Editorial Commentary

Robotic hepatectomy: challenge and progression

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As of June 30, 2022, approximately 7,135 da Vinci Surgical Robot units (da Vinci Intuitive Surgical Inc, Sunnyvale CA, USA), the most advanced technology in minimally invasive surgery (MIS), had been installed worldwide, with approximately 70 countries using the da Vinci Surgical Robot and over 10 million surgeries performed with the da Vinci Surgical Robot. Since the first successful application of this novel technology for hepatectomy in 2001 (1), an increasing number of studies had focused on the feasibility and safety of robotic surgery in the field of liver surgery. The rate of robotic hepatectomy continues to grow, because of improvements in surgical techniques and breakthroughs in surgical instrumentation, and also for the widespread recognition of robotic surgery.

Minimally invasive hepatectomy is known to be safe in expert centres and is suitable for robotic hepatectomy (2). When robotic hepatectomy was first mentioned in the international consensus statement, the limited findings showed that the outcomes of robotic hepatectomy were not inferior to other techniques, and it was considered to be easy for learning in minimally invasive liver surgery, even the instruments suitable for robotic surgery was far behind to others (3). Since then, experienced surgeons have gradually expanded the indications for robotic hepatectomy to include complex, deep, large-scale liver resections, and an increasing number of studies have concluded that robotic hepatectomy has advantages over conventional laparoscopic surgery in difficult procedures when performed by experienced surgeons, such as in liver resection of lesions in the Sg1 (Segment 1), Sg7, and Sg8 segments (4), left hepatectomy (resection of Couinaud's segments 2 to 4) and extended left hepatectomy (5). Today's da Vinci robotic surgical system is known for its high-definition magnified three-dimensional view, fluorescence mode, flexible artificial wrists, tremor filter, and comfortable seat (6). These technical advances have overcome the inherent limitations of conventional laparoscopy in hepatectomy, provided a better view of the operative area, finer and more flexible stripping and suturing, faster and more effective bleeding control, theoretically facilitated the feasibility of hepatectomy, and ultimately improved perioperative outcomes. More importantly, it increased the confidence for surgeons to challenge the most difficult surgical procedures because the process for biliary and vascular reconstruction was simplified by robotic hepatectomy (7).

Current surgical indications for robotic hepatectomy include those for open hepatectomy, as well as living donor hepatectomy. As a purely altruistic act, donor hepatectomy should be the safest and least morbid operation. The safety and feasibility of minimally invasive donor hepatectomy (MIDH) used to reduce the trauma in surgical procedures and provide a better quality of life for the donor postoperatively, with no inferior recipient outcomes compared to open surgery (8). The advantages of minimally invasive donor hepatectomy, such as the potential to enable them to return to their daily activities earlier and provide better body image and cosmetic results, might reduce the concerns and increase the proportion of donors. However, the complexity of the procedure is one of the main factors for limiting laparoscopic approach. As a result, some transplant centres have begun to explore the benefits of robotic platforms in liver transplantation in recent years. Results from a single-centre study reported

by Schulze *et al.* suggested that lower conversion rates, lower donor complication rates, lower donor mortality, less postoperative pain, and shorter average length of stay might be associated with the superior suturing capabilities and bile duct visualization for the robotic platform, regardless of donor lobe type (9). Based on these encouraging findings, we believed that more and more experiences for liver transplantation using robotic platform could be shared in many transplant centres.

However, the significant advantages of robotic surgery over conventional laparoscopy have inspired experienced surgical teams to explore the potential of surgical robotics, and they have ventured into the application of robotic platforms for high-risk and controversial procedures, such as associating liver partitioning and portal vein occlusion for staged hepatectomy (ALPPS) and radical resection surgery for hilar cholangiocarcinoma (HCCA). ALPPS is a technique to generate compensatory hypertrophy of the future remnant liver and reduce the risk of liver failure after hepatectomy (10). Although the initial reported mortality and morbidity rates were unacceptable, with growing experience and advances in surgical techniques, ALPPS can be used as a treatment option for hepatocellular carcinoma and HCCA after a thorough preoperative evaluation and careful case selection (11,12). The original intention of applying minimally invasive techniques to ALPPS was to reduce the surgical trauma in the first stage. The current findings suggest that minimally invasive ALPPS may be able to reduce the morbidity and mortality for patients, and the application of robotic platform can extend this advantage (13).

As far as HCCA is concerned, the technical complexities associated with performing extended hemihepatectomy and multiduct hepaticojejunostomy, as well as the controversial extent of lymphadenectomy, have deterred many laparoscopists, even for experienced (14). Fortunately, robotic approaches have great potential in the surgical treatment of HCCA due to its technically enhanced EndoWrist, which enables surgeons to undertake these various complicated and challenging manoeuvres (15). Although a comparative study of an initial series reported by Xu *et al.* in 2016 demonstrated that robotic radical resection for HCCA was associated with a longer operative time and higher prevalence of morbidity than open surgery (16), recent systematic reviews and meta-analyses show that MIS for HCCA is noninferior to open surgery, at least in the perioperative period, and the authors hold a positive attitude towards the robotic approach (17).

A growing number of studies reported that robotic hepatectomy was a valuable treatment with the expand of indications. More and more patients would be benefited because the surgical procedures for robotic hepatectomy were standardized and reproduced though some of these were used in rare cases right now. In addition, the dual console of the robotic platform will address the huge demand training for surgeons. While procedures considered complex and technically difficult are still performed using an open approach in most hepatobiliary centres (18), we believe robotic surgery can provide patients with increasingly significant benefits from minimally invasive liver surgery.

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Footnote

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