CHAPTER 16

Techniques of Hepatic Resection

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Introduction

Hepatic resection is the most effective treatment for patients with primary and selected secondary malignant tumors. It is also indicated for certain benign lesions. In nearly all instances involving patients with malignant hepatic disease, resection is the only treatment with curative potential. Over the past 30 years, improvements in perioperative care and surgical technique have dramatically decreased the morbidity and mortality of major hepatic resection, thus making it a viable treatment option for many patients.

The risk of hemorrhage has been the major obstacle to the safety of hepatic resection. While this remains a concern, blood loss and transfusion requirements have been markedly reduced as a result of changes in operative technique. Although portal triad clamping reduces hepatic arterial and portal venous bleeding during parenchymal transection, this has no effect on bleeding from the hepatic veins which are usually the major source of blood loss. Inflow and outflow vascular control before parenchymal transection, low central venous pressure anesthesia, and anatomically based resections, are all important components of contemporary hepatic resection and play a role in minimizing operative blood loss. Total vascular isolation, a fundamentally different approach that is required in few cases, has not been shown to lower intraoperative blood loss or transfusion requirements.

Operative Technique

In patients with malignant disease, complete resection requires a negative histologic margin; resection with a positive margin is a well-known predictor of recurrence and poor survival. Although 1 cm of normal parenchyma around the tumor was previously considered to be essential, recent studies have shown that a resection margin of a few millimeters is probably adequate. Regardless, anatomically based segmental resections are the best means of achieving a negative margin. Wedge resections have a higher incidence of positive margins, are associated with greater blood loss, and should be avoided except for small peripheral lesions.

Major intraoperative bleeding is generally the result of injury to the hepatic veins or vena cava. To minimize venous bleeding, early control of the hepatic veins is performed before dividing the liver, and the venous outflow is divided after controlling the inflow blood supply. A low central venous pressure (CVP) of 5 mm Hg or less minimizes bleeding from disrupted hepatic veins, which may occur during mobilization or parenchymal transection. Early fluid restriction is maintained to achieve both low CVP and the minimal volume necessary for renal perfusion, but

Hepatobiliary Surgery, edited by Ronald S. Chamberlain and Leslie H. Blumgart.

low urine output during the resection is accepted. To minimize the risk of air embolism from disrupted hepatic veins, the resection is performed in 15° of Trendelenburg. 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.

In selected cases, laparoscopy is performed immediately prior to laparotomy. If the patient appears to be resectable, a right subcostal incision is made with extension of the incision as necessary. Exploration for extrahepatic disease is performed. The round ligament is divided, leaving a long suture on the hepatic side for traction. The falciform ligament is divided up toward the hepatic veins, and the right triangular ligament and the coronary ligament are partially divided with cautery (Fig. 16.1). Once fully mobilized, the liver is examined with bimanual palpation and intraoperative ultrasound (IOUS) both to identify the tumor(s), the presence of additional disease, and to assess the relationship of the tumor(s) to the major vascular structures.

For right-sided resections, the right liver is detached from its diaphragmatic attachments by completely dividing the right triangular ligament and exposing the bare area of the liver. This is facilitated by rotating the table away from the surgeon, retracting the right lobe of the liver medially and anteriorly, and pulling the diaphragm laterally. The peritoneum at the inferior border of the liver is divided lateral to medial, taking care to avoid injury to the right adrenal gland. Small veins draining from the liver into the IVC are separated from the caudate process all the way up to the hepatic venous confluence (Fig. 16.2). During this dissection, a ligamentous band is encountered which arises from the caudate lobe on the left, passes posterior to the IVC, and attaches to Segment VII. This ligament may contain small vessels or hepatic parenchyma and must be divided in order to expose the right hepatic vein. For left-sided resections, the left liver is mobilized by dividing the left triangular ligament and left coronary ligament to the lateral margin of the IVC, avoiding injury to the left hepatic vein. The lesser omentum should be incised and the ligamentum venosum, which runs along the anterior surface of the caudate lobe to enter the left hepatic vein, should be ligated and divided.

Right Hepatectomy

Right hepatectomy involves removing all hepatic parenchyma to the right of the middle hepatic vein (Segments V, VI, VII, and VIII). If necessary, the middle hepatic vein can be sacrificed during right hepatectomy since the umbilical and left hepatic veins will provide adequate drainage of the remaining left liver. After full mobilization, vascular inflow and outflow control should be achieved. Three general approaches have been described for achieving vascular inflow control: extrahepatic dissection within the porta hepatis with division of the right hepatic artery and right portal vein prior to division of the parenchyma (Fig. 16.3); intrahepatic control of the main right pedicle within the substance of the liver prior to parenchymal transection (pedicle ligation); or intrahepatic control of the pedicle during parenchymal transection. For the overwhelming majority of resections, we control the inflow extrahepatically with either a hilar dissection or, if possible, the pedicle ligation technique. Proceeding with liver resection before inflow control is achieved is not advised.

Extrahepatic vascular control begins with cholecystectomy. If the gallbladder is involved by the tumor, it should not be removed, but the cystic duct and cystic artery ligated and divided. The common hepatic artery should then be dissected

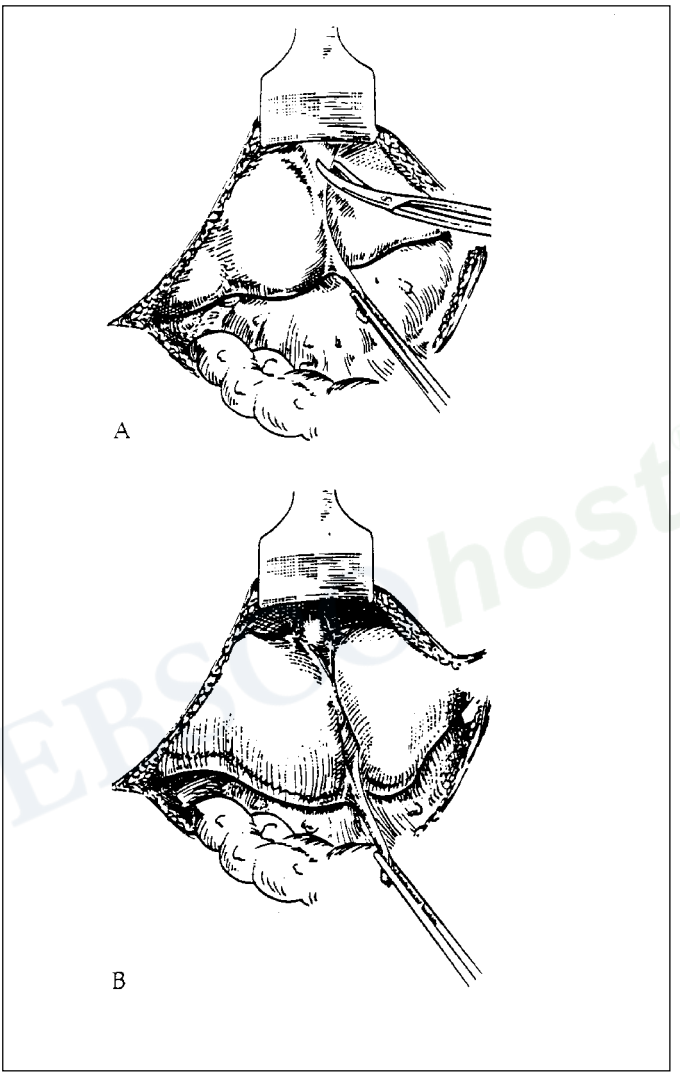

Fig. 16.1. Initial exposure of the liver. A. Upward retraction of the ribs is achieved with an overhead retractor. The ligamentum teres is divided. B. The falciform ligament is divided up toward the hepatic veins to expose the inferior vena cava. The divided end of the ligamentum teres is used to retract the liver. Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart, ed. 1994. © Churchill Livingstone.

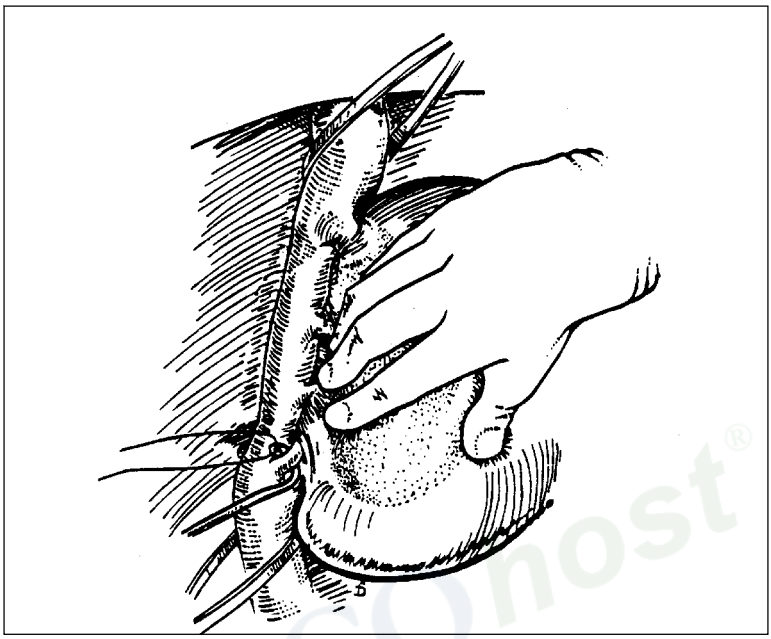

Fig. 16.2. The liver has been fully mobilized and is retracted laterally to the patient's right. Multiple small veins draining posteriorly from the liver into the inferior vena cava are carefully dissected and divided from the caudate process to the hepatic venous confluence. This allows full mobilization of the right lobe of the liver. Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2nd Edition. LH Blumgart, ed. 1994. © Churchill Livingstone.

sufficiently to reveal the right and left branches after which the right branch can be divided with suture ligatures. The portal vein is then exposed. Again, the right and left branches should be clearly identified. A small branch from the right portal vein to the caudate process is a constant finding and should be controlled early in the dissection. This maneuver facilitates exposure of an additional length of the right portal vein making it easier to divide. Once adequately dissected, the right portal vein may then be divided between vascular clamps and oversewn or, as we prefer, divided with a vascular stapler.

Vascular anomalies are not uncommon, and the surgeon should be prepared to deal with them. The common variations of arterial anatomy are well-described. However, variant anatomy of the portal vein is also encountered, the most common of which is a separate origin of the right anterior and posterior branches. For all major hepatic resections, it is essential to fully define the vascular anatomy in order to avoid potentially disastrous injury to the contralateral branch.

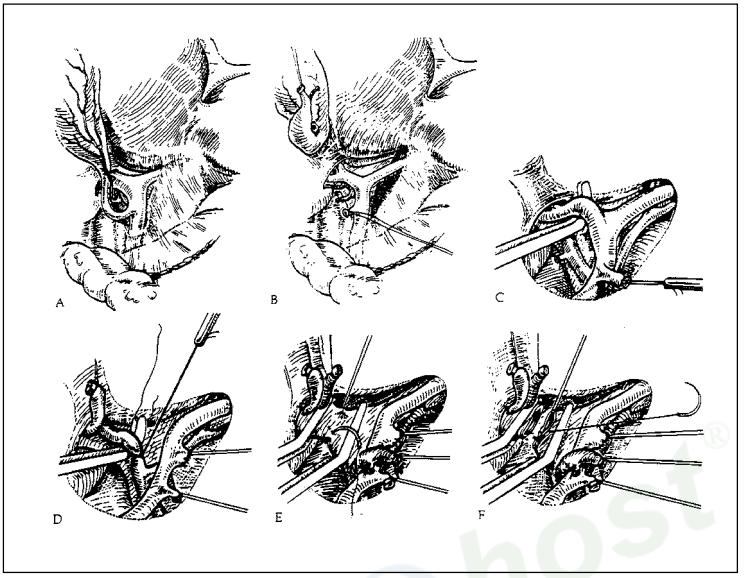

Fig. 16.3. Extrahepatic dissection within the porta hepatis for a right hepatectomy. A. The cystic and hilar plates are lowered to expose the right pedicle. B. The peritoneum overlying the common bile duct is incised. The cystic duct and cystic artery are ligated and divided. A tie has been left on the cystic duct for retraction. C. The right hepatic duct is dissected. D. The right hepatic duct has been ligated and divided with absorbable suture. The right hepatic artery is dissected, ligated and divided. E. The right portal vein is dissected, doubly clamped and divided. The branch from the caudate process is either divided prior to dividing the right portal vein. F. The proximal end of the portal vein is oversewn with vascular suture. Reprinted with permission from LH Blumgart, Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart, ed. 1994. © Churchill Livingstone.

When possible, we perform a pedical ligation maneuver to control the partial structures. This technique has several advantages over hilar dissection. After removing the gallbladder, two hepatotomy incisions are made medially at the base of the gallbladder fossa and within the caudate process parallel to the IVC (Fig. 16.4). With the portal triad occluded (Pringle), a finger or clamp is then passed into the substance of the liver to encircle the main right pedicle (Fig. 16.5), which is encased in a tough, fibrous sheath (Fig. 16.6). Bleeding from terminal branches of the middle hepatic vein may occur but is readily controlled. Residual liver tissue is then cleared away to expose the pedicle and identify the anterior or posterior branches to the individual segments for segmental resections. Before dissecting the pedicle, it is essential to divide all posterior venous branches entering the IVC (Fig. 16.2); otherwise, these veins may be torn and significant hemorrhage will occur. Once the right pedicle is isolated, it should be occluded temporarily and the portal triad clamp

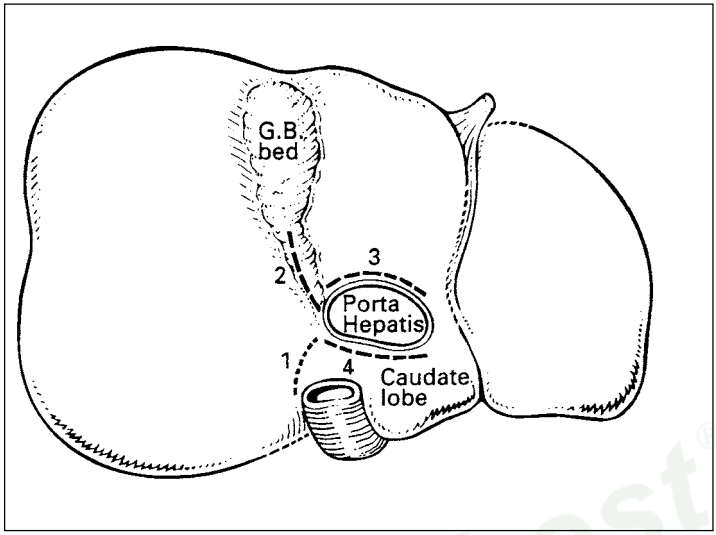

Fig. 16.4. Approach to pedicle ligation during right hepatectomy. The gallbladder has been removed and the cystic and hilar plates lowered. Hepatotomy incisions are made in the caudate process (1) and in the gallbladder fossa (2) to allow control of the right pedicle. Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet. Hepatic cryosurgery addendum by Y Fong. Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart ed. 1994. © Churchill Livingstone.

released to reveal the line of demarcation along the principal plane. Performance of a pedicle ligation eliminates the need for hilar dissection, thereby saving time and reducing the potential of injury to the bile duct or contralateral vascular structures. Once again, we stress 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 after the vascular pedicle is isolated. This maneuver risks injury to the biliary confluence. Control of the right hepatic duct can be obtained during parenchymal transection.

With the inflow controlled, outflow control of the right hepatic vein is achieved next (Fig. 16.7). Although the right hepatic vein is visible after initial mobilization, complete control requires further dissection of the avascular tissue along the suprahepatic vena cava, between the right and middle hepatic veins. The right vein can then be encircled and divided with a vascular stapler (preferably) or divided between vascular clamps and oversewn. Alternatively, the right vein may also be controlled and divided within the substance of the liver during parenchymal transection, although extrahepatic control is our preference.

The line of parenchymal transection may be to the left or right of the middle hepatic vein, depending on the location of tumor. The surgeon should not hesitate

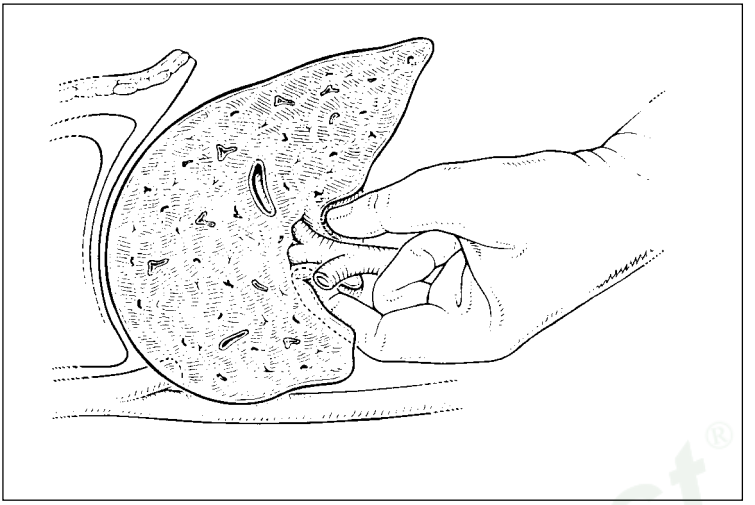

Fig. 16.5. Intrahepatic control of the right pedicle using finger dissection. After the hepatotomy incisions are made, finger dissection of the parenchyma is used to isolate the right pedicle. A curved clamp may also be used. Note the proximity of the middle hepatic vein. Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart ed. 1994. © Churchill Livingstone.

to divide the middle vein if necessary, since the umbilical vein will provide adequate drainage of Segment IV. Parenchymal division begins by marking the line of transection with the electrocautery and cutting the capsule with scissors. Stay sutures of 0 chromic catgut are placed on either side of the transection plane and used for traction 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. Although the liver can tolerate warm ischemia for up to 60 minutes, intermittent portal triad clamping during the parenchymal transection phase allows decompression of the mesenteric veins. After transection is complete, the raw surface of the liver is examined for hemostasis and bile leaks. The argon beam coagulator is used to control raw surface oozing. Biliary leaks should be clipped or suture ligated.

The authors do not use closed suction drainage after routine hepatic resection unless concomitant biliary resection and reconstruction have been performed, if a portion of the diaphragm has been resected and repaired, or if there is obvious bile leakage that cannot be fully controlled with suture ligation.

Extended Right Hepatectomy (Right Hepatic Lobectomy or Right Trisegmentectomy)

The additional removal of Segment IV during right hepatectomy (V, VI, VII, VIII) constitutes an extended right hepatectomy or right trisegmentectomy. The initial steps are similar to right hepatectomy, with division of the right hepatic vein

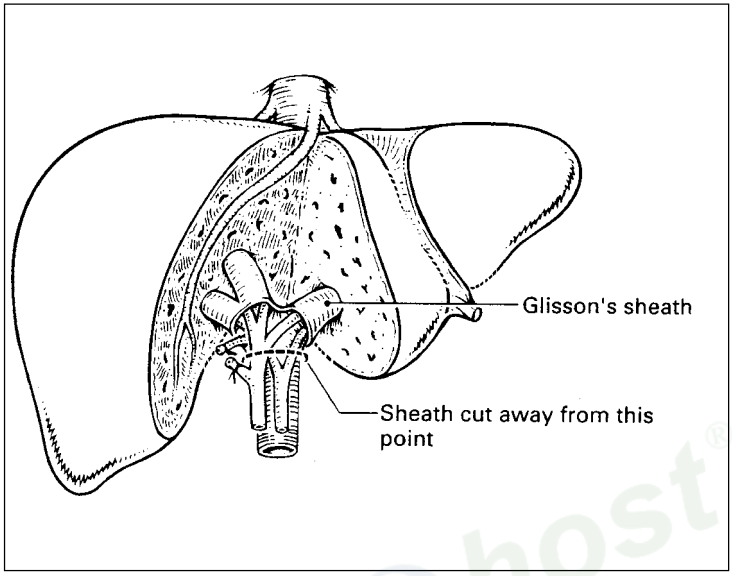

Fig. 16.6. Isolation of the portal pedicles. A portion of the liver has been removed to demonstrate the intrahepatic portion of the main right portal pedicle. Within the liver, the pedicles are encased within a thick fibrous sheath. Again, note the proximity of the right pedicle to the middle hepatic vein. Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart ed. 1994. © Churchill Livingstone.

and portal pedicle. The bridge of tissue connecting Segments III and IV, which may be well-developed hepatic parenchyma in some patients, is divided to reveal the lower part of the umbilical fissure. The ligamentum teres can be seen within the umbilical fissure, joining the left portal vein.

After the right pedicle is divided, the recurrent vessels from the umbilical fissure to Segment IV are controlled (Fig. 16.8). This may be achieved within the umbilical fissure or during parenchymal transection. The right hepatic vein is 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 is encountered as dissection progresses deeper within the liver and can be ligated or stapled at that point. Care should be taken to avoid injury to the left hepatic vein which usually enters the middle hepatic vein. This is of particular concern for tumors involving Segment IVa.

Left Hepatectomy

Removal of Segments II, III and IV constitutes a left hepatectomy. After full mobilization of the left triangular ligament, inflow control is achieved outside of the liver at the base of the umbilical fissure (Fig. 16.9). The bridge of tissue connecting

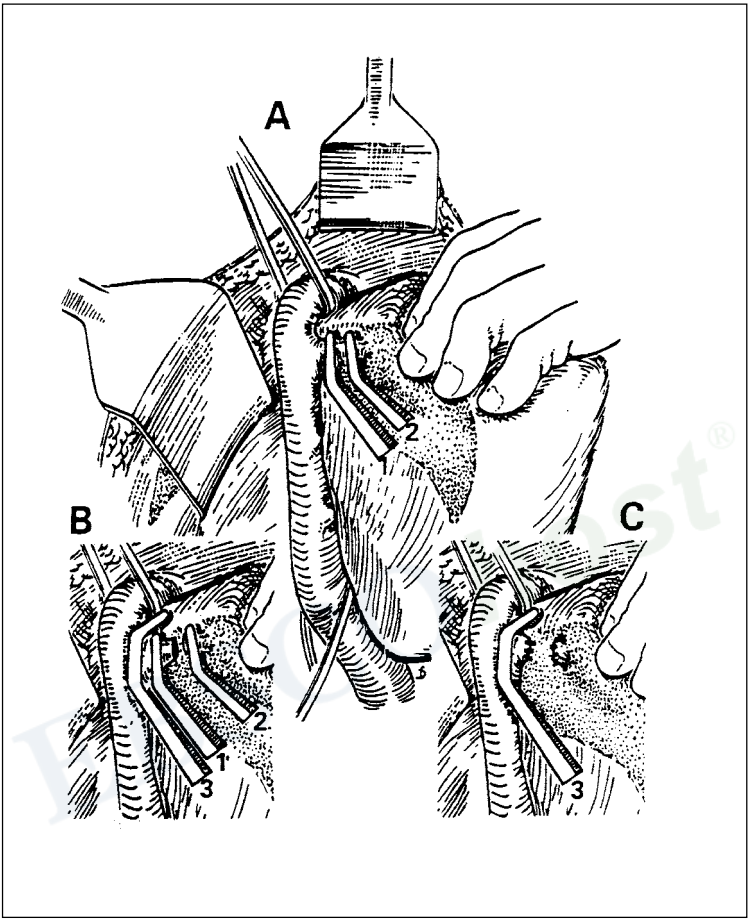

Fig. 16.7. Isolation of the right hepatic vein. The right liver has been fully mobilized and the inferior vena cava completely exposed up to the right hepatic vein. A. Vascular clamps have been applied to the right hepatic vein. B. A second vascular clamp is applied to the caval side of the vein. C. The right hepatic vein had been divided and the stump oversewn with vascular suture. It is generally not necessary to control the vena cava above and below the liver. Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet. Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart ed. 1994. © Churchill Livingstone.

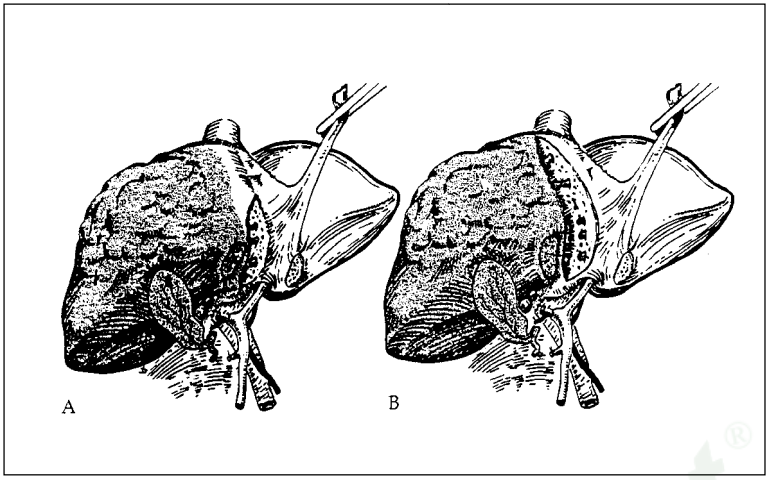

Fig. 16.8. Extended right hepatectomy. A. Recurrent vessels from the umbilical fissure to Segment IV are divided and suture-ligated just to the right of the falciform ligament. The recurrent vessels may also be divided from within the umbilical fissure, taking care to avoid injuring the main left pedicle. B.Division of the liver parenchyma proceeds toward the inferior vena cava to the right of the falciform ligament. Reprinted from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart ed. 1994. © Churchill Livingstone.

Segments III and IV on the undersurface of the liver must be divided. The hilar plate is lowered and the left hepatic artery identified and divided. The portal vein is identified at the base of the umbilical fissure. If the caudate is to be preserved, then the portal vein is controlled beyond the origin of the principal caudate branch which usually arises from the left portal vein. The long extrahepatic course of the left bile duct can be identified behind the portal vein and divided at the umbilical fissure, or controlled from within the hepatic parenchyma.

The left and middle hepatic veins are controlled after mobilizing the left lobe and lifting it anteriorly and to the right (Fig. 16.10). The gastrohepatic ligament is initially divided exposing the ligamentum venosum, which itself is divided just prior to entry into 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 lobe from below. The middle and left hepatic veins most often enter the IVC as a single trunk (Fig. 16.10), but may be independent in some cases. The veins are divided and stay sutures placed along either side of the principal plane, followed by parenchymal transection.

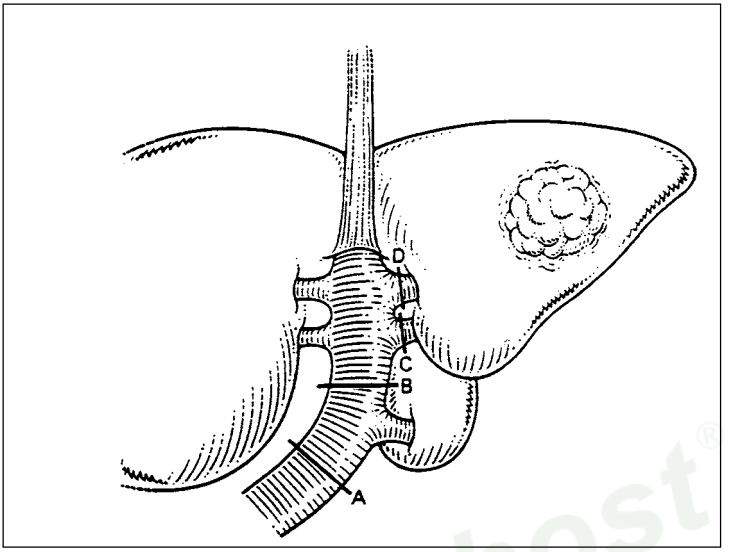

Fig. 16.9. The main left portal pedicle as it courses along the undersurface of Segment IV into the umbilical fissure. A. Division at this level will devascularize the entire left liver including the caudate lobe. B. Division above the caudate branch will preserve the caudate blood supply and devascularize 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. Note: 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 LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart ed. 1994. © Churchill Livingstone.

Left Lateral Segmentectomy (Left Lobectomy)

Removal of Segments II and III constitute a left lateral segmentectomy. The bridge of tissue overlying the umbilical fissure, and running between Segments III and IV, is divided after mobilization. For tumors lying close to the fissure, the pedicles to Segments II and III can be dissected individually within the umbilical fissure (Fig. 16.9). An alternate approach for peripheral lesions is splitting the liver anteroposteriorly just to the left of the falciform ligament. The Segment II and III pedicles can then be divided during parenchymal transection. The left hepatic vein can be controlled and divided within the liver substance posteriorly, thus obviating the need for extrahepatic dissection. However, if the tumor approximates the left hepatic vein, extrahepatic dissection and control are essential.

Extended Left Hepatectomy (Left Trisegmentectomy)

An extended left hepatectomy involves removal of Segments V and VIII (the anterior sector of the right liver) in addition to a left hepatectomy (Segments II, III

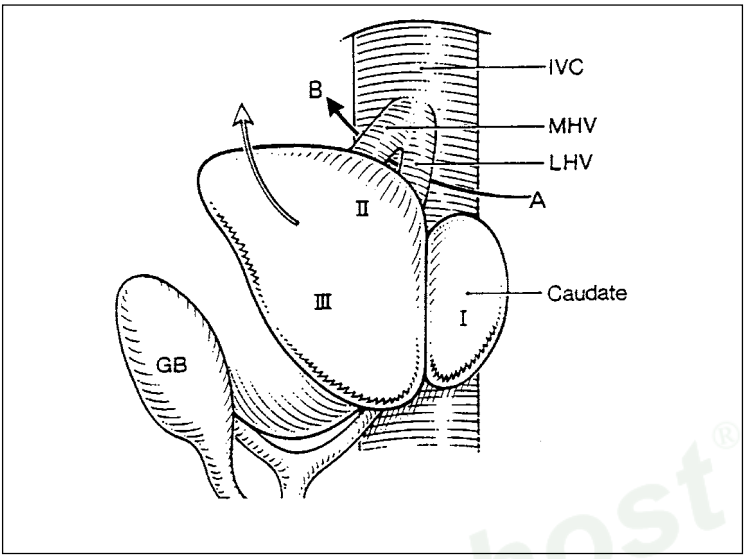

Fig. 16.10. Approach to the left and middle hepatic veins. The left lobe is completely mobilized and lifted anteriorly and to the right (open arrow). The gastrohepatic ligament is divided and dissection continues at the ligamentum venosum, which is divided as it enters the left hepatic vein. A passage is developed from just to the right of the middle hepatic vein from above and the superior border of the caudate lobe (A to B). The veins are clamped, ligated and divided. IVC = inferior vena cava; MHV = middle hepatic vein; LHV = left hepatic vein; GB = gallbladder. Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). In: LH Blumgart ed. Surgery of the Liver and Biliary Tract, 2nd Edition. 1994. Edinburgh UK.

and IV). This is among the most challenging of hepatic resections; the difficulty lies in defining the plane of transection (Figs. 16.11 and 16.12). Injury to the posterior sectoral pedicle, or to the right hepatic vein, must be avoided at all cost.

The presence of a large accessory right hepatic vein is a potentially important finding, especially for tumors encroaching on the main right hepatic vein origin, and may allow sacrifice of the main right hepatic vein for tumor clearance. Dissection proceeds as with a left hepatectomy, with the portal triad approached from the left side. If the caudate lobe is to be included in the resection (Fig. 16.11, inset), the left hepatic artery and portal vein should be ligated close to their origins in order to disconnect the blood supply to both caudate and Segments II and III (Fig. 16.9). If the caudate is preserved, the left portal triad is transected at the base of the umbilical fissure, preserving the blood supply to the caudate (Fig. 16.9). If possible, the anterior pedicle supplying Segments V and VIII should be controlled before parenchymal transection. After the inflow has been controlled, outflow control is obtained.

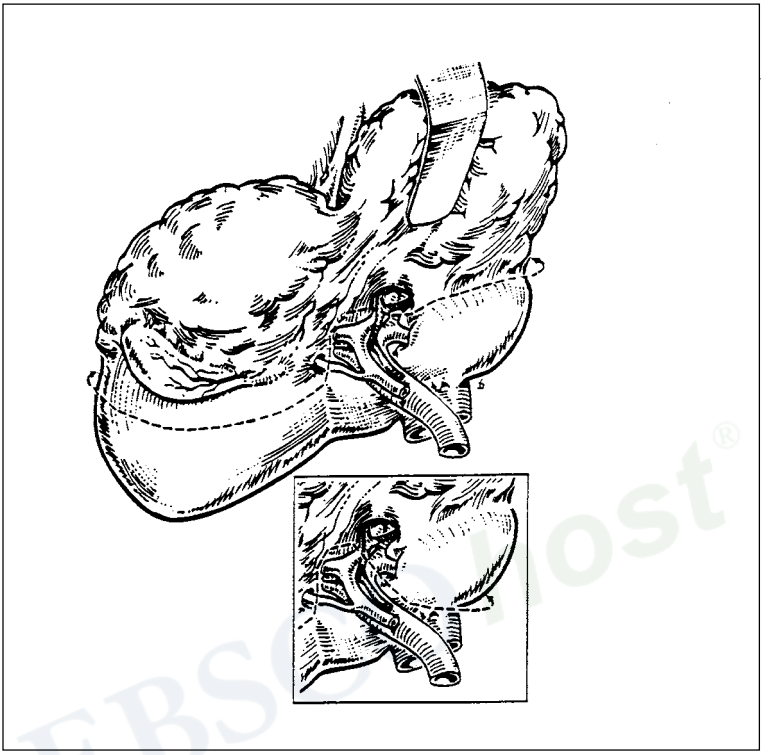

Fig. 16.11. Extended left hepatectomy. The line of transection as indicated is horizontal and parallel to the right scissura. If the caudate is to be preserved, as shown, the portal vein is divided beyond the caudate branch. The line of transection is along the ligamentum venosum, the base of the quadrate lobe and hilus, and along the right scissura lateral to the gallbladder fossa. If the caudate lobe is to be resected, the left hepatic artery and left branch of the portal vein are divided close to their origins (inset). Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). In: LH Blumgart ed. Surgery of the Liver and Biliary Tract, 2d Edition. 1994. © Churchill Livingstone.

Controlling the middle and left hepatic veins extrahepatically is important to reduce blood loss during parenchymal transection.

The greatest challenge to the procedure is defining the plane of transection, which is horizontal and anterior and parallel to the right scissura, just lateral to the gallbladder fossa. If the inflow has been completely divided, the line of transection will be shown extending from the anterior border of the right hepatic vein to an area to the right of the gallbladder fossa. If the right anterior sectoral pedicle has not been controlled, which may not be possible initially because of proximity of the tumor, the plane of transection is more difficult to conceptualize.

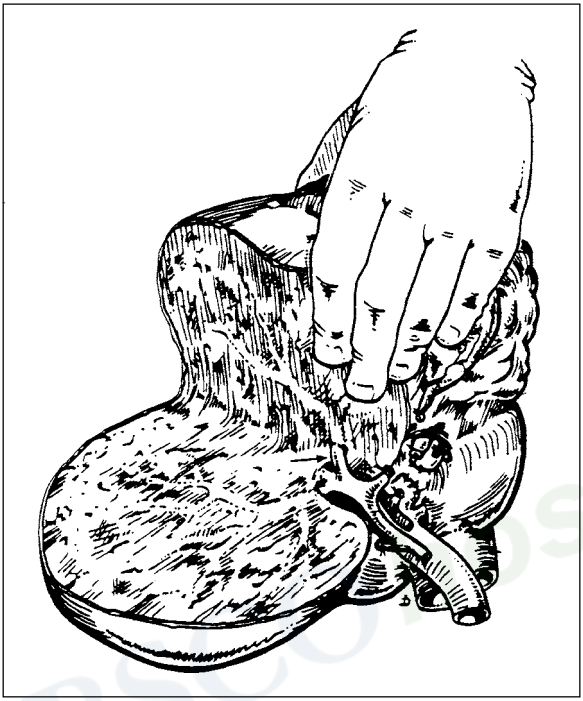

Fig. 16.12. Extended left hepatectomy. The liver parenchyma is divided just anterior to the lower limit of the right scissura. The anterior sectoral pedicle (small arrow) may be taken within the liver substance. Reprinted with permission from LH Blumgart. Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). In: LH Blumgart ed. Surgery of the Liver and Biliary Tract, 2nd Edition. 1994 © Churchill Livingstone.

Using intermittent portal triad occlusion, the parenchyma is divided from the inferior surface upwards and from right to left in a horizontal plane. In order to facilitate the dissection, the liver is rotated clockwise to convert the horizontal plane to a vertical one. 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, since tumors close to the posterior pedicle or the right hepatic vein will limit the resection.

Extended left resections can be done safely with mortality rates only slightly higher than other resections. Postoperative morbidity is significant, however, with biliary leak and abdominal abscess being the major complications. Because of the small remnant, significant postoperative liver dysfunction may result and patients are more likely to develop significant ascites.

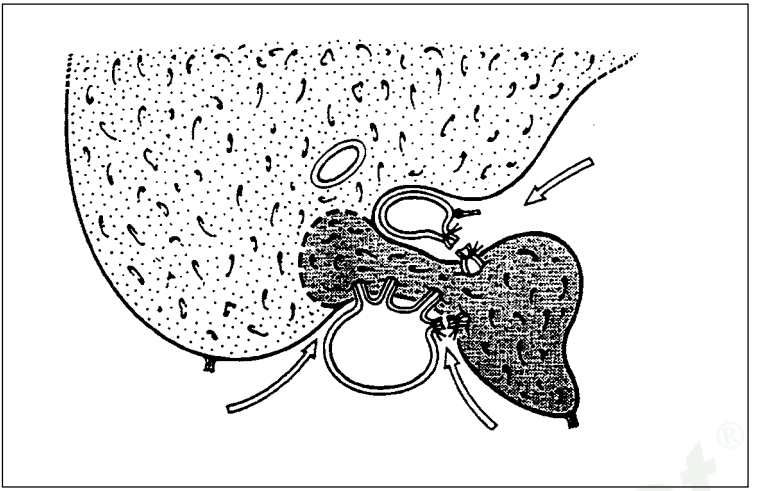

Fig. 16.13. Caudate lobe resection. The caudate lobe may be approached from the right or left, although dissection from both sides is often necessary. The attachment from the caudate to the IVC has been divided. The inflow to the caudate has been divided (above) and the caudate veins are now controlled in turn. Note the proximity of the middle hepatic vein to the right lateral aspect of the caudate lobe. Reprinted with permission from LH Blumgart. Liver resection for benign disease and for liver and biliary tumors. In: LH Blumgart, Y Fong eds. Surgery of the Liver and Biliary Tract, 3d Edition. 2000. © W.B. Saunders.

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 (Figs. 16.13 and 16.14). The caudate may be approached from the right or left, although dissection from both sides is often necessary (Fig. 16.13). Dissection from the right side is necessary for bulky lesions that prevent access from the left or when the caudate is excised en bloc with the right liver. After division of the gastrohepatic omentum and the ligamentous attachments from the caudate to the IVC, the right liver is mobilized with division of the posteriorly draining veins along the entire retrohepatic cava. The dissection then proceeds along the anterior surface of the IVC, lateral to medial with control of the caudate veins. Some of these veins may be more easily controlled from the left side. The branches to Segment I from the left portal vein and hepatic artery are then dissected close to the base of the umbilical fissure just before the entry of the left portal triad. The caudate is then separated from its attachment to the right liver with inflow occlusion.

A principal approach from the left side may be possible with smaller tumors or when the caudate is to be removed en bloc with the left liver. The left lateral margin of Segment I is freed by dividing the fibrous attachment posteriorly to the IVC and

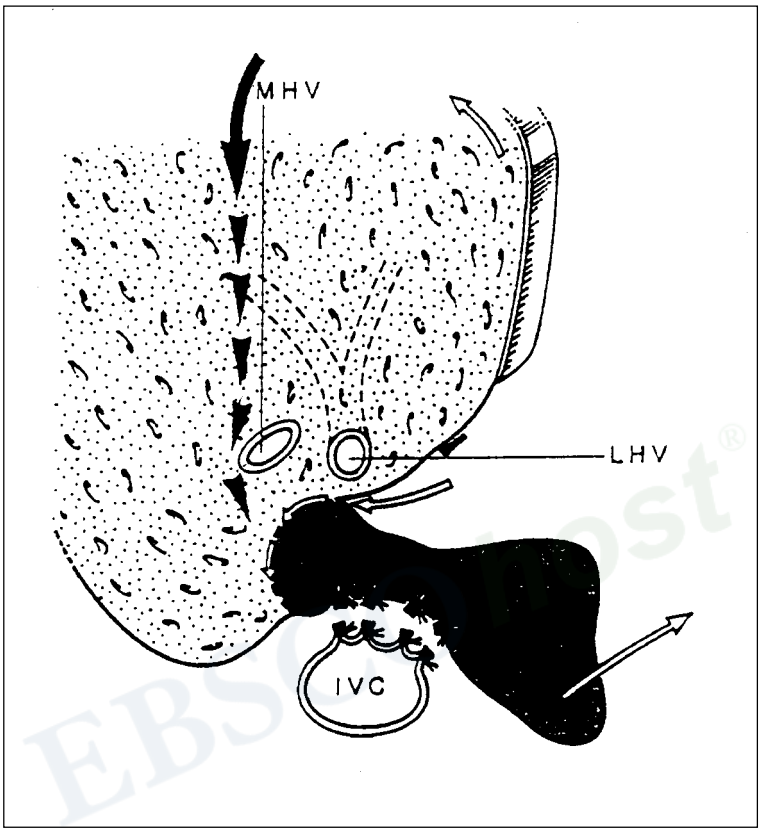

Fig. 16.14. An alternative approach to isolated caudate resection. The liver is split along the principal plane to allow detachment of the right side of the caudate under direct vision of the middle hepatic vein. This approach may help reduce the risk of inadvertent injury to the middle vein, which can result in significant hemorrhage. Reprinted with permission from LH Blumgart, Liver resection for benign disease and for liver and biliary tumors. In: LH Blumgart, Y Fong eds. Surgery of the Liver and Biliary Tract, 3d Edition. 2000. © W.B. Saunders.

diaphragm, exposing the veins draining the caudate into the cava. The approach to the inflow vessels remains the same.

An alternative approach to an isolated Segment I resection involves mobilization of the caudate as described above, followed by splitting of the hepatic parenchyma along the principal plane (Fig. 16.14). This approach provides access to the right border of the caudate, which can be disconnected under direct vision of the middle hepatic vein and may prevent uncontrolled bleeding.

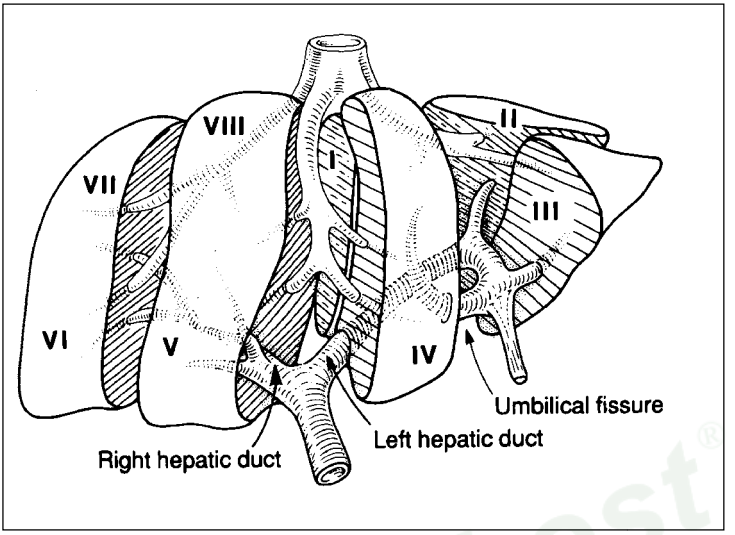

Fig. 16.15. Segmental anatomy of the liver showing the principal scissurae, as defined by the hepatic veins, and the portal pedicles supplying each segment. Reprinted with permission from LH Blumgart, Liver resection—liver and biliary tumours (with comments by B Launois and C. Huguet, Hepatic cryosurgery addendum by Y Fong). Surgery of the Liver and Biliary Tract, 2d Edition. LH Blumgart ed. 1994. © Churchill Livingstone.

Segmental Resection

Because they are defined by anatomic structures with their own pedicles, each hepatic segment can be resected individually (Fig. 16.15), or in combination with other segments as part of a larger resection. This section describes some of the more commonly performed anatomical sub-lobar hepatic resections.

Right Posterior Sectorectomy (Segments VI and VII)

Removal of Segments VI and VII constitutes a posterior sectorectomy. In this resection, all hepatic tissue below and lateral to the right hepatic vein is removed. The right hepatic vein can also be sacrificed, if necessary, since the middle hepatic vein will provide adequate drainage of Segments V and VIII (anterior sector). Even if the right hepatic vein is to be preserved, it should be fully dissected and exposed to allow rapid control if injured during parenchymal transection. The right portal pedicle is exposed and the anterior and posterior branches identified. The posterior pedicle is clamped and the line of demarcation between the anterior and posterior sectors is demonstrated. The pedicle may be divided and parenchymal dissection performed. The line of transection is horizontal and posterior to the right hepatic vein, but may be extended into the anterior sector with sacrifice of the right hepatic vein, if necessary.

Right Anterior Sectorectomy (Segments V and VIII)

Removal of the Segments V and VIII constitutes a right anterior sectorectomy. This resection removes all hepatic tissue between the right and middle hepatic veins. The right hepatic vein must be preserved, but the middle hepatic vein may be sacrificed. The right lobe must be fully mobilized and the right hepatic vein completely exposed. The approach is similar to that used for posterior sectorectomy except that the anterior pedicle is divided, and the line of transection indicated between the right and middle hepatic veins. The line of transection can be extended into Segment IV if necessary for complete tumor clearance.

Segment IV Resection

Segment IV is divided into a posterosuperior portion (IVa) and an anteroinferior portion (IVb), which can be resected together or separately. 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 vein provides additional drainage and may drain into the middle or left vein. Division of the bridge of tissue overlying the umbilical fissure is performed and the hilar plate 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 just to the right of the falciform ligament and along the principal plane. Control of the Segment IV feedback vessels is as described for extended right hepatectomy. Initial division of these vessels will delineate the extent of the resection. The middle hepatic vein may be preserved or divided.

Central Resection

Removal of Segments IV, V, and VIII (Segment IV plus an anterior sectorectomy) constitute a central resection. This seemingly complex procedure is used to maximize the amount of remnant liver left after resection because both the posterior sector and the left lateral segment are preserved. The approach to a central resection is similar to that used for a posterior sectorectomy and left lateral segmentectomy, except these are preserved rather than removed. The right anterior and posterior sectoral portal triads are identified and the anterior pedicle clamped. Transection is performed with intermittent Pringle, carefully preserving the right posterior pedicle and the right hepatic vein. Segment IV is devascularized and resected as described for a Segment IV resection. The middle hepatic vein must be divided; a vascular clamp may be used to occlude the vein during parenchymal transection.

Wedge Resections

Wedge resections are associated with 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. After dissection of the porta hepatis to place an umbilical tape, intraoperative ultrasound is performed to confirm the lesion, identify other lesions, and define the relationship of the lesion to major vascular structures. An adequate margin of excision is marked using cautery. Stay sutures are applied on either side of the lesion and within the area of excision. Parenchymal dissection is performed in a standard fashion using a crushing technique

to ensure that the normal parenchyma does not fracture around the tumor and that adequate margins are maintained without "coning" in on the lesion.

Postoperative Care

As discussed above, drains are not necessary for routine hepatic resection without concomitant biliary resection and reconstruction; in fact, drains are associated with an increased complication rate in patients undergoing hepatic resection. Postoperatively, intravenous fluids should include phosphorus because liver regeneration requires large amounts of high-energy phosphates and serum phosphorus levels can drop quite low without supplementation. For large-volume liver resections, electrolytes, blood count and coagulation profiles are checked postoperatively and daily for three days, with particular attention to the prothrombin time (PT) and hemoglobin. Hypoglycemia is not a major concern after hepatic resection. In our experience, administration of 10% dextrose solutions (which is commonly practiced) is never necessary and only serves to raise the serum glucose levels and induce an osmotic diuresis. 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 sec. An understanding of the decreased clearance of hepatic-metabolized drugs is important in selecting pain medication as small doses may linger. 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 within a few days with percutaneously placed drains; reoperation is rarely necessary.

Selected Reading

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