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·特邀述评·

Advancements and challenges in laparoscopic hepatectomy in Japan

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Abstract In the 2010s, laparoscopic hepatectomy (LH) rapidly gained popularity in Japan as a minimally invasive approach for liver resections. It offers significant advantages, such as reduced postoperative pain and faster recovery. The Glissonean pedicle approach, employed during LH, enables precise anatomical resection, particularly for hepatocellular carcinoma and metastatic liver tumors. Innovations in training, including the use of animal models and the Japan Society for Endoscopic Surgery certification program, have been instrumental in improving surgical expertise. However, complex hepatectomies involving vascular or biliary reconstruction pose substantial technical challenges. Robot-assisted hepatectomy (RAH) has shown great potential for improved precision and visualization, though its high costs and uncertain long-term benefits limit its widespread adoption. Further technological advancements, enhanced training programs, and large-scale comparative trials are necessary to evaluate the long-term efficacy of both LH and RAH.

Key words Hepatectomy; Laparoscopes; Anatomical Hepatectomy; Glissonean Pedicle Approach

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日本腹腔镜肝切除术的进展与挑战

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摘 要 在21世纪10年代，腹腔镜肝切除术（LH）作为一种微创肝切除方法，在日本迅速获得了广泛应用。其显著优势包括减少术后疼痛和更快的恢复时间。LH中使用的Glissonean蒂入路，有助于精确的解剖性切除，尤其适用于肝细胞癌和转移性肝肿瘤。在培训方面的创新，如动物模型的使用和日本内镜外科学会认证项目，对提升外科医生的技术水平起到了关键作用。然而，涉及血管或胆道重建的复杂肝切除术仍面临较大的技术挑战。机器人辅助手术（RAH）在提高精确度和可视化方面展现出巨大的潜力，但其高昂的成本和不确定的长期效益限制了其广泛应用。未来需要进一步的技术进步、强化培训

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项目以及大规模的对比试验，以评估 LH 和 RAH 的长期疗效。

关键词　肝切除术；腹腔镜；解剖性肝切除术；Glissonean 蒂入路

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In the 2010s, laparoscopic hepatectomy (LH) rapidly gained popularity as a minimally invasive approach for liver resections, with Japan leading global advancements in this technique[1–2]. LH offers significant advantages over traditional open hepatectomy, including lesser postoperative pain, shorter recovery time, and fewer complications[3–4]. However, its application in more complex cases, such as hepatectomies involving vascular or biliary reconstruction, remains limited due to technical challenges. Highlights recent developments in LH in Japan, current research and practice trends, and unresolved challenges, including complex procedures and robot-assisted hepatectomy (RAH)[5].

1　Analysis

1.1 Advancements in Anatomical Resections

One of the major breakthroughs in LH has been its application in anatomical hepatectomies. Techniques, like the Glissonean pedicle approach have made precise anatomical resections possible while preserving the liver parenchyma[6–8]. This approach is valuable for treating hepatocellular carcinoma (HCC), intrahepatic cholangiocarcinoma, and metastatic liver tumors[9]. Despite these advances, laparoscopic anatomical resections in difficult-to-reach liver segments (such as the posterosuperior segments) remain technically demanding[6–7, 10–11].

The caudal view, a unique operative view provided by inserting the laparoscope through the trocar placed at the lower abdominal wall, has unintentionally contributed to improving the liver surgeons' understanding of the intrahepatic vascular anatomy[2]. Because both the Glissonean vessels and hepatic veins branch radially, rooting at the posterior center of the liver, their branching pattern can be read easily in the caudal view[12], thus contributing to the frequent use of caudal approach with LH[13–14].

Advanced dissection tools, such as the cavitron ultrasonic surgical aspirator (CUSA), have enhanced LH's precision[12]. This device allows surgeons to carefully dissect liver tissue while minimizing blood loss, which is critical in laparoscopic surgeries, where bleeding control is more challenging than in open surgeries. To resolve these challenges, we proposed “excavating blood vessels in a dry operative field” as a concept for safe anatomical resections, thus enlightening liver surgeons in Japan.

1.2 Establishment of significant advantages in a laparoscopic approach

Liver segments 7 (S7) and 8 (S8), located in the posterosuperior regions of the liver, are challenging to access in the open and laparoscopic approaches owing to their deep and posterior placement. However, several studies on LH in these segments, including ours, have documented the advantages of laparoscopic hepatectomy over open surgery[15–18]. Usually, a huge incision is necessary in the open approach for these segments; therefore, the benefits of the laparoscopic approach, such as reduced postoperative pain and quicker recovery times, are apparent. Furthermore, safe and meticulous hepatectomies were possible by utilizing the caudal or caudodorsal view obtained by complete mobilization of the right liver in the laparoscopic procedure for S7. In addition, visualization and isolation of the root of the Glissonean branch of S7 from the posterior surface of the liver have been recognized as the standard techniques for ideal anatomical S7 resection worldwide[6,10,14]. In the laparoscopic procedure for S8, the introduction of intercostal trocar placement allows for a more direct route to the resection area, significantly improving the accessibility for surgeons without mobilization of the right liver[7, 19]. The lack of mobilization of the right liver is beneficial, especially for patients with liver cirrhosis, along with minimal incisions of the abdominal and/or thoracic wall, resulting in fewer incidences of postoperative ascites[19–22].

2 Key questions

2.1 Long-term oncological outcomes

Some studies suggest that LH offers comparable survival rates for patients with HCC and colorectal liver metastases[23-24]. However, while LH has demonstrated clear short-term benefits, including faster recovery and fewer complications, its long-term oncological outcomes remain questionable when compared to open surgery. Large-scale, multicenter trials are warranted to determine whether LH provides superior long-term outcomes.

2.2 Technical limitations

Another unresolved issue is the technical challenge of performing LH in patients with larger or more complex tumors. Although significant strides have been conducted concerning LH application in anatomical hepatectomies, major hepatectomies with vascular or biliary reconstructions continue to pose difficulties. Surgeons must contend with the risk of uncontrolled bleeding and the challenge of ensuring clear surgical margins during these procedures.

2.3 RAH

RAH has attracted considerable interest owing to its potential advantages in complex hepatectomies. Robotic systems offer enhanced precision, better dexterity, and three-dimensional visualization, which can theoretically aid in achieving clearer surgical margins and reduced bleeding[25]. However, significant challenges, such as high costs and lack of clear long-term benefits, limit the widespread adoption of RAH[26-27].

3 Implications

The development of LH in Japan has significant implications for the global surgical community. The successful adoption of anatomical resections and innovations in training have broadened the scope of laparoscopic liver surgery. In Japan, the Endoscopic Liver Surgery Study Group, established by Professors Hironori Kaneko and Go Wakabayashi, has conducted hands-on seminars on surgical training using live swine models since 2009. This educational activity contributed to disseminating appropriate and safe LH techniques throughout Japan. In 2004, the Japan Society for Endoscopic Surgery (JSES) initiated a laparoscopic surgery certification program[28]. In this system, the surgeon's skill is evaluated by viewing a full-length clinical video of the surgery, performing a sufficient number of cases, publishing and presenting original studies on laparoscopic surgery, and attending the JSES annual meeting is mandatory for certification. Submission of LH videos has been allowed since 2012, and 137 surgeons who submitted LH videos have been licensed until 2023. The mean annual pass rate was 23%. The reviewing board for LH has provided a main concept of proper LH, which is the "excavation in a dry operative field" technique and disclosed the examination standard to assess whether the examinee performed LH according to this concept. This concept is steadily disseminated in Japan, allowing surgeons seeking LH certification to learn about it.

Although Japan has successfully expanded LH to more minor and moderate hepatectomies, major hepatectomies remain a significant challenge[29]. These procedures have a greater risk of complications, including uncontrolled bleeding from the main hepatic vein trunk[30]. Further advancements in surgical training and technology are warranted to make LH a viable option for major hepatectomy. Training is critical for the successful adoption of LH, particularly as the complexity of the procedures increases. Using live animal models for surgical training provides a realistic environment for surgeons to practice anatomical hepatectomies[31-32]. These programs allow surgeons to practice laparoscopic techniques in a controlled, risk-free environment, thereby reducing the steep learning curve associated with LH[33]. While swine models are commonly used for LH training, we standardized a goat model as a training program for laparoscopic anatomical hepatectomy because the liver anatomy of goats is similar to that of humans[34]. Our goat model has been used extensively to simulate laparoscopic left hemihepatectomy, offering a hands-on experience crucial for mastering major laparoscopic hepatectomies using the Glissonean pedicle approach.

Despite these challenges, several promising areas, such as technological advancements and cost reduction,

should be focused on for future development. Continued advancements in robotic technology, such as improved haptic feedback and further intuitive control systems, can improve the safety and effectiveness of RAH. The integration of real-time imaging and artificial intelligence into robotic platforms also has the potential to enhance surgical decision-making during hepatectomies[35]. However, skepticism exists concerning the potential for cost reduction of robotic systems presumably contributing to the widespread use of RAH, because surgical device-developing companies generally increase the costs of newly released versions by installing additional features and functions[36]. Future research should focus on conducting large-scale comparative trials of RAH, LH, and open surgery to provide more conclusive evidence on the long-term outcomes, particularly cancer recurrence rates, survival, and patient quality of life.

4 Conclusion

LH has advanced significantly in Japan, with innovative techniques, such as the Glissonean pedicle approach and enhanced training models, expanding its use. Despite the success of moderate hepatectomies, challenges in applying LH to complex procedures, such as hepatectomy with vascular or biliary reconstruction, remain owing to technical constraints, such as bleeding control and ensuring clear margins. Although using RAH appears promising, considering potential future advancements, its high cost and unclear long-term benefits limit its adoption. Further comparative trials and technological advancements are warranted to evaluate and fully optimize these approaches for complex surgeries.

Conflict of interest: *The authors declare that they have no conflicts of interest to disclose.*

References

[1] Nguyen KT, Gamblin TC, Geller DA. World review of laparoscopic liver resection-2,804 patients[J]. Ann Surg, 2009, 250(5): 831−841. doi:10.1097/SLA.0b013e3181b0c4df.

[2] Wakabayashi G, Cherqui D, Geller DA, et al. Recommendations for laparoscopic liver resection: A report from the second international consensus conference held in Morioka[J]. Ann Surg, 2015, 261(4):619−629. doi:10.1097/SLA.0000000000001184.

[3] Kaneko H, Takagi S, Otsuka Y, et al. Laparoscopic liver resection of hepatocellular carcinoma[J]. Am J Surg, 2005, 189(2): 190−194. doi:10.1016/j.amjsurg.2004.09.010.

[4] Buell JF, Thomas MJ, Doty TC, et al. An initial experience and evolution of laparoscopic hepatic resectional surgery[J]. Surgery, 2004, 136(4):804−811. doi:10.1016/j.surg.2004.07.002.

[5] Tanaka S, Kubo S, Ishizawa T. Positioning of minimally invasive liver surgery for hepatocellular carcinoma: from laparoscopic to Robot-Assisted liver resection[J]. Cancers, 2023, 15(2): 488. doi: 10.3390/cancers15020488.

[6] Okuda Y, Honda G, Kobayashi S, et al. Intrahepatic glissonean pedicle approach to segment 7 from the dorsal side during laparoscopic anatomic hepatectomy of the cranial part of the right liver[J]. J Am Coll Surg, 2018, 226(2): e1−e6. doi: 10.1016/j.jamcollsurg.2017.10.018.

[7] Ome Y, Honda G, Doi M, et al. Laparoscopic Anatomic Liver Resection of Segment 8 Using Intrahepatic Glissonean Approach[J]. J Am Coll Surg, 2020, 230(3):e13−e20. doi:10.1016/j.jamcollsurg.2019.11.008.

[8] Honda G, Kurata M, Okuda Y, et al. Totally laparoscopic hepatectomy exposing the major vessels[J]. J Hepatobiliary Sci, 2013, 20(4):435−440. doi:10.1007/s00534−012−0586−7.

[9] Yoon YI, Kim KH, Cho HD, et al. Long-term perioperative outcomes of pure laparoscopic liver resection versus open liver resection for hepatocellular carcinoma: a retrospective study[J]. Surg Endosc, 2020, 34(2): 796−805. doi: 10.1007/s00464−019−06831−w.

[10] Ome YSE, Seyama YSI, Doi M. Laparoscopic anatomic resection of segment 7 of the liver using the intrahepatic Glissonean approach from the dorsal side (with video) [J]. J Hepatobiliary Pancreat Sci, 2020, 27(1):E3−E6. doi:10.1002/jhbp.679.

[11] Morise Z. Laparoscopic liver resection for posterosuperior tumors using caudal approach and postural changes: A new technical approach[J]. World J Gastroenterol, 2016, 22(47): 10267−10274. doi:10.3748/wjg.v22.i47.10267.

[12] Honda G, Ome YSE, Yoshida N, et al. How to dissect the liver parenchyma: Excavation with cavitron ultrasonic surgical aspirator[J]. J Hepatobiliary Pancreat Sci, 2020, 27(11): 907−912. doi:10.1002/jhbp.829.

[13] Ferrero A, Lo Tesoriere R, Giovanardi F, et al. Laparoscopic right posterior anatomic liver resections with Glissonean pedicle-first and venous craniocaudal approach[J]. Surg Endosc, 2021, 35(1): 449−455. doi:10.1007/s00464−020−07916−7.

[14] Cao J, Li WD, Zhou R, et al. Totally laparoscopic anatomic S7 segmentectomy using in situ split along the right intersectoral and intersegmental planes[J]. Surg Endosc, 2021, 35(1): 174−181. doi:

10.1007/s00464-020-07376-z.

[15] Berardi G, Wakabayashi G, Igarashi K, et al. Full laparoscopic anatomical segment 8 resection for hepatocellular carcinoma using the glissonian approach with indocyanine green dye fluorescence[J]. Ann Surg Oncol, 2019, 26(8): 2577-2578. doi: 10.1245/s10434-019-07422-8.

[16] Kawaguchi Y, Fuks D, Kokudo N, et al. Difficulty of laparoscopic liver resection: proposal for a new classification[J]. Ann Surg, 2018, 267(1):13-17. doi:10.1097/SLA.0000000000002176.

[17] Siddiqi NN, Abuawwad M, Halls M, et al. Laparoscopic right posterior sectionectomy (LRPS): surgical techniques and clinical outcomes[J]. Surg Endosc, 2018, 32(5): 2525-2532. doi: 10.1007/s00464-017-5958-2.

[18] Cho JY, Han HS, Yoon YS, et al. Outcomes of laparoscopic right posterior sectionectomy in patients with hepatocellular carcinoma in the era of laparoscopic surgery[J]. Surgery, 2015, 158(1): 135-141. doi:10.1016/j.surg.2015.02.007.

[19] Lee W, Han HS, Yoon YS, et al. Role of intercostal trocars on laparoscopic liver resection for tumors in segments 7 and 8[J]. J Hepatobiliary Pancreat Sci, 2014, 21(8): E65-E68. doi: 10.1002/jhbp.123.

[20] Ogiso S, Conrad C, Araki K, et al. Laparoscopic transabdominal with transdiaphragmatic access improves resection of difficult posterosuperior liver lesions[J]. Ann Surg, 2015, 262(2): 358-365. doi:10.1097/SLA.0000000000001015.

[21] Ishizawa T, Gumbs AA, Kokudo N, et al. Laparoscopic segmentectomy of the liver: from segment I to VIII[J]. Ann Surg, 2012, 256(6):959-964. doi:10.1097/SLA.0b013e31825ffed3.

[22] Hallet J, Soler L, Diana M, et al. Trans-thoracic minimally invasive liver resection guided by augmented reality[J]. J Am Coll Surg, 2015, 220(5):e55-e60. doi:10.1016/j.jamcollsurg.2014.12.053.

[23] Sposito C, Battiston C, Facciorusso A, et al. Propensity score analysis of outcomes following laparoscopic or open liver resection for hepatocellular carcinoma[J]. Br J Surg, 2016, 103(7): 871-880. doi:10.1002/bjs.10137.

[24] Taillieu E, De Meyere C, Nuytens F, et al. Laparoscopic liver resection for colorectal liver metastases—short- and long-term outcomes: A systematic review[J]. World J Gastrointest Oncol, 2021, 13(7):732-757. doi: 10.4251/wjgo.v13.i7.732.

[25] Jang EJ, Kang SH, Kim KW. Exploring the feasibility of robotic liver resection in a limited resource setting[J]. J Robot Surg, 2024, 18(1):187. doi: 10.1007/s11701-024-01901-1.

[26] Ayabe RI, Azimuddin A, Tran Cao HS. Robot-assisted liver resection: the real benefit so far[J]. Langenbecks Arch Surg, 2022, 407(5):1779-1787. doi: 10.1007/s00423-022-02523-7.

[27] Kose E, Karahan SN, Berber E. Robotic Liver Resection: Recent Developments[J]. Curr Surg Rep, 2020, 8:9. doi: 10.1007/s40137-020-00254-6.

[28] Kazama K, Numata M, Aoyama T, et al. Does the endoscopic surgical skill qualification system improve patients' outcome following laparoscopic surgery for colon cancer? a multicentre, retrospective analysis with propensity score matching[J]. World J Surg Oncol, 2021, 19(1):53. doi: 10.1186/s12957-021-02155-z.

[29] 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]. J Hepatobiliary Pancreat Sci, 2016, 23(11): 721-734. doi: 10.1002/jhbp.405.

[30] Dagher I, O'Rourke N, Geller DA, et al. Laparoscopic major hepatectomy: an evolution in standard of care[J]. Ann Surg, 2009, 250(5):856-860. doi:10.1097/SLA.0b013e3181bcaf46.

[31] Teh SH, Hunter JG, Sheppard BC. A suitable animal model for laparoscopic hepatic resection training[J]. Surg Endos, 2007, 21(10):1738-1744. doi:10.1007/s00464-007-9209-9.

[32] Al Faris AA, Bannai JA, Abdulsamd RK. Laparoscopic liver resection in the goat[J]. Basrah J Vet Res, 2015, 14(1): 156-166. doi: 10.33762/BVETR.2015.100043.

[33] Koscielny S. What is the value of animal models in laparoscopic surgery? —A systematic review[J]. Ann Laparosc Endosc Surg, 2020, 7:1-11. doi:10.21037/ales-21-52.

[34] Kawamoto Y, Honda G, Ome YSE, et al. Laparoscopic left hepatectomy in a goat as a training model for laparoscopic anatomic liver resection: results of training courses with a total of 70 goats[J]. Surg Endosc, 2023, 37(5): 3634-3641. doi: 10.1007/s00464-023-09864-4.

[35] Bijlstra OD, Broersen A, Oosterveer TTM, et al. Integration of Three-Dimensional liver models in a multimodal Image-Guided robotic liver surgery cockpit[J]. Life (Basel), 2022, 12(5):667. doi: 10.3390/life12050667.

[36] Crew B. Worth the cost? A closer look at the da Vinci robot's impact on prostate cancer surgery[J]. Nature, 2020, 580(7804):S5-S7. doi: 10.1038/d41586-020-0103.

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