Editorial

Robotic liver surgery: advantage beyond pure laparoscopic approach?

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Minimally invasive liver surgery has gained popularity worldwide since the first-reported laparoscopic wedge resection of a benign hepatic lesion by Reich *et al.* in 1991 (1). Laparoscopic liver resection (LLR) was considered an accepted approach for both benign and malignant conditions after two international consensus conferences held in Louisville in 2008 (2) and Morioka in 2014 (3). With the advancement of energy device, laparoscopic video system and increasing surgeons' experience, partial hepatectomy in all hepatic segments (4), major hepatectomy (5), liver donor hepatectomy (6) and associating liver partition and portal vein ligation for staged hepatectomy (ALLPS) (7) can now be performed in laparoscopic approach. Favorable short-term and long-term outcomes have been reported for both benign and malignant conditions in recent meta-analyses (8,9). However, laparoscopic hepatectomy is technically challenging due to the limitations of laparoscopic approach which include rigidity of laparoscopic instruments, poor ergonomic, tremor amplification and 2-dimensional laparoscopic view. Laparoscopic hepatectomy is associated with a steep learning curve (10) and relatively high conversion rate (11).

Robotic liver surgery has emerged as the latest development of minimally invasive liver surgery since the first-reported robotic hepatectomy by Giulianotti *et al.* in 2003 (12). Robotic surgical system provides a steady working platform, high resolution three-dimensional image with instruments of 7 degrees of freedom, which may overcome some of the limitations of conventional laparoscopic surgery. Furthermore, robotic surgery provides a more ergonomic operating platform which render complex liver procedure less exhausting. Favorable short-term and long-term outcomes have been shown in patients underwent robotic hepatectomy comparing to open approach. Wong *et al.* reported a meta-analysis of 7 retrospective, case-control studies on robotic and open hepatectomy conducted between 2013 and 2016 (13). The results revealed that robotic hepatectomy had a longer operative time, but there was no significant difference in intraoperative blood loss and blood transfusion rate. Robotic hepatectomy led to shorter length of stay, lower overall complication rate and major complication rate, comparing to open approach. Wang *et al.* (14) published a single-center retrospective study in 2018 comparing oncological outcomes in patients with hepatocellular carcinoma who underwent robotic hepatectomy (n=63) and open hepatectomy (n=177) between June 2013 and July 2016. It was shown that there was no significant difference with regard to the R0 resection rate, overall recurrence rate and survival duration. The follow-up data showed that the robotic and open hepatectomy groups had no significant difference in the 1-, 2- and 3-year disease-free survival and overall survival.

For comparison of clinical outcomes of robotic hepatectomy and conventional laparoscopic hepatectomy, clinical evidence is limited to non-randomized retrospective studies. There is no available randomized controlled trial. Robotic surgery still bears certain limitations as compared to laparoscopic approach. Lack of tactile and force feedback to surgeons and cost-effectiveness are major drawbacks

in robotic surgery. With respect to liver surgery, some of those widely used devices for liver parenchyma transection in open and laparoscopic surgery, including Cavitron Ultrasonic Surgical Aspirator (CUSA) and water jet dissectors are not available for robot-assisted liver resection. Although harmonic scalpel which is commonly used for parenchymal transection is available in robotic surgery system, it lacks Endowrist function and does not have the degrees of freedom like other robotic instruments (15). Besides, bulkiness of robotic surgery system and need for robotic arms docking limit patient re-positioning during operation which may be necessary in complex hepatic procedures like central hepatectomy. Thus, whether robotic hepatectomy results in superior clinical outcomes comparing to conventional laparoscopic approach remains unknown.

In the paper "*Robotic vs. laparoscopic liver surgery: what are the advantages of the robot?*", Croner *et al.* conducted a systemic review on literatures comparing outcomes after robotic and laparoscopic hepatectomy and presented their experience of robotic versus laparoscopic left lateral sectionectomy (16). Articles which compared laparoscopic with robot-assisted liver resection based on original data were selected. Meta-analyses and reviews were excluded. Between 2010 and 2020, 29 papers including 1,392 patients who underwent robotic liver resection (RLR) and 1,965 patients who underwent conventional LLR were analyzed. While parameters like patient age, body mass index (BMI), mean tumor size, mean operative time, mean blood loss and transfusion rate were similar between RLR and LLR groups, it appears that peri-operative overall morbidity (RLR: 0–68.0%, LLR: 0–35.3%) and mortality (RLR: 0–10.0%, LLR: 0–5.0%) were increased in RLR group. Margins with residual tumor (R1) appears to be less common in RLR group (RLR: 0–11.1%, LLR: 0–23.1%). Oncological outcomes were compared in three studies, all showed no significant difference in terms of disease-free survival and overall survival (17-19). Cost analysis was included in five papers. It was consistently shown that cost was higher in RLR group.

In a subgroup analysis focusing on major hepatectomy, five studies including 196 patients who underwent RLR and 222 patients who received LLR were analyzed. The mean operation time and blood loss between RLR and LLR groups were similar. It appears that the conversion rate was lower in RLR groups (RLR: 4.0–14.3%, LLR: 4.0–25.0%). Morbidity and mortality also appeared more favorable in RLR patients in major hepatectomy subgroup (morbidity: RLR: 0–28.1%, LLR: 10.4–36.0%; mortality: RLR: 0%, LLR: 0–4.0%). R1 resection was less frequent in RLR group (RLR: 0–8.3%, LLR: 7.4–25.0%).

In the local cohort of patients who underwent laparoscopic and robotic left lateral sectionectomy, mean operation time was longer in RLR group. There was no statistically significant difference in other perioperative parameters. Overall morbidity was comparable between RLR and LLR groups. It was commented that heterogeneity in outcome measures made it difficult to evaluate clinical data from selected studies. The authors concluded that robotic hepatectomy might be beneficial in advanced cases and suggested to measure and evaluate impact on operating surgeons in terms of working ergonomics.

The main drawback of this study is that it is a systemic review summarizing results of published comparative studies by simple pooling of data. It lacks proper appraisal and weighting of selected studies and assessment of risk of bias. With the absence of appropriate statistical testing, one cannot tell whether the apparent differences in clinical outcomes comparing RLR and LLR are genuine or purely by chance. Therefore, the level of evidence is limited.

Nevertheless, this paper is a comprehensive systemic review of a controversial topic comparing robotic and laparoscopic hepatectomy. The authors observed a trend of less conversion rate, R1 resection rate as well as morbidity and mortality rate in RLR cohorts in the context of major hepatic resection. This highlighted an important message that there might be a superior role of RLR in a subgroup of patients. In fact, by stratifying hepatic resection into low, intermediate and difficult level according to a difficulty scoring system as advocated by Ban *et al.* (20), experience from our center found that surgical outcomes in patient who underwent robotic and conventional laparoscopic hepatectomy were similar in cases with low and intermediate difficulty whereas robotic system allowed minimally invasive approach in cases with higher difficulty level (21). In a propensity score matched analysis by Cipriani *et al.* (22), while robot-assisted liver resections did not show operative or clinically significant benefits over conventional LLR for low- and intermediate-difficulty resections, robot-assisted liver resection could favor operative feasibility of difficult resections as evidenced by a reduced conversion rate.

In summary, with continuous improvement of surgical equipment and robotic surgery operating platform, whether robotic or conventional laparoscopic is the preferred approach of minimally invasive liver surgery is still under debate. It seems that robotic approach may be superior

to conventional laparoscopic approach in a subgroup of patients undergoing complex liver resection. Future studies with focus on proper patient selection, ergonomic impact to operating surgeons and effect on surgical training will further define the role of RLR.

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