confluence to segment IV are frequently encountered and are of importance during resection (Fig. 8–11).

Aberrant portal venous anatomy is occasionally seen, most commonly involving the right vein. The right anterior and posterior sectoral branches may arise independently, or the right anterior trunk may even arise from the left portal vein. Congenital absence of the left portal vein has been described in which a single portal venous trunk enters the liver at the hilum and provides branches to the right and left sides from within the parenchyma. Although uncommon, these variations assume great importance during resection and must be recognized to avoid interruption of the portal flow to the liver remnant.

Lymphatic Drainage of the Liver

In the connective tissue beneath Glisson’s capsule lie the superficial lymphatics. Drainage is superior to the anterior and middle phrenic nodes and inferior to the hepatic nodes. The deep lymphatics drain up to the middle phrenic and down to the nodes of the porta. These portal nodes may also drain to nodes along the hepatic artery to the celiac nodal basin.

The anatomy of the liver is the foundation of modern hepatic resectional surgery and provides the surgeon with flexibility regarding the types of resection that are possible (Fig. 8–12). Major resections (lobectomy or trisegmentectomy) remain the most commonly performed procedures. However, more limited resections (such as isolated segmentectomies or bisegmentectomies) are being performed with increasing frequency in the appropriate setting. These more limited resections are oncologically sound, spare uninvolved hepatic parenchyma, and may result in lower postoperative morbidity and shorter hospital stay. Our general approach to partial hepatectomy (described in detail in the following sections) relies on initial inflow and outflow vascular control, with subsequent parenchymal transection along anatomic planes.

PREOPERATIVE EVALUATION

The preoperative evaluation begins with a thorough history and physical examination that assesses not
only the present illness but also the patient’s general health. It is especially important to identify underlying comorbid medical conditions or chronic underlying liver disease that would preclude a major hepatic resection. Although chronic liver disease is not an absolute contraindication to liver resection, the morbidity and mortality increases prohibitively with increasing hepatic dysfunction. Childs class B or C patients are generally excluded from major resections whereas Childs A patients may be candidates. Radiologic studies should also be scrutinized for evidence of portal hypertension, such as splenomegaly, collateral venous circulation, or ascites.

For patients with cancer, determining the extent of disease is obviously a critical component of the evaluation. The pathology, if any, should be reviewed and appropriate imaging studies obtained to assess the hepatic disease and the feasibility of resection. Any suspicion of extrahepatic disease should be pursued with a biopsy since such disease almost always precludes any possibility of a curative resection.

In patients with malignant disease but who are otherwise considered candidates for resection, assessment of resectability should be made by an experienced surgeon. Tumors are potentially resectable if they can be removed completely (negative histologic margin) while leaving behind an adequate well-perfused liver remnant with an intact biliary and hepatic venous drainage. In a healthy, noncirrhotic patient, up to 80 percent of the functional parenchyma can be removed with a reasonable expectation of subsequent regeneration. The technical feasibility of tumor removal is predicated on the individual surgeon’s judgment and skill. In selecting patients for resection, preoperative imaging studies clearly play a critical role in patient selection.

Ultrasonography (US) is a noninvasive modality that can provide useful information regarding size, extent, and characteristics of hepatic lesions. Although operator-dependent, it may be particularly useful in characterizing small lesions, distinguishing solid from cystic lesions, and assessing major vascular structures for patency or tumor involvement. We find duplex US particularly useful for assessing patients with hilar cholangiocarcinoma.

Helical computed tomography (CT) with dynamic studies makes excellent detailed images of the liver, providing critical anatomic information regarding tumor proximity to major pedicles and hepatic veins. It may also help in characterizing the

**Figure 8–11.** Branches of the portal system outside the liver; dissection of the portal vein within the porta hepatis. The right branch of the portal vein is isolated in a vessel loop. A small branch of the portal vein (small arrow) draining the caudate process (large arrow) has been tied and is being divided. This branch is a constant finding and must be controlled to avoid hemorrhage during dissection in this area. The divided right hepatic artery is being retracted to the left (arrowhead).
type of lesion. Hemangiomas and other benign lesions have characteristic appearances on CT, which may help establish the diagnosis if in doubt. Computed tomography will also reveal lobar atrophy, a little-appreciated yet important finding that is highly suggestive of portal venous involvement by tumor. Computed tomography is also useful in assessing the abdomen and pelvis for extrahepatic disease and involvement of adjacent organs. Current CT techniques also allow three-dimensional reconstruction of vascular structures, which may be helpful for planning the resection or for assessing the hepatic arterial anatomy in patients being considered for hepatic artery pump placement (Fig. 8–13).

Magnetic resonance imaging (MRI) is proving increasingly valuable for differentiating benign from malignant tumors and may also help differentiate among the various benign tumors. Like CT, MRI provides information regarding the number of hepatic tumors and the relationship of tumor to major vascular structures. Moreover, magnetic resonance angiography (MRA) and cholangiopancreatography (MRCP) are emerging modalities that provide detailed images of the hepatic vascular and biliary tract anatomy, respectively. In our experience, MRCP combined with duplex US is the investigation of choice for evaluating patients with proximal biliary obstruction and will likely supplant direct cholangiography for the routine evaluation of these patients.

Angiography, previously a common preoperative investigation, is no longer used routinely. Advances in cross-sectional imaging and the detailed information provided by these studies have rendered angiography unnecessary in most cases. Angiography is used most often to assess arterial anatomy prior to the placement of hepatic arterial infusion pumps. However, even this role may well be diminished as CT and MRA improve.

Laparoscopy has become a useful tool for assessing patients for radiographically occult unresectable disease and thus avoiding unnecessary laparotomies. Some earlier reports have suggested that up to 50 percent of patients considered to have potentially resectable tumors on radiologic grounds had unresectable disease, the majority of which were identified at laparoscopy. More recently, in a prospective comparison of staging laparoscopy to no laparoscopy, we found that approximately two-

Figure 8–12. Hepatic resections and nomenclature. A, The various resections and their names are indicated on the left as segmental resections. B, The major hepatic resections: (A) right hepatectomy, (B) left hepatectomy, (C) right lobectomy, (D) left lobectomy, (E) extended left lobectomy. (Reprinted with permission from Blumgart LH. Liver resection—liver and biliary tumours. In: Blumgart LH, editor. Surgery of the liver and biliary tract. 2nd ed. Edinburgh [UK]: Churchill Livingstone; 1994. p. 1495.)
thirds of patients underwent a potentially curative resection and that only 17 percent avoided an unnecessary laparotomy. Despite this low yield, however, laparoscopic identification of unresectable disease significantly reduces length of stay and hospital costs.\textsuperscript{12}

\section*{OPERATIVE TECHNIQUE}

\subsection*{Preparation}

Preparing a patient for major hepatic resection requires the correction of underlying metabolic abnormalities, anemia, or coagulopathy. Jaundiced patients should be appropriately hydrated preoperatively. Patients over the age of 65 years or at significant risk of cardiopulmonary disease should be evaluated by a cardiologist for fitness for surgery. A single preoperative dose of antibiotics is used for routine cases; however, in patients with indwelling biliary stents undergoing concomitant biliary resection, it is our practice to continue broad-spectrum antibiotics in the postoperative period.

\subsection*{Anesthesia}

A major hepatic resection requires communication between the surgeon and the anesthesiologist. Major life-threatening hemorrhage can occur quickly. Arterial lines and large-bore peripheral access and central venous access lines are placed once the decision is made to proceed with resection. Very large soft tumors such as hepatocellular carcinomas or metastatic sarcomas may be inadvertently disrupted during initial mobilization, resulting in significant hemorrhage, and the surgeon should be prepared for this possibility. Also, esophageal temperature probes are used to monitor the patient for hypothermia.

Most intraoperative blood loss results from injury to the hepatic veins and the vena cava. Several steps are taken to minimize the venous bleeding. Dissection and control of the hepatic veins is usually performed prior to parenchymal transection, and the venous outflow draining the liver to be removed is divided after dividing the inflow vessels. Mobilization and parenchymal transection are performed with a low central venous pressure (CVP) generally no higher than 5 mm Hg, which minimizes bleeding.
from disrupted hepatic venous branches. The anesthesiology team uses early fluid restriction and anesthetic techniques to maintain this low venous pressure until transection is complete. Urine output is monitored to try to achieve the minimal volume infusion necessary to maintain renal perfusion, but low urine output during the resection is accepted. To minimize risk of air embolism from disrupted hepatic veins, the resection is performed with the patient in the Trendelenburg position (15°). We have used this technique in well over 1,000 patients and have observed no clinically significant instances of air embolism. Likewise, in patients with no other risk factors such as sepsis or underlying renal insufficiency, the impact of low CVP anesthesia on postoperative renal function is minimal. On the other hand, the advantages of this approach are significant reductions in blood loss and perioperative transfusion requirements. At present, less than one-third of our patients require any blood products in the immediate perioperative period, and only one-half are transfused at some point during their hospital stay. We encourage all patients to donate one or two units of autologous blood before operation, which further reduces the burden on the hospital’s blood bank.

**Exploration**

The patient is positioned supine, with the arms extended 90°. We place a crossbar retractor toward the head of the table to allow self-retaining retractors to elevate the costal margin. Preparation of the operative field includes the area from the lower abdomen up to and including the chest, extending from axillary line to axillary line, thus allowing access to the thoracic cavity if a thoracoabdominal incision or extension is required; this is uncommon but should be considered for large tumors that encroach upon the hepatic venous confluence. The majority of liver resections are performed with either a right subcostal incision with midline extension or a chevron incision (Fig. 8–14).

![Figure 8–14. Common incisions used for hepatectomy. The majority of liver resections may be done with a right subcostal incision with midline extension (A, B, D) or a bilateral subcostal incision with midline extension (A, B, C, D). F indicates a right thoracic extension; E indicates a median sternotomy. (Reprinted with permission from Blumgart LH. Liver resection—liver and biliary tumours. In: Blumgart LH, editor. Surgery of the liver and biliary tract. 2nd ed. Edinburgh [UK]: Churchill Livingstone; 1994. p. 1504.)](image-url)
Laparoscopy is generally performed immediately prior to laparotomy. We place the laparoscopic ports in the upper abdomen (Fig. 8–15), along the line of the intended incision. If unresectable disease is not encountered (Fig. 8–16), a right subcostal incision is made initially, with subsequent extension of the incision as necessary. The round ligament is divided, leaving a long suture on the hepatic attachment for traction. The lymph nodes in the hilum and retroperitoneum are palpated, and suspicious nodes are sent for frozen-section analysis. The lower abdomen can be examined manually for recurrent disease. The lesser omentum is divided, and the caudate lobe is inspected and palpated. The falciform ligament is divided up toward the hepatic veins (Fig. 8–17). The liver is then freed of its diaphragmatic attachments. The right triangular ligament and the coronary ligament are divided with cautery. Once suitably mobilized, the liver is examined with bimanual palpation and intraoperative ultrasonography (IOUS) (Fig. 8–18) in a systematic fashion to identify the tumor(s), assess for additional disease, and assess the relationship of the tumor(s) to the major vasculature structures (Fig. 8–19). The major pedicles and branches to all segments, the hepatic veins, and the parenchyma are evaluated in turn. Intraoperative US is useful for confirming the preoperative findings, but in our experience, the findings on IOUS alone change the operative plan in only about 10 percent of patients and rarely identify unresectable disease.

If the decision is made to proceed, then mobilization of the liver is completed. The right liver is freed completely from the diaphragm by dividing the right triangular ligament and exposing the bare area of the liver. This is facilitated by rotating the table away from the operating surgeon, having the assistant gently retract the right lobe of the liver medially and anteriorly, and grasping the diaphragm and pulling it laterally. In this position, the attachments under tension may be divided on the surface of the liver. The peritoneum at the inferior border of the liver is divided lateral to medial to the IVC, taking care not to injure the adrenal gland. In some cases, tumors on the surface of the liver are adherent to the diaphragm although diaphragmatic invasion is rare. If the lesion is otherwise resectable, the surgeon should not hesitate to resect a portion of the diaphragm, which usually can be repaired primarily after the resection. Small veins draining posteriorly from the liver into the IVC are carefully dissected and divided from the caudate process up to the hepatic venous confluence (Fig. 8–20). In the course of this dissection, a ligamentous band is encountered that extends from the caudate lobe on the left, passes posterior to the IVC, and attaches to segment VII. This ligament, which often contains small vessels or hepatic parenchyma, must be divided in order to see and control the right hepatic vein.

The left liver is mobilized by dividing the left triangular ligament and left coronary ligament to the lateral margin of the IVC, taking care to avoid injuring the left hepatic vein. The lesser omentum should be divided completely. The ligamentum venosum should also be divided between clips or ties.

**Right Hepatectomy**

Right hepatectomy involves removing all hepatic parenchyma to the right of the middle hepatic vein...
(segments V, VI, VII, and VIII). After full mobilization and assessment, the surgeon should proceed with vascular inflow and outflow control. Three general approaches have been described for achieving vascular inflow control: (1) extrahepatic dissection within the porta hepatis, with division of the right

Figure 8–16. Unresectable disease found at the time of laparoscopy. This patient has peritoneal disease not seen on computed tomography scan but seen at the time of laparoscopy. The resection was aborted, and the patient was spared a laparotomy.

Figure 8–17. The ligamentum teres. A, The ligamentum teres is secure, and the falciform ligament is divided. B, The falciform ligament is divided up toward the hepatic veins to expose the inferior vena cava. (Reprinted with permission from Blumgart LH. Liver resection—liver and biliary tumours. In: Blumgart LH, editor. Surgery of the liver and biliary tract. 2nd ed. Edinburgh [UK]: Churchill Livingstone; 1994. p. 1505.)
hepatic artery and right portal vein prior to division of the parenchyma (Fig. 8–21); (2) intrahepatic control of the main right pedicle within the substance of the liver prior to parenchymal transection (pedicle ligation); and (3) intrahepatic control of the pedicle during parenchymal transection. For the overwhelming majority of resections, we control the inflow extrahepatically with hilar dissection or with the pedicle ligation technique. In general, it is not advised to proceed with liver resection before inflow control can be achieved.

Pedicle ligation, an approach described by Launois, has several advantages over hilar dissection. After removing the gallbladder, hepatotomy incisions are made medially at the base of the gallbladder fossa and within the caudate process, parallel to the IVC (Fig. 8–22). With the portal triad clamped (Pringle maneuver), a finger or clamp is

Figure 8–18. Intraoperative ultrasonography.

Figure 8–19. The use of intraoperative ultrasonography. A. Computed tomography scan showing a lesion in segment IV. B. Intraoperative ultrasonography image showing the anatomic relationship of the lesion to the portal vein and showing the left hepatic duct (arrow).
then passed into the substance of the liver to encircle the main right pedicle. Some bleeding from terminal branches of the middle hepatic vein may be encountered, but this is readily controlled. A small amount of residual liver tissue is then cleared away to expose the pedicle. Further dissection along the pedicular sheath allows a means of identifying the anterior or posterior pedicles or branches to individual segments for segmental or sectoral resections. Before attempting this maneuver, it is imperative to divide all venous branches entering the IVC from the right lobe; otherwise, these veins may be torn, and significant hemorrhage will ensue. With the right pedicle so isolated, it may be occluded and the portal-triad clamp released to reveal a clear line of demarcation along the principal plane and then divided. The right portal pedicle may be taken as a single unit, or the anterior and posterior pedicles can be divided separately. Pedicle ligation eliminates the need for hilar dissection, thereby saving time and also reducing the risk of injury to the bile duct or contralateral vascular structures. It must be emphasized, however, that this approach is not appropriate for tumors that encroach on the hilus since the resection margin will be compromised.

When hilar dissection is used, it is not necessary to attempt to encircle and divide the right hepatic duct. Such dissection risks injury to the biliary duct. Rather, control of the right hepatic duct can be obtained during parenchymal transection, which is safer.
Figure 8–22. Isolation of the portal pedicles. A, The main portal pedicles are seen in this cutaway drawing. B, The lines of incision for a pedicle ligation are shown. For a right hepatic resection, two approaches are used: A hepatotomy is made in the caudate process parallel to and 5 mm lateral to the inferior vena cava (1); in the first method, the full thickness of the caudate process is divided. The second hepatotomy is made in the center of the bed of the gallbladder, near the hilus (2); the second method is an anterior incision in front of the hilum (3), extending up the gallbladder bed (2). For left hepatectomies, a similar incision (2, 3) can be used although it is often easier to dissect the main sheath at the base of the caudate lobe (GB = gallbladder). C, During a right hepatectomy, the right portal pedicle is isolated by finger dissection, the finger being passed through a hepatotomy in the caudate process and brought out in the gallbladder fossa (see text). D, A vessel loop is passed about the right portal pedicle, which is strongly retracted toward the patient’s left. The left portal pedicle is protected. E, A stapling device is used to facilitate division of the right portal pedicle. Note that the point of division is well away from the left pedicular structure.
With the inflow controlled, attention is then turned to the control of the right hepatic vein (Fig. 8–23). During the initial mobilization, the posterior veins draining directly into the liver and the ligament along the lateral aspect of the IVC were ligated and divided. Any remaining branches are ligated and divided (Fig. 8–24). The right hepatic vein is now visible, but complete control requires further dissection above the liver (Fig. 8–25). Avascular tissue between the right and middle hepatic veins must be divided. The right vein can now be encircled and divided with a vascular stapler, or it can be clamped (Fig. 8–26), divided, and oversewn (Figs. 8–27 and 8–28). The right vein may also be controlled and divided within the substance of the liver. Extrahepatic control is preferable if possible. In some cases, the middle hepatic vein must be sacrificed, but it is usually taken within the liver parenchyma. The line of transection may be to the left or right of this vein, depending on the situation. If the middle vein is divided, venous drainage of segment IV will be provided by the umbilical vein. The surgeon must be prepared to extend the incision into the right chest or to perform a sternotomy should there be difficulty in controlling the hepatic veins or vena cava.

At this point, parenchymal division is begun. The line of transection along the principal plane is marked with electrocautery and then cut with scissors. Stay sutures of 0 chromic catgut are placed on either side of the plane of transection and used for traction, separation, and elevation as dissection proceeds. A Kelly clamp is used to crush the liver parenchyma, and exposed vessels are controlled with clips, ligatures, or the vascular stapler (Fig. 8–29). Although the liver can tolerate warm ischemia for up to 60 minutes, the authors use intermittent portal-triad clamping during the parenchymal transection phase, mainly to allow decompression of the gut. After the specimen is removed, the raw surface of the remnant liver is carefully examined for hemostasis and bile leaks. The argon beam coagulator is excellent for controlling raw surface oozing. Biliary leaks should be clipped or suture ligated. The retroperitoneal surfaces should also be examined carefully for hemostasis, and the argon beam should be used where necessary.

Extended Right Hepatectomy: Right Hepatic Lobectomy or Right Trisegmentectomy

The additional removal of segment IV during right hepatectomy (normally removing segments V, VI, VII, and VIII) constitutes an extended right hepatectomy. The initial steps are similar to those of the right hepatectomy, with mobilization being performed and the right hepatic vein and the right portal pedicle being exposed and divided. The bridge of tissue connecting segments III and IV is divided with electrocautery after passing a Kocher director beneath, revealing the lower part of the umbilical fissure. In some patients, this tissue consists of an avascular ligament; in others, it consists of hepatic parenchyma.
Figure 8–24. The right lobe of the liver has been mobilized and turned toward the left. The vena cava is exposed. Retrohepatic veins are dissected and controlled, commencing from below and progressing upward.

Figure 8–25. After division of the small draining veins posteriorly, the right hepatic vein is visible (arrow) but requires further dissection for isolation.
The ligamentum teres can be seen running in the umbilical fissure and joining the left portal vein. The right pedicle is controlled intra- or extrahepatically as above. The recurrent vessels from the umbilical fissure to segment IV are divided and suture ligated (Figs. 8–30 and 8–31). If the tumor is near the fissure, these recurrent vessels should be divided from within the umbilical fissure, taking care to avoid injury to the main left pedicle. Alternatively, they may be ligated and divided during parenchymal transection. The right and middle hepatic veins are divided as described above.

The liver is transected just to the right of the falciform ligament, using the standard parenchymal crushing technique. The middle hepatic vein must be ligated, and it is encountered as dissection progresses deeper in the upper portion of the liver; it can be ligated or stapled at this point. During this portion of the procedure, care must be taken to avoid injury to the left hepatic vein, which usually enters the middle hepatic vein.

**Left Hepatectomy**

Removal of segments II, III, and IV constitutes a left hepatectomy. The left liver is mobilized in standard fashion as described above, with division of the left triangular ligament. Our preference is to perform

---

**Figure 8–26.** A, The right hepatic vein is exposed for subsequent division. A Kelly clamp passes easily between the right and middle hepatic veins on the anterior surface of the inferior vena cava. B, The Endo-GIA vascular stapler is used to divide the right hepatic vein.
Figure 8–27. The right hepatic vein may be divided between clamps and then oversewn. Note that the inferior vena cava has been completely freed from the posterior surface of the liver.

Figure 8–28. The black arrow indicates the divided right hepatic staple line. A clamp has been passed beneath the common trunk of the middle and left hepatic veins (white arrow).
inflow control outside the liver, at the base of the umbilical fissure (Fig. 8–32). The hilar plate is lowered, and the left hepatic artery is identified, ligated, and divided (see Fig. 8–21). Within the gastrohepatic ligament, an accessory or replaced left hepatic artery may be found and should be divided and lig-
During an extended right hepatic lobectomy (right trisegmentectomy), feedback vessels arising from the umbilical fissure and progressing to segment IV are divided between clamps. The dissection proceeds backward just to the right of the falciform ligament. The arrow indicates the ligamentum teres and the falciform ligament. Segment IV is marked.

Figure 8–31. The portal anatomy of the umbilical fissure. A, Division here devascularizes the entire left liver, including the caudate lobe. B, Division above the caudate branch will preserve the caudate blood supply and devascularize segments II, III, and IV. C, The point of division to divide the segment II pedicle. D, The point of division to divide the segment III pedicle. The pedicles to IVa and IVb branch off the right side of the left portal triad with the umbilical fissure and can be controlled here for an extended left lobectomy. (Reprinted with permission from Blumgart LH. Liver resection—liver and biliary tumours. In: Blumgart LH, editor. Surgery of the liver and biliary tract, 2nd ed. Edinburgh [UK]: Churchill Livingstone; 1994. p. 1518.)

ated. The portal vein is identified at the base of the umbilical fissure. Care must be taken to preserve the principal caudate branch, which usually arises from the left portal vein. If the caudate lobe is to be preserved, then the portal vein is controlled beyond the origin of this branch.

The left bile duct has a long extrahepatic course and can be identified beneath the quadrate lobe behind the portal vein and divided at the umbilical fissure or (as with a right hepatectomy) controlled from within the hepatic parenchyma.

The left and middle hepatic veins are controlled after mobilizing the left lobe and lifting it up anteriorly and to the right (Fig. 8–33). The gastrohepatic ligament is divided, and dissection continues at the ligamentum venosum, which is divided as it enters the left hepatic vein. Control of the veins is obtained by careful dissection from above and below the liver; a passage is developed from just to the right of the middle hepatic vein from above and the superior border of the caudate process from below. The veins are clamped, ligated, and divided. The middle and left hepatic veins most often enter the IVC as a single trunk but may be independent in some cases.
Stay sutures are placed along either side of the principal plane (along the line of demarcation) (Fig. 8–34), the line of transection is marked, and the parenchyma is divided as described above.

Left Lateral Segmentectomy: Left Lobectomy

Removal of segments II and III constitute a left lateral segmentectomy. The bridge of tissue overlying the umbilical fissure is divided, and the left triangular ligament is divided, mobilizing the left lobe. Within the umbilical fissure, the pedicles to segments II and III can be dissected and controlled individually (see Fig. 8–32). For tumors lying close to the fissure, this approach is important. An alternate approach for peripheral lesions is splitting the liver anteroposteriorly just to the left of the ligamentum teres and the falciform ligament. The pedicles to segments II and III can then be divided serially during parenchymal transection. The hepatic vein can be controlled and divided within the liver substance posteriorly, without having to dissect the vein extrahepatically. However, if the tumor is close to the junction of the left and middle hepatic veins, extrahepatic dissection and control of the vein should be performed.

Extended Left Hepatectomy: Left Trisegmentectomy

An extended left hepatectomy involves the removal of segments V and VIII in addition to a left hepatectomy. This is among the most challenging of hepatic resections and is used when tumors involving the left liver extend into the anterior sector of the right lobe or when the anterior sector is the site of additional metastatic disease. The difficulty of the procedure lies in defining the plane of transection, which is horizontal rather than vertical and parallel but anterior to the right scissura (Figs. 8–35 and 8–36). Injury to the pedicle supplying the posterior sector or to the right hepatic vein is the major concern and must be avoided.

Dissection begins with division of the falciform ligament to the hepatic veins and IVC. Complete mobilization follows, including division of the left triangular ligament as well as mobilization of the right side. The presence of a large accessory right hepatic vein is a potentially important finding, especially for tumors encroaching on the main right hepatic vein, and may allow sacrifice of the main right hepatic vein if necessary for tumor clearance. Dissection proceeds as with a left hepatectomy, with the liver rotated right and the portal triad approached from the left side. If the caudate lobe is to be resected as well, the left hepatic artery and left branch of the portal vein should be ligated close to their origins to disconnect the blood supply to the caudate lobe and segments II and III. If segment I is not to be resected, the left portal triad is taken at the base of the umbilical fissure, preserving the blood supply to the caudate lobe.

After the inflow has been controlled, the outflow is controlled, and dissection of the left hepatic vein and IVC is performed. It is advantageous to control the middle and left hepatic veins extrahepatically for this procedure because it reduces blood loss during parenchymal transection.
The greatest challenge to extended left resections lies in defining the plane of transection—a horizontal plane anterior and parallel to the right scissura, just lateral to the gallbladder fossa. Another way of describing this plane is as a horizontal plane extending from the anterior border of the right hepatic vein to an area to the right of the gallbladder fossa. The plane can be more clearly defined if the right anterior sectoral pedicle is controlled, as this will demarcate the line of dissection. This can only be done when the tumor is away from the main right portal pedicle; otherwise, the surgical margin may be compromised.

Using intermittent portal-triad occlusion, the parenchyma is divided from the inferior surface upward and from right to left in a horizontal plane. By rotating the fully mobilized liver clockwise, the horizontal plane of transection is converted to a vertical plane, easing the dissection. The dissection proceeds anterior to the right posterior pedicle (when the liver is rotated, the dissection will be just medial to the pedicle). The line of transection is often dictated by the tumor. Large tumors in proximity to the posterior pedicle or the right hepatic vein will limit the possible size of the resection margin since these structures must be preserved. Such tumors often produce a fibrous zone of atrophic parenchyma peripherally, however, and dissection will proceed in this plane.

Although challenging, extended left resections can be done safely, with mortality rates only slightly higher than those of other types of resection. Postoperative morbidity is significant, however, with biliary leak and abdominal abscess being the major complications. Removal of all but the posterior sector may also result in significant postoperative liver dysfunction, and patients are more likely to have ascites postoperatively.

Caudate Lobe Resection:
Segment I Resection

The caudate lobe is most commonly removed en bloc as part of a major hepatic resection to achieve tumor clearance and (less commonly) as an isolated caudate resection. Damage to the middle or left hepatic veins is a major risk of isolated caudate lobectomy (Fig. 8–37). The caudate lobe may be approached mainly from the right or left although dissection from both sides is necessary most often (see Fig. 8–37). An approach from the right side may
be necessary for bulky lesions that prevent access from the left or when the caudate lobe is to be removed en bloc with the right liver. After division of the gastrohepatic omentum and the ligamentous attachments from the caudate lobe to the IVC (Fig. 8–38), the right liver is mobilized as above, and the posteriorly draining veins along the entire retrohepatic cava are divided. The liver is rotated, and the dissection proceeds along the anterior surface of the IVC, lateral to medial, allowing identification and control of the caudate veins. Some of these veins may not be easily controlled from the right side. The attachments of the caudate lobe to the IVC must also be divided. The branches to segment I from the left portal vein and left hepatic artery are then dissected (Fig. 8–39) close to the base of the umbilical fissure just before the entry of the left portal triad, where they are ligated and divided. The caudate lobe is then separated from its attachment to the right liver, under inflow occlusion.

A principal approach from the left side may be possible with smaller tumors or when the caudate lobe is to be removed en bloc with the left liver. As with a left hepatectomy, the left liver is mobilized. The left lateral margin of segment I is freed by dividing the fibrous attachment posteriorly to the IVC and diaphragm, exposing the veins draining the caudate lobe into the cava (Fig. 8–40). The approach to the inflow vessels is the same.

An alternative approach to isolated segment I resection has been described and involves mobilization...
Techniques of Hepatic Resection

ation of the caudate lobe as described above (Fig. 8–41), followed by splitting of the hepatic parenchyma along the principal plane. This provides access to the right border of the caudate lobe, which can be disconnected under direct vision below the middle hepatic vein and may thus prevent uncontrolled bleeding. The right and left hemilivers are split but not resected.

Segmental Resection

Because each segment is defined by an anatomic structure with its own pedicles, each segment can be resected separately (Figs. 8–42 and 8–43) or resected with other segments as part of a larger resection. The following describes some of the more commonly performed anatomic sublobar hepatic resections.
Figure 8–39. Caudate lobe resection. Branches to segment I from the portal vein and left hepatic artery are dissected close to the base of the umbilical fissure. The caudate lobe is retracted to the left with forceps.

Figure 8–40. Caudate lobe resection. Veins draining the caudate lobe posteriorly are exposed by mobilizing the left lateral margin of segment I, dividing the fibrous attachment posteriorly to the inferior vena cava.
Techniques of Hepatic Resection

Right Posterior Sectorectomy
(Segments VI and VII)

Removal of segments VI and VII constitutes a posterior sectorectomy. The procedure begins with the full mobilization of the right lobe of the liver from its diaphragmatic attachment and the division of the posterior draining veins, as described above. Dissection of the right vein will permit rapid repair or removal should it be damaged during dissection. The right portal pedicle is exposed, and the anterior and posterior branches are identified. The posterior pedicle is clamped, and the line of demarcation is evident. The pedicle may be divided, and parenchymal dissection may be performed in standard fashion. The line of transection is horizontal and posterior to the right hepatic vein. However, the right vein may be sacrificed during this procedure since the anterior sector will be adequately drained by the middle hepatic vein.

Segment IV Resection

Segment IV is divided into a posterosuperior portion (IVa) and an anteroinferior portion (IVb). Resection can include either portion or both portions. The left branches of the portal vein and hepatic artery supply the inflow to segment IV. The middle hepatic vein provides venous drainage via medial branches. The umbilical hepatic vein below the falciform ligament provides additional drainage and may drain into the middle or left veins. The first maneuver is division, with electrocautery of the bridge of liver tissue overlying the umbilical fissure. The hilar plate is lowered. Branches from the umbilical portion of the left portal vein, left hepatic artery, and bile duct are the principal inflow to segment IV. The parenchyma is divided with two incisions. One incision is just to the right of the ligamentum teres, with control of the segment IV feedback vessels as described for extended right

Figure 8–41. Caudate lobe resection. An alternative approach to segment I resection involves splitting the hepatic parenchyma along the principal plane (black arrow). This provides access to the right border of the caudate lobe, which can be disconnected under direct vision below the middle hepatic vein (MHV). The caudate lobe has been detached from the inferior vena cava (IVC). (Reprinted with permission from Blumgart LH. Liver resection for benign disease and for liver and biliary tumors. In: Blumgart LH, Fong Y, editors. Surgery of the liver and biliary tract. 3rd ed. Edinburgh [UK]: Churchill Livingstone, 2000.)

Figure 8–42. Segment III resection. The ligamentum teres is indicated by the arrow. Segment III has been excised, leaving segment II fully vascularized.
The initial division of these vessels will delineate the extent of the resection. The other incision is for division in the principal plane back toward the IVC. The middle hepatic vein will be encountered; it may be preserved or taken, depending on the situation (Fig. 8–44).

Central Resection

Removal of segments IV, V, and VIII (segment IV plus an anterior sectorectomy) constitutes a central resection. This seemingly complex procedure is used to maximize the amount of remnant liver left.

Figure 8–43. Segmental liver resection. The falciform ligament is indicated. Segment IV remains intact, as does segment II. Segment III has been precisely removed, as has segment V.

Figure 8–44. Resection of segment IVb for metastatic colorectal cancer.
after resection as both the posterior sector and the left lateral segment will remain. In essence, the approach to a central resection is similar to the approach to a posterior sectorectomy and to a left lateral segmentectomy, except that the posterior sector and the left lateral segment are preserved rather than removed. The liver is fully mobilized, with the posterior draining veins ligated. A Pringle maneuver is performed. The right anterior and posterior sectoral portal triads are identified, and the anterior pedicle is clamped. Transection is performed with an intermittent Pringle maneuver, carefully preserving the right posterior pedicle and the right hepatic vein. Segment IV is devascularized and resected as described above, with dissection just to the right of the umbilical fissure. The middle hepatic vein must be taken. Initial exposure of the middle vein can be achieved as would be done for a left hepatectomy. A vascular clamp may be used to occlude the vein during parenchymal transection, and the vein may be divided within the liver during the resection.

**Wedge Resections**

Wedge resections have a higher incidence of positive margins and greater blood loss and should therefore be avoided in most cases. However, they may be appropriate in selected cases. Small peripheral lesions can be safely excised with adequate margins, using an intermittent Pringle maneuver. Isolated lesions close to the surface can be similarly excised. After dissection of the porta hepatitis and placement of an umbilical tape, division of the falciform, and mobilization of the liver, IOUS is performed. This allows confirmation of the lesion, identification of other lesions, and definition of the relationship of the lesion to the major vascular structures. Using electrocautery, an adequate margin of excision is drawn around the lesion. Stay sutures are applied on either side of the lesion and within the area of excision. Parenchymal dissection is performed in standard fashion, using a crushing technique. Extra care must be taken to ensure that the “normal” parenchyma does not fracture around the tumor during manipulation and that adequate margins are maintained at all times.

**Resection for Hilar Cholangiocarcinoma and Gallbladder Cancer**

Tumors of the proximal biliary tree often invade the adjacent hepatic parenchyma or vascular structures within the porta hepatis and frequently require partial hepatectomy to achieve negative margins. Involvement of the portal-vein branch on the side of the tumor is not uncommon, and this demands that a concomitant partial hepatectomy be performed. Preoperatively, this may be seen on imaging studies and is highly suggested by the presence of lobar atrophy.

Once distant disease has been excluded, full mobilization of the duodenum is performed, dividing the common bile duct just above the duodenum. For hilar cholangiocarcinoma, the gallbladder is taken down but left attached to the bile duct; however, this cannot be done in patients with gallbladder cancer. The hilar plate is lowered. The transected bile duct is elevated, and the lymphatic tissue within the porta hepatis is dissected free and taken with the specimen. Elevation of the ductal structures allows dissection posterior to the tumor and is the only way to assess for vascular invasion. Palpation of the tumor will help determine its extent within the bile duct and whether resection is feasible. For example, a tumor that involves the right branch of the portal vein or that invades the right liver will require a right hepatectomy; however, this is not feasible if the tumor also extends well up into the left hepatic duct, precluding a negative resection margin. Once it is determined that the vasculature is free and that complete tumor clearance can be achieved, resection is performed as above, with extrahepatic control of the inflow and outflow. It is important to confirm negative margins intraoperatively with frozen-section histology. If positive, an additional length of duct may be resected. Also, tumor involvement of the caudate duct orifice demands a concomitant resection of the caudate lobe, which is always required for tumors involving the left hepatic duct. In cases of tumor adherence to the portal venous confluence, resection with reconstruction of the portal vein may be possible.

**Cryoassisted Resection**

Cryoassisted resection is a technique that may be useful in selected patients for achieving a complete tumor.
resection with maximal sparing of uninvolved hepatic parenchyma. This would be useful in the case of small lesions deep within the parenchyma that would necessitate the removal of a large amount of normal hepatic tissue or for patients with underlying liver disease who would not tolerate a major resection.

Intraoperative ultrasound is used to define the lesion, and the cryoprobe is inserted into the tumor, using a modified Seldinger technique. The probe is cooled to $-180^\circ$, freezing the tumor until a 1- to 2-cm margin of uninvolved tissue is frozen. The advancing ice ball can be seen by US. The tumor and the margin of normal parenchyma are then excised, dividing any pedicles or hepatic vein branches and using the cryoprobe as a handle to aid the resection. The applicability of this technique is limited to tumors that are less than 5 cm in size and that do not involve major vascular structures. In the appropriate setting, however, this is a reasonable approach. In addition, freezing the tumor and a margin of parenchyma eliminates fracturing at the tumor-margin interface, a common cause of positive histologic margins during wedge resection of hard tumors such as colorectal metastases.16

**POSTOPERATIVE CARE**

Closure of the abdominal wall is done in continuous fashion in one or two layers with absorbable monofilament (#1 PDS, Ethicon). Skin is closed with staples or in subcuticular fashion. Drains are not necessary for routine hepatic resection without concomitant biliary resection and reconstruction. Indeed, a prospective randomized study of patients undergoing liver resection showed an increased complication rate in patients in whom drains were placed compared to those without drains.20

Patients are kept in the recovery room for approximately 1 day. The large-bore central lines are changed to triple-lumen catheters prior to discharge to the floor. This facilitates electrolyte replacement if necessary. Intravenous fluids should include phosphorous as liver regeneration requires large amounts of high-energy phosphates and as serum phosphorous levels can drop quite low without supplementation. In fact, one of the signs of appropriate liver regeneration is a transient drop in serum phosphate levels, beginning 24 to 48 hours postoperatively. For large-volume liver resections, electrolytes, blood count, and coagulation profile are checked postoperatively, then daily for 3 to 4 days. Particular attention is paid to the prothrombin time (PT). The threshold for administering blood products varies with the clinical situation and the surgeon. In general, packed red blood cells are administered if the hemoglobin falls to 8 mg/dL or lower, and fresh frozen plasma is given if the PT is greater than 17 seconds. Bleeding is the principal concern in the immediate postoperative period, and any significant drop in the hemoglobin or any hemodynamic instability should prompt a return to the operating room. Patients are transferred to the ward on the first postoperative day and are encouraged to ambulate three times per day. Postoperative pain control is achieved with patient-controlled analgesia. Understanding the decreased clearance of hepatically metabolized drugs is extremely important in selecting medication for pain control as small doses may linger. Clear liquids with a rapid advancement of diet are begun on or around postoperative day 3 unless a biliary-enteric anastomosis has been performed. Peripheral edema is common after major hepatic resection and may be treated with spironolactone. Unexplained fever or rising bilirubin with normalization of other hepatic function parameters suggests an intra-abdominal bile collection and should be investigated with a CT scan. Such collections usually resolve after a few days with percutaneously placed drains; reoperation is rarely necessary. The median length of stay for major hepatic resection is 8 days.

**REFERENCES**


