A narrative review of minimally invasive liver resections for hepatocellular carcinoma

Kohei Mishima^, Go Wakabayashi^

Center for Advanced Treatment of HBP Diseases, Ageo Central General Hospital, Saitama, Japan

Contributions: (I) Conception and design: Both authors; (II) Administrative support: Both authors; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: None; (V) Data analysis and interpretation: None; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

Correspondence to: Go Wakabayashi, MD, PhD, FACS. Department for Advanced Treatment of HBP Disease, Ageo Central General Hospital, Saitama, Japan. Email: gowaka@ach.or.jp.

Abstract: Hepatocellular carcinoma (HCC) is the most common primary cancer of the liver and the third leading cause of cancer-related deaths worldwide. Liver resection has been widely accepted as the mainstay of HCC treatment, leading to long-term survival in well-selected patients. Over the last two decades, laparoscopic liver resection (LLR) has developed worldwide parallel to technological advancements and increased experience of liver surgeons. Several meta-analyses revealed that LLR for HCC has yielded better short-term outcomes without compromising long-term outcomes, compared to open liver resection (OLR). During treatment of HCC patients with chronic liver disease or liver cirrhosis, LLR decreases blood loss and postoperative complications including refractory ascites, leading to a shorter hospital stay. In the treatment of recurrent HCC, LLR makes subsequent procedures easier by minimizing adhesion formation. The procedure of laparoscopic major liver resection (major LLR) is yet to be standardized and is still in exploration stage according to the Morioka international conference, 2014. Laparoscopic parenchyma-sparing anatomical liver resection (Lap-PSAR) is a novel surgical strategy to resect all malignant tissues while preserving enough liver parenchyma to prevent postoperative liver failure. In conclusion, LLR has many advantages for the treatment of HCC patients and generally results in better short-term outcomes. Further investigations are needed to standardize the procedures of major LLR and Lap-PSAR.

Keywords: Minimally invasive liver resection (MILR); laparoscopic liver resection (LLR); hepatocellular carcinoma (HCC); parenchymal sparing anatomical liver resection (PSAR); extrahepatic Glissonian approach

Received: 23 June 2020; Accepted: 14 September 2020; Published: 25 October 2021.
doi: 10.21037/ls-20-100
View this article at: http://dx.doi.org/10.21037/ls-20-100

Introduction

Development of laparoscopic liver resection (LLR)

LLR was first reported in 1991 (1). Since then, sporadic reports of partial liver resections were published in mid-1990's, followed by reports of left lateral sectionectomies (2,3) in 1996. Due to advancements in surgical techniques and development of equipment for LLR, the procedure was expanded to include hemi-hepatectomies (4,5), followed by left medial, right anterior and posterior sectionectomies (6-8). During this period, two international consensus conferences on LLR (ICCLLR) were convened (9,10). In 2008, the first ICCLLR was held in Louisville (9). Standardized terminologies on LLR were defined and variable techniques for parenchymal transection were introduced, leading to a global spread of LLR. In 2014,

^ ORCID: Kohei Mishima, 0000-0003-4284-2989; Go Wakabayashi, 0000-0002-8383-9666.

the second ICCLLR was held in Morioka (10), with the dual objective of defining the role of LLR and developing recommendations. The jury recommendations confirmed that minor LLR was to be a standard practice, but major LLR was an innovative procedure in its exploratory phase (11). The summary of expert technical recommendations covered a difficult scoring system, conceptual changes in LLR, techniques for bleeding control and parenchymal transection, and suitability of energy devices (12,13). After two ICCLLRs, LLR spread globally with rapidity and the proportion of major LLRs has gradually increased. According to a nationwide survey of the national clinical database (NCD) 2011–2017 of Japan (14), the number of LLRs increased from 1,868 (9.9% of all liver resections) in 2011 to 5,648 (24.8%) in 2017. The rates of morbidity (Clavien-Dindo II or more) and 30-day mortality of LLR were 10.8% and 0.5%, respectively, which were better than those of open liver resection (OLR) (19.9% and 0.9%, respectively) in 2017.

Treatment strategies for hepatocellular carcinoma (HCC)

HCC is the most common primary cancer of the liver and the third leading cause of cancer-related deaths worldwide (15). The treatment options for HCC include liver resection (LR), liver transplant, local ablation therapy, transarterial chemoembolization (TACE), and systematic therapy (16). Over the years, LR has been widely accepted as the mainstay of HCC treatment, leading to long-term survival in well-selected patients (17). Indications for LR for HCC should be determined with multi-parametric assessment of tumor characteristics, residual liver function, expected volume of the remnant liver tissue, and patients' co-morbidities (18). Currently, LR is the first choice of treatment for very-early and early stage (BCLC 0-A) HCC and a secondary choice for intermediate stage (BCLC B) HCC, according to the modified Barcelona Clinic Liver Cancer (BCLC) staging system (18-20). The overall survival at 1, 3, and 5 years was as follows: 95%, 80%, and 61% for BCLC 0-A; 88%, 71%, and 57% for BCLC B; and 76%, 49%, and 38% for BCLC C (21).

Objectives

In this review, we summarized the current role of minimally invasive liver resections for HCC and discussed its future aspects. We present the following article in accordance with the Narrative Review reporting checklist (available at http://dx.doi.org/10.21037/ls-20-100).

Methods

We conducted a PubMed research to select articles of interest. The following keywords were used to search in titles or abstracts: "HCC" or "hepatocellular carcinoma" and "liver resection" or "hepatectomy" and "laparoscopic" or "minimally invasive"1. Our enquiry was restricted to English articles, published from January 1990 to December 2019 and for which full text was available.

Discussion

LLR vs. OLR for the treatment of HCC in patients with liver cirrhosis

LR for cirrhotic patients has been a surgical challenge due to its rates of mortality and morbidity (22). The most common postoperative complication of LR in cirrhotic patients is ascites (23). Over the last two decades, LLR has developed worldwide in parallel to significant technological advancements and increased experience of liver surgeons (24). The latest clinical practice guidelines of European Association for the Study of the Liver (EASL) stated that LLR is an effective option primarily for HCC located in superficial or antero-lateral positions (18). In 2006, Cherqui *et al.* pointed out that the benefits of LLR might be more evident in cirrhotic patients as the risk of postoperative liver failure and postoperative ascites could be reduced with LLR (25). In 2007, Belli *et al.* reported that LLR for HCC in patients with histologically proven liver cirrhosis resulted in fewer postoperative complications and shorter hospital stay compared to OLR (23). Since then, several meta-analyses have reported better short-term outcomes of LLR in HCC patients compared to those of OLR with comparable long-term outcomes (26-28). In 2015, Takahara *et al.* conducted a propensity score analysis with Japanese national clinical database and concluded that LLR was associated with less blood loss, shorter hospital stay, and fewer postoperative complications (29).

Laparoscopic major liver resection (major LLR) for HCC

Major LLR, defined by the Louisville Statement in 2008 (9), includes resection of 3 or more Couinaud segments (30) and resection of the difficult posterosuperior segments (4a, 7, 8). Although first reported in 1998 (31), major LLR has been less commonly performed due to the complexity of procedures and fear of uncontrolled hemorrhage, combined with high-level technical demands (5,32). Jury recommendations at the Morioka international consensus in 2014 (11) concluded that major LLR was still an innovative procedure in its exploratory phase. Since then, several studies have described the feasibility and safety of major LLR (33-35). In 2016, Takahara *et al.* compared major LLR and OLR using a propensity score analysis of national clinical database of Japan, reporting that major LLR was associated with less blood loss, shorter hospital stays, and fewer complications (33). Similar results were obtained from meta-analyses of cases where major LLR was performed for HCC patients (34,35). Several studies have looked at the learning curve for major LLR, and one center analyzed their experiences using the CUSUM technique and concluded that 45 standard major LLRs are required to overcome the initial learning curve, and expertise in more complex or technically demanding major LLRs can be achieved over the next 30 cases (36). In Japan, the percentage of advanced LLRs [= trisectionenctomy, hemihepatectomy, and sectionectomy (anterior, posterior, or medial)] increased from 3.3% of all resections in 2011 to 10.8% in 2017, with its mortality being 3.6% in 2011 and 1.0% in 2017 (14). Major LLRs remain challenging as the effective performance of the procedure requires experience; however, it has low mortality rate relative to major OLRs.

Repeat LLR

Approximately 90% of HCCs are associated with underlying etiologies, including chronic viral hepatitis (B and C), alcohol intake, and non-alcoholic fatty liver disease (NAFLD) (37). Liver cirrhosis is an important risk factor for multicentric metachronous HCCs, leading to an increase in the number of patients going for repeat LRs. LLR (as an initial LR) usually minimizes postoperative adhesion and makes subsequent procedures (repeat LLRs) easier (38,39). Kanazawa *et al.* reported that the operation time for repeat LLR after previous LLR was significantly shorter than that after previous OLR (40) Although technically demanding, repeat LLRs were associated with less blood loss, fewer postoperative complications, and shorter hospital stay compared with repeat OLRs (41). LLR can facilitate meticulous dissection of adhesions with its magnified view and can avoid unnecessary adhesiolysis when adhesion does not affect the procedure (42). Repeat LLR is the first choice of treatment for metachronous HCCs, causing fewer adhesions as a preceding operation, and reducing the need for adhesiolysis in subsequent operations (42).

Laparoscopic parenchymal sparing anatomical liver resection (Lap-PSAR) with extrahepatic Glissonian approach

HCC tends to metastasize through the intrahepatic portal venous system, and intrahepatic metastasis can occur as the tumor grows (16,18). Anatomical liver resection (AR) involves systemic removal of the liver parenchyma confined by tumor-bearing portal tributaries (31,43), and it has been shown to improve the oncological outcomes in HCC patients (44,45). However, radical resection of the large extent of the liver could increase the risk of postoperative liver failure in cirrhotic patients (22), and surgeons need to maintain a balance (45). In 2019, our team reported a novel technique of laparoscopic parenchymal sparing AR (Lap-PSAR) (46) with extrahepatic Glissonian approach. Our principle of Lap-PSAR, which includes sub-segmentectomies and segmentectomies, is to resect all of the malignant tissue (tumor and possible satellite nodules) while preserving enough liver parenchyma. The extent of LR is planned prior to surgery by means of CT liver volume calculation. The laparoscopic-specific view via caudal approach optimizes extrahepatic Glissonian approach and transection of the liver parenchyma in LLRs (13). Concordance between preoperative three-dimensional (3D) simulation and intraoperative resection was 98.7% and favorable short-term outcomes were achieved (46). Precise preoperative planning and a standardized surgical technique enable performing safe laparoscopic AR for HCC while exploiting the benefits of the minimally invasive technique and minimizing surgical stress to the patient.

Robotic-assisted liver resection (RALR)

The first series of RALRs were reported in 2003 (47). Since then, robotic liver resection has continuously disseminated worldwide and the first international consensus statement on RALR was published in 2018 (48). RALR is expected to be an alternative minimally invasive approach in liver surgery as a result of improvements in visualization and articulated instruments (49). To date, there are no randomized controlled trials to compare LLR and RALR. A meta-analysis reported that perioperative outcomes of RALR were comparable with those of LLR (50). Limitations include increased operation time and lack of tactile feedback.

Conclusions

In conclusion, MILR (LLR) offers several advantages for the treatment of HCC patients and generally results in better short-term outcomes. Further investigations are needed to standardize the procedures for major LLR, Lap-PSAR, and RALR.

Acknowledgments

We would like to thank Editage (www.editage.com) for English language editing.
Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editor (Giammauro Berardi) for the series "Minimally Invasive Resections for Liver Malignancies: Among Certainties and Controversies" published in *Laparoscopic Surgery*. The article has undergone external peer review.

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at http://dx.doi.org/10.21037/ls-20-100

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/ls-20-100). The series "Minimally Invasive Resections for Liver Malignancies: Among Certainties and Controversies" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

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.

References

1. Reich H, McGlynn F, DeCaprio J, et al. Laparoscopic excision of benign liver lesions. Obstet Gynecol 1991;78:956-8.
2. Azagra JS, Goergen M, Gilbart E, et al. Laparoscopic anatomical (hepatic) left lateral segmentectomy-technical aspects. Surg Endosc 1996;10:758-61.
3. Kaneko H, Takagi S, Shiba T. Laparoscopic partial hepatectomy and left lateral segmentectomy: technique and results of a clinical series. Surgery 1996;120:468-75.
4. O'Rourke N, Fielding G. Laparoscopic right hepatectomy: surgical technique. J Gastrointest Surg 2004;8:213-6.
5. Dagher I, O'Rourke N, Geller DA, et al. Laparoscopic major hepatectomy: an evolution in standard of care. Ann Surg 2009;250:856-60.
6. Cho A, Yamamoto H, Kainuma O, et al. Safe and feasible extrahepatic Glissonean access in laparoscopic anatomical liver resection. Surg Endosc 2011;25:1333-6.
7. Machado MA, Makdissi FF, Galvao FH, et al. Intrahepatic Glissonian approach for laparoscopic right segmental liver resections. Am J Surg 2008;196:e38-42.
8. Tomishige H, Morise Z, Kawabe N, et al. Caudal approach to pure laparoscopic posterior sectionectomy under the laparoscopy-specific view. World J Gastrointest Surg 2013;5:173-7.
9. Buell JF, Cherqui D, Geller DA, et al. The international position on laparoscopic liver surgery: The Louisville Statement, 2008. Ann Surg 2009;250:825-30.
10. Wakabayashi G, Cherqui D, Geller DA, et al. Recommendations for laparoscopic liver resection: a report from the second international consensus conference held in Morioka. Ann Surg 2015;261:619-29.
11. Wakabayashi G. What has changed after the Morioka consensus conference 2014 on laparoscopic liver resection? Hepatobiliary Surg Nutr 2016;5:281-9.
12. Morise Z. Developments and perspectives of laparoscopic liver resection in the treatment of hepatocellular carcinoma. Surg Today 2019;49:649-55.
13. Wakabayashi G, Cherqui D, Geller DA, et al. Laparoscopic hepatectomy is theoretically better than open hepatectomy: preparing for the 2nd International Consensus Conference on Laparoscopic Liver Resection. J Hepatobiliary Pancreat Sci 2014;21:723-31.

14. Ban D, Tanabe M, Kumamaru H, et al. Safe Dissemination of Laparoscopic Liver Resection in 27,146 Cases Between 2011 and 2017 From the National Clinical Database of Japan. Ann Surg 2020. [Epub ahead of print]. doi: 10.1097/SLA.0000000000003799.
15. Bray F, Ferlay J, Soerjomataram I, et al. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2018;68:394-424.
16. El-Serag HB. Hepatocellular carcinoma. N Engl J Med 2011;365:1118-27.
17. Lai EC, Fan ST, Lo CM, et al. Hepatic resection for hepatocellular carcinoma. An audit of 343 patients. Ann Surg 1995;221:291-8.
18. EASL Clinical Practice Guidelines: Management of hepatocellular carcinoma. J Hepatol 2018;69:182-236.
19. Llovet JM, Fuster J, Bruix J. The Barcelona approach: diagnosis, staging, and treatment of hepatocellular carcinoma. Liver Transpl 2004;10:S115-20.
20. Tejeda-Maldonado J, Garcia-Juarez I, Aguirre-Valadez J, et al. Diagnosis and treatment of hepatocellular carcinoma: An update. World J Hepatol 2015;7:362-76.
21. Torzilli G, Belghiti J, Kokudo N, et al. A snapshot of the effective indications and results of surgery for hepatocellular carcinoma in tertiary referral centers: is it adherent to the EASL/AASLD recommendations?: an observational study of the HCC East-West study group. Ann Surg 2013;257:929-37.
22. Regimbeau JM, Kianmanesh R, Farges O, et al. Extent of liver resection influences the outcome in patients with cirrhosis and small hepatocellular carcinoma. Surgery 2002;131:311-7.
23. Belli G, Fantini C, D'Agostino A, et al. Laparoscopic versus open liver resection for hepatocellular carcinoma in patients with histologically proven cirrhosis: short- and middle-term results. Surg Endosc 2007;21:2004-11.
24. Fuks D, Aldrighetti L, Jiao LR, et al. Laparoscopic Management of Hepatocellular Carcinoma: A Critical Reappraisal. Surg Laparosc Endosc Percutan Tech 2017;27:203-5.
25. Cherqui D, Laurent A, Tayar C, et al. Laparoscopic liver resection for peripheral hepatocellular carcinoma in patients with chronic liver disease: midterm results and perspectives. Ann Surg 2006;243:499-506.
26. Yin Z, Fan X, Ye H, et al. Short- and long-term outcomes after laparoscopic and open hepatectomy for hepatocellular carcinoma: a global systematic review and meta-analysis. Ann Surg Oncol 2013;20:1203-15.
27. Morise Z, Ciria R, Cherqui D, et al. Can we expand the indications for laparoscopic liver resection? A systematic review and meta-analysis of laparoscopic liver resection for patients with hepatocellular carcinoma and chronic liver disease. J Hepatobiliary Pancreat Sci 2015;22:342-52.
28. Ciria R, Gomez-Luque I, Ocana S, et al. A Systematic Review and Meta-Analysis Comparing the Short- and Long-Term Outcomes for Laparoscopic and Open Liver Resections for Hepatocellular Carcinoma: Updated Results from the European Guidelines Meeting on Laparoscopic Liver Surgery, Southampton, UK, 2017. Ann Surg Oncol 2019;26:252-63.
29. Takahara T, Wakabayashi G, Beppu T, et al. Long-term and perioperative outcomes of laparoscopic versus open liver resection for hepatocellular carcinoma with propensity score matching: a multi-institutional Japanese study. J Hepatobiliary Pancreat Sci 2015;22:721-7.
30. Couinaud C. Liver anatomy: portal (and suprahepatic) or biliary segmentation. Dig Surg 1999;16:459-67.
31. Makuuchi M, Hasegawa H, Yamazaki S. Ultrasonically guided subsegmentectomy. Surg Gynecol Obstet 1985;161:346-50.
32. Tzanis D, Shivathirthan N, Laurent A, et al. European experience of laparoscopic major hepatectomy. J Hepatobiliary Pancreat Sci 2013;20:120-4.
33. Takahara T, Wakabayashi G, Konno H, et al. Comparison of laparoscopic major hepatectomy with propensity score matched open cases from the National Clinical Database in Japan. J Hepatobiliary Pancreat Sci 2016;23:721-34.
34. Chen K, Pan Y, Hu GY, et al. Laparoscopic Versus Open Major Hepatectomy for Hepatocellular Carcinoma: A Meta-Analysis. Surg Laparosc Endosc Percutan Tech 2018;28:267-74.
35. Wang ZY, Chen QL, Sun LL, et al. Laparoscopic versus open major liver resection for hepatocellular carcinoma: systematic review and meta-analysis of comparative cohort studies. BMC Cancer 2019;19:1047.
36. Brown KM, Geller DA. What is the Learning Curve for Laparoscopic Major Hepatectomy? J Gastrointest Surg 2016;20:1065-71.
37. Akinyemiju T, Abera S, Ahmed M, et al. The Burden of Primary Liver Cancer and Underlying Etiologies From 1990 to 2015 at the Global, Regional, and National Level: Results From the Global Burden of Disease Study 2015. JAMA Oncol 2017;3:1683-91.
38. Soubrane O, Goumard C, Laurent A, et al. Laparoscopic resection of hepatocellular carcinoma: a French survey in 351 patients. HPB (Oxford) 2014;16:357-65.

39. Morise Z. Status and perspective of laparoscopic repeat liver resection. World J Hepatol 2018;10:479-84.
40. Kanazawa A, Tsukamoto T, Shimizu S, et al. Laparoscopic liver resection for treating recurrent hepatocellular carcinoma. J Hepatobiliary Pancreat Sci 2013;20:512-7.
41. Belli G, Cioffi L, Fantini C, et al. Laparoscopic redo surgery for recurrent hepatocellular carcinoma in cirrhotic patients: feasibility, safety, and results. Surg Endosc 2009;23:1807-11.
42. Morise Z, Aldrighetti L, Belli G, et al. Laparoscopic repeat liver resection for hepatocellular carcinoma: a multicentre propensity score-based study. Br J Surg 2020;107:889-95.
43. Takasaki K, Kobayashi S, Tanaka S, et al. Highly anatomically systematized hepatic resection with Glissonean sheath code transection at the hepatic hilus. Int Surg 1990;75:73-7.
44. Hasegawa K, Kokudo N, Imamura H, et al. Prognostic impact of anatomic resection for hepatocellular carcinoma. Ann Surg 2005;242:252-9.
45. Zhao H, Chen C, Gu S, et al. Anatomical versus non-anatomical resection for solitary hepatocellular carcinoma without macroscopic vascular invasion: A propensity score matching analysis. J Gastroenterol Hepatol 2017;32:870-8.
46. Berardi G, Igarashi K, Li CJ, et al. Parenchymal Sparing Anatomical Liver Resections With Full Laparoscopic Approach: Description of Technique and Short-term Results. Ann Surg 2021;273:785-91.
47. Giulianotti PC, Coratti A, Angelini M, et al. Robotics in general surgery: personal experience in a large community hospital. Arch Surg 2003;138:777-84.
48. Liu R, Wakabayashi G, Kim HJ, et al. International consensus statement on robotic hepatectomy surgery in 2018. World J Gastroenterol 2019;25:1432-44.
49. Lafaro KJ, Stewart C, Fong A, et al. Robotic Liver Resection. Surg Clin North Am 2020;100:265-81.
50. Guan R, Chen Y, Yang K, et al. Clinical efficacy of robot-assisted versus laparoscopic liver resection: a meta analysis. Asian J Surg 2019;42:19-31.

doi: 10.21037/ls-20-100
Cite this article as: Mishima K, Wakabayashi G. A narrative review of minimally invasive liver resections for hepatocellular carcinoma. Laparosc Surg 2021;5:46.