Anatomical laparoscopic right posterior sectionectomy

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Abstract: Due to the difficulty in bleeding control and visualization of the surgical field, lesions in the postero-superior segments are generally considered not suitable for laparoscopic resection. However, with gaining experience and improvement in technology, the safety and feasibility of laparoscopic major resection, including those in the postero-superior segments, have been published in recent years. On the other hand, anatomical resection seeks to preserve as much of the liver volume as possible, aids post-operative recovery and may allow future repeat hepatectomy in cases of recurrences. It offers several advantages over non-anatomical resection. This review will discuss about indications, case selection, technical aspects, outcome and learning curve of laparoscopic anatomical right posterior sectionectomy.

Keywords: Hepatectomy; laparoscopy; technique; outcome; learning curve

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Introduction

Laparoscopic liver resection has evolved tremendously over the past two decades. It is shown to be associated with less wound pain, shorter hospital stay with a comparable oncological outcome with the open liver resection. Patients with solitary lesion, tumour less than 5 cm in diameter and located in the peripheral liver segments (i.e., Couinaud segments 2–6) are the best candidates for laparoscopic liver resection, as suggested in the First International Position on laparoscopic liver surgery published in 2008 (1). Due to the difficulty in bleeding control and visualization of the surgical field, lesions in the posterosuperior segments are generally considered not suitable for laparoscopic resection (2-4). With gaining experience and improvement in technology, the safety and feasibility of laparoscopic major resection, including those in the posterosuperior segments, have been published in recent years (4-9). Nonetheless, it is still considered in its experimental phase with incompletely defined risks in the Second Consensus Meeting held in Morioka (10). This manuscript aims to review the indications and the technical aspects of laparoscopic resection of the right posterior segments.

Anatomical resection

Anatomical resection is preferred for hepatocellular carcinoma (HCC), which has the propensity to invade the portal and hepatic veins, leading to intrahepatic metastasis. In fact, portal venous tumor extension and intrahepatic metastasis are two factors proven to be associated with poor prognosis (11-20). Anatomical resection is the systemic removal of the hepatic segment supplied by the tumor-bearing tributaries (21). Non-anatomical resection, on the other hand, may leave behind non-perfused ischaemic liver tissues and so it may not true parenchymal-sparing. Segment oriented anatomical resection preserves well-perfused non-tumour bearing liver parenchyma, which is important for patients with chronic liver diseases and cirrhosis. In the retrospective cohort study by Imamura, anatomical resection was shown to have significantly better recurrence-free survival (P=0.012) in a median follow-up of

480 days (22). Similar findings are also reported in other series (13,14).

On the other hand, there is no survival benefit for anatomical resection of colorectal liver metastasis. A meta-analysis of 5,207 patients showed that overall survival (hazard ratio 1.06, 95% confidence interval: 0.95–1.18) and disease-free survival (hazard ratio 1.11, 95% confidence interval: 0.99–1.24) did not differ significantly between anatomical resection and non-anatomical resection (23). The reason we still aim for anatomical resection even for selected cases of colorectal liver metastasis is that laparoscopic non-anatomical resection of segment 6 or 7 is a difficult procedure. Cho *et al*. reported that the operative time and blood loss for wedge resection of lesions in segment 6 or 7 were similar to those of major liver resection (24). This finding suggests that non-anatomical resection of the posterosuperior segment can be as difficult as major hepatectomy. It is also difficult to estimate and achieve an adequate resection margin for deep or large tumours located in the right posterior sections, despite frequent assessment by intraoperative ultrasound (17). Because of lack of tactile sensation through laparoscopy, by following the intersegmental plane along the right hepatic vein, resection margin can be better secured. Therefore, laparoscopic right posterior sectionectomy should be considered for deep and large lesions in the upper part of the right posterior sections of the liver. On the other hand, if the tumour is close to the right hepatic vein, conversion to right hepatectomy or extended right posterior sectionectomy with excision of the right hepatic vein should be contemplated to secure R0 resection.

Case selection

Careful patient selection is of paramount importance for the benefits of laparoscopic resection to be observed. In our center, we routinely perform indocyanine green retention (ICG) test and volumetry of the future liver remnant volume for all patients undergoing laparoscopic right posterior sectionectomy (8). We limit our indication of laparoscopic right posterior sectionectomy to tumor size up to 5 cm (1). For tumors that are not readily visualized on laparoscopy, anatomical resection and frequent use of intraoperative ultrasound (IOUS) to assess the resection margin is recommended. If the tumor is very close to the right hepatic vein, conversion to right hemihepatectomy or extended right posterior sectionectomy with excision of the right hepatic vein should be considered to secure complete resection. Cho *et al*. performed 24 laparoscopic right posterior sectionectomies with three open conversions (12.5%) due to inadequate tumor-free resection margin (9). This illustrates the importance of careful case selection in performing successful laparoscopic right posterior sectionectomy.

Operative technique

Glissonian approach for laparoscopic right posterior sectionectomy has the advantage of selective inflow control without jeopardizing the blood supply to the liver remnant. Parenchymal transection along the vascular demarcation of the right posterior sections and early identification of the right hepatic vein are the keys to precise anatomical resection. The techniques of retraction and exposure, meticulous dissection and secure hemostasis will be discussed.

Liver retraction and exposure

Gravity is a silent, obedient and reliable surgical assistant in liver retraction. Different patient positioning has been proposed in previous case series. In the case series by Tomishige *et al*. (25) and Cheng *et al*. (8), the left lateral position is adopted. The control of the Glissonian pedicle and liver parenchymal transection are performed without mobilization of the right lobe of liver. In this position, the vertical vector of the gravitational pull facilitates the visualization and approach of the transection plane from the caudal approach. Alternatively, the semi-prone position is used in the Ikeda series (26). The right triangular and coronary ligaments are divided and the weight of the liver helps to retract the liver from the diaphragm towards the left side. This creates space for the insertion of intercostal ports to facilitate parenchymal transection in the superior segments and control of hepatic vein branches. In addition, the Rouviere's sulcus, the fissure housing the right posterior Glissonian pedicle, is readily seen after insertion of laparoscope in the semi-prone position. Nonetheless, these two positions place the operating surgeon in a non-ergonomic position on the left side of the patient. Therefore, the 30° semi-left lateral position with the lower limbs apart is proposed by the Korean group (9). In this way, the surgeon will be working in between the legs and the operating table can be tilted to the desired angle for the gravitational pull to work on liver retraction.

Parenchymal transection and bleeding control

Inflow and outflow control is important for correct anatomical resection and bleeding control. The intrahepatic Glissonian control is the mostly used method of inflow control (27). The right posterior Glissonian pedicle is approached via a hepatotomy along the fissure of Ganz with ultrasonic scalpel. The pedicle is then temporarily controlled with laparoscopic vascular clamp, which serves as a partial Pringle maneuver for bleeding control. An ischemic demarcation will then be seen and guide our parenchymal transection along the anatomical plane.

For outflow control, the right coronary and triangular ligaments need to be divided and the right lobe is mobilized from the inferior vena cava (IVC) until the root of the right hepatic vein (RHV) is found. Small hepatic veins branches are divided with clips or bipolar sealing device (9). The RHV is isolated and encircled with tape to allow prompt control of any brisk bleeding from the vein branches. Nevertheless, not all surgeons routinely perform outflow control and some prefer the anterior approach without mobilization of right lobe of liver for better retraction and visualization of the transection plane (8,25,28).

In addition, early identification of the RHV is important in guiding anatomical resection along the correct intersegmental plane. More bleeding is anticipated when we dissect close to the RHV. Having said that, parenchymal transection along the course of the RHV indicates the complete removal of the right posterior section without leaving devitalized liver tissue. Adhering to the right fissure is not easy as this is a curvilinear plane. The transection plane can be better visualized using flexible laparoscope and the course of the RHV can be clearly identified. Small hepatic vein branches are identified and controlled with clips or energy device. When bleeding is encountered, homeostasis can be readily achieved with bipolar diathermy, gauze compression or sutures (29). During parenchymal transection, the central venous pressure is kept low to less than 5 mmHg (30). When bleeding is encountered from the hepatic vein or even the IVC, the CO_2 pneumoperitoneum can be increased to 15 to 20 mmHg to temporarily slowdown the rate of bleeding before applying energy device or suture for definitive control (31). Though CO_2 gas embolism is one of the concerns from raising the intraperitoneal pressure, a swine model has demonstrated that this event occurs without much significant effects on the hemodynamic (32). By varying the intraperitoneal pressure during parenchymal transection, haemostasis can be readily accomplished with less blood loss in laparoscopic hepatectomy (31).

Various parenchymal transection techniques have been described in the literature. Ultrasonic scalpel is the most commonly used device (33). Other energy devices include cavitron ultrasonic surgical aspirator (CUSA), bipolar vessel sealer, monopolar sealer with saline tip and argon beam coagulator. Mechanical methods include crush clamp and stapler. Some reports use radiofrequency or microwave for pre-coagulation. In fact, the method of liver parenchymal transection is more of the surgeons' preference and the evidence for the best technique is lacking. Nonetheless, there are some basic principles to uphold regardless of the energy device used. To minimize blood loss and maintain a clear surgical field, meticulous dissection and isolation of the intrahepatic vessels should be performed. These vessels can then be sealed and transected using clips, ultrasonic scalpel or cautery-based vessel sealer. Use of staples shall be limited to the transection of vascular pedicles.

Intercostal ports

The approach to the superoposterior segments of the liver is difficult from the caudal approach in laparoscopic hepatectomy. The addition of intercostal trocars as instrument port or camera port has been described to access the superior segments cranially (34-36). To avoid injury to the lung during insertion of the intercostal trocars, the cranial side of the diaphragm is compressed with the forceps introduced through the abdominal trocar (29). The intercostal trocars are then fixed to the thoracic wall by inflating the balloon to prevent migration of the pneumoperitoneum into the thoracic cavity (35). Camera can then be placed for direct vision of right hepatic vein by this lateral approach. The root of the hepatic vein can then be dissected and any bleeding here can be readily sutured (34). Upon completion of the operation, the diaphragmatic incisions will be closed with laparoscopic sutures from the caudal view and any remaining gas in the thoracic cavity is aspirated. Chest drain is usually not required.

Indocyanine green-fluorescence imaging

Indocyanine green (ICG) is excreted in bile and the excitation of the protein-bound ICG by non-infrared light cause it to

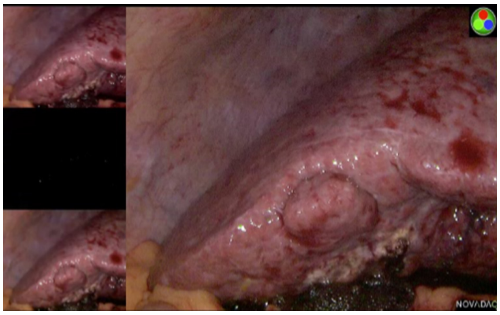

Figure 1 Ischaemic demarcation after clamping of right posterior Glissonian pedicle on regular laparoscopy.

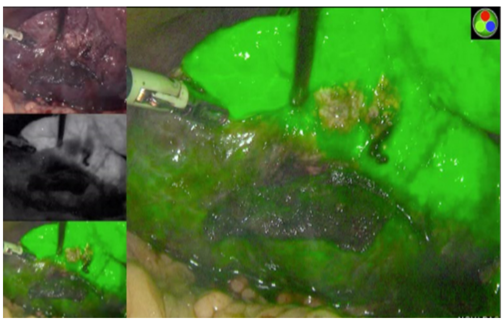

Figure 2 Counter-demarcation of right posterior section on ICG-fluorescence imaging (superior sturface). ICG, indocyanine green retention.

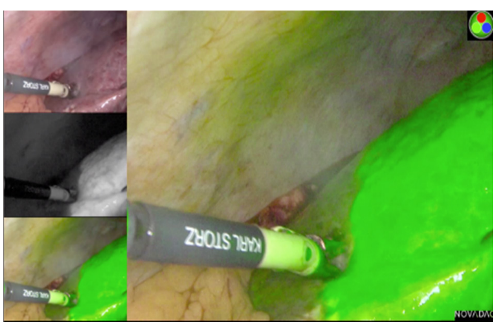

Figure 3 Counter-demarcation of right posterior section on ICG-fluorescence imaging (inferior surface). ICG, indocyanine green retention.

fluorescent (37). This unique property makes ICG a very useful tool in hepatectomy.

The Glissonian pedicle approach guides the parenchymal transection with an ischemic demarcation along the right fissure. However, this demarcation may be difficult to be visualized in patients with macronodular cirrhosis (*Figure 1*). To demonstrate the intended transection line along the anatomical plane, a counter-demarcation technique can be used (38). After temporary control of the right posterior pedicle with laparoscopic vascular clamp, 2.5 mg (0.5 mg per kg body weight) of ICG is injected intravenously. The right posterior section will be void of fluorescence and the demarcation can be clearly seen on the fluorescence laparoscopy (*Figures 2* and *3*).

Secondly, ICG can be used for tumour staining due to its propensity to accumulate in HCC and in the non-cancerous liver parenchyma around metastatic adenocarcinoma (39,40). While ICG is readily taken up by differentiated HCC, the biliary excretion of ICG by the cancerous tissue is impaired, leading to retention of the fluorescence in the tumour. On the contrary, there is no uptake of ICG in liver metastasis and the biliary excretion of ICG by the surrounding non-cancerous hepatic parenchyma is also impaired, giving rise to a rim-type fluorescence. Such differential uptake of ICG and fluorescent pattern allow deep subcapsular lesions to be visualized on laparoscopy, enabling better margin control (38).

Furthermore, the biliary excretion of ICG can potentially help detecting bile leak over the resection surface. However, this novel technique requires further study before its widespread use in laparoscopic hepatectomy.

Hand-assisted laparoscopic hepatectomy and conversion

Similar to other laparoscopic surgeries, conversion should not be considered a failure. Conversion from pure laparoscopy to hand-assisted hepatectomy should be considered to control bleeding or to complete a difficult hepatectomy (1). Caution must be taken during conversion as the sudden loss of the pneumoperitoneum can result in massive hemorrhage. Therefore, attempts should be made to temporarily slowdown the bleeding by bipolar diathermy or compression with gauze packing before laparotomy. Surgeons embarking on laparoscopic resection should be facile with laparoscopic suturing and other techniques of hemorrhage control, negating the need to emergency conversion.

Operative outcome

Right posterior sectionectomy has been considered a relative contraindication to laparoscopic surgery because of perceived worse outcome when compared to resection of anterolateral segments (2,3). As experience accumulates, more recent series have shown comparable postoperative outcomes for different tumour locations. Cho *et al*. compared the outcomes of laparoscopic liver resection for 28 posterosuperior versus 54 anterolateral segments (4). They found that laparoscopic liver resection for tumors located in posterosuperior segments required longer operative time when compared with anterolateral segments (320 versus 210 minutes, P<0.001). There were no differences in the conversion rate, median blood loss, rate of intraoperative transfusion, median tumor-free margin, median hospital stay and complication rates between the two groups. Similar results were shown in another series by Kazaryan *et al*. published in 2011. In this series, no significant difference in the operative time was shown (41).

To our knowledge, there are only two case series on pure laparoscopic anatomical right posterior sectionectomy for HCC. Cheng *et al*. reported on the short-term outcomes of 13 patients undergoing laparoscopic anatomical right posterior sectionectomy for HCC (8). Up to one-third (30.8%) of these patients had cirrhosis on histology. The median operative time was 381 minutes with a conversion rate of 23%. The median resection margin was 8.7 mm and median hospital stay was 7 days. The conversion rate is comparable to previous reports for laparoscopic major hepatectomies (42-44), which have been shown to improve with experience (42,45). In the series by Cho *et al*., there was no difference in the mean resection margin and postoperative complications rate when compared with open surgery (9). However, the operative time was significantly longer in the laparoscopic group (567.4 *vs*. 316.1 minutes, P<0.001), but there was no significant difference in the length of hospital stay (10.6 versus 11.1 days, P=0.892). With the comparable short-term outcomes, laparoscopic right posterior sectionectomy is safe and feasible for experienced surgeons, yet technically demanding with longer operative time. It offers alternatives to right hepatectomy in selected patients if the functional liver remnant volume is inadequate (9).

Technical aspect aside, the long-term survival outcome of laparoscopic right posterior sectionectomy remains our primary concern. Nonetheless, it follows the oncological principle of anatomical resection and reports have shown comparable resection margin to open surgery. Whether these principles translate into clinical survival benefits is yet to be shown. Further prospective study with survival analysis will be needed in this regard.

Learning curve

One of the criticisms of laparoscopic hepatectomy is the lack of proper training and credentialing. One recent publication from France evaluated 173 patients for the learning curve for operating time using the cumulative sum (CUSUM) method (46). They stratified their experience into three phases: the initial learning curve consisting of 45 patients, followed by the plateau phase involving 30 patients with increased competency with laparoscopy, and lastly the mastery phase in which more complex procedures were performed with the subsequent 98 patients. Another study from England analyzed 159 patients who underwent laparoscopic hemihepatectomy (47). Risk-adjusted CUSUM analysis demonstrated a learning curve of 55 laparoscopic hemihepatectomies for conversions. However, these two studies did not include patient who underwent right posterior sectionectomies.

Cheng *et al*. studied on the learning curve for laparoscopic major hepatectomy analyzed 49 patients, including 13 laparoscopic right posterior hepatectomies (45). A shift in the average operative time was shown at the 25th case for laparoscopic major hepatectomy. In the subgroup analysis, the median blood loss for right posterior sectionectomy was significantly more than hemihepatectomy (1,500 *vs*. 500 mL, P=0.034); whereas the operative time, conversion rate, resection margin, complications and length of hospital stay were comparable. While the learning curve for laparoscopic right posterior sectionectomy is yet to be defined, this case series demonstrated the safety and feasibility of the procedure. Nonetheless, it is a technically demanding procedure and it should be performed by experienced hepatobiliary surgeons who have overcome the learning curve and proficient in laparoscopic hemihepatectomies.

Conclusions

Laparoscopic right posterior sectionectomy is technically demanding. Careful patient selection and preoperative planning cannot be emphasized more. The Glissonian approach as inflow control and transection along the correct intersegmental plane are the keys to anatomical resection. With the use of flexible laparoscope and various energy devices, a clear and bloodless surgical field can be maintained. Short term postoperative outcomes have been shown to be comparable with open operation. Further large scale prospective study is needed to define the long term oncological outcome.

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Footnote

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