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The role of robotics in liver surgery

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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 Motions 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 postero-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.

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REFERENCES

1. Hori T, Machimoto T, Kadokawa Y, Hata T, Ito T, Kato S, et al. Laparoscopic appendectomy for acute appendicitis: How to discourage surgeons using inadequate therapy. World J Gastroenterol. 2017 Aug 28;23(32):5849-59.
2. Lorenzon L, Bini F, Balducci G, Ferri M, Salvi PF, Marinozzi F. Laparoscopic versus robotic-assisted colectomy and rectal resection: a systematic review and meta-analysis. Int J Colorectal Dis. 2016 Feb 1;31(2):161-73.
3. Nguyen KT, Marsh JW, Tsung A, Steel JJ, Gamblin TC, Geller DA. Comparative benefits of laparoscopic vs open hepatic resection: a critical appraisal. Arch Surg. 2011 Mar 1;146(3):348-56.
4. Azagra JS, Goergen M, Gilbart E, Jacobs D. Laparoscopic anatomical (hepatic) left lateral segmentectomy-technical aspects. Surgical Endoscopy. 1996 Jul 1;10(7):758-61.
5. Morise Z, Wakabayashi G. First quarter century of laparoscopic liver resection. World J Gastroenterol. 2017 May 28;23(20):3581-8.
6. Gagner M. Pioneers in laparoscopic solid organ surgery. Surgical Endoscopy. 2003 Nov 1;17(11):1853-4.
7. Kaneko H, Otsuka Y, Kubota Y, Wakabayashi G. Evolution and revolution of laparoscopic liver resection in Japan. Ann Gastroenterol Surg. 2017 Apr;1(1):33-43.
8. Cai X. Laparoscopic liver resection: the current status and the future. Hepatobiliary Surg Nutr. 2018 Apr;7(2):98-104.
9. Liu F, Wei Y, Li H, Wang W, Wen T, Wu H, et al. LigaSure versus CUSA for parenchymal transection during laparoscopic hepatectomy in hepatocellular carcinoma patients with cirrhosis: a propensity score-matched analysis. Surg Endoscopy. 2018 May 1;32(5):2454-65.
10. Badawy A, Seo S, Toda R, Fuji H, Ishii T, Taura K, et al. Evaluation of a new energy device for parenchymal transection in laparoscopic liver resection. Asian J Endoscopic Surgery. 2018 May 1;11:123-8.
11. Wakabayashi G, Cherqui D, Geller DA, Buell JF, Kaneko H, Han HS, et al. Recommendations for laparoscopic liver resection: a report from the second international consensus conference held in Morioka. Ann Surg. 2015 Apr 1;261(4):619-29.
12. Clavien PA, Barkun J. Consensus conference on laparoscopic liver resection: a jury-based evaluation. Ann Surg. 2015 Apr 1;261(4):630-1.
13. Hanna T, Imber C. Robotics in HPB surgery. Ann Royal Coll Surg Eng. 2018 May 2;100(6_sup):36-44.
14. Kam JH, Goh BK, Chan CY, Wong JS, Lee SY, Cheow PC, et al. Robotic hepatectomy: initial experience of a single institution in Singapore. Singapore medical journal. 2016 Apr;57(4):209-14.
15. Caruso S, Patriti A, Ceccarelli G, Coratti A. Minimally invasive liver resection: has the time come to consider robotics a valid assistance?. Hepatobiliary Surgery and Nutrition. 2018 Aug 3;7: 195-8.
16. Ghezzi TL, Corleta OC. 30 years of robotic surgery. World J Surg. 2016 Oct 1;40(10):2550-7.
17. Tsuda S, Oleynikov D, Gould J, Azagury D, Sandler B, Hutter M, et al. SAGES TAVAC safety and effectiveness analysis: da Vinci® surgical system (Intuitive Surgical, Sunnyvale, CA). Surg Endoscopy. 2015 Oct 1;29(10):2873-84.
18. Bonapasta SA, Bartolini I, Checcacci P, Guerra F, Coratti A. Indications for liver surgery: laparoscopic or robotic approach. Updates Surg. 2015 Jun 1;67(2):117-22.
19. Troisi RI, Patriti A, Montalti R, Casciola L. Robot assistance in liver surgery: a real advantage over a fully laparoscopic approach? Results of a comparative bi-institutional analysis. Int J Med Robotics Computer Assisted Surg. 2013 Jun;9(2):160-6.
20. Kim JK, Park JS, Han DH, Choi GH, Kim KS, Choi JS, et al. Robotic versus laparoscopic left lateral sectionectomy of liver. Surg Endosc. 2016 Nov 1;30(11):4756-64.
21. Khan S, Beard RE, Kingham PT, Fong Y, Boerner T, Martinie JB, et al. Long-term oncologic outcomes following robotic liver resections for primary hepatobiliary malignancies: a multicenter study. Ann Surg Oncol. 2018 Sep 1;25(9):2652-60.
22. Kingham TP, Leung U, Kuk D, Gönen M, D'Angelica MI, Allen PJ, et al. Robotic liver resection: a case-matched comparison. World J Surg. 2016 Jun 1;40(6):1422-8.
23. Wu CY, Chen PD, Lee CY, Liang JT, Wu YM. Robotic-assisted right posterior segmentectomies for liver lesions: single-center experience of an evolutional method in left semi-lateral position. J Robotic Surg. 2018 Jul 11:1-7.
24. Lee JH, Han DH, Jang DS, Choi GH, Choi JS. Robotic extrahepatic Glissonean pedicle approach for anatomic liver resection in the right liver: techniques and perioperative outcomes. Surg Endosc. 2016 Sep 1;30(9):3882-8.
25. Guan R, Chen Y, Yang K, Ma D, Gong X, Shen B, et al. Clinical efficacy of robot-assisted versus laparoscopic liver resection: a meta analysis. Asian J Surg. 2019;42(1);19-31.
26. Efanov M, Alikhanov R, Tsvirkun V, Kazakov I, Melekhina O, Kim P, et al. Comparative analysis of learning curve in complex robot-assisted and laparoscopic liver resection. HPB. 2017 Sep 1;19(9):818-24.
27. Chen PD, Wu CY, Hu RH, Chen CN, Yuan RH, Liang JT, et al. Robotic major hepatectomy: is there

a learning curve?. Surgery. 2017 Mar 1;161(3):642-9.
28. Krishnamurthy J, Naragund AV, Mahadevappa B. First ever robotic stage one ALPPS procedure in India: for colorectal liver metastases. Indian J Surg. 2018 Jun 1;80(3):269-71.
29. Vicente E, Quijano Y, Ielpo B, Fabra I. First ALPPS procedure using a total robotic approach. Surg Oncol. 2016 Dec 1;25(4):457.
30. Choi GH, Chong JU, Dai Hoon Han JS, Lee WJ. Robotic hepatectomy: the Korean experience and perspective. Hepatobiliary Surg Nutr. 2017 Aug;6(4):230-8.
31. Chen PD, Wu CY, Hu RH, Ho CM, Lee PH, Lai HS, et al. Robotic liver donor right hepatectomy: a pure, minimally invasive approach. Liver Transplantation. 2016 Nov 1;22(11):1509-18.
32. Iavazzo C, Gkegkes ID. Cost–benefit analysis of robotic surgery in gynaecological oncology. Best Practice Res Clin Obstetr Gynaecol. 2017 Nov 1;45:7-18.
33. Wright JD, Kostolias A, Ananth CV, Burke WM, Tergas AI, Prendergast E, et al. Comparative effectiveness of robotically assisted compared with laparoscopic adnexal surgery for benign gynecologic disease. Obstetr Gynecol. 2014 Nov;124(5):886.
34. Daskalaki D, Gonzalez-Heredia R, Brown M, Bianco FM, Tzvetanov I, Davis M, Kim J, Benedetti E, Giulianotti PC. Financial impact of the robotic approach in liver surgery: a comparative study of clinical outcomes and costs between the robotic and open technique in a single institution. J Laparoendoscopic Adv Surg Tech. 2017 Apr 1;27(4):375-82.
35. Sham JG, Richards MK, Seo YD, Pillarisetty VG, Yeung RS, Park JO. Efficacy and cost of robotic hepatectomy: is the robot cost-prohibitive?. J Robotic Surg. 2016 Dec 1;10(4):307-13.
36. Ceccarelli G, Andolfi E, Fontani A, Calise F, Rocca A, Giuliani A. Robot-assisted liver surgery in a general surgery unit with a" referral centre Hub&Spoke learning program". Early outcomes after our first 70 consecutive patients. Minerva Chirur. 2018 May 24;73:460-8.
37. Giulianotti PC, Bianco FM, Daskalaki D, Gonzalez-Ciccarelli LF, Kim J, et al. Robotic liver surgery: technical aspects and review of the literature. Hepatobiliary Surg Nutr. 2016 Aug;5(4):311-21.
38. Ishizawa T, Saiura A, Kokudo N. Clinical application of indocyanine green-fluorescence imaging during hepatectomy. Hepatobiliary Surg Nutr. 2016 Aug;5(4):322-8.
39. Pessaux P, Diana M, Soler L, Piardi T, Mutter D, Marescaux J. Towards cybernetic surgery: robotic and augmented reality-assisted liver segmentectomy. Langenbeck's Arch Surg. 2015 Apr 1;400(3):381-5.
40. Tang R, Ma LF, Rong ZX, Li MD, Zeng JP, Wang XD, et al. Augmented reality technology for preoperative planning and intraoperative navigation during hepatobiliary surgery: a review of current methods. Hepatobiliary Pancreatic Dis Int. 2018 Feb 19.

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