ABSTRACT

Laparoscopic surgery has become a staple in many tertiary care centres worldwide. However, due to the inherent limitations of laparoscopic surgery, adoption of minimal access approaches in surgery of the liver has been slow and patchy. Every hepatobiliary surgeon knows the limitations of laparoscopic surgery of the liver. Advanced robotic surgical systems have been introduced to fill gaps in the technical feasibility of minimal access liver resections. We try to explore the use of advanced robotic systems in hepatobiliary surgery and how the novel system could help circumvent the inherent limitations of laparoscopic liver surgery. The manuscript reviews the current data concerning laparoscopic, as well as, open versus robotic approaches in liver surgery. Authors show that although robotic surgery is in its infancy, the promising role cannot be ignored. With the increasing trend towards parenchymal saving liver resection, robotics will only positively aid in the wider adoption and growth of minimally invasive techniques. Although robotics is still evolving, the need in liver surgery is evident. Further long-term research is required, however, to confirm the huge potential of robotics in liver surgery.

Keywords: da Vinci surgical system, EndoWrist™, Hepatobiliary surgery, Laparoscopic liver resection, Parenchymal sparing liver surgery, Robotic surgery

INTRODUCTION

The last few decades have seen a meteoric rise in global adoption of minimally invasive surgical techniques. Owing to significantly reduced post-operative morbidity, length of ICU and hospital stay and better cosmesis, laparoscopic procedures for appendectomy, cholecystectomy, gastric resection and colectomy have become a staple in many tertiary care centers.1,2

In the same vein, surgery of the liver, once thought unattainable due to excessively high mortality rates, has become safe enough to allow cautious development of minimally invasive approaches.3,4 The initial reports on laparoscopic liver resection published in the beginning of the 1990s were followed by reports of left lateral sectionectomy in 1996.5,6 Evermore, laparoscopic liver surgery expanded to include hemi-hepatectomy, sectionectomy, segmentectomy, and recently, parenchymal preserving and modified anatomical resections, mirroring the technological, as well as, the conceptual advances in liver surgery.7,8

REVIEW OF LITERATURE

Introduction of advanced laparoscopic devices and liver parenchymal transection equipment have since aided specialists to improve the performance of liver resections.9,10 Indeed, the 2nd consensus meeting on laparoscopic liver resection, held in Morioka, Japan, established that minor laparoscopic liver resection is now a standard practice, evidencing lower postoperative morbidity, shorter hospital stay and reduced blood loss.
compared to open procedures, with analogous oncologic outcomes. However, major resection was considered innovative, and robotic liver resection categorized as developmental.11,12

Nonetheless, there are some limitations inherent to laparoscopy, including low depth perception and rigid, straight instruments that have to work within a fixed fulcrum.13 The complex nature of hepatobiliary surgery, in addition, has made universal adoption of the laparoscopic method slow and patchy.13,14 Caruso et al, point out, for instance, that in Italy and in Netherlands, only 10.3% and 11% of the total number of liver resections, respectively, were performed laparoscopically.15 Although, the acceptance of the procedure has gained momentum in the last few years, the vast percentage of liver resections is still being performed open.

Advanced robotic surgical systems are slowly being introduced to fill gaps in the technical feasibility of minimal access liver resections. Intuitive Surgical Inc. (Sunnyvale, CA, US) is the single supplier for the platform and has been used for more than 3 million minimally invasive surgical procedures in various subspecialties.16 Formed after the merger in 1993 between two initially competing companies, Computer Motion Inc. and Intuitive Surgical, the da Vinci Xi robot is their fourth and latest rendition that was approved by the United States Food and Drug Administration in 2014.17

Fundamental to the technology are a high-definition, magnified 3-D view for greater depth perception, articulated instruments (EndoWrist™) that mimic the motion of the human hand, and tremor filtration for precise suture placement. All this is packaged in an ergonomic console which allows the surgeon to work sitting down in a comfortable position. These features, proponents argue, will be particularly advantageous for laparoscopically challenging resections of posterior-superior segments (segments IVa, VII and VIII) that require warped transection lines, delicate hepatocaval dissections required during right hemi-hepatectomies, as well as, biliary reconstructions and suturing for bleeding management during parenchymal transection.13,18,19

**DISCUSSION**

Several studies using the da Vinci have been published recently that conclude robotic hepatectomy is a safe, feasible and effective alternative to laparoscopic liver resections.13,20-22 A study comparing robotic liver surgery with open and laparoscopic procedures demonstrated robotic hepatectomy to be non-inferior in their long term oncologic outcomes.21

Some authors have also demonstrated that lesions in the right posterior liver segments are safe and feasible for robotic resection.23,24

A recent meta-analysis showed no difference in the transfusion rate, complication rate, conversion rate, the R1 resection rate and hospital stay between robot assisted and laparoscopic liver resection. However, the robot assisted approach was associated with longer operative time, more intraoperative blood loss and higher cost.25

Notably, some authors demonstrated significant improvements in surgical and postsurgical outcomes with growing experience.26-27 The faster learning curve might, therefore, help in reducing operative time in technically demanding cases. Recently, even more complex surgeries such as staged hepatectomy and living donor right hepatectomy have been studied.28-31 However, results of large scale, prospective, randomized control trial studies are still warranted.

The greatest hindrance to robotic surgery had been its cost and the further requirement of specialized surgeons and trained surgical staff, available only in a handful of select tertiary centers.32,33 Skeptics thus argued against the clinical applicability and worldwide translatability of the solitary system. However, with various subspecialties already embracing the system, sharing of costs could help robotic liver surgery grow as well.

Recent studies suggest the reduced overall morbidity, length of ICU and hospital stay could lead to a decrease in average costs.34,35 Furthermore, a recent study concluded that even referrals to higher centers could be reduced using a Hub and Spoke program.36

Other major limitations include absence of a haptic feedback during tumor resection, and lack of specialized robotic instruments such as the CUSA (Cavitron Ultrasonic Surgical Aspirator) readily available in laparoscopy and open procedures.14 However, compatibility with newer technologies such as the indocyanine green (ICG)-fluorescent imaging for better distinction between normal liver parenchyma and tumor cells and the use of augmented reality for direct real time visualization of 3D images superimposed in the patient, holds great promise.37-40 With the help of future competing and complementary systems, similar to the development of laparoscopy, progress is inevitable.

**CONCLUSION**

Although robotics is still evolving, the need in liver surgery is evident. With the increasing trend towards parenchymal saving liver resection, robotics will positively aid in the wider adoption and growth of minimally invasive techniques. Robotics needs to be incorporated into not just the surgeon’s arsenal but also the surgical education curriculum. Innovative proctoring programs are required to develop a proper standard of care for the robotic patient and to reduce the need for referrals. Further long-term research is required, however, to confirm the huge potential of robotics in liver surgery.
Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES


