Standardization of Anatomic Segmentectomy VIII by Extrahepatic Glissonean Pedicle Isolation and HV Root - At First One-way Resection Based on Laennec's Capsule: Open and Laparoscopic Approaches

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ABSTRACT

Anatomic resection of the segment VIII (SVIII) of the liver (segmentectomy VIII) is technically demanding either in open or laparoscopic procedure. Our approaches to anatomic liver resections are composed of the extrahepatic Glissonean pedicle approach (GPA) to isolate hilar pedicles and hepatic vein (HV) root-at first one-way resection of liver parenchyma in the cranio-caudal direction starting from the landmark HV root. Both techniques are based on Laennec's capsule. Herein, we describe our standardized techniques for open and laparoscopic segmentectomy VIII. The standardized GPA to the Glissonean pedicle of SVIII (G-VIII) starts with cystic plate cholecystectomy and isolation of the anterior section pedicle by detaching the pedicle sheath from the Laennec's capsule. Isolation of segment V pedicle facilitates that of G-VIII using the subtraction method. After confirmation of the demarcation line by clamping G-VIII, parenchymal dissection starts from exposing the roots of middle (MHV) and right hepatic veins, which are tracked in the cranio-caudal direction. During such one-way parenchymal resection, G-VIII exposed below MHV is divided, and anatomic segmentectomy VIII is completed at the right edge of SVIII. In conclusion, segmentectomy VIII, either open or laparoscopic, can be standardized by extrahepatic GPA and HV-root at first cranio-caudal one-way parenchymal resection based on Laennec's capsule.

Key words: segment VIII, segmentectomy, laparoscopic liver resection, Laennec's capsule, Glissonean pedicle, hepatic vein

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Abbreviations:

GPA: Glissonean pedicle approach
HV: hepatic vein
SVIII: segment VIII of the liver
G-VIII: the Glissonean pedicle of segment VIII
G-V: the Glissonean pedicle of segment V
G-ant: the Glissonean pedicle of the anterior section of the liver
MHV: the middle hepatic vein
RHV: the right hepatic vein
Lap SVIII: laparoscopic segmentectomy VIII

INTRODUCTION

Anatomic resection of the segment VIII (SVIII) of the liver (segmentectomy VIII) is a technically demanding hepatectomy procedure in the open, laparoscopic or even robotic setting. The main technical difficulty may lie in the unestablished method of intraoperative accurate determination of SVIII. Furthermore, particularly in laparoscopic and robotic procedures for segmentectomy VIII, the location of SVIII per se raises hurdles to ensuring the operative field and liver handling during parenchymal dissection.

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The previously reported methods of intraoperative determination of anatomic SVIII include the controlled method (1), the coloring method using dye injection into the corresponding portal vein branches (2), intrahepatic Glissonean approach with preceding liver parenchymal dissection along the main portal fissure (3) and extrahepatic Glissonean approach with minor parenchymal dissection at the hilum (3-5). Regarding the parenchymal dissection for segmentectomy VIII, both caudo-cranial and cranio-caudal approaches have been reported (3,6). Particularly in the minimally invasive liver resection setting, favorable approaches to segmentectomy VIII are undefined.

To standardize any types of anatomic liver resection and increase their safety and feasibility, we have proposed a combination of two approaches; one is for hepatic inflow control and the other is for hepatic outflow control, based on the anatomical background of Laennec's capsule of the liver (7). Herein, we present the details of our surgical techniques of segmentectomy VIII as one of the most difficult anatomic liver resection procedures and discuss the essential points and potential advantages in our techniques.

Surgical techniques for anatomic segmentectomy VIII

Our surgical techniques for any types of anatomic liver resections are composed of two basic approaches and widely applicable to open, laparoscopic or robotic procedures. One is the extrahepatic Glissonean pedicle approach (GPA) at the hilum to isolate the responsible pedicles supplying the anatomic liver area to be resected without any parenchymal dissection. The other is the hepatic vein (HV) root-at first one-way resection of liver parenchyma, in which the root of the landmark HV is exposed in the first place, followed by parenchymal dissection in the cranio-caudal direction tracking the landmark HV. Our method of GPA to any Glissonean pedicles including the first, second, third or fourth order portal vein branches is in an extrahepatic fashion. This approach is based on the anatomical backgrounds of Laennec's capsule, which covers the entire liver parenchyma, as well as on the Gate theory, which serves to designate the optimal access points of the liver-pedicle border to isolate the pedicles (7).

In anatomic segmentectomy VIII, 'the cystic plate cholecystectomy' (7) should be the first procedure, because this allows a good access to the root of the Glissonean pedicle of the anterior section (G-ant). At the hepatic hilum, the serosa, i.e. the visceral peritoneum, continuously covers the liver and the

hepatoduodenal ligament. The first step to approach G-ant is dividing the serosa at the border between the surface of liver parenchyma and the adjoining surface of the hepatoduodenal ligament. Behind the cut serosa, you can find several pieces of thin or thick fibrous tissue connecting the hilar plate and the confronting liver parenchyma, which we call 'anchor'. Only by dividing these several 'anchors' at the hilum, you can find or create the space between the liver parenchyma and the Glissonean pedicle sheaths. Liver parenchyma at the hilum is also covered by Laennec's capsule, and the layer between the pedicle sheath or the hilar plate and the Laennec's capsule that covers the confronting parenchyma can be readily dissected (7). Such Laennec's capsule-based layer dissection at Gates IV and V according to the Gate theory facilitates extrahepatic isolation of G-ant, by passing a tape from Gate IV to Gate V. Laparoscopic magnified caudal view toward the hilum seems to be useful for meticulous and accurate layer dissection and isolation of pedicles.

The next step is extrahepatic isolation of the pedicle of segment VIII (G-VIII). The ventral surface of G-ant is dissected along the layer between the G-ant sheath and Laennec's capsule and the pedicle of segment V (G-V) is isolated extrahepatically. Caudal traction of the taped G-ant is useful during dissection of G-V because an increased tension between G-ant and the confronting parenchyma makes it easier to dissect the layer between G-V and the parenchyma. Then, the right stump of the tape holding G-ant is passed under G-V and switched cranially over G-V, which ends up with isolating G-VIII extrahepatically. This method of isolating deeper pedicles is what we call 'the subtraction method'. By clamping G-VIII, isolated SVIII becomes ischemic before parenchymal dissection. Division of G-VIII at this point is usually very difficult because of the limitation of space. In addition, ligation of G-VIII at this point is not recommended because as G-VIII is isolated at its wide root by the subtraction method, its ligation at this level may involve part of the tissue of G-V or G-ant.

After confirmation of the demarcation line, resection of the discolored parenchyma starts from exposing the root of the middle hepatic vein (MHV). Systemic intravenous injection of indocyanine green after G-VIII occlusion can clearly discriminate the ischemic SVIII and the perfused other liver parts by negative-staining visualization method. During parenchymal dissection, MHV is tracked and exposed from the root side to the peripheral side in the cranio-caudal direction, which we call 'HV root-at first one-way resection'. Then, the root of the right hepatic vein (RHV) is similarly exposed and

parenchymal dissection continues along RHV in the cranio-caudal direction. During exposure of the wall of these major HVs, it is technically important to dissect the parenchyma by from-cranial-to-caudal movement of instruments such as an ultrasonic aspirator. Several hepatic vein tributaries from SVIII to MHV are divided. In the middle of parenchymal resection, G-VIII, which was already isolated at the hilum, is exposed just on the dorsal side of MHV and in between MHV and RHV. G-VIII is fully exposed by additional parenchymal dissection around the pedicle and then divided at a level with enough distance kept from its root without involving G-V and G-ant. In cases where several G-VIII branch separately off G-ant, each of them is divided individually. Division of G-VIII is followed by parenchymal dissection in the left-to-right and cranio-caudal direction and several hepatic vein branches from the dorsal part of SVIII draining into RHV are divided. Anatomic segmentectomy VIII is completed at the right edge of the SVIII. We do not use Pringle maneuver in this method of segmentectomy VIII in more than 90% of cases.

Preparation in the laparoscopic procedure

In laparoscopic segmentectomy VIII (Lap SVIII), the patient is set at the left decubitus position with the arms stretching toward the left side and with the legs closed. The surgeon stands on the left side of the patient. The endoscope trocar is placed at about 5-cm right side of the umbilicus, and four 12-mm working trocars are placed at the epigastrium, the right subcostal region on the parasternal line, the right subcostal region on the mid-clavicular line and the right subcostal region on the pre-axillary line, respectively. We do not use intercostal trocars. During hilar dissection, it is important that the liver-side stump of the divided round ligament is lifted up to the epigastrium for ensuring a wide operative field at the hilum, a smooth insertion of instruments to Gates III and IV and further dissection of G-V and G-VIII without obstacles.

Video description of our open and laparoscopic techniques of anatomic segmentectomy VIII

Herein, we present our techniques of segmentectomy VIII by open and laparoscopic approaches in video. Both approaches share the common technical concepts and applications.

DISCUSSION

In anatomic segmentectomy VIII, intraoperative

accurate determination of SVIII that is to be resected is technically demanding and four different approaches are considered to have been proposed previously (1-5). First is the controlled method, in which the hepatic artery, portal vein and bile duct supplying SVIII are individually dissected at the hilum (1). However, this method is not always successful because of frequent anatomical variations inside the hilar plate with increased risks of anatomical misjudgment and injuries to other parts of the liver. The second method is the coloring of SVIII by injection of a dye into the corresponding portal vein branches through the ultrasound-guided needle puncture of the veins (2). The third method is intrahepatic Glissonean approach, in which parenchymal dissection along MHV is preceded under Pringle maneuver, followed by the identification and division of G-VIII below the MHV, providing discoloration of SVIII (3). The fourth approach is extrahepatic GPA, in which G-VIII is isolated through minimal dissection of liver parenchyma around G-ant (3-5). Although our method is classified as an extrahepatic GPA, it is somewhat different from the Takasaki's method in that G-VIII is isolated and devascularized extrahepatically without parenchymal dissection.

To achieve safe and systematic extrahepatic isolation of G-ant, G-V and G-VIII, we recognize and utilize Laennec's capsule during the dissection of layers between the liver parenchyma and the Glissonean pedicle sheath, and also use the subtraction method. Furthermore, the Gate theory effectively designates the optimal access points (Gates IV and V) for isolation of G-ant (7). From the technical aspect, our method may serve to isolate G-VIII safely and securely with minimal bleeding or bile duct injury by damaging neither liver parenchyma nor Glissonean pedicles.

The other important approach included in our method of segmentectomy VIII is HV-root at first one-way parenchymal resection, in which Laennec's capsule is an anatomically relevant structure because it also covers the liver parenchyma attaching the major HVs. Laennec's capsule can be preserved on the HV wall by dissecting between the liver parenchyma and Laennec's capsule. Exposing and tracking the landmark HV from its root side during parenchymal dissection may have several advantages. First, Laennec's capsule is naturally preserved on the HV wall, which serves to protect the thin HV wall from tearing injuries. Also, bleeding on the major HV can be controlled simply by light coagulation probably because of the contraction of Laennec's capsule on the wall. Second, the possibility of misjudgment on the venous branch anatomy may be reduced, because both the landmark HV and the

branch roots are always seen in the same view. Third, the cranio-caudal resection along the landmark HV may decrease the risk of branch-tearing injuries because the venous branches join the HV at acute angles from the caudal side by nature. Another merit of one-way parenchymal resection particularly in Lap SVIII is that as the resection plane is always seen from one side in the caudal view, the operator and assistants do not need to change their positions depending on the situations and can continue the same device operations until the end of parenchymal dissection. Nevertheless, although these potential advantages of HV root-at first one-way parenchymal dissection for segmentectomy VIII can be postulated and we prefer this approach to the caudal-to-cranial counterpart, there are no comparison data concerning which approach is better. Further studies comparing the surgical and oncologic results between the two approaches are strongly needed.

Only a few authors have reported techniques or surgical results of anatomic Lap SVIII, probably because of its technical difficulties (8,9). Most of the reported techniques are based on Glissonean approach and are associated with favorable surgical results (8,9). Our standardized techniques for Lap SVIII are different from the reported ones in some points. Ome et al. reported an intrahepatic Glissonean approach for this procedure, which needs substantial parenchymal dissection to access G-VIII (8). In our extrahepatic GPA, parenchymal dissection does not precede the isolation and occlusion of G-VIII. Jang et al. reported a case of Lap SVIII using a 3-dimensional flexible laparoscope as well as an intercostal trocar (9). In our method, we also prefer to use a 3-dimensional flexible laparoscope, but do not use intercostal trocars. They may be helpful during Lap SVIII (9), but we do not think it is mandatory and have never used them for this procedure in view of minimal invasiveness. However, they could be useful during resection of large tumors in the posterior portion of SVIII for optimal operative view and better handling of the liver and tumors.

We think that there are some tips on the patient side supporting the surgical procedures in our method of Lap SVIII. The patient's left decubitus position and the use of an epigastric trocar are crucial. This position may render G-ant to stand at a nearly vertical angle, which we call 'zero-o'clock' placement of G-ant. Such setup of G-ant and the use of an epigastric trocar enables easy instrument insertion (from the upper left to the lower right) to encircle G-ant. In addition, such

patient position and the epigastric trocar allow a good access to the MHV and RHV roots and facilitate cranio-caudal one-way resection with less operational restriction. The left decubitus position is also helpful for lowering the left liver by the gravity force and opening the parenchymal dissection plane. Moreover, the hepatic venous hydrostatic pressure in SVIII is lowered by its upward elevation, thereby potentially reducing hepatic venous bleeding. Another tip is to assign a right subcostal trocar to the laparoscope to better visualize HV roots or cranial part of the liver.

CONCLUSION

Anatomic segmentectomy VIII, either open or laparoscopic, can be highly standardized as a safe and feasible procedure by extrahepatic GPA and HV-root at first cranio-caudal one-way parenchymal resection based on Laennec's capsule.

Disclosures

The authors have no conflicts of interest to disclose relevant to the content of this article.

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