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REVIEW

Application of Robotic Surgery in Hepatocellular Carcinoma

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Abstract: Hepatocellular carcinoma (HCC) has a lot of possible treatment strategies. At present, the clinical treatment of Hepatocellular carcinoma is mainly surgical treatment, according to the different conditions of patients, there are also differences in the choice of surgical methods. Open liver resection, laparoscopic liver resection, and robotic liver resection are some of the suitable treatment options. In this paper, the current advantages, limitations, and future of robotic surgery in HCC are reviewed and analyzed for clinicians' reference.

Keywords: Hepatocellular carcinoma, robotic liver resection, surgery

Introduction

HCC is a complex disease, and possible treatment strategies vary depending on the liver cancer staging system. The c (LR) is one of the primary possible curative forms of treatment for HCC. Patients with tumors ≥3 cm in diameter and 3 or fewer tumors are well suited for surgery.[1] In recent years, surgical techniques of minimally invasive liver resections have evolved.

Since the first report of robotic hepatectomy in 2003, the robotic approach has continuously increased in the surgical treatment of HCC.[2] A lot of articles suggest robotic liver resection (RLR) is feasible and safe.[3] Robotic hepatectomy (RLR) has a shorter operative time (Med:181 vs 201 minutes) and lower estimated blood loss compared to open liver resection (OLR) (Med: 200 vs 400 minutes).[4] However, in another study, RLR had a longer surgical time than ORR (Med:295 vs 200 minutes), but there have been few large-data randomized controlled trials to show the mid- and long-term efficacy of robotic hepatobiliary surgery (2.8% vs.11.3%).[4] At present, there are few large-data randomized controlled trials showing the medium- and long-term efficacy of robotic liver and gallbladder surgery.

Advantages and Limitations of Robotic Surgery

Since the first left lateral sectionectomy was performed in 2008, more and more major robotic hepatectomies have been performed, such as hemi-hepatectomies, Associating Liver Partition and Portal vein ligation for Staged hepatectomy (ALPPS) procedures, and Klatskin resections.[5–7] There are efforts to expand the indications for RLR. Also, as a minimally invasive approach, laparoscopic liver resection (LLR) is worldwide accepted. LLR is characterized by better short-term outcomes and lower rates of postoperative complications. A comprehensive meta-analysis of LLR involving 2,804 patients showed the open surgical conversion rates for LLR of approximately 4.1% and a postoperative death rate of 0.3%.[8] Compared to LLR, RLR has the following advantages, including ergonomics with diminished surgeon fatigue, increased stability, tremor filtration, instrument flexibility, and superior visualization with a magnified 3-dimensional vision. A large meta-analysis of 2630 participants reported a longer mean operative time (mean: 281 versus 221 minutes, $p < 0.001$), less mean intraoperative blood loss (mean: 286 versus 301 mL, $p < 0.001$), and

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a significantly lower rate of readmission (odds ratio: 0.43, p = 0.005) compared with LLR, suggesting that RLR is safe and effective.[9] However, there were no significant differences between RLR and LLR in OS and DFS at 3 years.[10] Notably, the incidence of abdominal adhesions in patients in the RLR group was almost twice as high as in patients in the LLR group (63.6% versus 35.5%).[11] This result may be due to the fact that RLR has an extra trocar than LLR, resulting in stronger traction on the peritoneum and so-called case selection offset, but there has been no research to demonstrate whether a previous surgical history of abdominal induced adhesion may affect the safety of RLR and adhesion complications.

Learning curves for robotic liver resection are generally shorter than standard laparoscopic surgery. It is important to avoid paving the way for complex minimally invasive liver surgery too early in the learning curve while neglecting the safety aspect. The validity of simulation for robotic surgical training has been confirmed.[12] Effective procedural simulation and surgical experience can reduce complications and shorten operative time.[13] Building an advanced robotic surgery program may provide better surgical training techniques and experiences. In addition, the application of indocyanine green (ICG) fluoroscopy in robotic-assisted surgery offers an effective method to improve the identification of tumor regions.[14] I think ICG can also be used to display the internode plane of the tumor, which will make the surgery better.

Robotic platforms are not suitable for all liver surgeries. The ideal real robot is one that does not require external tools, can be used on existing platforms, is suitable for any type of liver resection. One of the main limitations of the robotic system is the absence of available transection devices to parenchymal transection. Robotic surgeons need the help of bed-side laparoscopic Ultrasonic Aspirator (UA) transection. Achieving true robots can rely on the selective use of inserted bipolar clamps and monopolar scissors, or the "micro-fractural-coagulation" (MFC) transection method, which achieves safe transection by precise and precise anatomy of key structures. Minimize bleeding (The average blood loss is 168.1 mL) and complications occur. At the same time, slight bile leaks can be identified to the greatest extent to facilitate early detection and suturing or cutting. However, systematization has not been achieved at present, so the data is questionable.[15] Robotic surgery has 10x magnification and 3D resolution, enabling precise resolution even at preoperative sites that are unfamiliar with either laparoscopic or open surgery. While robotic hepatectomy has led to visual innovations, lack of force feedback increases the difficulty and risk for the surgeon. In generally, the high cost significantly limits the clinical popularity of RLR. Robotic platforms require significant start-up costs including the cost of equipment and training of support staff to efficiently implement technology. Another limitation of robotic-assisted surgery is the operative time. The robotic cart docking is considered to be most time-consuming part.

Challenges of Robotic Surgery

The learning curve is defined as the improvement in performance or the ability to complete a task over time until failure rates decrease to a consistently acceptable level. There are limited data directly comparing the learning curves of RLR and LLR. In a 2017 study, two surgeons treated 25 cases of RLR versus LLR (minor hepatectomy) and found that RLR resulted in better outcomes in terms of blood loss, hospital stay, and postoperative complications.[16] In another recent study, the authors selected a single surgeon for Minimally invasive liver surgery and found that there was a significant similarity in the learning curves of robotic and laparoscopic techniques prior to moderately difficult liver resection.[17] A single-center study (140 cases) looked at the conversation of open surgery during the learning phase and found an improved conversion rate after 30 cases compared to 60 cases of laparoscopic hepatectomy.[18] The learning curve for robotic liver surgery is less steep compared to laparoscopic surgery, which will have a huge impact on future outcomes.

Although robotic surgery overcomes the problems of low visualization and limited range of motion in traditional laparoscopic surgery, it still requires careful operation by experienced surgeons. Compared to laparoscopic techniques, the changeover time of robotic instruments is still significantly longer (196.6 ± 28.8 vs 224.1 ± 45.7 minutes), which can lead to the inability to treat bleeding immediately in cases of clinically severe bleeding. Additionally, for inexperienced surgeons, uncontrolled pressure applied by robotic instruments can have uncontrolled effects during traction and knot tying. When adverse events occur, it is particularly important to have additional physicians immediately convert the surgery to an open procedure. This also requires doctors to have the ability and judgment to quickly switch surgical methods.

Where are We Going at RLR?

Robotic surgery has come a long way in the past 20 years.[19] We are committed to providing people with a new and effective minimally invasive technique. But safety concerns have arisen as robotic-assisted surgery becomes more common. How to improve safety and reduce harm for patients without a surgeon at the bedside and a large incision. As more and more outcomes and experiences of robotic surgery were shared in the world, new standards of RLR would be continuously evolving. This development has been achieved, on the one hand, through the continuous improvement of robotic instruments (eg, The cavitron ultrasonic surgical aspirator (CUSA) and bipolar-mediated parenchymal dissection) and, on the other hand, through the continuous adaptation and further development of surgical techniques and conceptual approaches (eg, the "caudal approach" or (Distance, Illumination, Minimum tissue trauma, Optimal view, No direct dissection, Differential dissection) DIAMOND technique).[20] This also favors expanding the choice of dissection methods in robotic surgery. How to reduce high costs is an important question influencing robotic surgery widely available. Compared to laparoscopy, robotic systems are more costly. A recent meta-analysis that included 11,000 hepatectomies showed that LLR was $759 cheaper compared to RLR, but not statistically significant.[21] Robust insurance company reimbursement systems and lower acquisition and operating costs for robotic systems can be expected to address this issue.

Conclusions

In conclusion, robotic surgery has become an important alternative to laparoscopic and open hepatectomy techniques. The use and indications of RLR for HCC will undoubtedly increase in the coming years. Systems such as the latest Hinotori™ Surgical Robotics System and several new multiport robotic surgical systems can broaden their indications while achieving the same clinical outcomes as the DA Vinci robotic surgical platform.[22,23] Successful robotic-assisted liver surgery requires careful patient selection and a rigorous safety protocol. Robotic surgical care is also an important factor in rapid patient recovery. We believe that in the future, robotic liver resection for HCC centers will emerge all over the world. Even though we are still limited by high cost, lack of systematization, reimbursement issues, and lack of a large amount of prospective experimental data, we still believe that in the future, robotic hepatectomy treatment centers for HCC will emerge around the world.

Core Tip

The liver resection (LR) is one of the primary possible curative forms of treatment for Hepatocellular carcinoma. Robotic surgery is an important surgical method in rapid patient recovery in HCC.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no conflict of interest.

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