

Laparoscopic Anatomical Resection of Liver Segment 8 via a Hepatic Parenchymal Transection-first Approach Guided by the Middle Hepatic Vein

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Research Article

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Abstract

Background Although recent technological developments and improved endoscopic procedures have further extended the application of laparoscopic liver resection, pure laparoscopic anatomic resection of liver segment 8 (S8) is still rarely performed due to the lack of an appropriate surgical approach. This article discusses the technical tips and operation methods for laparoscopic anatomical resection of liver S8 via a hepatic parenchymal transection-first approach.

Methods Clinical data of 14 patients who underwent laparoscopic anatomical resection of liver segment 8 via a hepatic parenchymal transection-first approach guided by the middle hepatic vein (MHV) in the Second Affiliated Hospital, Third Military Medical University (Army Medical University) from May 2017 to December 2019 were retrospectively analyzed. The operation time, intraoperative blood loss, postoperative complications, and hospitalization duration were observed.

Results The operation was successful with no complications. No other abnormality was noted during outpatient follow-up examination.

Conclusions Laparoscopic anatomical resection of liver S8 is still quite challenging at present, and it is our goal to design a reasonable procedure with accurate efficacy and high safety. We use hepatic parenchymal transection-first approach guided by the MHV for laparoscopic anatomical resection of liver S8. This technique overcomes the problem of high technical risk, greatly reduces the surgical difficulty and achieves technological breakthroughs, but there are still many problems worth further exploration.

Background

Liver segment 8 (S8) corresponds to the anterosuperior portion of right paramedian sector, which lies between the middle hepatic vein (MHV) and the right hepatic veins (RHV) [1]. Because of the absence of anatomical landmarks on the liver surface of S8 and the many variations and deep location of the Glisson pedicle, laparoscopic anatomical liver resection (LALR) for lesions in S8 can be very challenging and is considered one of the most difficult laparoscopic surgeries. However, with increasing experience and developments in surgical techniques and instruments, limited reports in the last few years have shown the feasibility and safety of this surgery [2]. There are many technical tips for LALR of S8, and the core technical tip is how to choose an appropriate laparoscopic approach, which is a main determinant of surgical success. To date, the approaches for LALR of S8 roughly include ultrasound-guided S8 segmental portal branch puncture, a hepatic hilum Glisson pedicle approach, and a left and right hemi-hepatic splitting approach [3-5]. However, all these approaches have certain drawbacks. Through continuous learning and exploration, we have carried out LALR via a hepatic parenchymal transection-first caudal approach guided by the MHV and applied it to anatomical resection of S8. Laparoscopic anatomical resection of liver S8 via a hepatic parenchymal transection-first approach guided by the MHV is a feasible and effective technique. The specific strategy described here may help laparoscopic surgeons safely perform this challenging procedure.

Patient And Methods

Patients

The data of patients who underwent laparoscopic liver resection in the Second Affiliated Hospital, Third Military Medical University (Army Medical University) between 2017 and 2019 were retrospectively collected. The selection criteria for patients in this study included (1) male or female patients aged 18–75 years, (2) liver function classified as Child–Pugh class A; (3) histologically confirmed hepatocellular carcinoma (HCC) and (4) patients underwent laparoscopic anatomical resection of liver segment 8 via a hepatic parenchymal transection-first approach. The following patients were excluded: (1) the presence of severe dysfunction of organs, (2) liver function classified as Child–Pugh class B or C, (3) intrahepatic and distant metastases. Patients received the whole course of antiviral treatment for Hepatitis B virus (HBV). The prophylactic antibiotic therapy was intravenously administered 30 min before the surgery and maintained until the second postoperative day. Post-operative management included hemostasis, hepatic function protection, analgesia, rehydration and other symptomatic and supportive care.

Methods

The patient was placed in a reversed Trendelenburg and left semilateral position with head up 30° and leg splitting (Fig. 1). The surgeon stood on the right side of the patient, the camera assistant stood between the spread legs, and the assistant and monitor were on the left side of the patient, facing the surgeon. The trocars were inserted according to the 5-port-method. The initial trocar (10-mm) is placed at a site 2 cm right of the umbilicus and was used as observation port. Two 12-mm ports were inserted at 5 cm below the costal margin on the right midclavicular line (for the right main working) and below the xiphoid (for the left main working), respectively. The 5-mm port was placed at the midpoint of xiphoid process and the umbilicus as the left subsidiary port. Additional 5-mm port was placed at the subcostal area that meets the right anterior axillary line as the right subsidiary port (Fig. 2). To prepare for extracorporeal Pringle's maneuver, a 3-mm length incision was made between left two ports through which a self-designed tube would be inserted for holding a cotton tape around the hepatoduodenal ligament.

Intraoperative procedure: (1) Liver mobilization: the round and falciform ligaments were divided to the second hepatic hilum to expose the root of the MHV and RHV and the crypt between MHV and RHV. The right coronary ligament next to the second hepatic hilum was also divided. (2) Preparing for Pringle's maneuver: Laparoscopic Pringle's maneuver was prepared in case of abrupt bleeding during the parenchymal transection. (3)

Intraoperative laparoscopic ultrasonography (IOUS): IOUS was performed on the liver surface to localize the tumor range and central position and to determine the courses of main trunk of MHV and RHV, and the position of the S8 Glissonian pedicle or ventral branch of S8 portal pedicle (P8v) and dorsal branch

of S8 portal pedicle (P8d) and mark them accordingly. (4) Dissection of the left side transection plane and caudal side transection plane liver parenchyma: Hepatic resection is begun from the caudal side of the liver at the intersection of the S8 Glissonean pedicle level which was positioned by ultrasound and the Cantlie line via a hepatic parenchymal transection-first approach. The resection is continued from the caudal to cranial side along the markings of MHV (left of the vein), until the critical separation of S8 from S4a was completed. Then, the hepatic resection was continued from the above-depicted starting point toward the right direction of caudal side transection plane and the caudal side liver transection plane parenchyma was divided 1-2 cm for better visualization. The left side transection plane resection and caudal side transection plane resection continued alternately to expose the root of the MHV. S8 was retracted cephalically during this procedure. The resection was continued until the S8 Glissonean pedicle or P8v and P8d were naturally exposed on the resected liver surface. (5) Management of the S8 Glissonean pedicle: The S8 Glissonean pedicle or P8v and P8d is clamped, and the liver surface ischemic line is marked along the resulting discoloration using electrocautery. Then, the right side transection plane hepatic parenchyma was initially transected along the ischemic line, followed by ligated and divided of the S8 Glissonean pedicle. (6) Management of the ventral branch of the draining vein from S8 (V8v) and intermediate vein for S8 (V8i) branches: When hepatic resection is continued further cranially along the MHV, the S8 branches of the middle hepatic vein, including the V8v and V8i branches and small ducts, are ligated and divided. (7) Dissection of the right side transection plane liver parenchyma: To expose the root of the RHV, the transection of the liver parenchyma was continued from the root of the MHV toward right side, in the crypt between MHV and RHV and the RHV direction. Subsequently, the RHV is exposed. Then, liver resection is performed toward the caudal direction e along the RHV and ischemic line, and the main trunk of the RHV is exposed. At that point, the surgeon was standing at the left side of the patient and performed the parenchyma transection via a cranial approach. After the completion of S8, the following structures are exposed at the resected liver surface: MHV, stump of S8 Glissonean pedicle, and RHV. (8) Bagging of the resected specimen: A protective bag was inserted intra-abdominally into which the resected specimen was placed. (9) Management of the resection margin: The surgical field was irrigated. The margin was carefully checked for any bleeding or bile leakage. Hemostasis was achieved by using bipolar electrocoagulation or Prolene sutures ligation. Any bile leakage from the suspicious bile ducts was ligated using 5-0 Prolene sutures. Hemostatic products were routinely used. (10) Specimen removal: After the specimen was resected, the incision for extracorporeal Pringle's maneuver was extended to the incision for the left subsidiary port for removal of the specimen. (11) Drainage and wound closed: After a silastic drain placed under the right diaphragm, the wound was closed in layers with absorbable sutures (Fig. 3A-I).

Results

All 14 patients underwent blood biochemistry and tumor markers analyses, imaging examination (Fig. 4), indocyanine green clearance test, and 3-dimensional reconstruction (Fig. 5) before the operation. After surgery, all patients were diagnosed with HCC. All patients completed the operation successfully without conversion to open surgery. The median operation time was 220 ± 52 min, median blood loss was 350

mL (200-500 mL), and blood transfusion was not needed. Pathology showed free surgical margins. The postoperative median hospital stay was 8 d (7–12 d). All the patients recovered well without severe complications.

All 14 patients were followed for 13.5-31.8 months, with a median follow-up time of 16.7 months. During the follow-up period, none of them developed hemorrhage, bile leakage, and other complications. There was no reoperation or perioperative mortality during the follow-up. Imaging examination scans showed portal branch of segment 5 (P5) and portal branch of posterior segment (PP) were clearly exposed in almost their entirety and then preserved and the main trunk of the MHV was also preserved. All patients survived tumor-free.

Discussion

Anatomical hepatectomy primarily refers to liver resection according to liver segmentation, including single hepatic resection and multiple segmental hepatic (half hepatic) resection. Theoretically, anatomical liver resection has oncologic benefit compared with nonanatomical resection, because it systemically removes potentially tumor-bearing portal and venous tributaries around the malignant lesion. Limited resection of hepatic parenchyma can save postoperative functional hepatic reserve and enhance the possibility for future repeat hepatectomy [6, 7]. Since Azagra [8] and Kaneko [9] et al. reported laparoscopic anatomical liver resections in 1996, advancements in laparoscopic surgical techniques have led to increasing reports of laparoscopic anatomical liver resections. However, due to the lack of anatomic landmarks on the liver surface, anatomical variations and cross distribution of intrahepatic Glisson and hepatic venous systems, laparoscopic anatomical resection of liver S8 is considered a difficult and challenging surgical procedure by the minimally invasive surgery community. In laparoscopic anatomical resection of liver S8, the main difficulty lies in the choice of surgical approach. The choice of laparoscopic surgical approach for anatomical resection of liver S8 is not simply a “road of entry” but a series of strategic decisions on how to accomplish the surgical goals while ensuring the safety and effectiveness of the surgery [10].

To date, the approaches for laparoscopic anatomical resection of liver S8 include an ultrasound-guided S8 portal branch puncture and localization approach, hepatic hilum Glisson pedicle approach, and left and right hemi-hepatic splitting approach. The ultrasound-guided S8 portal vein puncture and localization approach refers to ultrasound-guided injection of the methylene blue and ICG dye into the S8 portal vein branches to determine the extent of resection during surgery. The puncture is different from the one under ultrasound guidance during open surgery. The existing laparoscopic ultrasound probe and puncture needle are not the best fit for surgeon’s expectations. The intrahepatic portal vein puncture technique under laparoscopic ultrasound requires an experienced hand and specific attention to the puncture angle. Moreover, the portal vein is deeply positioned in S8 and is usually divided into ventral and dorsal branches. Thus, puncturing the corresponding portal veins one by one is difficult, and the borders of the S8 area with dye staining may not display accurately. The above factors lead to a low puncture success rate, and therefore, this approach has been difficult to popularize in a short time [3]. The Glisson pedicle

approach refers to removal of S8 after isolation of S8 Glissonean pedicle branch from the right anterior and posterior pedicles. This approach is essentially an extra-Glissonian approach and is safer. However, this approach is difficult and not practical because of the deep location of the S8 Glissonean pedicle, anatomical variation, the small space in the liver hilum area, the difficulty in exposing the hilar plate, the long initial transection plane, the requirements of the dissection technique and the limitations of laparoscopic instruments [11, 12]. This approach is useful and reasonable when S8 Glissonean pedicle ramifies from the right anterior Glissonean pedicle near the hepatic hilum. The left and right hemi-hepatic splitting approach refers to liver resection that is performed from the caudal to cranial side along the Cantlie line, superiorly to the second hepatic hilum and inferiorly to the first hepatic hilum, to complete the mid-split of the liver parenchyma and expose the MHV and then to separate the S8 Glissonian pedicle and remove S8. This approach is associated with a large wound, a risk of biliary leaks and bleeding and may damage right anterior Glissonean pedicle, Glissonean branches of liver segment 5 (S5) and S5 hepatic vein (V5), which increases the difficulty of application [13].

Laparoscopic anatomical resection of liver S8 should follow the principle of “simplification of complicated surgery”. Ome and colleagues found that hepatic parenchyma transection from the root of MHV toward the periphery, called cranial approach is feasible and safe when used in LALR of S8. This approach can avoid complex anatomical separation, accurately determine the transection plane in a simple and convenient manner, and simplify the operation steps [14]. Since the direction of endoscopic view and liver dissection are from the foot to the head side, most surgeons have not got used to perform the cranial approach. Moreover, we believe that the critical problems of cranial approach are thoracic organ injuries and postoperative pneumothorax using intercostal trocars.

We have also carried out related research and explored feasible and safe approach. During laparoscopic right and left hepatectomies, we used a hepatic parenchymal transection-first approach guided by the MHV to control the hepatic Glissonean pedicle and achieved good outcomes [15, 16]. Precise parenchymal transection of the liver is necessary to locate the Glissonean branch of S8 because it is located in the deep parenchyma. Moreover, the main trunk of the MHV is a landmark in anatomical resection of liver S8 and the location of the MHV is relatively stable [17, 18]. Therefore, we wondered whether the hepatic parenchymal transection-first approach guided by the MHV can be extended for laparoscopic anatomical resection of liver S8. After clinical practice, we proposed laparoscopic anatomical resection of liver S8 via the hepatic parenchymal transection-first approach guided by the MHV and made it a standardized and streamlined procedure after continuous exploration and improvement. Different from the cranial approach, our method used caudal approach which makes the operation line with the operation habits of most surgeons. Our method is simple, fast, safe and accurate and has higher clinical application value in laparoscopic anatomical resection of liver S8.

The precautions for laparoscopic anatomical resection of liver S8 are listed as follows: (1) Preoperative and intraoperative high resolution thin-sliced enhanced CT scanning, helical CT arterial portography and 3D reconstruction visualization system can be used to make accurate assessments of the location and courses of Glissonean pedicles, MHV, and RHV in S8 to avoid damaging the vessels that need to be

preserved during surgery [19]. (2) This technique is not dependent on liver staining by injection of special dye. Meanwhile, there was no ischemic line to guide parenchyma transected before S8 Glissonean pedicle ligated and divided. Therefore, intraoperative ultrasonography is a useful and convenient step to accurately locate the S8 Glissonean pedicle (caudal side transection plane), the MHV (left side transection plane) and the RHV (right side transection plane) and determine their relationship with the tumor and to locate the larger branches of the MHV and RHV. The parenchymal transection along the anatomic landmark veins results in the anatomical segmentectomy of S8. According to the intraoperative situation, it is possible to repeatedly adjust the transection plane under guidance of intraoperative ultrasound. To reduce air interference in IOUS, saline can be injected on the transection plane [20]. Without IOUS instrument or lack of technical experience in operating IOUS, a more thorough comprehension of the LALR techniques and imaging data are required. The boundary between S8 and S4a can also be determined by right or left Glissonean pedicle temporary clamping to form ischemic line. (3) The starting point of the parenchymal dissection generally starts from the intersection of the S5 and S8 boundaries and the Cantlie line, but during surgery, this point is difficult to determine. To avoid excessive or insufficient parenchymal transection, we generally use the intersection between the caudal side transection plane where the S8 Glissonean pedicle is at and the Cantlie line as the starting point for parenchymal transection. (4) Exposure of the intrahepatic MHV and anatomical separation of the S8 Glissonean pedicle are the key steps for success of the laparoscopic anatomical resection of liver S8 guided by the MHV. We use IOUS to locate the middle hepatic vein to determine the left transection plane. The transection starts from the starting point on the caudal side, superiorly to the crypt between MHV and RHV, and then returns to the starting point and turns to the right for further transection. The dissection of left side transection plane and the caudal side transection plane are continued alternately (Fig. 6). The liver parenchyma separation does not go deeper than the level of the MHV (the area beyond this is the right caudal lobe), and then, the MHV and the S8 Glissonean pedicle can be exposed in the liver parenchyma. When the S8 Glissonean pedicle is controlled, segment resection can be performed relatively accurately along the ischemic line and RHV. In order to full exposure, partial hepatic parenchyma of S5 and/or S4a could be dissected [21]. (5) During surgery, attention should be paid to not damage the venous that drained S5, which leads to congestion of liver S5. If hepatic vein injury occurs, hemostatic gauze compression, vessel clipping, and suturing under the endoscope can be used as rescue according to the type of hepatic vein injury. (6) S8 Glissonean pedicle have many variations and are generally divided into trunk and branch types. The branches include ventral, dorsal, and lateral branches. The management method should be based on findings of 3D reconstruction visualization system and other imaging assessments to individualize a method. Either branch ligation or main trunk clipping can be used. (7) There may be problems, such as inadequate exposure during initial transection of the liver parenchyma. The exposure can be improved by S8 suspension using suture and adjusting patient positioning during the procedure or retracting the liver toward the left and inferior side. The exposure will be sufficient after splitting of the liver parenchyma. (8) When parenchymal transection along the RHV to the caudal side, the surgeon should move from the right side of the patient to the left, and the parenchyma is transected from the cephalic side to the caudal side. Alternatively, two-surgeon technique can be used in which the surgeon and the assistant exchange roles as needed [22].

The clinical value of laparoscopic anatomical resection of liver S8 via the hepatic parenchymal transection-first approach guided by the MHV is mainly reflected in the following aspects: (1) The resection range can be easily determined with accuracy. IOUS can be used to locate the S8 Glissonean pedicle, MHV and RHV to determine transection plane. Exposing the hepatic veins with anatomical landmarks in the transection plane can improve the accuracy of liver resection and achieve precise S8 resection. (2) The MHV is a landmark vein in liver resection. Due to its special anatomical position, it is easy to locate with IOUS. Therefore, in anatomical resection of liver S8, the MHV is a good landmark for the hepatic parenchymal transection-first approach, which is direct, convenient, and capable of reducing the length of the initial transection plane. (3) The use of the hepatic parenchymal transection-first approach can avoid the need to perform an elaborate hilar dissection approach, bypassing the surgical obstacle caused by the complicated anatomic variation of hepatic hilar area. By dissection the left and caudal side transection plane of the hepatic parenchyma in relatively nonvascular planes, S8 can be fully lifted cephalically to expose the S8 Glissonean pedicle and MHV. The “dead liver” lacking inflow and outflow could be completely removed. Doing so can avoid damage to blood vessels and bile ducts in the residual liver and reduce the incidence of postoperative complications such as bile leakage, infection, and early tumor recurrence. (4) In our approach, the major hepatic fissure do not need completely divided. The risk of right anterior Glisson pedicle, Glisson branches of S5 and V5 laceration can be avoided [23].

Conclusion

Laparoscopic anatomical resection of liver S8 is still quite challenging at present, and it is our goal to design a reasonable procedure with accurate efficacy and high safety. We use hepatic parenchymal transection-first approach guided by the MHV for laparoscopic anatomical resection of liver S8. This technique overcomes the problem of high technical risk, greatly reduces the surgical difficulty and achieves technological breakthroughs, but there are still many problems worth further exploration: (1) The safety of this technique still requires multicenter, large-sample-sized, prospective, randomized controlled studies to verify. (2) Whether selective hemihepatic or total hepatic blood flow occlusion is needed requires continuous improvement based on the actual situation and technological developments. (3) Whether patients with malignant liver tumors will benefit in the long term from this technique is still controversial. Therefore, long-term survival benefits need to be further studied [24].

Abbreviations

CT, computed tomography; HBV, Hepatitis B virus; HCC, hepatocellular carcinoma; IOUS, Intraoperative laparoscopic ultrasonography; ICG, indocyanine green; LALR, laparoscopic anatomical liver resection; MHV, middle hepatic vein; MRI, magnetic resonance imaging; P5, portal branch of segment 5; P8d, dorsal branch of S8 portal pedicle; P8v, ventral branch of S8 portal pedicle; PP, portal branch of posterior segment; RHV, right hepatic veins; liver segment 5 (S5); S8, liver segment 8; V5, S5 hepatic vein; V8i, intermediate vein for S8; V8v, ventral branch of the draining vein from S8.

Declarations

Availability of data and materials

The raw data of the current study are not publicly available due to the protection of participants' personal information but are available from the corresponding author on reasonable request.

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Contributions

Nan You: designed research/study, performed research/study, collected data, analyzed data, wrote the paper, and edited the manuscript. Ke Wu: collected data, analyzed data, and reviewed/edited the manuscript. Jing Li and Lu Zheng: designed research, performed research, reviewed the manuscript, and revised the manuscript.

Co-corresponding Authors

Lu Zheng and Jing Li

Ethics declarations

Ethics approval and consent to participate

This study complies with the standards of the Declaration of Helsinki and current ethical guidelines. The study was approved by the Ethics Committee of the Second Affiliated Hospital of Third Military Medical University (Army Medical University). Informed consent was obtained from individual participant included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

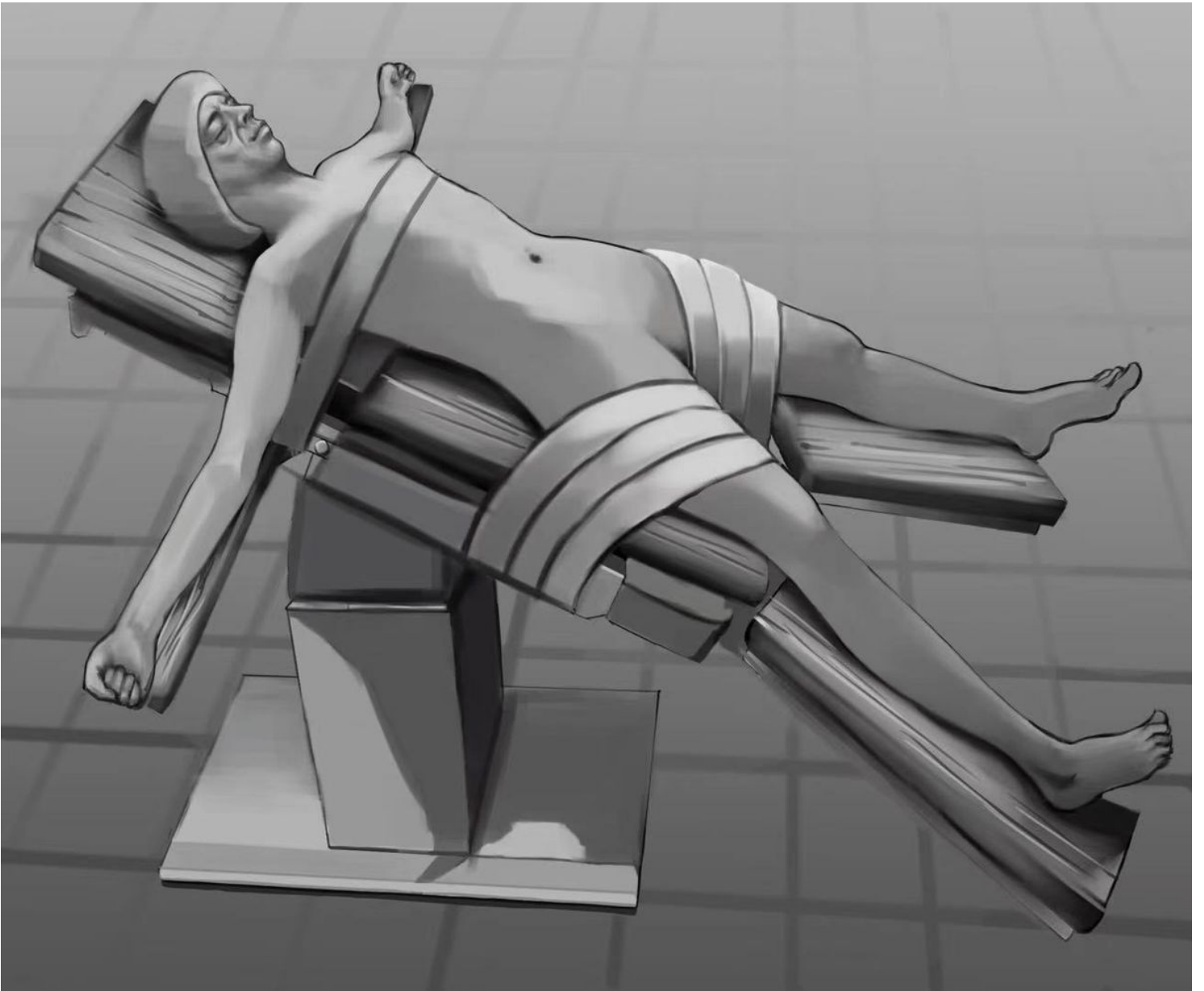


Figure 1

Patient position.

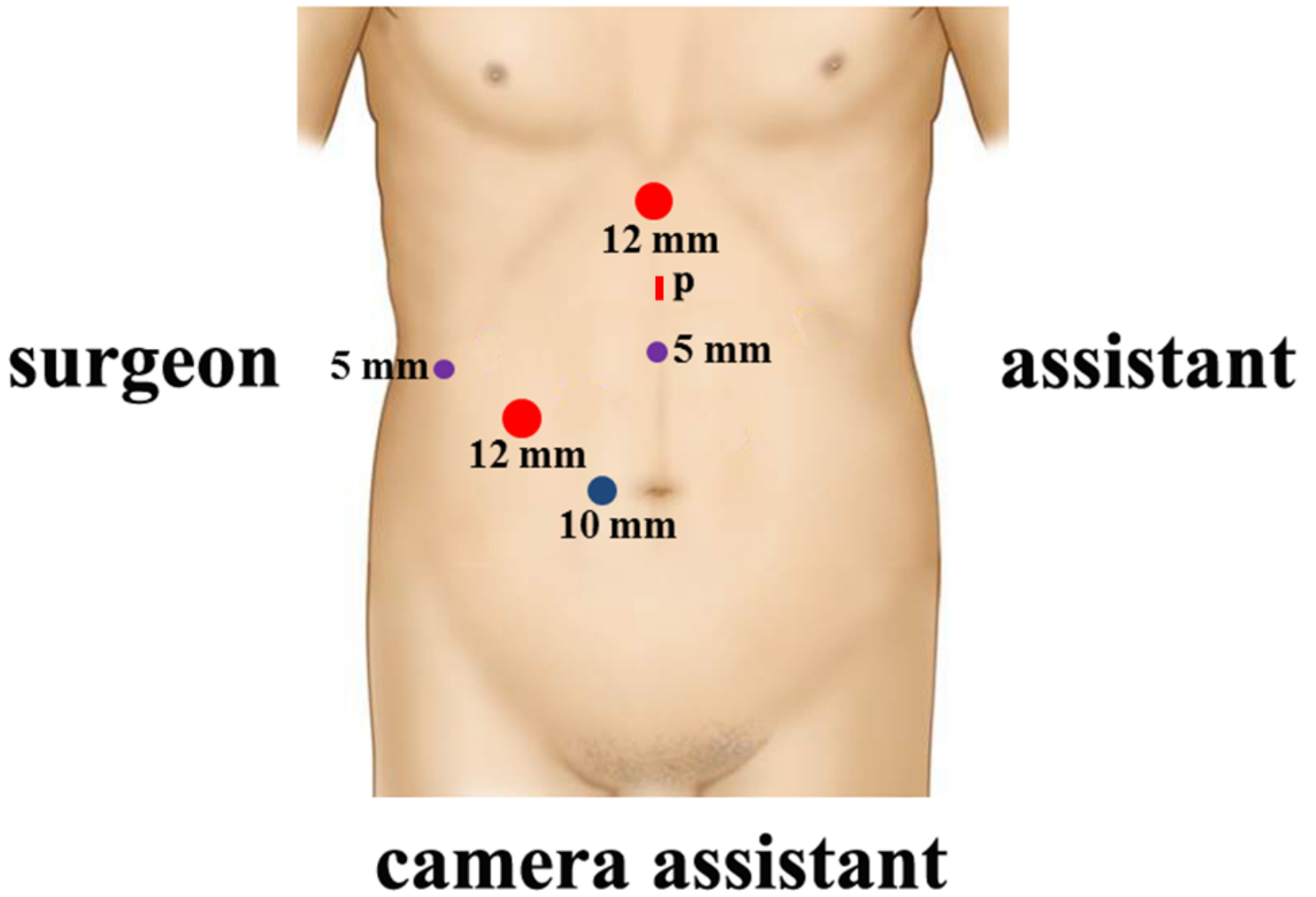


Figure 2

Diagrams of trocar placement for LALR of S8. Two 12-mm trocars, two 5-mm trocars and one 10-mm trocar are used. The incision marked with p was made 3 mm in length for insertion of extracorporeal Pringle's maneuver.

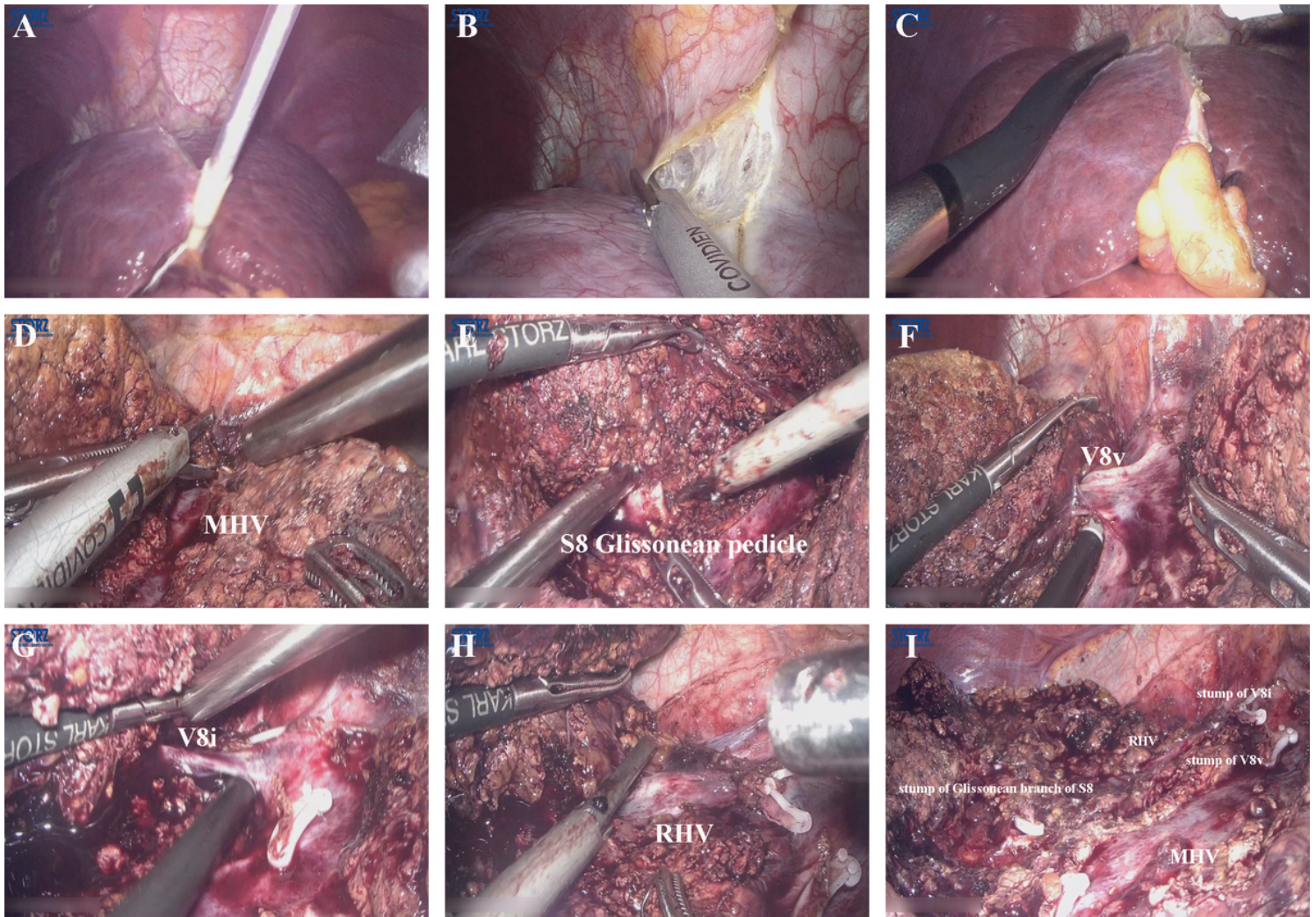


Figure 3

Laparoscopic technique and procedure. (A) Pringle maneuver; (B) preliminary liver mobilization; (C) IOUS was used to mark the the tumor range and central position and to determine the courses of main trunk of MHV and RHV, and the position of the S8 Glissonian pedicle or P8v and P8d; (D) Prior parenchymal transection along the MHV; (E) exposing and dividing the Glissonian pedicles to S8; (F) exposing and dividing the V8v; (G) exposing and dividing the V8i; (H) liver resection along the right hepatic vein toward the caudal direction and then resection completion; (I) Findings after anatomic hepatectomy of S8.

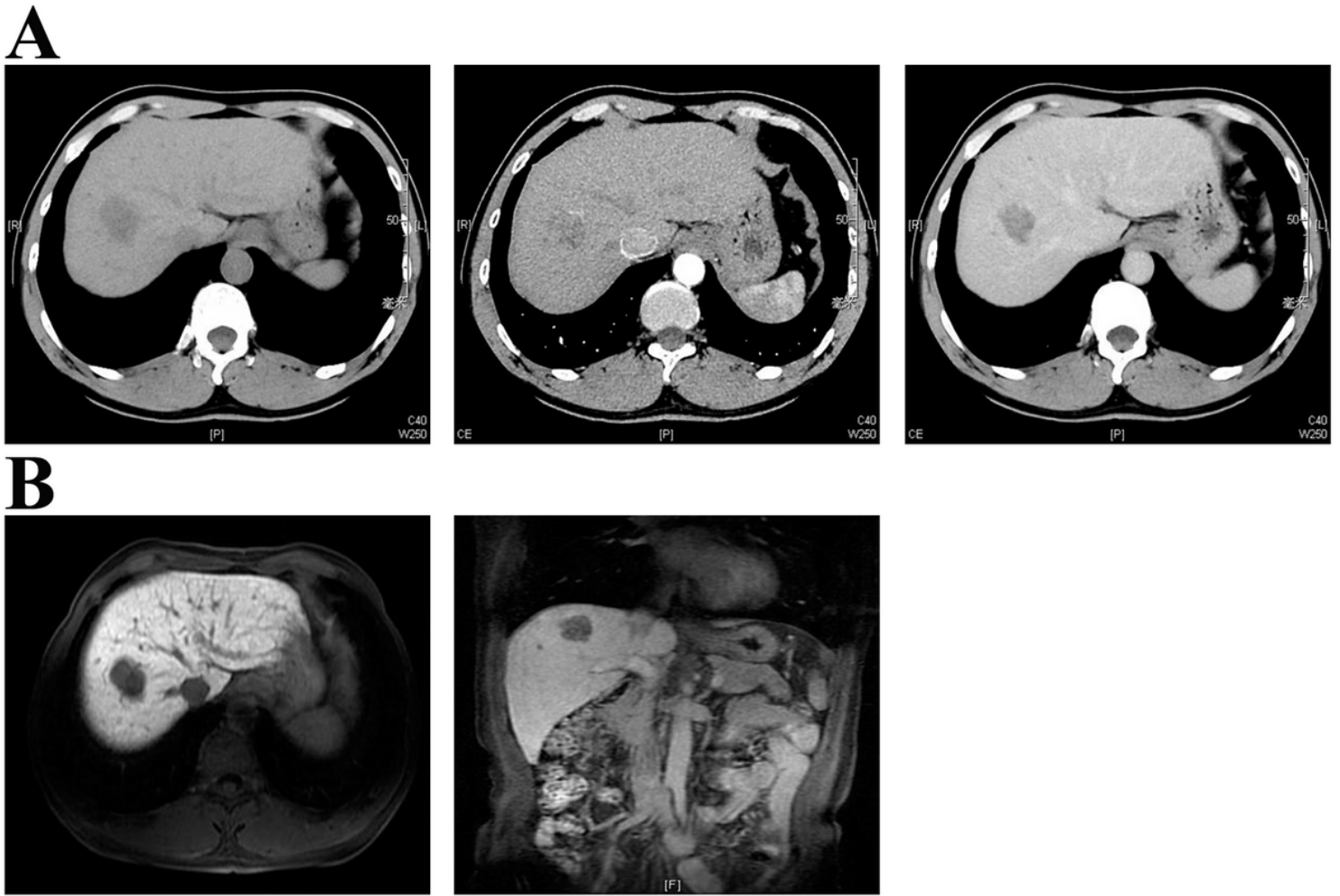


Figure 4

Preoperative CT (A) and MRI (B) of the liver. A 3.2 cm × 3.0 cm sized mass (arrows) was found on S8.

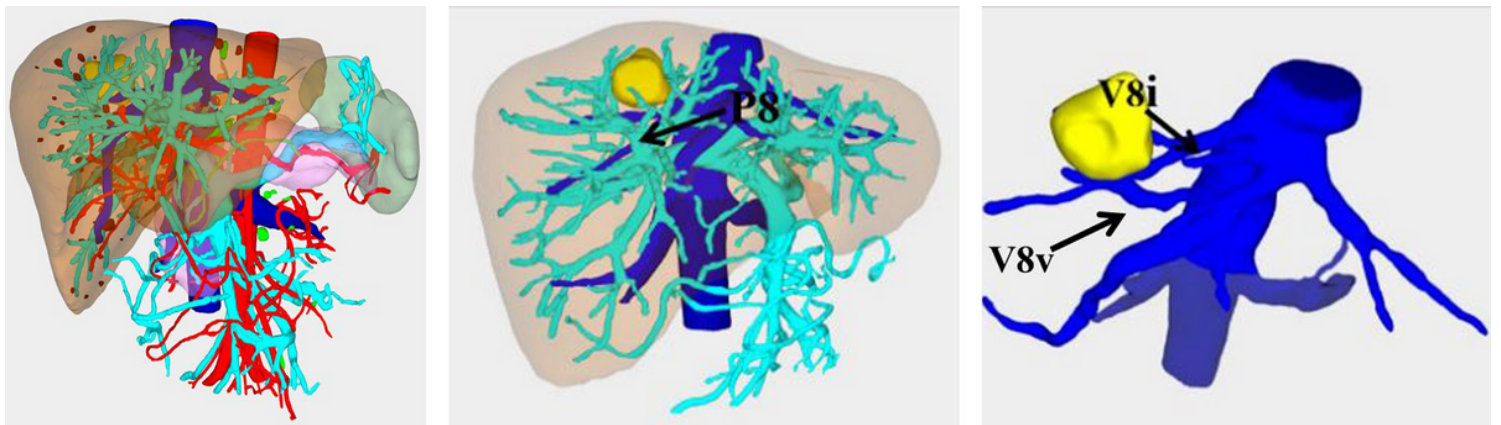


Figure 5

Preoperative 3D-CT reconstruction. The black arrow indicates the Glisson pedicle of liver S8. 3D-CT reconstruction shows V8v (black arrow) joining the MHV. V8i (black arrow): tributary of MHV running between the ventral part and dorsal part of S8.

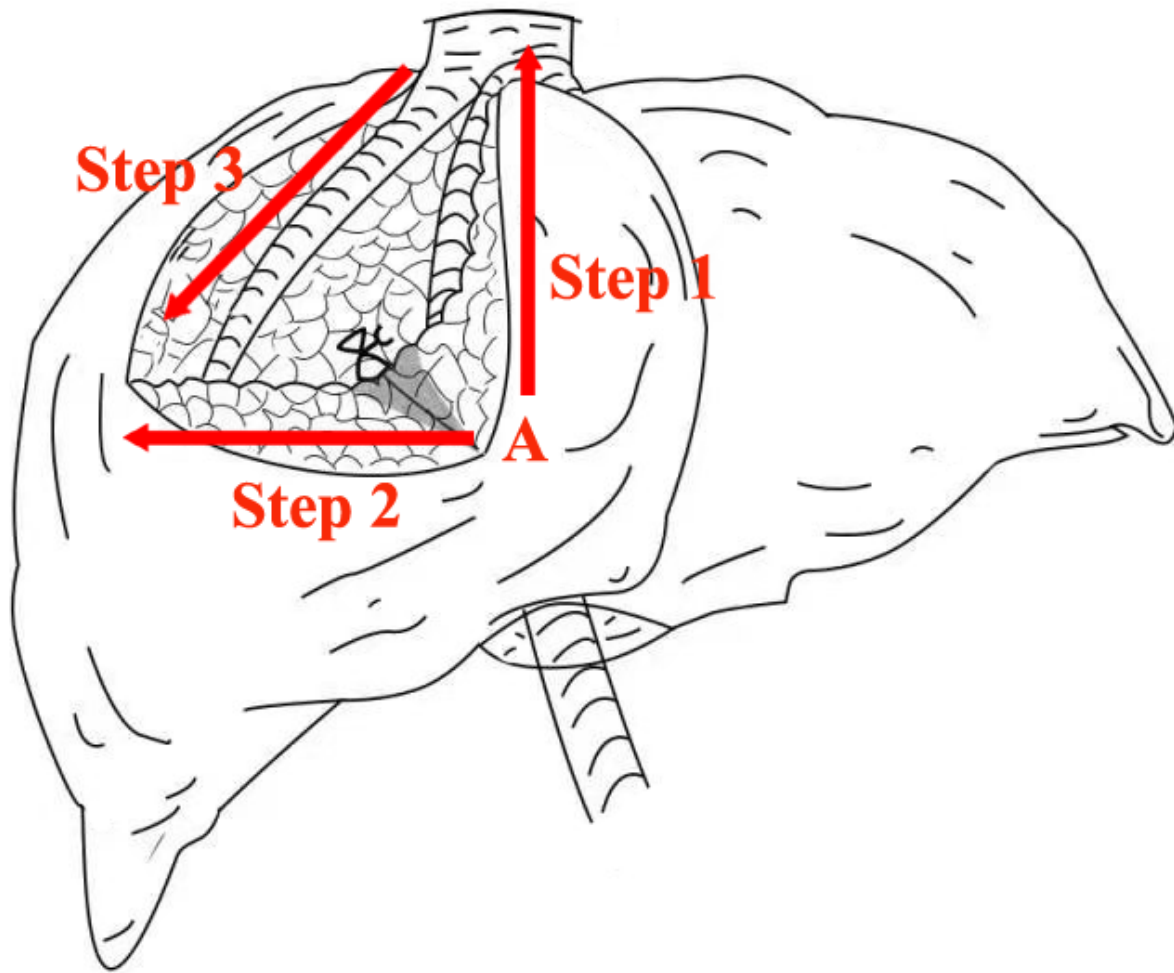


Figure 6

Diagram of hepatic parenchymal transection process. Site A indicates the starting point of the parenchymal dissection. Step 1. Hepatic resection is begun at Site A and continued further cranially along the MHV; and the trunk of the MHV was also exposed; Step 2. Next, the hepatic resection was continued from the Site A toward the right direction of caudal side transection plane; the Glissonian pedicles to S8 was exposed and divided; Step 3. Subsequently, the liver parenchyma between S8 and S7 was dissected along the RHV and ischemic line from the root side to the peripheral side; with this, transections finished.

In order to full exposure, Step 1 and Step 2 are continued alternately according to the intraoperative situation.