

Left hepatectomy or left trisectionectomy with resection of the caudate lobe and extrahepatic bile duct for hilar cholangiocarcinoma (with video)

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Abstract

Purpose Although left-sided hepatectomy, such as a left hepatectomy or left trisectionectomy with resection of the caudate lobe and extrahepatic bile duct, is used to treat hilar cholangiocarcinoma predominantly involving the left side of the hepatic hilum, it is associated with several difficult technical points. The important points during left-sided hepatectomy are described here.

Techniques There are anatomical variations of the sectional artery and bile duct. It is essential to understand the individual intrahepatic and hilar anatomy preoperatively. Surgical procedures consist of lymph node clearance, dissection of the distal bile duct, skeletonization resection of the hepatoduodenal ligament, mobilization of the liver and liver resection, dissection of the intrahepatic bile ducts, and biliary reconstruction. During lymph node dissection and skeletonization resection of the hepatoduodenal ligament, the nerve plexus around the hepatic artery is dissected, and its adventitia is exposed with great care to avoid injuring the hepatic artery. Mobilization of the caudate lobe is performed only from the left side. There is no clear landmark between the caudate lobe and the right posterior section during liver resection. In the final step of liver

resection, it progresses toward the right edge of the inferior vena cava. When dividing intrahepatic bile ducts, extreme care should be used to avoid injury to the corresponding hepatic arteries, especially the anomalous supraportal posterior sectional artery.

Conclusions Left-sided hepatectomy for hilar cholangiocarcinoma should be considered a more complicated and technically demanding procedure than right-sided hepatectomy. Surgeons need to pay close attention to anatomical variations in order to perform a left-sided hepatectomy safely and successfully.

Keywords Left hepatectomy · Left trisectionectomy · Hilar cholangiocarcinoma

Introduction

Both left hepatectomy and left trisectionectomy with resection of the caudate lobe and extrahepatic bile duct are standard procedures for performing curative resection of hilar cholangiocarcinoma. Although only one-third of the total liver volume is excised during a left hepatectomy, it is nevertheless associated with several difficult techniques, such as the accurate recognition of the border between the caudate lobe and the right posterior section, correctly determining the dividing line of the intrahepatic bile ducts, and so on. Left trisectionectomy is a complicated and extensive surgical procedure [1] with high morbidity rates due to the variations in the three-dimensional anatomical patterns of hilar blood vessels and bile ducts. It is essential to comprehend the individual hilar and intrahepatic anatomy preoperatively to accomplish these operations successfully. In this article, the techniques of left hepatectomy and left trisectionectomy with resection of the caudate lobe

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and extrahepatic bile duct for hilar cholangiocarcinoma are described.

Technical points regarding the surgical procedures

Laparotomy

The laparotomy is performed using a right subcostal incision with an upper midline extension (Fig. 1). The edge of the right subcostal incision reaches the level of the posterior axillary line. A right intercostal incision along the ninth intercostal space with a thoracotomy can also be applied instead of the right subcostal incision. Upon entering the abdominal cavity, the round ligament is ligated and divided, and the whole abdominal cavity is thoroughly examined to confirm the absence of liver metastasis and disseminated disease. Intraoperative ultrasonography is performed in order to assess the resectability. When percutaneous transhepatic biliary drainage catheters have been placed, these are cut extracorporeally, drawn into the abdominal cavity, and connected to the drainage bags.

Lymph node clearance and dissection of the distal bile duct

After Kocher's mobilization, para-aortic lymph nodes are sampled for frozen section examination. If the lymph nodes are negative for cancer metastasis, we do not perform a para-aortic lymph node dissection. If microscopic positivity for para-aortic node metastasis is revealed, then clearance of the para-aortic nodes between the root of the celiac trunk and the superior mesenteric artery is carried out.

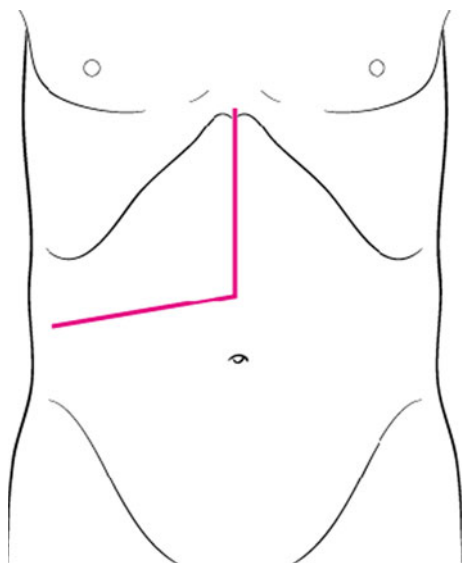


Fig. 1 Laparotomy is performed using a right subcostal incision with an upper midline extension

The right gastric and supraduodenal arteries and veins are ligated and divided along the gastric and duodenal walls, and the cranio-anterior surface of the pancreatic head is exposed. Following removal of the lymph nodes along the common and proper hepatic arteries, the nerve plexus around these arteries is dissected, the arterial adventitia is exposed, and vessel tapes are placed around these arteries. The proximal parts of the right and left hepatic arteries are also exposed and taped.

The common bile duct close to the upper margin of the pancreatic head is encircled and taped after removal of lymph nodes from behind the head of the pancreas. The posterior superior pancreaticoduodenal artery (PSPDA) runs in contact with the common bile duct near the upper margin of the head of the pancreas (Fig. 2). If the middle and lower bile ducts have no cancer involvement, the common bile duct can be ligated and divided at the level of the upper margin of the head of the pancreas with preservation of the PSPDA (Fig. 2). If the lower bile duct has to be divided in the head of the pancreas, the common bile duct is pursued into the pancreas following division of the PSPDA. The absence of any cancer invasion of the common bile duct stump should be confirmed by frozen section examinations.

Skeletonization resection of the hepatoduodenal ligament

Following dissection of the lymph nodes behind the portal vein, the portal trunk is encircled and taped. The stump of the common bile duct is raised in the cranio-ventral direction and skeletonization of the hepatic artery and portal vein is advanced up to the hepatic hilum.

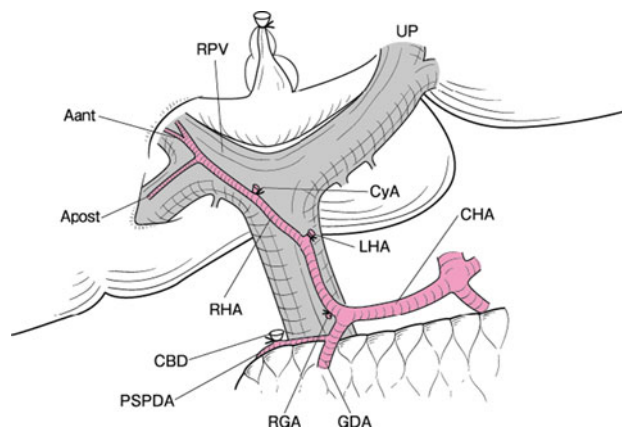


Fig. 2 The right posterior sectional artery commonly runs caudally to the right portal vein. *GDA* gastroduodenal artery, *RGA* the stump of the right gastric artery, *PSPDA* posterior superior pancreaticoduodenal artery, *LHA* the stump of the left hepatic artery, *RHA* right hepatic artery, *CyA* the stump of the cystic artery, *Aant* right anterior sectional artery, *Apost* right posterior sectional artery, *CBD* the stump of the common bile duct, *UP* umbilical portion of the left portal vein, *RPV* right portal vein

For left hepatectomy, the root of the left hepatic artery is doubly ligated and divided. The right anterior and right posterior sectional arteries are skeletonized and taped, respectively, after ligation and division of the cystic artery (Fig. 2). A right posterior sectional artery usually runs on the caudal and ventral aspect of the right portal vein (Fig. 2). However, it goes in the cranio-dorsal direction of the right portal vein in around 20% of cases (Fig. 3). Surgeons should pay special attention to this anomalous right posterior sectional artery so that they do not divide it by mistake. For left trisectionectomy, the right anterior sectional artery is ligated and divided, with preservation of the right posterior sectional artery. Caution should also be exercised regarding the anomalous right posterior sectional artery in this situation.

The portal trunk, portal bifurcation, and right portal vein are skeletonized in sequence. There are tiny caudate lobe portal branches behind the right and left portal veins. These branches are encircled, ligated, and divided with great care, and both the right and left portal veins are taped. Next, the root of the left portal vein is ligated and divided. If there is not enough length for ligation and division of the left portal vein due to cancerous invasion, the left portal vein is divided after clamping the portal trunk, right portal vein, and left portal vein (Fig. 4). The resected stump has to be closed with transverse continuous sutures to prevent stenosis of the portal vein (Fig. 5).

Following division of the left portal vein, the right anterior and posterior sectional portal veins are skeletonized. For left trisectionectomy, the right anterior portal vein is encircled, ligated, and divided. If sufficient length of the root of the right anterior portal vein for the full procedure cannot be exposed, then ligation alone can be performed at this point.

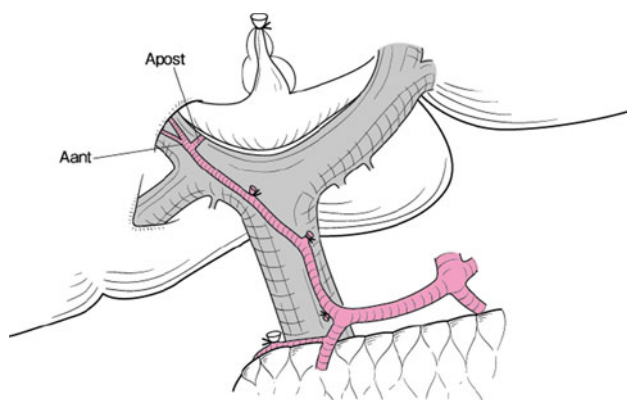


Fig. 3 The supraportal variant of the right posterior sectional artery runs cranially to the right portal vein. *Aant* right anterior sectional artery, *Apost* right posterior sectional artery

Mobilization of the left liver

The left coronary and triangular ligaments are divided, and the roots of the three hepatic veins are exposed. The left liver is mobilized to the right, and the minor omentum is opened. The attachment of the Arantius ligament to the root of the left hepatic vein can be easily recognized; it is then separated, ligated, and divided. To mobilize the left caudate lobe (Spiegel lobe), short hepatic veins between the dorsal surface of the caudate lobe and inferior vena cava (IVC) are ligated and divided following division of the left IVC ligament. There is at least one short hepatic vein which has to be divided using a clamp because of its thickness. Although the caudate lobe has to be fully separated from the IVC, the inferior or the middle right hepatic vein, if present, should be preserved to prevent a deterioration of the venous drainage in the right posterior section.

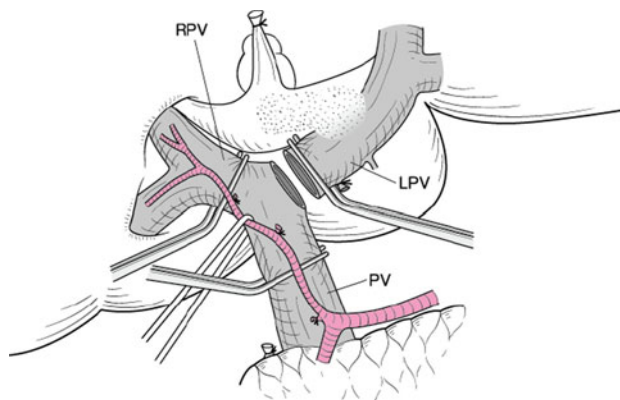


Fig. 4 If there is not enough length for ligation and division of the left portal vein (LPV) due to cancerous invasion, the left portal vein is divided after clamping the portal trunk (PV), right portal vein (RPV), and left portal vein

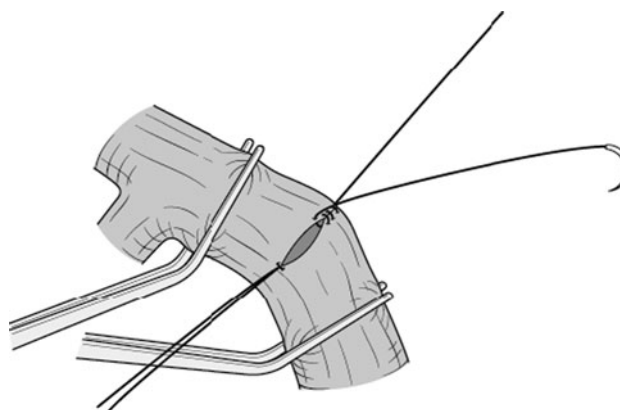


Fig. 5 The resected stump of the left portal vein should be closed with transverse continuous sutures to prevent stenosis of the portal vein

Liver resection

Left hepatectomy

A demarcation line is already present along the Rex-Cantlie line on the liver surface. The topographical relationship between the demarcation line and the middle hepatic vein (MHV) is confirmed by intraoperative ultrasonography.

Liver resection is usually started from the caudal-ventral edge of the demarcation line and advanced in the cranio-dorsal direction. After finding the MHV in the liver parenchyma, liver resection progresses to the root of the MHV, preserving it. When the left-side wall of the MHV is fully exposed up to its root, the root of the left hepatic vein is encircled and dissected. The direction of liver resection is then changed, and the dorsal surface of the MHV is exposed. There are tiny branches between the right caudate lobe and the dorsal surface of the MHV that surgeons should be sure to note. Following full exposure of the dorsal surface of the MHV, the direction of liver resection has to change again toward the right edge of the IVC (Fig. 6). There is no obvious landmark between the right caudate lobe and segment 7. If it is difficult to find an appropriate resection plane in this situation, it is a good idea to proceed to liver resection under the guidance of the surgeon's left index finger inserted along the right edge of the IVC. When the liver resection is accomplished, the right and left livers are connected only by hilar connective tissue containing the right hepatic duct.

For left hepatectomy with removal of the MHV, the liver parenchyma is resected along the right side of the MHV toward the right edge of the IVC (Fig. 6), and the common trunk of the left and middle hepatic veins is dissected using clamp forceps.

Left trisectionectomy

Surgeons can find a demarcation line on the liver surface between the right anterior and posterior sections. Liver resection is started from its caudal edge and progresses in the cranial direction, with complete preservation of the right hepatic vein (RHV) on the resection plane of the right posterior section. This plane is almost parallel to the IVC (Fig. 6) in cases with an average volume for the right posterior section. However, segment 8 is usually extended to a more dorsal area than the level of the root of the RHV at its most cranial part. Surgeons have to take care to completely remove this area to prevent postoperative bile leakage or a liver abscess. If the right anterior sectional portal vein cannot be dissected before liver resection, it can be dissected during liver resection.

When the liver resection is advanced up to the root of the RHV, then the common trunk of the left and middle

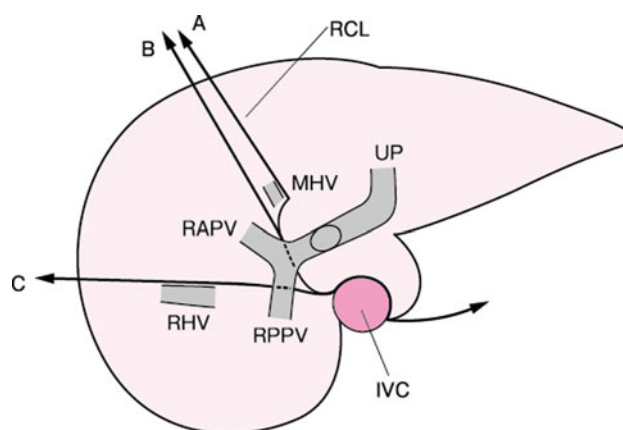


Fig. 6 Diagram of the resection planes of left hepatectomy (A), left hepatectomy with resection of the middle hepatic vein (B), and left trisectionectomy (C) in a cross section of the liver. *RCL* Rex-Cantlie line, *MHV* middle hepatic vein, *RHV* right hepatic vein, *RAPV* right anterior sectional portal vein, *RPPV* right posterior sectional portal vein, *UP* umbilical portion of the left portal vein, *IVC* inferior vena cava

hepatic veins is dissected using a clamp. After dissection of the liver parenchyma between the right caudate lobe and segment 7, the liver resection for the left trisectionectomy is accomplished.

Dissection of the intrahepatic bile ducts

Left hepatectomy

When dissecting the intrahepatic bile ducts, one of the critical complications is the occurrence of an injury to the corresponding arterial branches. To prevent this serious problem, intrahepatic arterial branches have to be carefully separated from the bile ducts up to a more peripheral area than the bile duct dissection line.

For a left hepatectomy, the right anterior sectional bile duct behind the MHV is dissected first (Fig. 7). Then, the direction of the tip of the scissors is changed, and the right posterior sectional bile duct is dissected along the cranial surface of the right portal vein (Fig. 8). If the anomalous right posterior sectional artery, which runs along the cranio-dorsal aspect of the right portal vein, is present, then extreme caution should be exercised not to injure it when dissecting the right posterior sectional bile duct.

Left trisectionectomy

When the liver resection for the left trisectionectomy is finished, the right posterior section and left trisections are connected only by connective tissue containing the right posterior sectional bile duct (Fig. 9). This is finally dissected, with great care being taken to avoid injuring the

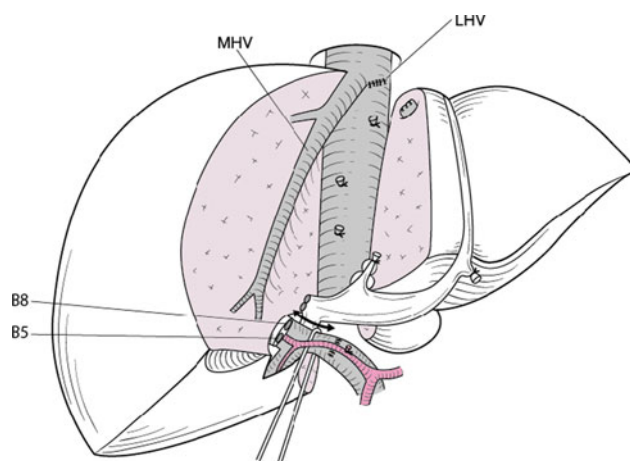


Fig. 7 In left hepatectomy for hilar cholangiocarcinoma, the right anterior inferior (B5) and right anterior superior (B8) segmental bile ducts are dissected following liver resection. The double-headed arrow indicates the dissection line of the right posterior sectional bile duct. MHV middle hepatic vein, LHV the stump of the left hepatic vein

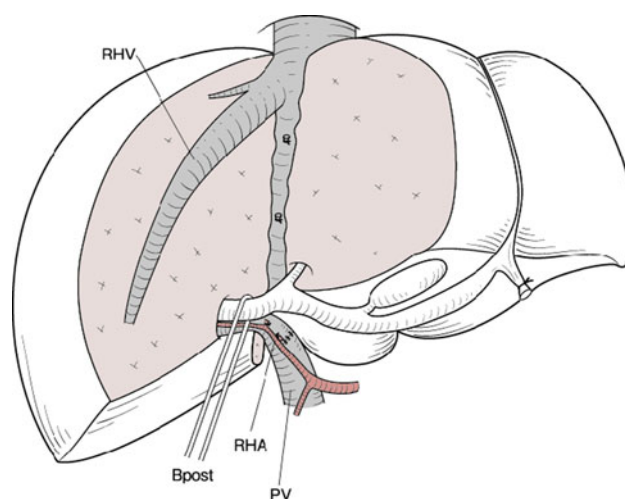


Fig. 9 When liver resection for left trisectionectomy is complete, the right posterior section and left trisections are connected only by connective tissue containing the right posterior sectional bile duct (Bpost). RHV right hepatic vein, RHA right hepatic artery, PV portal vein

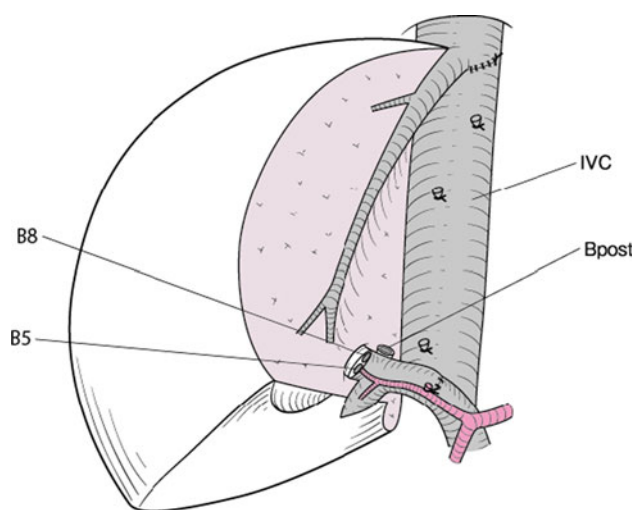


Fig. 8 In left hepatectomy for hilar cholangiocarcinoma, the specimen is taken out after dissection of the right posterior sectional bile duct (Bpost). B5 the stump of the right anterior inferior segmental bile duct, B8 the stump of the right anterior superior segmental bile duct, IVC inferior vena cava

right posterior sectional artery. If the bile duct branches of segments 6 and 7 are dissected separately, the arterial branches of segments 6 and 7 have to be carefully isolated from the bile ducts before dissection of the bile ducts (Fig. 10).

Biliary reconstruction

Biliary enteric reconstruction is performed by hepaticojejunostomy in a Roux-en-Y fashion using a 40-cm-long segment of the jejunum. The number of bile duct stumps is

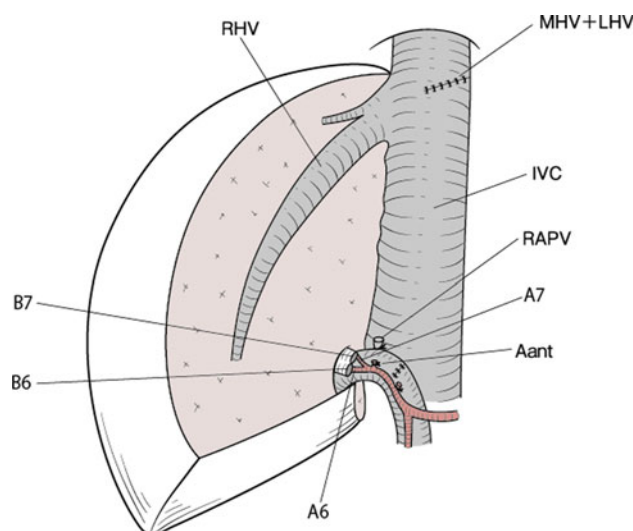


Fig. 10 When the bile duct branches of segments 6 and 7 have to be dissected separately, the arterial branches of segments 6 and 7 are carefully isolated from these bile ducts. B6 the stump of the right posterior inferior segmental bile duct, B7 the stump of the right posterior superior segmental bile duct, A6 right posterior inferior segmental artery, A7 right posterior superior segmental artery, Aant the stump of the right anterior sectional artery, RAPV the stump of the right anterior sectional portal vein, IVC inferior vena cava, MHV + LHV the stump of the common trunk of the middle and left hepatic veins, RHV right hepatic vein

two or more after left hepatectomy. These stumps are grouped by hepaticoplasty. The hepaticojejunostomy is performed using either interrupted or continuous sutures with 4-0 or 5-0 absorbable suture threads. A biliary stent is usually placed in each duct. Biliary enteric reconstruction is accomplished following end-to-side jejunojejunostomy.

Important points

1. There are numerous variations of the sectional artery and bile duct in the right liver. It is essential to comprehend the individual intrahepatic and hilar anatomy preoperatively in order to successfully perform a left-sided hepatectomy.
2. For skeletonization of the hepatic artery, the nerve plexus around the hepatic artery is dissected, and the adventitia is exposed. These procedures have to be performed gently to avoid iatrogenic injury to the hepatic artery.
3. After dividing the root of the left portal vein, the stump has to be closed by transverse running sutures to prevent stenosis of the portal vein.
4. Mobilization of the caudate lobe is performed only from the left side. The right posterior section should not be mobilized during left-sided hepatectomy.
5. There is no clear landmark between the caudate lobe and the right posterior section. In the final step of liver resection during a left-sided hepatectomy with caudate lobectomy, liver resection progresses toward the right edge of the inferior vena cava.
6. When dividing intrahepatic bile ducts, caution has to be exercised not to injure the corresponding hepatic arteries.

Do's and Don'ts

1. In left-sided hepatectomy with caudate lobectomy, mobilization of the caudate lobe is performed only from the left side. The right liver or right posterior section should not be mobilized.
2. When resecting the liver between the caudate lobe and the right posterior section, liver resection progresses from the dorsal aspect of the middle hepatic vein toward the right edge of the inferior vena cava. Surgeons have to pay attention to avoid injury to the portal pedicle of segment 7 by resecting the liver too deeply.
3. When dividing the right posterior sectional bile duct in a left hepatectomy with caudate lobectomy, take care not to cut it in the deep portion, because this makes biliary reconstruction difficult.

Comments

The morbidity rate for left trisectionectomy is high!

I have seen a lot of complications associated with left trisectionectomy. Some of them, such as misdissection of

the supraportal posterior sectional artery, misligation of the posterior superior segmental bile duct, and so on, were very serious. To avoid such terrible complications, it is important to understand the individual intrahepatic and hilar anatomy accurately by repeated and precise evaluation of the preoperative images.

Discussion

Aggressive surgery, including major hepatectomy with combined caudate lobectomy, has become widely accepted as a standard treatment procedure for hilar cholangiocarcinoma [2–6]. To achieve a curative resection with histologically negative surgical margins (R0), various hepatectomy procedures have so far been applied for this intractable disease. The indication criteria for the selection of the hepatectomy procedure are based on the following factors: the extent of longitudinal cancer spread along the bile duct, cancer invasion to the major hilar blood vessels, cancer involvement of the middle hepatic vein, and the functional reserve of the future remnant liver.

Left-sided hepatectomy, such as a left hepatectomy or left trisectionectomy, is applied to treat hilar cholangiocarcinoma predominantly involving the left side of the hepatic hilum. Of these procedures, left hepatectomy is mainly selected for type IIIb cancer according to the Bismuth–Corlette classification [7, 8], and left trisectionectomy may be applied for selected patients with Bismuth–Corlette type IIIb or IV lesions. Konstadoulakis et al. [9] reported that left-sided hepatectomy was associated with a higher incidence of positive surgical margins than right-sided hepatectomy, which resulted in a decreased 5-year survival rate in hilar cholangiocarcinoma patients undergoing left-sided hepatectomy. However, Shimizu et al. [8] reported that the R0 resection rate in patients undergoing left-sided hepatectomy was similar to the results for right-sided hepatectomy. Furthermore, he also described the 5-year survival in left-sided hepatectomy cases as comparable to that in right-sided hepatectomy cases. This difference in the R0 resection rate of left-sided hepatectomy might be attributable to the preoperative assessment of the longitudinal cancer extension along the bile duct, especially at the proximal site.

Recently, the preoperative staging of hilar cholangiocarcinoma has been greatly improved mainly due to the use of multidetector-row computed tomography [10, 11]. Detailed preoperative evaluation, especially for longitudinal cancer extension, results in a more appropriate selection of the hepatectomy procedure, with a favorable R0 resection rate.

The different areas of vulnerability of left-sided hepatectomy, compared with right-sided hepatectomy, for

achieving R0 resection have been reported [9, 12]. One of the most important factors is vertical cancer extension to the right hepatic artery. The right hepatic artery usually courses just behind the proximal bile duct near the hepatic hilum. The dissection of the connective tissue or neural plexus around the right hepatic artery may therefore cause cancer dissemination. Right-sided hepatectomy with the en bloc removal of the right hepatic artery and surrounding connective tissue clearly has an advantage regarding radicality. To overcome this problem in left-sided hepatectomy, resection and reconstruction of the right hepatic artery has been attempted by a few researchers [13–15]. Its clinical significance still remains controversial. However, Nagino et al. [15] recently reported two 5-year survivors after major hepatectomy with a combined resection and reconstruction of both the portal vein and hepatic artery. Although major hepatectomy with resection and reconstruction of the right hepatic artery is technically demanding, this procedure may be successfully performed by experienced surgeons on selected patients.

Another important factor is the complicated three-dimensional anatomy of the right side of the hepatic hilum. In this area, there are many different anatomical variations of the sectional bile ducts [16] and arterial branches. In most patients, the right posterior sectional bile duct runs cranially around the right portal vein to merge with the right anterior sectional bile duct. However, the entire or a part of the right posterior sectional bile duct runs caudal to the right portal vein to join to the right anterior sectional bile duct or proximal common bile duct in around 16% of patients [17]. Negative surgical margins of the proximal bile duct stumps in left-sided hepatectomy can be more easily obtained in the latter type of right posterior sectional bile duct than the former [17].

The anatomical variations of the right posterior hepatic artery are also important. Yoshioka et al. [18] reported that around 80% of patients had an infraportal right posterior hepatic artery which runs caudally to the right portal vein, whereas the remaining 20% had a supraportal variant of the entire or a part of the right posterior hepatic artery, as determined by a study using CT arteriography and portography. The supraportal variant of the right posterior hepatic artery runs just behind the right hepatic duct. Therefore, it is easily injured during left-sided hepatectomy or may be invaded directly by cancer due to the course of the right posterior hepatic artery itself [18]. Because of these anatomical variations, a left-sided hepatectomy for hilar cholangiocarcinoma can be considered to be a more complicated and technically demanding procedure than right-sided hepatectomy.

In conclusion, left hepatectomy or left trisectionectomy with caudate lobectomy and extrahepatic bile duct resection is a standard surgical procedure for the curative

resection of hilar cholangiocarcinoma predominantly involving the left side of the hepatic hilum. A precise preoperative evaluation of cancer extension, especially regarding any longitudinal cancer spread along the bile duct, is indispensable to obtain an R0 resection using these procedures. Surgeons therefore have to pay attention to any anatomical variations of the sectional arteries and bile ducts of the right liver to be able to safely and successfully perform a left-sided hepatectomy.

Conflict of interest None.

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