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ORIGINAL ARTICLE

Laparoscopic right posterior sectionectomy: single-center experience and technical aspects

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Abstract

Purpose Laparoscopic right posterior sectionectomy (LRPS) is a technically demanding procedure. The aim of this article is to share our experience with LRPS and to highlight technical aspects of this procedure.

Methods This is a single-center retrospective analysis of all patients who underwent LRPS between September 2011 and October 2017. Data were retrieved from a prospectively maintained database. Video-in-picture (VIP) technology is used to facilitate and to highlight the technical aspects of this procedure.

Results In total, 18 patients underwent LRPS. Indication for surgery was mainly liver metastases ($n = 11$) and hepatocellular carcinoma ($n = 6$). The Glissonean approach for inflow control was used in 13 patients. Median operative time was 162 (140–190) minutes. Median blood loss was 325 mL (IQR: 150–450). One conversion (5.5%) was required. There were two minor complications and one major complication. Median hospital stay was 6 days (range 5–8 days). All patients had an R0 resection. There was no 90-day mortality.

Conclusion The results of our experience in LRPS add weight to the feasibility and safety of this approach.

Keywords Hepatobiliary surgery · Laparoscopy · Posterosuperior segments · Glissonean approach · Techniques

Abbreviations

LRPS	Laparoscopic right posterior sectionectomy
VIP	Video-in-picture
CVP	Central venous pressure
IOUS	Intraoperative ultrasonography
RHV	Right hepatic vein
IQR	Interquartile range
ERCP	Endoscopic retrograde cholangiopancreatography
LLR	Laparoscopic liver resection
HPB	Hepato-pancreato-biliary
HCC	Hepatocellular carcinoma
CRLM	Colorectal liver metastasis
LHV	Left hepatic vein

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Introduction

Laparoscopic liver surgery is gaining acceptance in many hepato-pancreato-biliary units, and indications are continuously expanding. In experienced hands, a laparoscopic approach results in a lower complication rate, less blood loss, lower transfusion rate, and a shorter hospital stay compared to open approach [1, 2]. Moreover, recent evidence increasingly confirms comparable oncological outcomes between laparoscopic liver resections and open liver resections [1, 3].

Numerous reports have addressed laparoscopic minor liver resections and left lateral sectionectomies but only few papers have focused on laparoscopic right posterior sectionectomy (LRPS) [4–6]. LRPS is a technically challenging procedure. The open approach remains the reference standard in many units. In a recent worldwide analysis of more than 9000 laparoscopic liver resections, only 1.2% were LRPS (119/9527) [7].

The aim of this article is to share a single-center experience in LRPS, analyze its feasibility and safety, and highlight the technical aspects of the surgical technique using video-in-picture (VIP) technology.

Methods and technique

This is a single-center retrospective analysis of all patients who underwent a LRPS between September 2011 and October 2017. Indications for right posterior sectionectomy are the presence of multiple lesions in segments 6 and 7, large lesions involving segments 6 and 7, or lesions involving the right posterior pedicle (Fig. 4).

Patients who underwent a trisegmentectomy including segments 6 and 7 were also included in the analysis (segment 5-6-7 resection or segment 6-7-8 resection), as technical challenges are considered similar. Contraindication for LRPS was in case of very large tumors that reach the intended parenchymal transection line.

Pre-, peri-, and postoperative data were retrieved from a prospectively maintained electronic database. The Clavien-Dindo classification was used for morbidity classification [8]. The study was approved by the local ethics committee.

All procedures were performed by a single surgeon, trained in laparoscopic surgery, and hepatopancreatobiliary surgery. Referring to the IDEAL paradigm of surgical innovation, the performing surgeon is considered as "early adopter" in laparoscopic liver surgery [9]. Hence, technically and anatomically major laparoscopic liver resections (LLR) were already executed in the early phase of the learning curve. At the end of the study period, we had an experience of 369 liver resections performed, among which 246 LLR. Consequently, 66.6% of all liver resections were performed laparoscopically, and 6 of these LLR cases required conversion (2.4%).

Anesthesia protocol

The general anesthesia protocol has been extensively described elsewhere [10]. Different anesthetic interventions affect a surgeon's perioperative progression. Fluid administration was restricted, tidal volume was reduced, and a sufficient amount of muscle relaxant was administered for mild reduction of the central venous pressure (CVP) during parenchymal transection. CVP drop after hypovolemic phlebotomy is a strong independent predictor of estimated blood loss during liver resection, demonstrated in a previous study by this group. Hence, the authors advocate for the routine use of hypovolemic phlebotomy and this is a standard practice in our institution [11].

Patient positioning

Patients were placed in a semiprone position [12, 13]. A vacuum mattress supports the patients back into a left lateral position. To allow a large range of movement of the laparoscopic instruments during the procedure, the patient's ventral surface should be on the edge of the table.

After positioning in the left lateral position, the table was convexly flexed to optimize the working space. Over-flexing the table should be avoided as this may limit the expansion of the abdominal wall and thereby limit the working space during the procedure. The patient was carefully anchored with tape or straps, to avoid shifting on the table. Attention should be given not to strap the thorax too tightly; this could compromise the respiratory expansion. The table was turned by 30–45% toward the semiprone position, after draping the patient. The surgeon and first assistant stand on the left side of the patient. The scrub nurse stands on the right side of the patient.

Surgical technique

Access and exposure

Figure 1 illustrates the trocar positioning. A 15-mmHg pneumoperitoneum was created considering previous scars and patient habitus, and then a first 5-mm trocar was inserted at a point 5 cm to the right and above of the umbilicus. This is the optical port trocar. In our unit, a 5-mm 30° laparoscope is used. This approach requires 5 or 6 trocars in total, always placed in two rows. One additional 12 mm trocar was placed at the level of the optical trocar in the right pararectal line. The upper row consists of two 5-mm trocars below the right costal arch at the right midaxillary line, right midclavicular line, and a 12-mm trocar just below the xiphoid. Pneumoperitoneum pressure is then reduced and maintained at 12 mmHg during all procedures.

During every procedure, intraoperative ultrasonography (IOUS) was used to perform a systematic segment-by-segment examination to determine the target lesion and to screen for potential undetected lesions preoperatively. All lesions were surveyed by size and relationship to segmental portal and hepatic veins. In order to access the left liver lobe for IOUS in semiprone position, a window was created through the falciform ligament to allow adequate evaluation by IOUS. Before continuing to the next step, two gauzes (7.5 cm × 7.5 cm) are placed in the abdomen in an easily accessible location (f.e. right paracolic gutter). When unexpected bleeding occurs, immediate hemostasis by pressure

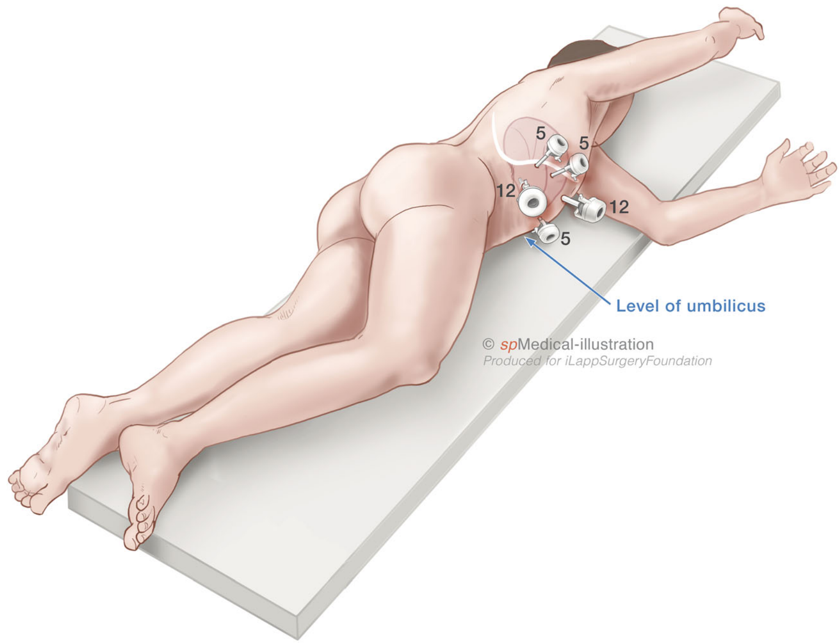

Fig. 1 Trocar positioning during a standard LRPS. The umbilicus is indicated with an arrow for correct orientation. The 5-mm optical trocar is positioned 5 cm to the right and above the umbilicus. This approach requires 5 or 6 trocars in total, always placed in two rows. One additional 12-mm trocar was placed at the level of the optical trocar in the right pararectal line. The upper row consists of two 5-mm trocars below the right costal arch at the right midaxillary line, right midclavicular line, and a 12-mm trocar just below the xiphoid

with the gauzes can be performed. In all cases, the right hemiliver was fully mobilized.

Inflow control

In our unit, the Glissonean approach—described by Galperin and modified by Machado [14–16]—is our preferred approach for LRPS. This approach can only be used for lesions at a distance from the origin of the right posterior pedicle. Based on small hepatotomies at anatomic landmarks, this approach allows for highly selective control of Glissonean pedicles without hilar or extensive parenchymal dissection. The advantage in LRPS is that the sulcus of Rouvière, apparent in 82% of patients, serves as the easily identifiable anatomical landmark, as it contains the posterior sectoral pedicle. Two hepatotomies are made, one above and one beneath Rouviere's sulcus. After test-clamping using a laparoscopic atraumatic vascular clamp, demarcation of the posterior sector is observed. The posterior Glisson's pedicle is then divided en masse using a 35-mm linear vascular stapler (Fig. 2, Box 1). For cases with a tumor less than 1 cm from the origin of the posterior pedicle or in absence of Rouvière sulcus, an IOUS-guided resection was performed or hilar dissection was performed for inflow control.

For the reader's convenience, video-in-picture (VIP) technology was used to demonstrate our preferred surgical approach for inflow control using the Glissonean approach based on Rouvière's sulcus. VIP technology, developed by the iLappSurgery Foundation (a non-profit organization), was first used by Knol and colleagues in their paper on technical aspects in transanal total mesorectal excision [17]. This technique allows for readers to link images in the article to video content. This new method of interactive reading has the advantage, especially for surgical manuscripts highlighting technical pearls, that videos provide instant detailed supplementary material. Instructions for optimal VIP use are summarized in Box 1.

Box 1 Instructions for VIP (video-in-picture) use

"Video-in-picture" (VIP):

The VIP application is available for download in the Google Play store (Android devices) as well as the Apple store (iPhone/iPad). Search for "VIPicture," download the application, and allow the application to access your camera. This will activate the camera within the application, hence enabling the app to recognize the image within the manuscript (Fig. 2), thereby linking you to the appropriate video demonstration of the technique. Images that qualify for use with the application can be identified by the presence of the "VIP" logo. For more information, please visit http://www.iLappSurgery.com and click on the "iLappVIP" section.

Outflow control

Outflow control was only performed in cases requiring en bloc resection of the right hepatic vein (RHV) when the tumor was in close contact with the RHV. The RHV was dissected and isolated at the hepatocaval confluence. A drain was placed around the origin of the right hepatic vein allowing traction on the origin of the right hepatic vein in order to have outflow control during parenchymal transection and in order to safely staple the origin of the RHV (Fig. 3).

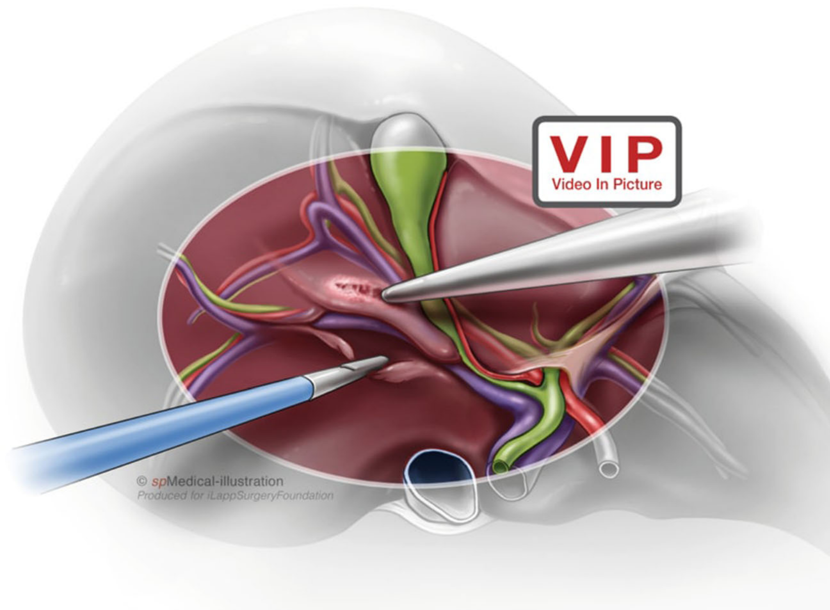

Fig. 2 Image showing the Glissonean approach for laparoscopic right posterior sectionectomy using VIP technology (see box 1)

Parenchymal transection

With the demarcation line serving as the transection border, two traction sutures were placed on the liver surface. The superficial hepatic parenchyma is transected using an ultrasonic scalpel or bipolar sealing device (ENSEAL® G2 Tissue Sealers by Ethicon Endo-Surgery Inc., Cincinnati, OH, USA) and the deeper portion of the parenchyma is transected with a laparoscopic Cavitron ultrasonic surgical aspirator (CUSA, Plainsboro, NJ, USA). The small branches of the hepatic veins are controlled with endoclips or vessel-sealing instruments. The large branches of the RHV and the RHV itself are transected with a vascular stapler.

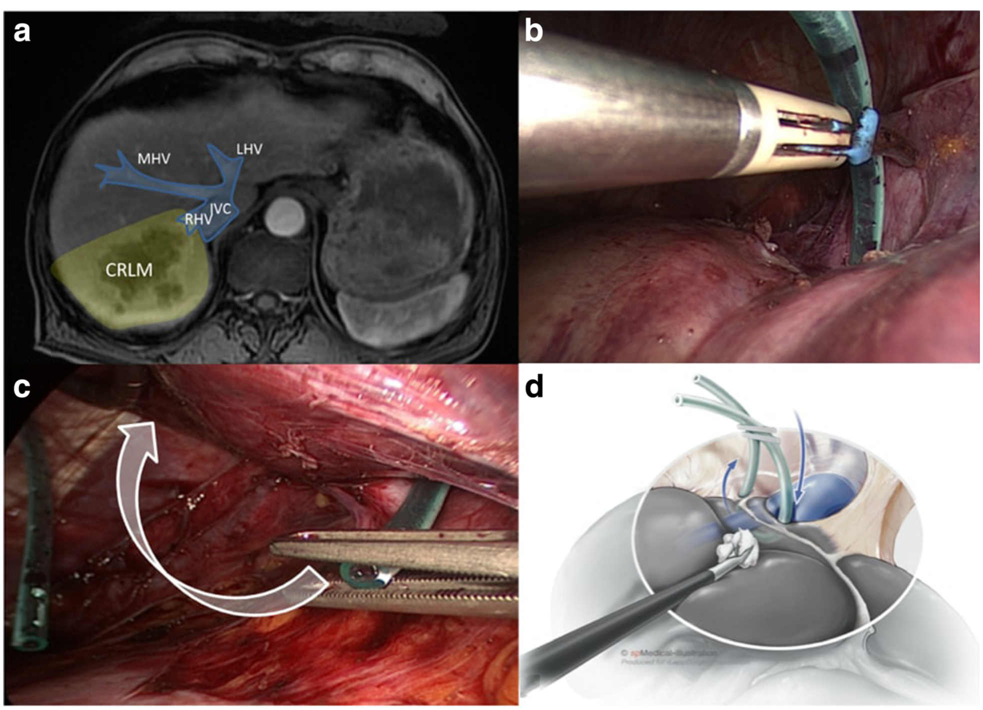

Fig. 3 Outflow control using a "hanging maneuver" of the right hepatic vein. **A**. MRI of a case with one large liver colorectal liver metastases in segment 7 involving the RHV. A second lesion (not shown) was present in segment 6. The patient underwent a laparoscopic right posterior sectionectomy with en bloc resection of the RHV. **B**. After right hemiliver mobilization the left side of the RHV is dissected and exposed. A drain is placed into the space between the RHV and left hepatic vein (LHV). **C**. The drain is turned around the RHV. **D**. Both ends of the RHV are clipped in order to be able to manipulate the origin of the RHV and to protect the inferior vena cava (IVC) during stapling of the origin of the RHV

Hemostasis

After the parenchymal transection phase is finished, several gauzes are placed against the transected parenchymal surface. The specimen is placed in an endobag and retrieved via a small Pfannenstiel incision or, if applicable, via a previous existing midline incision. The specimen is analyzed by the pathologist to ensure R0 resection.

The pneumoperitoneum is reinstalled after closure of the incision, and the surface-covering gauzes are slowly retracted to diagnose any bile leakage. In the case of bile leakage, transfixation sutures are placed. A fibrinogen and thrombin-coated collagen patch (TachoSil, Takeda Pharmaceuticals International GmbH, Zurich, Switzerland) was then applied to the cut surface of the liver. In some cases, a gelatin and human thrombin-containing hemostatic matrix was used (FLOSEAL Hemostatic Matrix, Hayward, CA, USA). A silicone drain was placed in all patients.

Results

Of 243 laparoscopic liver resections since October 2011, 18 patients (11 females) underwent LRPS. The median age was 67.5 (60–71). Table 1 illustrates the demographic characteristics and operative data. In 2 patients, a trisegmentectomy with en bloc resection of segment 5 was performed. One patient had a trisegmentectomy including segment 8. These 3 patients were included in the analysis, as technical challenges are considered similar.

Pringle maneuver was not performed in this series. Inflow control was achieved using the Glissonean approach in 13 patients. In 2 patients, we opted for a hilar dissection and in 3 for an IOUS-guided resection along the right hepatic vein. Reasons for performing a hilar approach or IOUS-guided approach were absence of the Rouvière sulcus in 3 patients and proximity of the tumor to the origin of the right posterior pedicle in 2 patients (Fig. 3). Outflow control was performed in 3 patients requiring en bloc resection of the RHV (Fig. 3b). Median operative time was 162 min. The median perioperative blood loss was 325 mL (IQR: 150–450). The three patients with the highest amount of blood loss all underwent an IOUS-guided resection. These patients had 650 ml, 800 ml, and 1500 cc blood loss. Two of these patients required perioperative administration of blood products, due to extensive bleeding.

One conversion was required, due to extensive adhesions between the liver and the diaphragm, attributed to previous liver surgery in this case (non-anatomical resection in segment 7). There was no postoperative mortality. Two minor complications (Clavien-Dindo grade I or II) occurred: one patient had a symptomatic urinary infection, treated with antibiotics, and one patient had postoperative persistent hypertension requiring anti-hypertensive medication. One major complication occurred (Clavien-Dindo grade IIIb). This patient had a postoperative biliary leakage on the parenchymal transection plane, treated with ERCP with transpapillary stenting. This patient was discharged on day 8. The stent was removed on day 42 postoperatively at the outpatient clinic.

Median hospital stay was 6 days (range 5–8 days). All patients had an R0 resection, which is defined as a tumor-free resection margin of ≥ 1 mm. Six patients required adjuvant

Table 1 Characteristics of patients undergoing laparoscopic right posterior sectionectomy

	Overall (*n* = 18)	
	N	%
Sex (F/M)	11/7	61.1/39.9
Age at time of surgery median (IQR)	67.5 (60.0–71.0)	
Age groups		
< 35 year	1	5.6
35–55 year	3	16.7
56–75 year	11	61.1
> 75 year	3	16.7
ASA score		
1	5	27.8
2	10	55.6
3	3	16.7
Indication		
Hepatocellular carcinoma	6	33.3
Liver fibrosis	1	16.7
Cirrhosis Child A	5	83.3
Colorectal liver metastases	6	33.3
Non-colorectal liver metastases	5	27.8
Benign	1	5.6
Type resection Brisbane		
LRPS	15	83.3
Trisegmentectomy	3	16.7
Inflow control		
Glissonean-Rouvière sulcus	13	72.2
Hilar approach	2	11.1
IOUS guided (RHV)	3	16.7
Outflow control—RHV	3	16.7
Pringle maneuver	0	0.0
Conversion	1	5.6
R0 (≥ 1-mm tumor free resection margins)	18	100
Blood loss (ml) median (IQR)	325 (150–450)	
Blood transfusion	2	11.1
Operative time (min) median (IQR)	162.5 (140.0–190.0)	
Postoperative complication	3	16.7
Clavien I	0	0.0
Clavien II	2	11.1
Clavien IIIa	0	0
Clavien IIIb	1	5.6
Clavien IV	0	0.0
90-day mortality	0	0.0
Length of hospital stay (days) median (IQR)	6.0 (5.0–8.0)	
Interval surgery—adjuvant chemotherapy (days) median (IQR)	38.5 (36.0–40.0)	

HCC, hepatocellular carcinoma; *CRLM*, colorectal liver metastasis; *non-CRLM*, non-colorectal liver metastasis; *LRPS*, laparoscopic right posterior sectionectomy; *RHV* right hepatic vein; *IQR*, interquartile range chemotherapy due to disease characteristics. Median time to chemotherapy was 38.5 days.

Discussion

Since the first laparoscopic liver resection was reported, data on over 9000 laparoscopic liver resections has been published [7]. Although laparoscopic liver surgery is gaining acceptance, LRPS is considered a technically challenging procedure reserved for skilled liver surgeons with experience in advanced laparoscopic liver resections [18–21]. Minimal working space, necessity for curvilineair parenchymal transection, difficulty in controlling bleeding from the tributaries of major hepatic veins all contribute to the technical complexity of the operation.

This study presents the results of a single-center experience in the minimally invasive approach for LRPS emphasizing the importance of a standardized approach. For lesions in the right posterior sector, often a right hemihepatectomy is the treatment of choice. Recently, the importance of parenchymal-sparing approaches such as the right posterior sectionectomy has been highlighted as these approaches have multiple benefits. The parenchymal-sparing approach is associated with a decreased risk of post-hepatectomy liver failure, a decreased mortality and, in addition, the ability to repeat hepatic resections resulting in a prolonged survival [22–28]. Furthermore, the role of minimal invasive techniques in parenchymal-sparing liver resections for colorectal liver metastases was recently demonstrated by the Oslo-CoMet study [2]. Patients scheduled to have parenchymal-sparing liver resection for colorectal metastases were randomized between open and laparoscopic approach. Laparoscopic surgery was associated with significantly less postoperative complications compared to open surgery.

Indications for right posterior sectionectomy are the presence of multiple lesions in segments 6 and 7, large lesions involving segments 6 and 7 or lesions involving the right posterior pedicle. In Fig. 4 three cases were selected (Fig. 4).

According to the Louisville statement, resections of lesions in the difficult posterosuperior segments are considered major resections [29]. Recently, however, two subcategories were proposed for the category of major hepatectomies: first, the laparoscopic traditional major hepatectomy including hemihepatectomies and trisegmentectomies, and second, the laparoscopic "posterosuperior" major hepatectomy, including resection of posterosuperior segments 4a, 7, and 8. Traditional major hepatectomies are associated with significantly longer operation time, higher intraoperative blood loss, and longer hospital stay compared to laparoscopic major posterosuperior hepatectomies [30]. It is important that surgeons take a step-by-step approach when introducing laparoscopic major hepatectomy in their practice [31].

Smaller parenchymal-sparing resections are technically more challenging and complex compared to larger procedures resecting more liver parenchyma, and the latter is sometimes favored for that reason. The Morioka guidelines jury expressed their concern on this matter, stating that laparoscopy enables magnified visualization of hence increasing the feasibility of sparing liver parenchyma. Three studies have reported on the feasibility and safety of LRPS [4–6]. Table 2 gives an overview of the current literature (series > 10 cases) on LRPS and the applied technique.

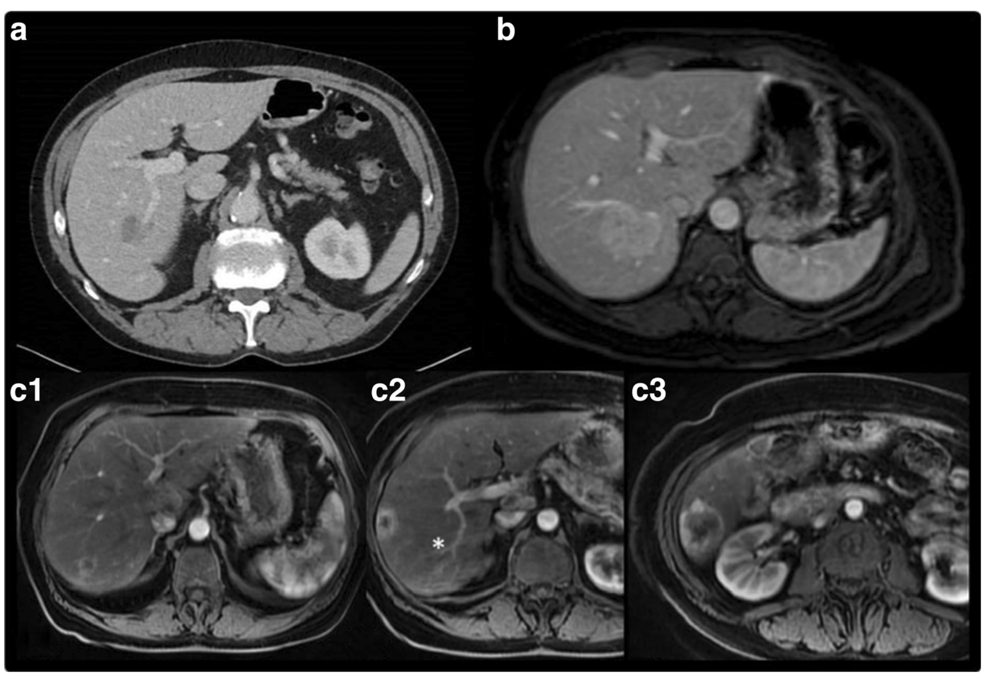

Fig. 4 Indications suitable for LRPS. **A**: lesions involving the right posterior sectoral pedicle. **B**. Large lesions involving segments 6 and 7. **C**. multiple lesions in the posterior sector in the same patient (C1, C2, C3). * indicates area of a vanishing colorectal liver metastasis (CRLM) after neoadjuvant chemotherapy. A LRPS was performed in order to resect all three visible lesions and the area of a vanishing CRLM

Table 2 Overview of current literature on laparoscopic right posterior sectionectomy

Author	No. of patients	Technique	Blood loss (mL)	Operative time (min)	Length of hospital stay (days)	Conversion	Complications
Cheng et al. [5]	13	1: 0 2: 0 3: 13 (intrahepatic Glissonean)	1500 (IQR, 300–1850)	381 (IQR, 302.5–489.5)	7 (IQR 6–19.5) (median)	3/13 all early in series	1 duodenal perforation 1 ascitic leakage 1 minor bile leak
Cho et al. [4]	24	Not, Glissonean approach in most patients	Not reported	567.4 ± 212.4	10.6 ± 4.8 (mean)	3/24, all early in series Insufficient tumor margin	1 fluid collection 1 biliary fistula
Siddiqi et al. [6]	29	1: 20 2: 4 3: 5	600 (100–2500)	240 (150–480)	5 (2–30) (mean)	2/29 One for liver bleeding One for IVC bleeding	Clavien-Dindo II: Urinary tract infection Vomiting Atrial fibrillation Pulmonary edema Pleural effusion Clavien-Dindo IIIb: Intraperitoneal bleeding
D'Hondt et al. (Current series)	18	1: 3 2: 2 3: 13	325 (IQR: 150–450)	162.5 (140–190)	6 (IQR 5–8) (median)	1/18 due to extensive adhesions between the liver and the diaphragm (redo surgery)	Clavien-Dindo II: Urinary tract infection Hypertension Clavien-Dindo IIIb: biliary leakage

Technique: 1: Intra operative ultra sound guided 2: Hilar 3: Glissonean IQR: interquartile range

Three different approaches for inflow control are proposed by the Southampton group when performing a LRPS [6]. These are ultrasound-guided resection, hilar dissection, and finally Rouvière's sulcus exploration (Fig. 5). In their series, the IOUS approach was the preferred approach. In the presented series, the majority of resections were performed using the Rouvière's sulcus exploration (Glissonean) approach (13/18). Rouvière's sulcus exploration is explained in detail in the methods section of this paper and demonstrated in the video-in-picture. Machado et al. recently published a 7-year observational study regarding laparoscopic Glissonean approach. They noted a shorter operative time, lower transfusion rates, less positive margins, less morbidity, and a shorter hospital stay [16].

The approach is influenced by the surgeon's preference but is also dictated by the localization of the lesion. Three IOUS-guided resections were performed due to an absent Rouvière's sulcus. In two patients, the tumor was in close proximity to the origin of the right portal pedicle, and a hilar approach was used. In the three IOUS approaches, blood loss was 650 ml, 800 ml, and 1500 ml respectively, representing the three cases with the highest amount

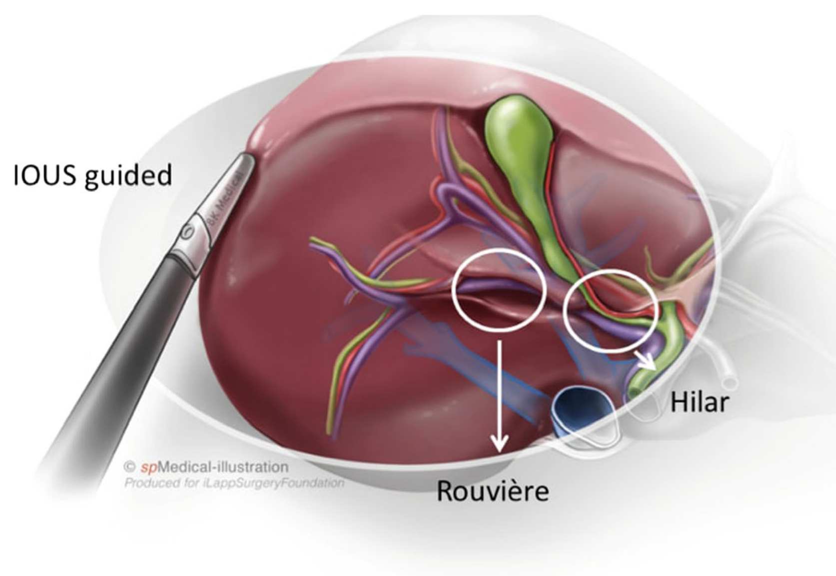

Fig. 5 Three different approaches for LRPS. Intraoperative ultrasound (IOUS)-guided approach without previous inflow control. Glissonean approach using the sulcus of Rouvière. Hilar approach which consists of a hilar dissection and identification of the right posterior sectoral pedicle

of blood loss in our series. In these cases, using the Pringle maneuver might have resulted in less blood loss and is something we now perform routinely during IOUS-guided LRPS.

To the authors' knowledge, three studies have reported on the feasibility and safety of LRPS (Table 2). With one major (Clavien-Dindo IIIb) and 2 minor complications, the data from our series is in line with other reported series.

Median blood loss was 325 ml in this series. Two patients required postoperative blood transfusion. One of the complexities of the laparoscopic approach for lesions in the right posterior sector lies in its difficulty in obtaining bleeding control. Different strategies are available. Inflow control and a Pringle maneuver may impact blood loss from the portal structures. In addition to inflow control, hypovolemic phlebotomy and placing the patient in semiprone position may reduce blood loss from the hepatic veins [11]. The advantages of positioning the patient in semiprone instead of supine position have been well described by several groups including our own experience [10, 25, 32, 33]. By placing the patient in the semiprone position, a maximum amount of space is created between the right subphrenic region, creating extra working space. In this position, the right hepatic vein is also in a higher level than the inferior vena cava, which also reduces the risk of bleeding from the right hepatic vein in LLR in the posterior segments [33]. Ensuring an R0 resection remains of the utmost importance. In our series, all patients had negative resection margins. These results compare favorably to the literature. In the study of Cho and colleagues, there were three conversions (3/24; 12.5%) due to inadequate tumor-free margin. These patients were treated at the beginning of their laparoscopic experience, highlighting the importance of gaining skills and experience.

Evidently, more studies are needed to analyze the potential benefits of minimally invasive surgery compared to open liver surgery. Currently, the international multi-center ORANGE Segments trial (NCT03270917) is randomizing patients between laparoscopic or open parenchymal preserving posterosuperior liver segment resection, with time to functional recovery as a primary outcome.

Conclusion

The results of our experience add weight to the feasibility and safety of this approach. However, LRPS is a technically demanding procedure and these minimal invasive resections should be performed by HPB surgeons who accumulated considerable experience with other minor resections. Several surgical techniques can be used to facilitate LRPS as shown in this paper.

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Authors' contributions MD participated in the study conception and design. MD, SO, and MV participated in the analysis and interpretation of data. All authors participated in the acquisition of data, drafting of the manuscript, and critical revision of the manuscript.

Compliance with ethical standards

This article was written in accordance with the ethical standards of the institutional review board and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent was obtained from all human subjects as is the standard of care and as with compliance with institution guidelines.

Conflicts of interest The authors declare that they have no conflict of interest.

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