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Laparoscopic Liver Resection: A Journey from Strength to Strength

Ye Xin Koh[1], Ser Yee Lee[1,2], Goh Kim Poh, Brian[1,2], Chung Yip Chan[1,2]

[1]*Department of Hepatopancreatobiliary and Transplant Surgery, Singapore General Hospital,*
[2]*Duke-NUS Medical School, Singapore*

1. Overview/epidemiology of PNEN

Laparoscopic liver resection (LLR) is a relatively new surgical technique that has gradually evolved and improved over the years. The indications and volume of LLR have grown steadily, with almost 10,000 reported cases worldwide.[1] In, 2008, an international consensus meeting in Louisville considered laparoscopic approach as the standard of care for left lateral sectionectomies and indications included small lesions in the anterolateral segments of the liver.[2] This was followed by the 2014 Morioka international consensus meeting which concluded that laparoscopic surgery is the standard of care for minor liver resections but laparoscopic major liver resection still in the explorative phase.[3] Recently, this group of LLR pioneers and thought leaders in the field have organized and formed the International Laparoscopic Liver Society (ILLS) with the objectives to facilitate worldwide collaboration, the training and education of laparoscopic liver resection.[4]

Indeed, laparoscopic liver resection has progressed from strength to strength as a result of the enterprise and perseverance of hepatobilary surgeons worldwide.[4] Its application in liver surgery has been shown in several studies to confer the perioperative benefits such as lower postoperative morbidity, less blood loss, shorter hospitalization.[1-5] The initial concerns of tumor dissemination and adverse oncological outcomes were not substantiated. Several large propensity matched studies showed that oncological outcomes after laparoscopic resection for colorectal liver metastases and hepatocellular carcinomas were not different from that of open resection.[6-8]

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Corresponding author: Ser Yee Lee, MD
Department of Hepatopancreatobiliary and Transplant Surgery, Singapore General Hospital, The Academia, 20 College Road Singapore 169856
Tel: +65-63265564, Fax: +65-6220932365-6326
E-mail: lee.ser.yee@singhealth.com.sg

In the earlier stages, laparoscopic liver surgery began with resection for smaller tumors in more accessible peripheral locations and progressed to its current state where deep-seated lesions in difficult locations and/or close to major vascular structures requiring major hepatectomies are being safely performed in expert tertiary centers.[9-11] Laparoscopic surgery should be approached with caution for complex and major resections because control of bleeding and compromise of margins during the surgery remains a challenge in these cases. The benefits of laparoscopic liver surgery include improved visuals with the laparoscope, reduction of hepatic venous bleeding with the pneumoperitoneum and less post-operative ascites.[12] The surgeons should be adroit with advanced laparoscopic hemostasis and be vigilant during dissection in difficult areas. Indeed, laparoscopic liver resection remains a continual challenge as we endeavor to extend its indications without compromising patient safety.

The recent international laparoscopic liver resection consensus meeting has made two important recommendations to ensure the continued safety of LLR, (1) a difficulty score for laparoscopic liver resection (2) an established training and education structure.

Laparoscopic liver resection presents new challenges, it is a significant change from open liver surgery, requiring the acquisition of a unique set of skills and techniques due to the different approaches and perspectives of the same procedure. Although the complexity of laparoscopic liver resection is well recognized, there remains a significant gap in stratifying the level of difficulty of a particular LLR procedure objectively. The traditional measures of complexity in open surgery do not correlate well with the technical difficulty of laparoscopic liver resection for the same procedure.[3,12] A laparoscopic liver resection difficulty score was proposed in 2014.[13] This difficulty score was based on 86 patients who had a pure LLR. The degree of difficulty was assessed by the operator using a score of 1-10 and translated to 3 levels of difficulty (low, intermediate and high). The concordance between the operators' and reviewers' assessments of difficulty was based on inter-rater agreement calculations. Several preoperative variables comprising of the extent of the planned procedure, degree of liver cirrhosis, tumor's size, location and its proximity to major vessels were weighted and incorporated into a scoring system in an attempt to objectively quantify the difficulty of the planned procedure. This difficulty score correlated well with surrogates of difficulty as such blood loss and operative time.[12,14,15]

The traditional Brisbane definition of major and minor liver resections was based on open liver surgery and its significance to the assessment of the level of complexity to LLR is limited. To illustrate the point, laparoscopic surgery for lesions located in the posterosuperior segments necessitating posterior sectionectomy or non-anatomic resections of segments 7 and 8 tumors are technically challenging because these transection planes are difficult to establish laparoscopically, and the limited view needs to be overcome with angled or flexible laparoscopes.[16,17] These LLR procedures are increasingly performed and accepted as major and complex hepatectomies due to the technical complexity, despite not fulfilling the Brisbane definition of major hepatectomy. Many LLR experts around the world also hold this view.[13,14,21] Lee and Strasberg et al. reported a perceived complexity score for open liver resection based on a survey of 66 experts worldwide. In this survey, the open liver resection complexity score of a right posterior sectionectomy is perceived to be between 5-6 on a score of 1-10 (10 being the most complex). In contrast, a laparoscopic right posterior sectionectomy will be at least a 9 on a score of 1-12 on the LDS.[18,19] This is also reflected by our own experience with LLR for left lateral sectionectomies, we have shown it to be a safe and feasible procedure, and when compared to open surgery were less likely to require Pringle's maneuver and had a shorter hospitalization period.[20] In our experience with LLR for posterosuperior segment lesions, we showed that there was a higher open conversion rate and longer operative time in LLR for posterosuperior segments compared to anterolateral lesions congruent with the difficulty of LLR for posterosuperior segments.[21] In well-selected cases, LLR is also safe and feasible in patients with recurrent hepatocellular carcinomas.[22,23]

The surgical learning curve is a journey through apprenticeship programs such as residency, fellowships, courses and proctorships.[24] There is a delicate balance between pushing the technical envelope and patient's safety and outcomes. Various centers have attempted to quantify the level of experience required to progress through the learning curve for laparoscopic hepatectomies.[7-11] Our own institution's experience revealed that individual and institutional volumes were both important factors affecting conversion rates of LLR.[25] In a large single center series of LLR, they demonstrated that the proportion of LLR increased progressively over time as techniques became more standardized and eventually codified into a systematic approach, this was also associated with improved conversion rates, operative time, blood loss and overall morbidity.[26] In that study, using the technique of cumulative sum analysis (CUSUM), about 60 cases were required before the operative conversion rate reached the average value for the cohort and only improved thereafter. In another study, a single tertiary center evaluated their experience over a year and stratified their learning phases using the CUSUM method. The initial phase 45 cases, middle phase 30 case and final phase 98 cases. The final phase showed improvement in operative time, blood loss, conversion rate and length of stay. It was suggested that about 45 cases were required to shorten the operative time and mount the initial learning curve and additional 30 cases needed for mastery of the more complex and technically challenging major hepatectomies.[11] The number of cases required to achieve a certain level of mastery probably lie between 60-70 cases.

However, the assessment of the learning curve might not be that straightforward because the cases and surgical teams are widely heterogenous in terms of the level of difficulty and experience, respectively. Without an accurate preoperative prediction or stratification of the difficulty level of the cases, navigating the learning curve will be more arduous. As surgeons progress to more difficult cases, the CUSUM for operative conversions might take the form of an uneven pattern. It would have alternating periods of improvement and regression amid an overall trend towards improvement as opposed to the classical "idealized" learning curve.[27] This indicates that it is crucial for accurate preoperative stratification such that the approach and assigning a level of difficulty of LLR for a learning surgeon is systematized and safe.

Our institution performed a validation study of the LLR difficulty score (LDS) suggested by Ban et al.[13] Each LLR was retrospectively scored from 1-12 and then classified to low, intermediate and high difficulty levels by 2 independent HPB surgeons who were blinded to the patients' outcomes. The three groups of LDS were then statistically evaluated against the perioperative outcomes. We found a clear and significant correlation of the level of difficulty as predicted by the LDS with operative time, blood loss, and Pringle's time. The more difficult cases predicted a longer operative time, greater blood loss and Pringle's duration. (Unpublished data) The preoperatively determined LDS was useful in guiding preoperative planning such as patient selection. We are in the process of collaborating with a Western tertiary center to comprehensively validate the LDS to demonstrate if it is applicable and robust in diverse patient populations with different disease patterns.[28] Moving ahead, the next phase of application of the LDS can be applied to assigning appropriate cases to the surgical trainee's skill level.

The difficulty of LLR can be influenced by a multitude of other factors. Patient factors such as body mass index (BMI), previous surgical and medical history, disease factors such as the type of tumor or its nature (e.g. cystic vs. solid tumors) - all can affect in a way or another. However, based on our data, the correlation of BMI and previous surgery were tenuous with operative time and conversion rates and at the current state cannot incorporated effectively into the LDS. (Unpublished data) Other assessments of intra-abdominal visceral fat may be a better predictor than BMI to study obesity as a potential risk factor for conversion, retrorenal visceral fat thickness (vertical distance between the left posterior renal capsule and the junction of the abdominal wall and paraspinal musculature at the level of the left renal vein) as a surrogate for visceral fat mass has been shown to predict conversions in laparoscopic pancreatic surgery.[29] Further studies are needed to evaluate these factors and eventually interpret their significance meaningfully.

Laparoscopic liver resection relies significantly on a well-established and systematized set-up, experienced surgical and anesthetic teams, excellent nursing support and advanced surgical equipment, many factors are crucial to its success. The drive to push the technical frontiers in surgery must be secondary to patients' safety. As guardians of our patients' health, we should adopt a steady and cautious approach, especially in complex LLR so as to minimize unnecessary surgical risks. A well-validated scoring system may help surgeons better select their cases and to plan for appropriate level of trainee participation, maximizing the training value of each case without compromising patient safety and outcomes. Future studies will help to better refine the score and its applications in robotic assisted LLR.[14,30]

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