—Review—

Current Status of Laparoscopic Hepatectomy

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Before the first laparoscopic hepatectomy (LH) was described in 1991, open hepatectomy (OH) was the only choice for surgical treatment of liver tumors. LH indications were initially based solely on tumor location, size, and type. Use of LH has spread rapidly worldwide because it reduces incision size. This review systematically assesses the current status of LH. As compared with OH, LH is significantly less complicated, requires shorter hospital stays, and results in less blood loss. The long-term survival rates of LH and OH are comparable. Development of new techniques and instruments will improve the conversion rate and reduce complications. Furthermore, development of surgical navigation will improve LH safety and efficacy. Laparoscopic major hepatectomy for HCC remains a challenging procedure and should only be performed by experienced surgeons. In the near future, a training system for young surgeons will become mandatory for standardization of LH, and LH will likely become better standardized and have broader applications. (J Nippon Med Sch 2019; 86: 201–206)

Key words: laparoscopy, liver resection, hepatectomy, hepatocellular carcinoma (HCC)

Introduction

Before the first laparoscopic hepatectomy (LH) was described in 1991[1], open hepatectomy (OH) was the only choice for surgical treatment of liver tumors, such as hepatocellular carcinoma (HCC) and metastatic liver tumors. The liver is a highly vascular solid organ, so liver resection is associated with high morbidity, especially in patients with liver cirrhosis. LH indications were initially based solely on tumor location, size, and type but have recently expanded[2]. Because it reduces incision size, LH has spread rapidly worldwide. This review systematically assesses the current status of LH.

Indications and History of Guidelines

In 1991, Reich et al. performed the first LH for benign tumors[1]. In Japan, LH was initially used for treatment of HCC by Hashizume et al.[3] in 1995 and Kaneko et al.[4] in 1996. Since then, LH cases have occasionally been reported. The indications for LH have expanded and are now very similar to those for OH. However, LH remains contraindicated for some conditions. In Japan, partial resection and left lateral sectionectomy have been covered by the national health insurance system since April 2010, and the numbers of cases and centers performing LH have increased rapidly. LH is more technically challenging than OH because surgeons must master the skills required for both laparoscopic surgery and OH. The Japanese Endoscopic Liver Surgery Study Group has evaluated the state of LH in Japan every year since 2007[5].

LH has been performed for HCC[6–8], metastatic liver tumors[9,10], hepatic cysts[11,12], and benign tumors[1,13]. Only a few reports have described LH for intrahepatic cholangiocarcinoma[14–16], so evaluation of its safety and utility is challenging.

Cherqui et al.[17] reported the first laparoscopic left lateral sectionectomy in living donors, in 2002. Recently, totally laparoscopic associating liver partition with portal vein ligation for staged hepatectomy (ALPPS) was reported[9,18,19].

In 2008, the first International Consensus Conference on LH, in Louisville, Kentucky, United States[20], concluded that laparoscopic left lateral sectionectomy should be

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considered standard practice. Acceptable indications for LH were solitary lesions (≤5 cm) located in liver segments 2 through 6.

In 2014, the second International Consensus Conference on LH, in Morioka, Japan[21–23], stated that preoperative estimation of LH difficulty based on surgeon experience and skill level was useful when selecting patients, and a system for rating difficulty, the IWATE criteria, was established.

In 2016, the first Asia-Pacific consensus meeting on HCC was held in conjunction with the Seventh Asia-Pacific Primary Liver Cancer Expert Meeting in Hong Kong, to define the role of LH in HCC management and develop recommendations and guidelines. The inherent advantage of LH is the potential for less blood loss if the procedure is performed by experienced staff. Laparoscopic major hepatectomy for HCC remains a challenging technique and should only be performed by experienced surgeons[24].

In 2017, the First European Guidelines Meeting on Laparoscopic Liver Surgery was held in Southampton, to present and validate clinical practice guidelines for LH. The five sections of the guidelines (indications, patients and complex disease, procedures, technique, and implementation) were divided into subcategories[25]. These guidelines describe appropriate training for surgeons performing LH, which should only be performed by experienced staff.

Systems for Scoring Difficulty

Preoperative evaluation of LH difficulty is useful for selecting patients in relation to surgeon experience and skill level. The first difficulty scoring system for LH[26] included three difficulty levels based on five preoperative factors: tumor location, extent of hepatic resection, tumor size, tumor proximity to major vessels, and liver function. Using this system, surgeons could predict the difficulty of LH and intra- and postoperative outcomes. The system was validated by the Japanese Endoscopic Liver Surgery Study Group. Clinical and surgical data from 2199 patients who had undergone LH for hepatic tumors in Japan were analyzed, and the three difficulty levels were significantly associated with LH surgical outcomes[27]. However, the original system did not include segment 1 as a category for tumor location, conflated segments 4a and 4b, and did not include a category for hand-assisted laparoscopic surgery (HALS) and laparoscopic-assisted hepatectomy, known as hybrid hepatectomy.

In 2014, the original difficulty scoring system was revised, and the IWATE criteria were established at the Second International Consensus Conference on Laparoscopic Liver Resection, in Morioka, Japan[21,22]. Tumor location, tumor size, liver function, extent of liver resection, proximity to major vessels, and hybrid hepatectomy/HALS were combined in a single score in the IWATE criteria, which yielded four difficulty levels: low, intermediate, advanced, and expert. The IWATE criteria were validated by using clinical and surgical data from 1867 patients who had undergone LH for hepatic tumors in Japan[28]. The IWATE criteria do not consider body mass index, repeat hepatectomy, or neoadjuvant chemotherapy.

The Institut Mutualiste Montsouris (IMM) group recently developed a new scoring system for LH difficulty (the IMM classification). The IWATE criteria include a category for Child-Pugh grade, but the IMM classification does not. In the IMM classification, LH procedures are divided into three groups according to scores based on operative time, blood loss, and conversion rate[29]. In the IMM classification system, Grade 1 (0 points, low level) includes wedge resection and left lateral sectionectomy. Grade 2 (2 points, intermediate level) includes anterolateral segmentectomy and left hepatectomy (the anterolateral segments are defined as Couinaud's segments 2, 3, 4b, 5, and 6). Grade 3 (3 points, high level) includes posterosuperior segmentectomy, right posterior sectionectomy, right hepatectomy, central hepatectomy, and extended left/right hepatectomy (the posterosuperior segments are defined as segments 1, 4a, 7, and 8). Major complications increase significantly from Grade 1 (1.1%) to Grade 2 (4.0%) and Grade 3 (20.4%).

Laparoscopic Liver Resection Procedures

Preoperative examination of liver function is important in hepatic surgery, especially for elderly patients with HCC[30–32]. Use of three-dimensional reconstruction for preoperative simulation of intrahepatic vessels is necessary for safe LH[33,34]. Laparoscopic ultrasound should be performed before liver transection and reveals tumor location, vascular anatomy, and the adequate incision line. Various instruments are used in LH.

The patient is usually placed in supine position, but other positions can be used when required by tumor location or surgical procedure. After an umbilical incision, a trocar for the laparoscope is inserted. Most procedures require four trocars: at the bilateral abdomen, epigastrium, and right hypochondrium[35]. When resecting the superior region of the liver, intercostal or transthoracic

trocars are occasionally inserted[36]. Single-site port LH has recently been introduced[37–39], and current evidence indicates that the multi-port and single-port methods have comparable effectiveness and safety for treatment of liver disease[37].

In difficult cases, HALS or hybrid hepatectomy is performed[40–44]. An international multicenter study reported that operation times and hospital stays were shorter for patients who underwent HALS or hybrid hepatectomy than for those who underwent pure LH[45].

The Pringle maneuver is the traditional method of controlling intraoperative bleeding in hepatectomy. To avoid ischemia-reperfusion injury and hemodynamic change, occasionally selective inflow occlusion is performed during anatomical major liver resections[46]. In LH, hepatic inflow control is not a routine procedure, but preparation for the Pringle maneuver is necessary for safe LH. A low central venous pressure (<5 cm H_2O) reduces intraoperative blood loss during liver resection[47]. Reducing airway pressure is also effective in reducing intraoperative blood loss[48]. In right posterior sectionectomy, the semiprone position lifts the right hepatic vein anterior to the vena cava and reduces bleeding[49]. In LH, pneumoperitoneum reduces bleeding from exposed vessels at the transected surface of the liver. Previously, pneumoperitoneum pressure in LH was kept high (12 to 18 mm Hg) to reduce back-bleeding. CO_2 is soluble in human plasma[50], but the incidence of gas embolism in major LH is 0.2%[51]. To reduce this risk, pneumoperitoneal pressure should be set to the minimum required to maintain a clear operative field (8 to 10 mm Hg) during LH.

Refinement of surgical instruments, operative techniques, and perioperative management has reduced the mortality rate for LH[52–58]. Stapleless LH was recently introduced[59], and robotic liver resection enables more precise operations[60].

Outcomes of LH and OH

Macacari et al.[61] reported a comparative analysis of LH and OH for left lateral sectionectomy. Laparoscopic left lateral sectionectomy resulted in less blood loss, lower transfusion rates, and shorter hospitalization than did open left lateral sectionectomy. Operative time and biliary, cardiac, and pulmonary complication rates did not significantly differ between the groups. Using propensity score matching in a multicenter study, Takahara et al.[7] compared outcomes of LH (n=446) and OH (n=2,969) for treatment of HCC. LH resulted in less bleeding, fewer complications, and shorter hospital stays, but survival rates did not significantly differ. Yin et al.[62] reported a comparative analysis of LH and OH for posterosuperior segmentectomy. LH resulted in significantly fewer overall complications than did OH, and hospital stays were shorter after LH. Mortality, transfusion, R0 resection, tumor-free margins, and operative time were comparable, as were long-term survival rates. Morise et al.[63] conducted a meta-analysis of the outcomes of LH and OH for HCC, and LH yielded better short-term outcomes. Recently, several randomized clinical trials were performed[64–67]. In the Oslo-Comet Study (LH vs. OH for colorectal liver metastases), LH resulted in significantly fewer postoperative complications than did OH[64,65]. In the ORANGE II-trial Study (LH vs. OH for left lateral sectionectomy), the trial was stopped on the advice of an independent Data and Safety Monitoring Board in the Netherlands and thus could not reach a conclusion[66,67].

Few studies have investigated intrahepatic cholangiocarcinoma[14–16], so the results are difficult to evaluate. However, some advantages of LH have been reported for intrahepatic cholangiocarcinoma, namely shorter hospital stays, less intraoperative blood loss, and fewer postoperative complications. For cholangiocarcinoma, the status of the resected margins is the most important factor for postoperative survival[68]. The 3- and 5- year survival rates for LH were similar to those for OH[16].

Conclusion

As compared with OH, LH resulted in significantly fewer complications, shorter hospital stays, and less blood loss when the procedure was performed by experienced practitioners. The long-term survival rates for LH and OH are comparable. Refinement of techniques and instruments will improve the conversion rate and reduce complications. Furthermore, development of surgical navigation will improve LH safety and efficacy. Laparoscopic major hepatectomy for HCC remains challenging and should only be performed by experienced staff. To standardize LH, a system for training young surgeons should be made mandatory in the near future. LH will likely become a more standardized procedure with broader applications.

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