Original Article

Extended laparoscopic liver resection: initial experience and review of the literature

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Background: Laparoscopic extended liver resections have been limited to very few centers with only few cases reported so far. The aim with this study was to perform a comprehensive analysis of our experience with extended laparoscopic liver surgery using a prospective database.

Methods: In this study, consecutive patients undergoing extended laparoscopic liver surgery by this team between 2007 and 2016 were studied. The primary endpoint was safety of the procedure. Secondary endpoints were conversion rates, operative times, blood loss, need for transfusions, and hospital length of stay.

Results: Between 2007 and 2016, 23 extended laparoscopic liver resections were performed at our institution. Of these, 12 (52%) were performed as a second stage in a staged liver resection and 11 (48%) were performed during one-stage resection with or without preoperative portal vein embolization. There were 13 women and 10 men with mean age of 56.3 years old [22–73]. The main indication for liver resection was colorectal liver metastases. Two patients required conversion to open surgery, one due to hemorrhage and one due to technical difficulties. Blood loss was significant in 6 patients with need for transfusion. The mean operative time was 245 minutes. Median hospital stay was 7 days. Significant complications occurred in six patients (26.1%). No 90-day mortality was observed.

Conclusions: This observational study shows that laparoscopic extended liver resections are safe and feasible. Adequate analysis of quality and volume of the future liver remnant (FLR) is essential. Complications, operative times, hospital stay and blood loss were comparable to open extended liver resections.

Keywords: Liver resection; laparoscopic; technique; trisectionectomy

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Introduction

The number of liver resections performed by minimally invasive approach has increased significantly in recent year (1-7). Laparoscopic extended liver resections have been limited to very few centers with only few reported papers so far (7-15).

The estimated number of minimally invasive extended liver resections, including pure laparoscopic, laparoscopic-assisted and robotic-assisted is 35 cases. Duplicated cases whenever identified were excluded (9,10,15).

The objective of this study is to perform a comprehensive analysis of our experience with extended laparoscopic liver surgery, with emphasis in the safety and feasibility.

Methods

All patients undergoing liver resection from a prospective database at our institution were analyzed. The prospective

database and the retrospective study were approved by our institutional review board and patient consent was waived due to anonymization of data in the database and its retrospective character. Patients submitted to extended laparoscopic liver surgery between 2007 and December 2016 were object of the present study. Future liver remnant (FLR) assessment was performed by either CT or MRI volumetry. Patients with insufficient FLR were submitted to preoperative portal vein embolization. In cases of bilateral disease and/or extremely small FLR, two-stage liver resection was performed.

Surgical technique

In all cases, the technique employed was the intrahepatic Glissonian approach, except two patients with intrahepatic cholangiocarcinoma with hilar extension that needed dissection of the portal triad at the level of the hepatic hilum and Roux-en-Y hepaticojejunostomy. The technique used in the majority of the patients is described below.

Right extended liver resection

Operation begins with examination of the abdominal cavity followed by intraoperative ultrasound. Patient is operated on in supine position with legs spread apart, with the surgeon placed between the patient's legs. Usually four or five trocars are necessary. For the control of the right pedicle, we use the intrahepatic Glissonian approach as previously described. Briefly, two tiny liver incisions are performed following specific anatomical landmarks (16,17). The first at the level of the hilum, and another is done in the transition zone between segments 7 and 1. A clamp is introduced through these incisions and its closure will result in ischemic discoloration of the right liver. The clamp is substituted by an endoscopic stapler (*Figure 1A*) and the right pedicle is completely partitioned (*Figure 1B*). Once this is performed, the pedicle from segment 4 is divided by inserting a stapler between two new incisions (*Figure 1C*); one above the hilum to the left and another on the right margin of the round ligament (*Figure 1D*), as previously reported (18,19). This maneuver will complete the inflow control to proceed with extended right hepatectomy (*Figure 1E*). The line of future transection is marked with cautery and parenchymal division is performed (*Figure 1F*).

Left extended liver resection

The main steps are the same as described for right extended hepatectomies. However the intrahepatic accesses for Glissonian pedicles for left extended hepatectomy are different and have already been described elsewhere (17,19). In brief, a tiny incision is made above the ligament of Arantius and another is performed above the hilum to the left (*Figure 2A*). Temporary insertion of a vascular clamp through these incisions (*Figure 2B*) will confirm control of the left liver Glissonian pedicle (segment 1 is spared). The left pedicle is then divided with stapler. To complete the inflow control for extended left hepatectomy, right anterior section (segments 5 and 8) pedicle needs to be divided. This can be achieved with two incisions, one above the hilum, and another on the right edge of the gallbladder bed (*Figure 2C*), as previously described (17). The pedicle is divided by stapler (*Figure 2D*) resulting in complete control of the inflow control for extended left hepatectomy (*Figure 2E*). Liver is transected as usual (*Figure 2F*).

Variables

Safety was assessed as the occurrence of complications and 90-day mortality. Feasibility was assessed by conversion rate, operative time, blood loss, need for transfusions, and hospital length of stay. The data was prospectively registered by the surgical team. Pathology reports were also reviewed.

Results

Between 2007 and 2016, 23 extended laparoscopic liver resections were performed. Twelve (52%) as a second stage in a staged liver resection and 11 (48%) were performed during one-stage resection with or without preoperative portal vein embolization. There were 13 women and 10 men with mean age of 56.3 years [22–73]. The main indication for liver resection was colorectal liver metastases (15 patients), cholangiocarcinoma (5 patients), hemangioendothelioma (2 patients) and one patient with angiomyolipoma. The latter patient was object of a previous publication (11). No patient presented cirrhotic liver but all colorectal patients' undergone preoperative systemic chemotherapy.

Two patients needed conversion to open surgery, one due to hemorrhage and one due to technical difficulties. Blood loss was significant in 6 patients with need for transfusion. The mean operative time was 245 minutes. One patient operated on for malignant disease presented with positive margins. Median hospital stay was 7 days.

Significant complications occurred in six patients

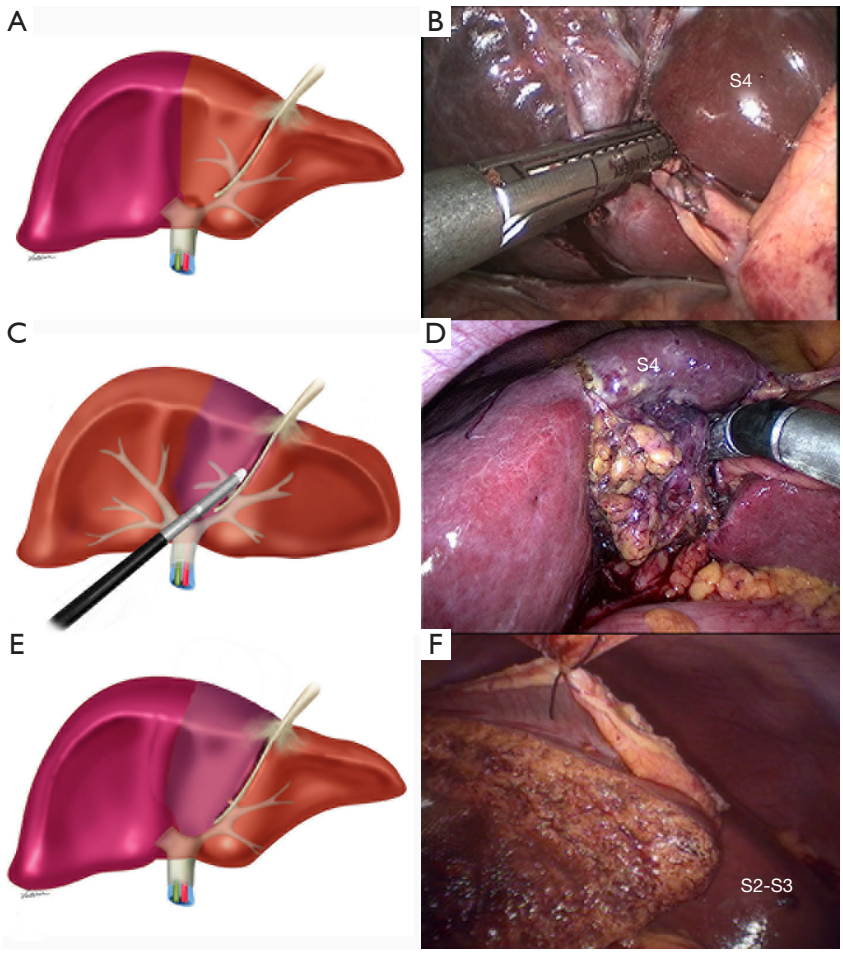

Figure 1 Main steps for laparoscopic extended right hepatectomy using the Glissonian approach. (A) Schematic drawing: intrahepatic Glissonian access of the main right pedicle results in ischemic discoloration of the right liver; (B) intraoperative view: a stapler is introduced through anatomical landmarks and the right pedicle is completely partitioned; (C) schematic drawing: pedicle from segment 4 is controlled by two new incisions; (D) intraoperative view: a stapler is introduced through these incisions and the pedicle from segment 4 (S2–S3) is divided; (E) schematic drawing: inflow control for extended right hepatectomy is completed; (F) intraoperative view: laparoscopic extended right hepatectomy is completed. Future liver remnant consists in segments 2 and 3 (S2–S3).

(26.1%). Three patients developed liver failure, two had infectious complications and one patient developed limited biliary fistula. No 90-day mortality was observed.

Discussion

Extended liver resections are rarely performed by laparoscopy (8-15). There are very few centers performing this operation in the literature. The main reason is that whenever a patient needs such a large liver resection the laparoscopic approach is seldom considered. However, high volume centers with experience in laparoscopic liver resection are performing this complex operation with excellent results.

The number of minimally invasive liver resections is rapidly increasing with more than 9,500 cases performed worldwide (20). The proportion of surgeries being done for malignancies has increased from 50% at the time of the first international consensus to 65% currently after the second international consensus (21). The total number of cases has rapidly increased from 2,804 to more than 9,500, according to a recent review (20).

In the present study, we share our experience and lessons learned with the performing of laparoscopic extended liver

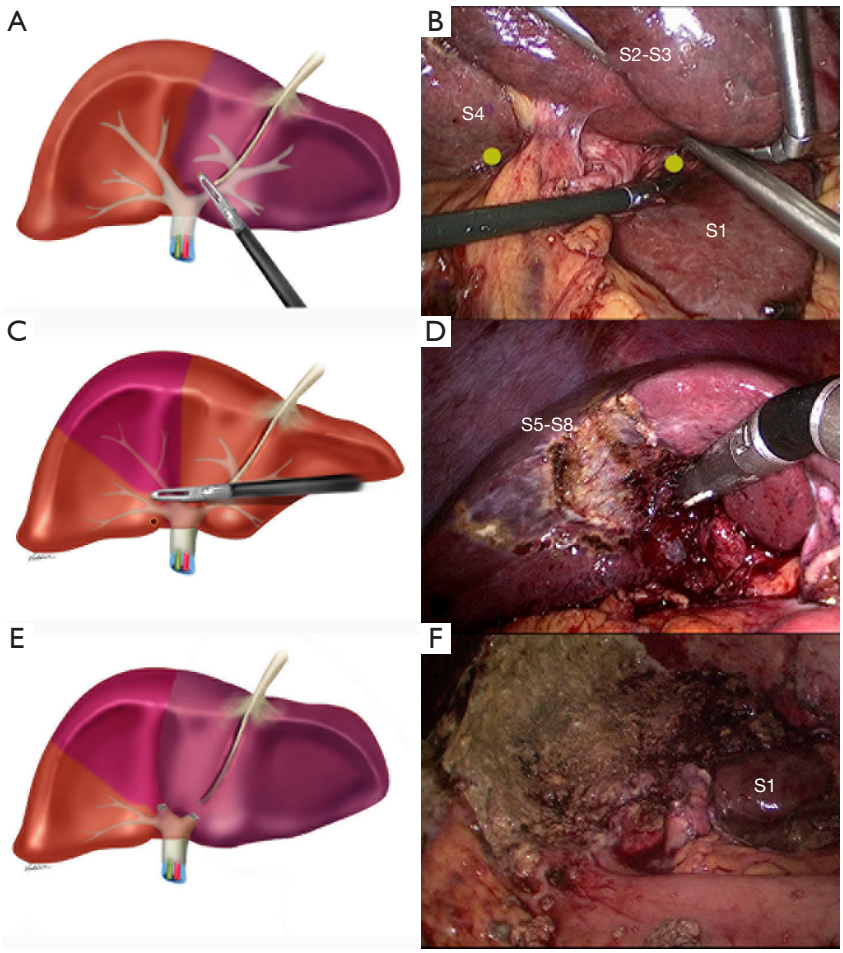

Figure 2 Main steps for laparoscopic extended left hepatectomy using the Glissonian approach. (A) Schematic drawing: intrahepatic Glissonian access of the main left pedicle results in ischemic discoloration of the left liver; (B) intraoperative view: landmarks used for control of the main left pedicle are show (yellow spheres). Segment 1 (S1) is spared; (C) schematic drawing: pedicle from right anterior pedicle, segments 5 and 8 (S5–S8) is controlled by two new incisions; (D) intraoperative view: a stapler is introduced through these incisions and the right anterior pedicle (S2–S3) is divided; (E) schematic drawing: inflow control for extended left hepatectomy is completed; (F) intraoperative view: laparoscopic extended left hepatectomy is completed. Future liver remnant consists in segments 6 and 7 (along S1).

resection. The main concern with this type of operation is indeed with the FLR. Another issue is the quality of the liver, once prolonged chemotherapy or underlined liver disease may compromise the safety of this operation. FLR should be precisely calculated with preoperative imaging. In the majority of cases, portal vein embolization or two-stage operations are valid strategies to supersede low FLRs.

In our experience, the use of the Glissonian approach was helpful in all cases where the tumor was not close to the hilar plate that warrants complete dissection of hilar elements. This situation was present in two of our cases; both of them were intrahepatic cholangiocarcinomas with invasion of the hilar plate and needed hepaticojejunostomy. This situation requires the same approach as for hilar cholangiocarcinoma (13,14). In all other cases, ischemic delineation after control of the Glissonian pedicles facilitated the correct identification of the future line of transection which is the main difficulty in such cases.

Despite the lack of randomized controlled trials, there is enough evidence to confirm the safety of laparoscopic liver surgery in selected patients (20). Non-anatomic wedge and left lateral resections are now considered standard in several

centers, including ours.

Although laparoscopic hemihepatectomies have been performed by our team since the beginning of our experience (22), minimally invasive left and right hepatectomies are still performed by a limited number of centers worldwide.

Meta-analysis of studies comparing laparoscopic to open liver surgery shows that laparoscopy is associated with less complications, less blood loss, less transfusions, less hospital stay, equivalent operative time and equivalent resection margins (23). However, most studies combine major and minor liver resections and there is still a debate whether laparoscopic major liver resection would have the same results and outcomes if studied separately.

Laparoscopic extended hepatectomies have been limited to very few centers and there still no clearly statement in the literature. During the second international consensus of laparoscopic liver surgery in Morioka (3), extended liver resection was not thoroughly discussed due to scarce literature and requires further evaluation and caution. To date, we found few studies mentioning extended liver resections, in a total of 35 cases. Adding 22 new cases from our center, we have now 57 cases in the literature so far.

Our initial experience with 23 patients showed that extended liver resections can be safely performed by laparoscopy if quality and volume of the FLR is adequately studied. Three patients presented with some degree of liver failure while one of them had a severe liver failure with full recovery after 10 days. These three patients were not submitted to preoperative portal vein embolization and retrospective analysis of the liver remnant showed that the future liver volume was overestimated in two of them and the quality of the liver was not well assessed in one of them (prolonged chemotherapy). Other complications were related to the liver resection per se and were not influenced by the degree of liver parenchyma removed.

Conclusions

In summary, this study shows that laparoscopic extended liver resections are safe and feasible. Adequate analysis of quality and volume of the FLR is of paramount importance and some patients may benefit from portal vein occlusion. Although these results could be related to increased expertize in laparoscopic liver resections, we observed complications, operative times, hospital stay and blood loss comparable to open extended liver resections.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The prospective database and the retrospective study were approved by our institutional review board and patient consent was waived due to anonymization of data in the database and its retrospective character.

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