Editorial Commentary

Pioneering the future of robotic liver surgery

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Hepatocellular carcinoma (HCC) is the sixth most commonly diagnosed cancer worldwide and represents the predominant form of primary liver cancer, accounting for approximately 90% of cases (1). Predictions indicate a significant rise in the incidence of liver cancer over the next two decades. This emphasises the urgent imperative for cutting-edge research to enhance patient outcomes and optimise surgical resection strategies for HCC (2).

Over the past two decades, hepatopancreatobiliary (HPB) surgeons have embraced and refined the robotic approach to liver resections, determined by a commitment to improving patient safety and efficacy of robotic liver resection (RLR). Safety in the field of RLR included blood loss and post-operative morbidity and mortality. Efficacy involved recurrence rates, survival, resection margin, patients reported outcomes and cost-effectiveness (3,4).

RLR has emerged as a transformative approach, offering distinct advantages over conventional open and laparoscopic surgery. RLR represents a promising frontier in surgical innovation, demonstrating safety and efficacy in treating a range of benign and malignant liver conditions. It has the advantages of three-dimensional (3D) vision enabling surgeons to navigate complex liver anatomy with precision, and superior depth perception (5). Robots provide HPB surgeons with enhanced dexterity and instruments articulation, facilitating scrupulous dissection and vascular control during parenchymal transection (6). The current robotic platforms offer HPB surgeons with improved ergonomics, reducing fatigue and boosting surgical performance. RLR benefits patients with reduced postoperative pain, shorter hospital stays, and faster recovery compared to open surgery. Contrarywise, the steep learning curve, the initial investment to start a robotic programme and ongoing maintenance costs associated with robotic systems pose economic challenges for healthcare facilities. Robotic platforms and instruments continue to innovate and the next generations of smaller and more ergonomics robotics and instruments are yet to be seen (7).

Recent systematic reviews and meta-analyses have provided an insight on the comparative outcomes of RLR versus open liver resection (OLR), revealing a refined picture of safety and efficacy. RLR was not associated with compromised resection margin or high mortality rate, and it was linked to lower morbidity and length of stay (6,8). Decrease estimated blood loss (EBL) and intraoperative blood transfusion is one of the findings featured in some studies (9). One of the criticisms we tend to receive on RLR is the longer operative time, while this is may have a logistic negative impact in some situations, the risk here is outweighed by valuable benefits achieved by RLR.

Transitioning from traditional open or laparoscopic approaches to robotic surgery necessitates structured training pathways. A stepwise training approach has been advocated by Ahmad *et al.*, involving proctored training levels with a specified number of procedures, supplemented by simulation and practical laboratory sessions. Challenges exist, including limited access to robotic platforms and availability of proctors, but these barriers are expected to lessen over time with increased experience and infrastructure development (10).

One critical aspect is determining the learning curve and requisite case volume for proficiency in robotic HPB surgery. International consensus guidelines suggest that optimal competence in major RLR requires approximately 25 cases, and 15 cases for minor RLR for experienced surgeons to overcome the learning curve, which is less than laparoscopic liver resection (LLR) (11). However, surpassing the learning curve is multifactorial, influenced by the surgeon's baseline experience, previous laparoscopic exposure, simulation training, and procedural complexity. For trainees, the learning process may vary based on prior laparoscopic experience. Studies indicate that trainees benefit from robotic surgery advantages in dexterity, 3D visualisation, and ergonomic design, leading to fewer errors and shorter learning curves compared to laparoscopic training (12). In the UK, the evolution of robotic HPB surgery has been noteworthy, and within few years, the landscape has transformed, with many units offering robotic HPB surgery and many surgeons have been trained by national and international proctors (13). This is contributing to the expansion and standardisation of robotic HPB surgery across the country. As robotic HPB surgery continues to evolve and expand, collaborative efforts in training, infrastructure development, and research will be pivotal in maximizing the benefits of this transformative technology for patients and surgical communities worldwide.

Di Benedetto *et al.* reported a retrospective observational study on 398 patients with HCC who underwent RLR (158 patients) in two European and two US centres in 10 years period, comparing that with patients who underwent OLR (240 patients) in the same time period at another non-robotic hospital. The objective of their report was to highlight the short- and long-term outcomes, as well as safety and efficacy of these two major procedures in high-volume centres. The primary endpoints of the study were safety, feasibility, and oncological outcomes of RLR in comparison to OLR. The authors used two scoring systems in their assessment of complexity of the liver resection (IWATE) and the risk of HCC recurrence (ERASL-pre). OLR was performed in a standard fashion using the Cavitron Ultrasonic Surgical Aspirator (CUSA), and RLR was performed using da Vinci Si or Xi robots and vessel sealer/harmonic (14).

After applying propensity score matching (PSM) to match 106 patients in each group for final analysis, RLR was associated with several prominent outcomes compared to OLR. Specifically, RLR procedures exhibited longer operative times and higher blood loss but resulted in shorter hospital stays and intensive care unit (ICU) stays. Essentially, RLR was associated with a reduced incidence of post-hepatectomy liver failure (PHLF) and microvascular invasion compared to OLR. Remarkably, there were no statistically significant differences between the groups in bile leak incidence or R status. However, it is worth noting that four patients in the RLR cohort experienced grade B bile leaks, and one patient had R1 resection, whereas none of these outcomes were occurred in the OLR group. These findings highlight specific considerations and potential trade-offs associated with RLR versus OLR in liver resection for HCC. Patients who underwent RLR showed similar 90-day overall survival (OS) rates compared to patients who underwent OLR. The 24-month estimated OS rates were comparable between the two groups, with an adjusted hazard ratio (HR) for OS favouring RLR but not statistically significant (14).

One of the interesting points in this study is that the incidence of PHLF was less in the RLR group, although there was no clear explanation provided. PHLF is more common in right or extended right liver resections, which was not the case here as both groups had similar number of right-side resections after PSM. It is noticed as well that the EBL was higher in RLR than OLR, which again is another contributing factor for PHLF, but it did not increase PHLF rate in this series. The lower rate of PHLF could be multifactorial and associated with the minimally invasive nature of the robotic surgery, and the selection of the patients.

The absence of CUSA in RLR has been a topic of debate, but advancements in robotic technology may rest this dispute. Many surgeons, have found alternative techniques such as vessel sealers, synchroseal, and staplers to be effective during RLR without compromising outcomes or increasing complications. As robotic technology continues to evolve, it is conceivable that a robotic CUSA may develop, potentially enhancing the precision and efficacy of RLR. Moreover, the cost disparity between RLR and OLR is likely to narrow over time, as the benefits of RLR, become more noticeable. At last, it is worth noting that LLR remains a remarkable competitor to RLR and warrants comparison in future studies. LLR offers its own set of advantages and may serve as a benchmark for evaluating the efficacy and cost-effectiveness of RLR in the long term.

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Footnote

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