Cohort Study

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Laparoscopic anatomical segmentectomy: A paradigm shift towards minimally invasive liver surgery in Nepal: A cohort study

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Introduction: Laparoscopic liver resection is taking stride in slowly replacing open surgeries for various hepatic pathologies in many developed countries. However, due to high cost and lack of expertise, there are only a handful of centres in the low-medium income countries who perform advanced laparoscopic liver resections regularly. In this study, a prospective analysis was carried out to assess and report the outcomes of laparoscopic anatomical segmentectomy (LAS) from a single centre in Nepal.

Methods: The clinical data of all patients who underwent LAS between 1 October 2021 to 30 September 2022 were prospectively recorded. Demographics, pathological diagnoses, types of resections performed, perioperative parameters, postoperative length of stay, postoperative complications data and IWATE score were collected and analyzed. All operations were performed using the extrahepatic Glissonean technique with the use of indocyanine green dye as an adjunct during the intraoperative period.

Results: In the study period, a total of 16 LAS were performed in our centre for various indications. The mean age of the patients in the series was 41.6 years, and seven of 16 patients were male. The majority of the cases were segment 2/3 resection indicated for various pathologies and segment 4b/5 indicated for carcinoma gallbladder. The median hospital stay was 6 days and only two cases developed major complication. There were no mortalities in our series.

Conclusions: Taking into account the results produced from a single centre in a low-medium income country, laparoscopic anatomical segmentectomy is technically feasible with an acceptable safety profile.

Keywords: indocyanine green, IWATE criteria, laparoscopy, minimally invasive surgery, segmentectomy

Introduction

Laparoscopic surgery has rapidly progressed and expanded worldwide since the 1980s, becoming the standard treatment approach for several indications across many surgical specialties. However, over the years, due to various technical issues, minimally invasive surgery for liver pathologies has been less frequently performed than minimally invasive surgeries for other gastrointestinal pathologies[1]. Moreover, in Nepal, due to limited access to advanced laparoscopic instruments and a lack of expertise, laparoscopic liver resections are performed in limited numbers in only a few centres, including ours. With the acquirement of advanced laparoscopic instruments and training in advanced laparoscopic liver surgery, laparoscopic anatomical segmentectomy (LAS) is now frequently performed in our centre for various indications. The advantages of LAS include reduced intraoperative blood loss, decreased need for postoperative analgesia, faster functional recovery, shorter postoperative hospital stay, decreased risk of wound infections, better cosmetic outcome and lower chance of incisional hernia[2]. Nonetheless, LAS remains challenging as it requires the surgeon to be well-versed in the detailed anatomy of the liver and proficient with advanced laparoscopic skills[3]. This study aims to present the early experience of laparoscopic

HIGHLIGHTS

- The intraoperative localization of tumours and the demarcation of liver segments to identify the transection line are both possible using indocyanine green (ICG) with the near-infra-red light.
- The literature is slowly beginning to address these benefits of using ICG in laparoscopic liver resection.
- Laparoscopic anatomical segmentectomy is safe and technically feasible.
- Excellent postoperative results can be achieved with the use of ICG and adequate training in liver anatomy.

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anatomical segmentectomy at our institution in a lower-middle-income country.

Methods

This study is a hospital-based prospective observational study conducted in the capital of Nepal, from 1 October 2021 to 30 September 2022. Written consent was obtained from all the participants, and confidentiality of information was maintained throughout the study. Ethical clearance for the study was obtained from the institutional review board, and the study was conducted abiding by the declaration of Helsinki. The same team of experienced hepato-biliary surgeons performed all liver resections. The work has been reported in line with the STROCSS criteria[4].

Patient selection

All patients with an indication for LAS between 1 October 2021, and 30 September 2022, were included in the study. The surgical indication was established before the surgery by the consultant surgeon. Patients were excluded from the study when they did not undergo the resection due to any reason or when the laparoscopic procedure was converted to an open. The enhanced recovery after surgery protocol[5] was employed in all patients.

Variables

The outcomes of the laparoscopic liver resection are categorized according to the IWATE difficulty criteria[6]. The 12 difficulty levels of resection are divided into four categories as low (0–3), intermediate (4–6), advanced (7–9) and expert-level difficulty (10–12). The total score was the sum of six difficulty indices, including (1) tumour location (score, 1–5); (2) extent of hepatic resection (score, 0–4); (3) tumour size (score, 0 or 1); (4) proximity to a major vessel (score, 0 or 1); (5) liver function (score, 0 or 1) and (6) HALS/hybrid (score, 0 or – 1). Postoperative complications were recorded and described according to the Clavien–Dindo classification[7].

Surgical technique

All laparoscopic resections were performed under carbon dioxide pneumoperitoneum maintained at an intra-abdominal pressure between 12 and 16 mmHg. The camera port was created at the right midclavicular line, and four to five instrument ports were utilized as required. The patients were positioned in a 30° reverse-Trendelenburg position during resection. After isolating and clamping the pedicle of the segment to be resected, indocyanine green (ICG) dye at a dose of 0.5 mg/kg was administered intravenously to delineate the hepatic segment. A harmonic scalpel© and bipolar device were used for parenchymal transection, and all segmentectomies and sectionectomies were performed via the extra-glissonian approach[8]. The hepatic vein was divided using a vascular stapler when required. An endo-bag (locally made using sterile gloves) was used to extract the surgical specimen, either through a suprapubic horizontal Pfannenstiel incision or an extended umbilical port. All ports larger than 5 mm were closed using 1-0 polyglactin 910 suture.

Statistical analysis

Descriptive statistics are presented as the mean or median for a continuous variable, and categorical variables are presented as frequency. All the statistical analyses were performed using SPSS 21 (Version 21.0. IBM Corp.).

Results

From 1 October 2021 to 30 September 2022, 16 laparoscopic anatomical segmentectomies were performed for various indications. The mean age of the patients in the series was 41.6 years, and seven of 16 patients were male. All patients were Child-Pugh grade A except one patient with Hepatocellular carcinoma in the background of hepatitis B who was Child-Pugh grade B. The types of resection performed were classified according to Brisbane terminology[9]. The anatomic liver resection was standardized using the extrahepatic Glissonean pedicle isolation, as described by Sugioka A *et al*.[10] The type of resection, the indication of surgery, and the number of patients is shown in Table 1.

The difficulty of laparoscopic liver resection in our series based on IWATE criteria and its correlation with the liver segment resected is shown in Table 2. *Segment 2/3* was noted to have the lowest difficulty score, whereas *segment 7* resection had the highest difficulty score in our series.

The median postoperative hospital stay was 6 days and ranged from 4 to 11 days. Fourteen patients developed Clavien–Dindo grade 1 and 2 complications, and two had grade 3 and 4 complications. The two patients with grade 3 and 4 complications had undergone right posterior sectionectomy and segment 7 resection. There were no mortalities in our series (Table 3). Perioperative images have been shown in Figures 1-4.

Discussion

In our series, we performed 16 laparoscopic anatomical segmentectomies or sectionectomies over 1 year with an acceptable outcome. Patient safety was prioritized with a low threshold for conversion to open surgery, especially when encountering difficult dissection or uncontrolled bleeding. The most commonly performed resection was a left lateral sectionectomy (segments 2/3) with the lowest IWATE difficulty score. Laparoscopic left lateral segmentectomy is technically less challenging than the resection of other segments, and its safety and feasibility have been well established[11]. Four out of 16 LAS were performed for suspected

Table 1

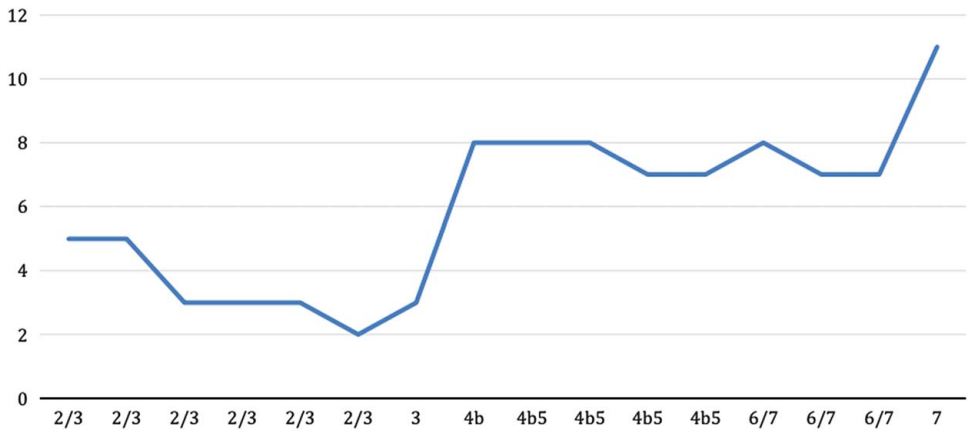
Indications for laparoscopic anatomical segmentectomy.

Segment/s resected	Indication	No. patients	Total
Segments 2 and 3	1. Hepatolithiasis	3	6
	2. HCC	2	
	3. Atypical hemangioma	1	
Segment 3	Colorectal metastasis	1	1
Segments 4b and 5	Carcinoma gallbladder (T1b ,T2)	3	4
	Xanthogranulomatous cholecystitis	1	
Segment 4b	Focal nodular hyperplasia	1	1
Segments 6 and 7	Biliary cystadenoma	1	3
	Hydatid cyst	2	
Segment 7	Colorectal metastasis	1	1

HCC, Hepatocellular carcinoma.

Table 2

Correlation of IWATE Score with the resected liver segment; *X*-Axis: anatomical segment, *Y*-Axis: IWATE difficulty scores



carcinoma gallbladder, one of which was later diagnosed as xanthogranulomatous gallbladder on histopathological examination. Carcinoma gallbladder has been a controversial subject in minimally invasive surgery due to its potential complication of port site recurrence, cancer dissemination due to bile spillage, and due to concerns about the overall safety of liver resection[12]. However, recent studies have shown favourable outcomes of laparoscopic surgery for gallbladder cancer. In a study by Jang and colleagues, overall survival of T2-stage gallbladder carcinoma between laparoscopic and open groups was comparable[13]. Moreover, the disease-free survival was significantly higher in the laparoscopic group (at 5 years of laparoscopic surgery vs. open surgery: 78% vs. 62.4%; $P = 0.0171$). There were no cases of port site recurrence in the laparoscopic surgery group[14]. Similarly, Agarwal and colleagues and Itano and colleagues retrospectively compared outcomes of laparoscopic and open radical cholecystectomy, showing no significant difference in postoperative morbidity, mortality, number of lymph nodes collected and recurrence rate[15,16].

Two hepatic hydatid cysts were managed with right posterior sectionectomy in our series. Although not a first choice of treatment for hydatid cysts, we undertook resection for these cases, as clinical features and imaging were not conclusive, they were completely intrahepatic, and the possibility of biliary cystadenoma/cystadenocarcinoma could not be ruled out. To deal with hydatid scolexes, we immediately suctioned any hydatid spillage and 3% saline-soaked gauze was used to any suspected spill sites.As per the WHO protocol, these patients also received oral Albendazole.

Table 3

Morbidity classified as per the Clavien–Dindo grading

Morbidity (Clavien–Dindo Grading)	Number
Grade 1 and grade 2	14
Grade 3 and grade 4	2
Grade 5	0

Similarly, two cases of Hepatocellular carcinoma underwent LAS in our series, which carried a considerable challenge as they were present in the background of liver cirrhosis secondary to hepatitis B. However, because of smaller incisions, the laparoscopic approach results in minimal disruption of the collateral circulation in the abdominal wall, decreased blood loss and lesser fluid shifts from exposure to the peritoneal cavity, thereby decreasing the chances of decompensation[17]. There was no post-hepatectomy liver failure in our series. Of note, ICG dye was extensively used as an adjunct during all the cases in our series. The ICG dye, in conjunction with near infra-red light, was used for intraoperative tumour localization, demarcation of liver segments to visualize transection line, intraoperative cholangiography and detection of bile leak from the raw surface of the liver. These advantages of using ICG in laparoscopic liver resection are slowly emerging in the literature[2,18].

We analyzed the postoperative outcomes of liver resection as per the 4-level IWATE criteria difficulties. The IWATE Criteria was proposed at the second international consensus conference

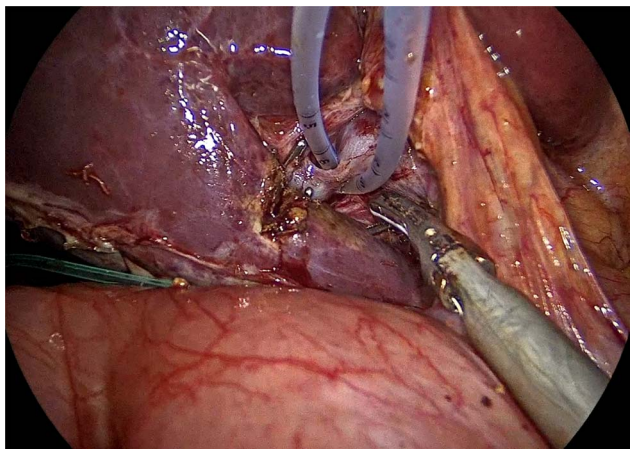


Figure 1. Right posterior pedicle isolated and slinged.

Figure 2. Right posterior section demarcation in NIR light after ICG administration. ICG, indocyanine green; NIR, near-infrared.

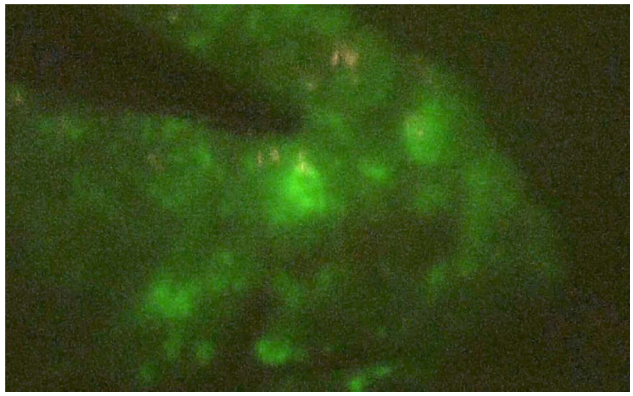


Figure 4. HCC in left lateral segment under near-infrared light with ICG (ICG retention). ICG, indocyanine green; HCC, Hepatocellular carcinoma.

on laparoscopic liver resections in 2014 and is a proposed classification system for assessing the surgical difficulty of laparoscopic liver resection. In our series, we noted grade 3 and 4 complications occurring more frequently in patients with higher IWATE scores.

In our study, 14 patients developed Clavien–Dindo grade 1 and 2 complications, of which superficial port site infections was noted in eight patients and was managed with proper wound care, urinary tract infections in two patients and chest infections in four patients managed medically. Two patients had grade 3 and 4 complications wherein intra-abdominal collections were noted and image guided pigtail catheter drain was placed. Finally, in a low-medium income country like Nepal, the cost factor is the Achilles heel for further development and dissemination of advanced laparoscopic surgery and more so the laparoscopic liver resections. The use of advanced energy devices such as ultrasonic dissectors and bipolar forceps, along with the requirement of laparoscopic endo-staplers for vascular division in some instances, adds to the brunt of the cost to the patients. However, early recovery and decreased postoperative stay following laparoscopic liver resection may justify this price for some individuals.

The present study yields several inherent limitations related to its small sample size in a single centre, and a larger cohort of patients is required to consolidate these findings. Nevertheless, to our knowledge, this study is the first to underscore the feasibility and safety of laparoscopic anatomical segmentectomy in a low-medium income country. Moreover, this study also highlights the advantages of using the ICG dye to improve the outcomes of LAS.

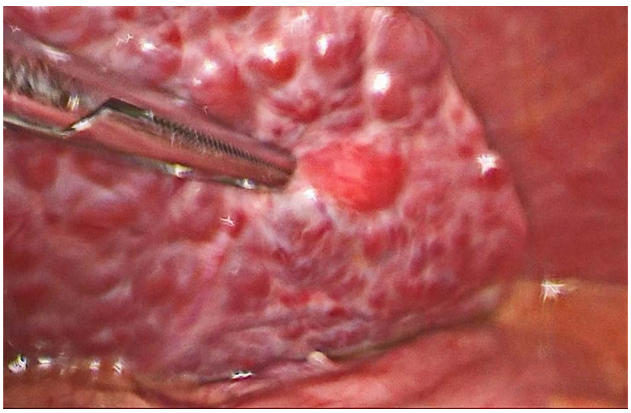


Figure 3. HCC in left lateral segment under white light (background liver cirrhotic). HCC, Hepatocellular carcinoma.

Conclusion

Laparoscopic anatomical segmentectomy is a technically challenging surgery. However, with adequate training, detailed knowledge of liver anatomy and the use of ICG, it is safe and feasible, yielding excellent postoperative outcomes.

Ethical approval

Obtained from the institutional ethics committee.

Consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal.

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None.

Author contribution

All authors contributed in collection and analysis of data, drafting and revising the paper, gave final approval of the version to be published and agree to be accountable for all aspects of the work.

Conflicts of interest disclosure

The authors declare no conflicts of interest pertaining to this work.

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References

[1] Kelley WE. The evolution of laparoscopy and the revolution in surgery in the decade of the 1990s. JSLS 2008;12:351–7.

[2] Urade T, Sawa H, Iwatani Y, *et al*. Laparoscopic anatomical liver resection using indocyanine green fluorescence imaging. Asian J Surg 2020;43:362–8.

[3] Schmelzle M, Krenzien F, Schöning W, *et al*. Laparoscopic liver resection: indications, limitations, and economic aspects. Langenbecks Arch Surg 2020;405:725–35.

[4] Mathew G, Agha R, Albrecht J, *et al*. STROCSS 2021: Strengthening the reporting of cohort, cross-sectional and case-control studies in surgery. Int J Surg 2021;96:106165.

[5] Melloul E, Hübner M, Scott M, *et al*. Guidelines for perioperative care for liver surgery: enhanced recovery after surgery (ERAS) society recommendations. World J Surg 2016;40:2425–40.

[6] Tanaka S, Kawaguchi Y, Kubo S, *et al*. Validation of index-based IWATE criteria as an improved difficulty scoring system for laparoscopic liver resection. Surgery 2019;165:731–40.

[7] Clavien PA, Barkun J, de Oliveira ML, *et al*. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 2009;250:187–96.

[8] Ahn KS, Han H-S, Yoon Y-S, *et al*. Laparoscopic anatomical S5 segmentectomy by the glissonian approach. J Laparoendosc Adv Surg Tech 2011;21:345–8.

[9] Strasberg SM, Belghiti J, Clavien P-A, *et al*. The Brisbane 2000 Terminology of Liver Anatomy and Resections. HPB 2000;2:333–9.

[10] Sugioka A, Kato Y, Tanahashi Y. Systematic extrahepatic Glissonean pedicle isolation for anatomical liver resection based on Laennec's capsule: proposal of a novel comprehensive surgical anatomy of the liver. J Hepatobiliary Pancreat Sci 2017;24:17–23.

[11] Sugawara T, Hashimoto M, Shindoh J. Laparoscopic left lateral sectionectomy: a three-port method. J Min Access Surg 2020;16:220.

[12] Vega EA, Sanhueza M, Viñuela E. Minimally invasive surgery for gallbladder cancer. Surg Oncol Clin North Am 2019;28:243–53.

[13] Choi YJ, Byun Y, Kang JS, *et al*. Comparison of clinical outcomes of borderline resectable pancreatic cancer according to the neoadjuvant chemo-regimens: Gemcitabine versus FOLFIRINOX. Gut Liver 2021;15:466–75.

[14] Jang JY, Han H-S, Yoon Y-S, *et al*. Retrospective comparison of outcomes of laparoscopic and open surgery for T2 gallbladder cancer—Thirteen-year experience. Surg Oncol 2019;29:142–7.

[15] Agarwal AK, Javed A, Kalayarasan R, *et al*. Minimally invasive versus the conventional open surgical approach of a radical cholecystectomy for gallbladder cancer: a retrospective comparative study. HPB 2015;17:536–41.

[16] Itano O, Oshima G, Minagawa T, *et al*. Novel strategy for laparoscopic treatment of pT2 gallbladder carcinoma. Surg Endosc 2015;29:3600–7.

[17] Kilburn DJ, Leung U, Cavallucci DJ, *et al*. Laparoscopic resection of hepatocellular carcinoma in patients with and without cirrhosis: the Brisbane experience. HR 2016;2:264.

[18] Rossi G, Tarasconi A, Baiocchi G, *et al*. Fluorescence guided surgery in liver tumors: applications and advantages. Acta Bio Medica Atenei Parmensis 2018;89:135–40.