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ORIGINAL ARTICLE

Retrospective Cohort Study

Laparoscopic anatomical SVIII resection *via* middle hepatic fissure approach: Caudal or cranio side

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Abstract

BACKGROUND

Laparoscopic hepatectomy is a proven safe and technically feasible approach for liver tumor resection, but laparoscopic anatomical SVIII resection (LASVIIIR) remains rarely reported due to poor accessibility, difficult exposure, and the deep-lying Glissonean pedicle. This study examined the safety, feasibility, and perioperative outcomes of LASVIIIR *via* a middle hepatic fissure approach at our institution.

AIM

To investigate the safety, feasibility, and perioperative outcomes of LASVIIIR *via* a middle hepatic fissure approach at our institution.

METHODS

From November 2017 to December 2022, all patients with a liver tumor who underwent LASVIIIR were enrolled. The perioperative outcomes and postoperative complications were evaluated.

RESULTS

Thirty-four patients underwent LASVIIIR *via* a middle hepatic fissure approach from the side or cranio side and were included. The mean operation time was 164 ± 54 minutes, and the intra-operative blood loss was 100 mL (range: 20-1000 mL). The mean operative times were, respectively, 152 ± 50 minutes and 222 ± 29 minutes (P = 0.001) for the caudal side and cranial side approaches. In addition, the median blood loss volumes were 100 mL (range: 20-300 mL) and 250 mL (range: 20-1000 mL), respectively, for the caudal and cranial sides (P = 0.064). Three patients treated using the cranial side approach experienced bile leakage, while 1 patient treated using the caudal side approach had subphrenic collection and underwent percutaneous drainage to successfully recover. There were no

differences regarding postoperative hospital stays for the caudal and cranial side approaches [9 (7-26) days *vs* 8 (8-19) days] (P = 0.226).

CONCLUSION
LASVIIIR resection remains a challenging operation, but the middle hepatic fissure approach is a reasonable and easy-to-implement technique.

Key Words: Laparoscopic liver resection; Anatomical liver resection; Middle hepatic fissure approach; Segment VIII resection; Caudal side; Cranial side

Core Tip: Laparoscopic anatomical SVIII resection (LASVIIIR) remains rarely reported due to poor accessibility, difficult exposure, and the deep-lying Glissonean pedicle. In this study, thirty-four patients underwent LASVIIIR *via* a middle hepatic fissure approach from the side or cranio side and were included. We found that there were no differences regarding postoperative hospital stays for the caudal and cranial side approaches. LASVIIIR remains a challenging operation, but a middle hepatic fissure approach is a reasonable and easy-to-implement technique.

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INTRODUCTION

Over the past decade, laparoscopic hepatectomy (LH) has been proven a technically feasible and safe approach for liver tumor resection. A recent systematic review indicated that performing LH yielded significant advantages regarding perioperative outcomes, including lower narcotic dose requirements, less blood loss, shorter hospital stay length, and no differences in oncological outcomes or perioperative complication rates compared with open hepatectomy[1]. However, for lesions in the poster-superior segments (including SIVa, SVII and SVIII), especially those fully covered by the costal cage, LH remains challenging due to the high risk of intraoperative bleeding and complications[2,3].

Anatomical liver resection has many advantages, such as complete removal of the tumor-bearing portal territory to eradicate potential micrometastases surrounding the tumors, minimal ischemic parenchyma left behind, and less blood loss[4-6]. Purely laparoscopic anatomical segmentectomy of the liver is still only performed in a few experienced centers because of technical difficulties due to the complex segmental anatomy of the liver and the hepatic veins (HVs) to be exposed on the cut surface[7]. Laparoscopic anatomical SVIII resection (LASVIIIR) is one of the most difficult procedures due to the tumor location; these tumors are poorly accessible, hard to expose, and surrounded by the trunk of the middle and/or right HVs (RHVs), and the Glissonean pedicle lies deep[8,9]. In this study, we present a standardized surgical technique of LASVIIIR *via* a middle hepatic fissure approach from the caudal or cranio side.

MATERIALS AND METHODS

Patients

Between November 2017 and December 2022, 34 consecutive patients who had undergone LASVIIIR at the Department of Hepatobiliary Surgery, Guangdong Province Traditional Chinese Medical Hospital, were enrolled. Patients who had tumor sizes larger than 5 cm and whose tumors were close to the right anterior hepatic pedicle were assigned for the caudal side methods. All operations were performed by one single surgeon. The indications for LASVIIIR were as follows: (1) Hepatocellular carcinoma location limited to S8 without vascular or biliary invasion and adequate surgical margin existed when resection was performed; and (2) Colorectal liver metastasis located deep in S8 were subject to anatomic resection to expose HVs as landmarks. The demographic, perioperative, and clinic pathological characteristics of the patients were analyzed retrospectively, and postoperative follow-up was performed with computed tomography (CT). This study was conducted according to the Helsinki Declaration, and written informed consent was obtained.

Operative procedures

Caudal side: Patients were placed in the supine position with head-high and leg-low under general anesthesia with endotracheal intubation. The surgeon stood between the legs of the patient, while the assistant stood on the left. A CO_2 pneumoperitoneum was established using an intra-abdominal pressure of 13-14 mmHg (1 mmHg = 0.133 kPa). The layout of the trocar is shown in Figure 1A. We first divided the falciform ligament and exposed the origins of the RHV

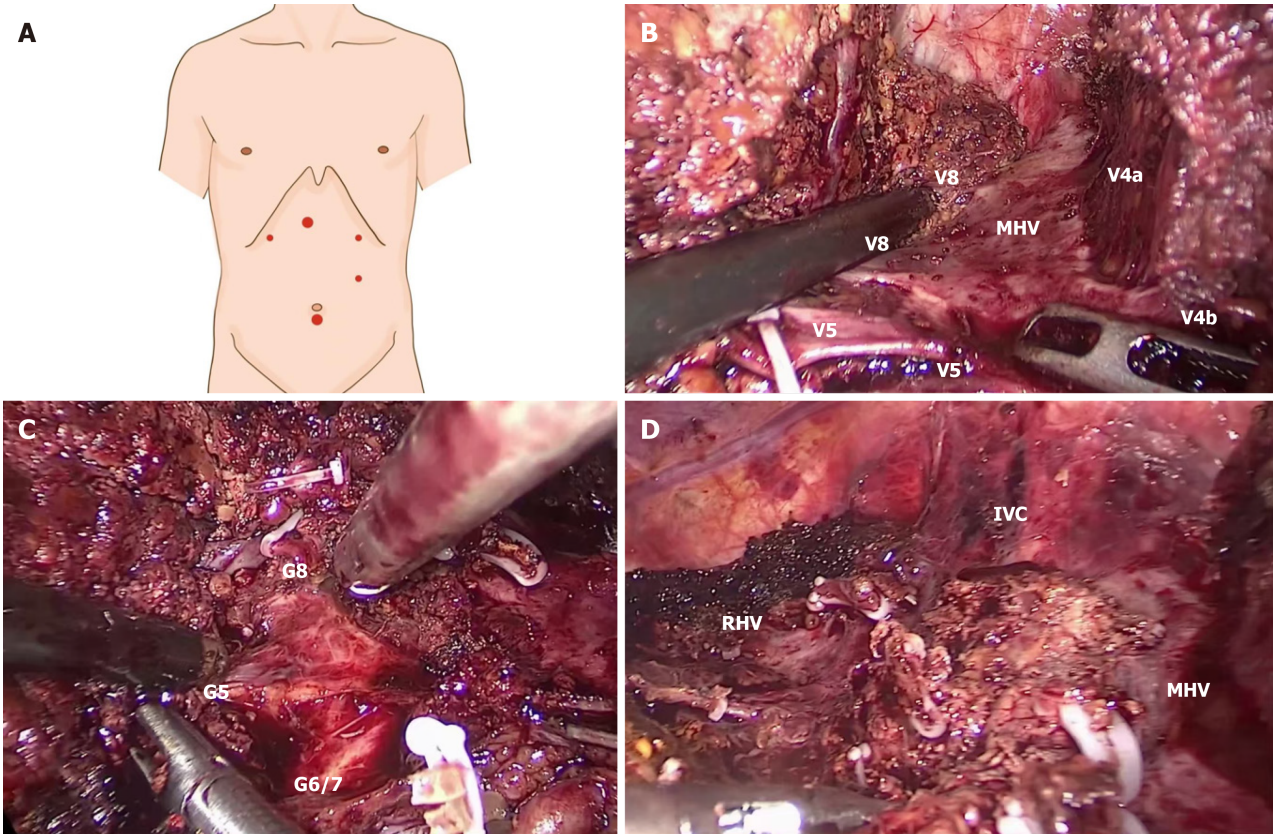

Figure 1 SVIII resection from caudal side. A: Port placement for SVIII resection from caudal side; B: Dissection the middle hepatic vein from caudal side; C: Exposing G8 from caudal side; D: Photograph after SVIII resection from caudal side. MHV: Middle hepatic vein; RHV: Right hepatic vein.

and the middle HV (MHV). Next, the position and direction of the MHV was determined according intraoperative ultrasonography (IOUS), and the resection line on the liver surface was marked.

The liver was first transected to identify V5 tributaries and then towards main trunk of the MHV. After arriving at the convergence of V5 and V4b, the MHV trunk was dissected towards its root from the posterior aspects, not the lateral aspects, to avoid split-injuries (Figure 1B). The middle hepatic fissure was opened completely to obtain a wide space. After dividing V5, the right anterior Glissonean pedicle was identified at the corner of the MHV trunk and V5; next, the Glisson 8 (G8) origin was isolated according to preoperative 3-dimensional computed tomography (Figures 1C and 2). After G8 ligation, the boundary between the SV and SVIII on the liver surface was determined by the ischemic line, and the depth was determined by fluorescent back staining or the intersegmental vein that ran between the SV and SVIII and joined the MHV. The RHV was exposed to the intersegmental plane between SVIII and SV. The right section side was guided by the RHV, and the main trunk of the RHV was exposed continuously from the root side. The bottom SVIII plane was identified between the transected stumps of G8 and the ventral surface of the supra-hepatic inferior vena cava (IVC) (Figure 1D), and a drain was placed. The specimen was then placed in a specimen bag and removed through an incision below the umbilicus.

Cranio side: Each patient's position and pneumoperitoneum pressure were the same as those used for the caudal side procedure, and the surgeon stood on the left of the patient, with the assistant on the right. The layout of the trocars was below the right costal arch as shown in Figure 3A. After the MHV and RHV origins were exposed, a small part of the SVa was resectioned to obtain a visual field not parallel to the MHV. Parenchymal dissection was initiated at the root of the MHV and advanced from the cranial side toward the periphery. The main trunk of the MHV was exposed continuously on the medial sector side. After safe exposure, the HV branches (V8v) were clipped and cut (Figure 3B). At the border between segment 5 (S5) and SVIII, which was estimated by IOUS, a 1-2 cm length of the middle hepatic fissure side was divided towards the cranio side, continuing from the cut line in the middle hepatic fissure. Next, the G8 roots were identified and ligated (Figure 3C). The subsequent liver parenchyma disconnection procedure was the same as that used for the caudal approach (Figure 3D).

Statistical analysis

The statistical review of the study was performed by a biomedical statistician. Patient baseline characteristics and perioperative outcomes are expressed as the mean ± SD for continuous data and as frequencies for categorical data. Categorical variables were compared by χ^2 or Fisher exact test, and the Wilcoxon rank sum test was used for continuous variables.

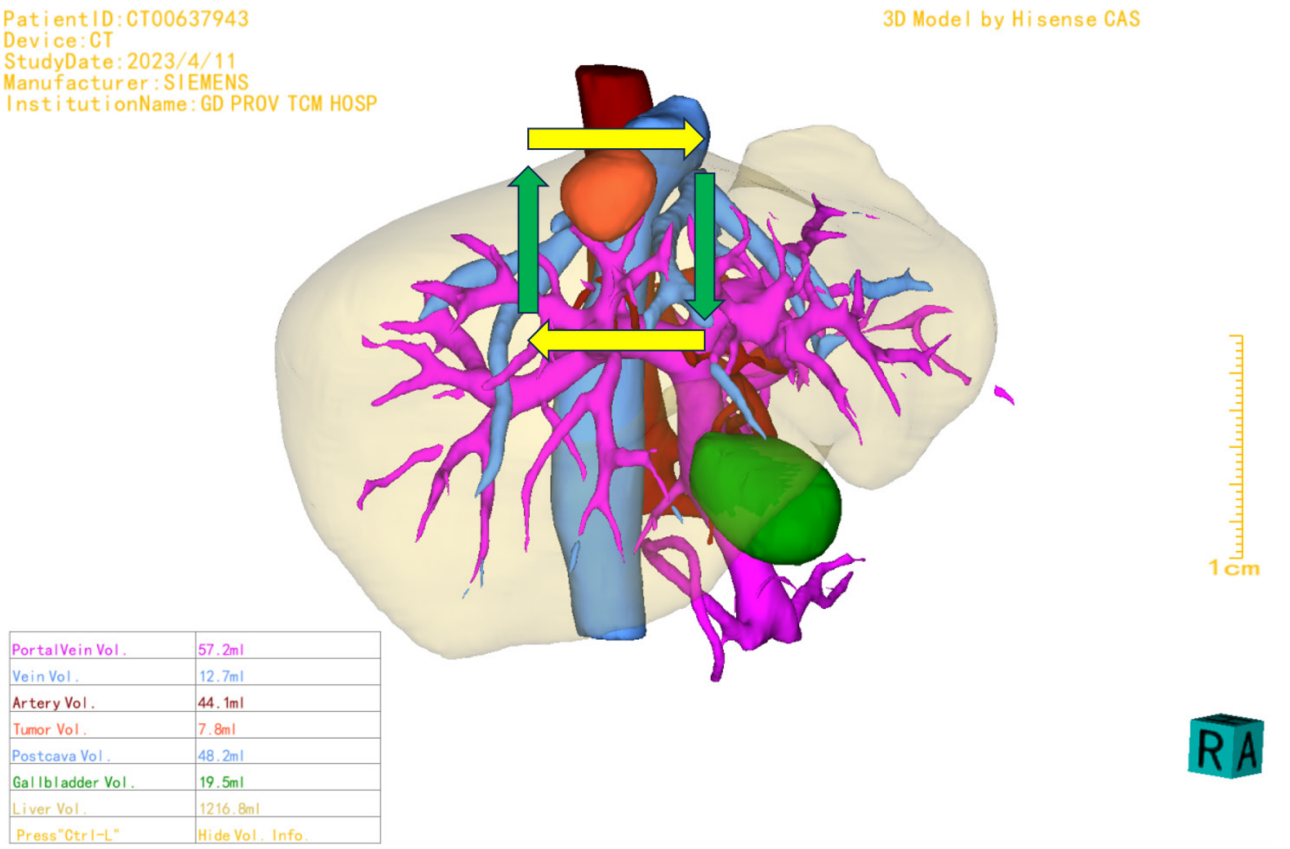

Figure 2 Three-dimensional reconstruction before the surgery. 3D: Three-dimensional.

RESULTS

Patient characteristics

The preoperative data of all patients are summarized in Table 1. Of the 34 patients, the caudal approach was used for 6, while the cranial approach was used for 28. Twenty-nine patients underwent entire SVIII resection; 4 underwent SVIII dorsal resection, and 1 underwent SVIII vent resection. There were 22 male and 12 female patients with a mean age of 57 ± 13 years. Thirty-two patients had 1 tumor, and 2 patients had 2 tumors; the median tumor diameter was 2.3 ± 1.8 cm. For the caudal and cranial side approaches, the median tumor diameters were 5.0 ± 2.5 cm and 2.7 ± 1.4 cm, respectively (P = 0.011). Twenty-nine patients had hepatitis B virus infection, and 26 patients had liver cirrhosis. All patients had Child-Pugh class A liver function. The mean ICG-R15 rate was 6.2% ± 4.5%.

Perioperative outcomes

No patients in this series were converted to open surgery. Intraoperative transfusion was needed for one caudal side approach patient, but none of the cranial side approach patients required this. The mean operation time was 164 ± 54 minutes, and the median intra-operative blood loss volume was 100 mL (range: 20-1000 mL) for all 34 patients. For the caudal and cranial side approach patients, the median operative times were 152 ± 50 minutes and 222 ± 29 minutes, respectively (P = 0.001), and the median blood loss volumes were 100 mL (range: 20-300 mL) and 250 mL (range: 20-1000 mL), respectively (P = 0.064). Postoperative pathological results showed that 27 cases were hepatocellular carcinoma, 2 cases were intrahepatic cholangiocarcinoma, 2 cases were epithelioid hemangioendothelioma, and 1 case was angioleiomyoma. R0 resection was achieved in all patients, and there was no intraoperative mortality. Three patients treated with the cranial side approach experienced bile leakage, while 1 patient treated with the caudal side approach had subphrenic collection; this patient underwent percutaneous drainage and successful recovered. The median postoperative hospital stay for all 34 patients was 9 days (range: 5-26 days). For the caudal and cranial side approaches, the median postoperative hospital stay lengths were 9 days (range: 7-26 days) and 8 days (range: 8-19 days), respectively (P = 0.226) (Table 1).

DISCUSSION

Anatomical resection is an essential surgical technique for hepatectomy; this approach minimizes the ischemic parenchyma left behind and ensures adequate oncological resection while optimizing post-resection liver function[10,11]. Laparoscopic liver resection has been applied widely, from minor resection to complex hepatectomy. However, LASVIIIR

Table 1 Patient characteristics and perioperative outcomes

No	Age	Sex	Procedure type	Procedure type	Liver disease	Liver cirrhosis	ICG-r15	Operation time (minute)	Blood lost (mL)	POHS (days)	Tumor size	Pathological diagnosis	Complication
1	57	Male	S8	Cranial	HBV	Yes	4.80%	148	150	10	1.3	HCC	No
2	66	Female	S8	Cranial	HBV	Yes	6.20%	174	200	7	2.2	HCC	No
3	30	Female	S8d	Cranial	HBV	Yes	2.40%	98	20	8	1.2	HCC	No
4	48	Male	S8	Cranial	HBV	Yes	5.30%	180	200	7	1.8	HCC	No
5	67	Female	S8	Cranial	HBV	Yes	4.40%	160	100	9	1.2	HCC	No
6	49	Male	S8	Cranial	HBV	Yes	4.10%	116	100	7	3.5	HCC	No
7	42	Male	S8d	Cranial	HBV	Yes	4.20%	190	100	8	1.0, 0.8	EHE	No
8	54	Male	S8d	Cranial	HBV	Yes	12.40%	87	100	19	2.5	HCC	No
9	54	Male	S8	Cranial	HBV	Yes	6.00%	130	100	8	2.3	HCC	Bile leakage
10	75	Male	S8	Cranial	HBV	Yes	6.30%	200	100	8	5.3	HCC	Bile leakage
11	58	Female	S8v	Cranial	HBV	Yes	5.50%	130	20	5	2.2	EHE	No
12	63	Male	S8	Cranial	-	No	3.60%	215	200	6	6.5	ICC	Bile leakage
13	23	Male	S8	Cranial	-	No	6.70%	155	200	8	1.4	HCC	No
14	82	Male	S8	Cranial	HBV	Yes	7.80%	149	200	12	1.5	HCC	No
15	66	Male	S8	Cranial	HBV	Yes	6.40%	155	200	7	2.9	HCC	No
16	53	Male	S8	Cranial	HBV	Yes	4.60%	210	300	8	2.5	HCC	No
17	61	Female	S8	Cranial	HBV	Yes	21.98%	95	50	10	5	HCC	No
18	66	Female	S8	Cranial	HBV	Yes	2.40%	60	100	8	3.5	HCC	No
19	67	Female	S8	Cranial	HBV	Yes	6.90%	56	10	7	3.8	HCC	No
20	66	Male	S8	Cranial	HBV	Yes	7.50%	183	100	12	2.2	HCC	No
21	51	Male	S8	Cranial	HBV	Yes	18.60%	289	150	12	2.5	HCC	No
22	69	Female	S8	Cranial	HBV	No	5.50%	105	50	8	3	ICC	No
23	47	Female	S8	Cranial	-	No	2.60%	190	50	12	1.1, 0.7	Angiomyolipoma	No
24	76	Female	S8	Cranial	HBV	Yes	16%	158	200	8	2.3	HCC	No
25	68	Male	S8	Caudual	HBV	Yes	6.50%	235	50	26	7.5	HCC	No
26	57	Female	S8	Caudual	HBV	Yes	3.70%	213	100	9	2.7	HCC	No
27	42	Female	S8	Caudual	-	No	0.40%	186	1000	9	5	HCC	No
28	68	Male	S8	Cranial	HBV	Yes	4.80%	200	100	10	3.3	HCC	No
29	38	Male	S8	Caudual	HBV	Yes	5.00%	195	300	8	2.5	HCC	Subphrenic collection
30	60	Male	S8	Caudual	HBV	Yes	2.00%	230	200	7	3.5	HCC	No
31	47	Male	S8	Cranial	-	No	3.70%	105	50	7	1.4	HCC	No
32	72	Male	S8	Cranial	HBV	Yes	6.30%	165	200	7	1.7	HCC	No
33	60	Male	S8	Caudual	HBV	No	4.30%	274	500	10	9	HCC	No
34	48	Male	S8d	Cranial	HBV	No	3.10%	152	50	7	2.5	HCC	No

HBV: Hepatitis B virus; HCC: Hepatocellular carcinoma; ICG: Indocyanine green; POHS: Preventive oral health services; EHE: Epithelioid hemangioendothelioma; ICC: Interstitial cells of Cajal.

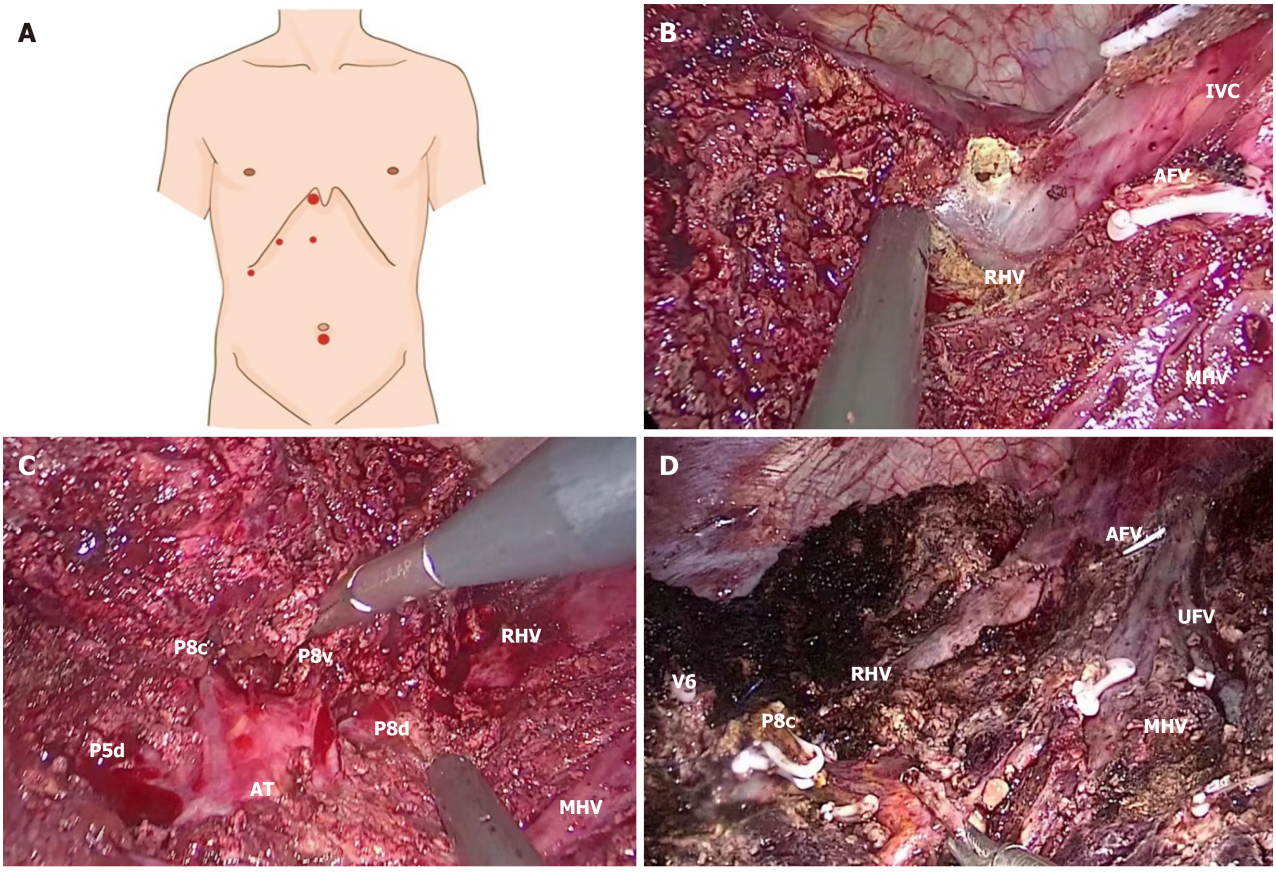

Figure 3 SVIII resection from cranio side. A: Port placement for SVIII resection from cranio side; B: Dissection the middle hepatic vein from cranio side; C: Exposing G8 from cranio side; D: Photograph after SVIII resection from cranio side. MHV: Middle hepatic vein; RHV: Right hepatic vein; AFV: Anterior fissure vein; IVC: Inferior vena cava; UFV: Umbilical fissure vein.

remains one of the most difficult and demanding liver resections to perform due to a number of anatomical characteristics [12,13]. First, the high SVIII position in the abdomen under the diaphragm restricts comfortable access with laparoscopic instruments, resulting in suboptimal surgical field view and dissection control. Second, the SVIII portal pedicle (G8) is deep-seated within the hepatic parenchyma, and no external landmarks exist to guide dissection. Lastly, SVIII is embedded amongst the RHV, MHV, and IVC. This intimate relationship of the main HVs and the IVC requires exposure of these major vascular structures, which comes with intrinsic life-threatening risk of hemorrhage. Additionally, there are various branching patterns of the tertiary G8 branches, and no current classification can consistently explain individual cases[14,15].

Experienced hepatobiliary surgeons have tried many approaches for LASVIIIR, but each method has its own advantages and disadvantages. No evidence exists to support the use of one over another (8): (1) The Glissonean-first approach: For this surgery, the right anterior Glissonean sheath is approached from the hepatic hilum; then, the SVIII portal pedicle (G8) is identified, isolated, clamped (confirming SVIII ischemia), and divided, followed by transection along the demarcation margins along the RHV and MHV planes. This structured, step-by-step method of identification of G8 through a secure path and sub-segmental SVIII resection can be achieved; however, it is time consuming and may cause biliary complications[16-18]; (2) Transparenchymal approach: The G8 is identified through IOUS on the ventral liver surface, and a small bridge of the parenchyma is divided to access the vascular space. The G8 is identified, and transection is then performed along the demarcation margins along the RHV and MHV planes. This approach involves less parenchymal disruption and avoids hilar dissection, which may be important for patients who suffer recurrence and need further liver surgery; this approach, however, is dependent on ultrasound puncture and fluorescence staining experience, and it is difficult to dissect the RHV and MHV from below[19-21]; and (3) Transthoracic approach: Lesions may be more easily approached using the transthoracic method. This technique is suitable for those who have already had extensive prior liver surgery because it may facilitate wedge resections that are not really anatomical hepatectomy. Usually, there are three to five branches of the SV originating from the right paramedian trunk or peripheral SVIII portal branches[21-23].

The peripheral branches of the Glissonean pedicle of segment VIII, such as the dorsal or ventral branch, are deep and farther from the hepatic hilum[24]. To have enough space to expose the G8, we applied a middle hepatic fissure approach from the caudal side when we launch LASVIIIR. We found that the caudal side conforms the visual requirements of the laparoscope and makes operation easy; the root of the hepatic pedicle and the main vein are easily exposed, which reduces the technical requirements and shortens the learning curve. However, this method has drawbacks, including considerable parenchymal disruption, and SV division can cause venous drainage and consequent SV congestion, which

can increase the risk of postoperative biliary leakage.

We also used this method on the cranial side[25]. When we applied the middle hepatic fissure approach from the cranial side, we did not use intercostal trocars as previously reported; rather, subcostal trocars were used, which may decrease the possibility of thoracic complications. We resected a small part of SIVa to expose the MHV, and we used IOUS-guided marking of the venous plane. Furthermore, when dissecting the MHV and RHV from the root, it is easy to find a plane to preserve Laennec's capsule[26], thereby making the resection plane simple to follow; this step also decreases the chance of "split-injuries" and avoids intraoperative massive hemorrhage[27]. Opponents propose cranial side dissection of the parenchyma first, but the G8 is identified late, which makes the resection plane less precise. Routine 3-dimensional reconstruction before the operation and intraoperative fluorescence imaging with indocyanine green fluorescence were also used, which facilitated the recognition of the resecting area and intersegmental plane[16,28].

CONCLUSION

Laparoscopic SVIII resection remains a challenging operation, but the middle hepatic fissure approach is a reasonable and easy-to-implement technique.

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FOOTNOTES

Author contributions: Peng JX and He JM conceived and designed the project; Ye Q, Mo JQ, and Wang JY collected the data; Liu ZY painted the figure; Li HL analyzed and interpreted the data and drafted the manuscript. All authors read and approved the final manuscript.

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