Training robotic hepatectomy: the Hong Kong experience and perspective

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Abstract: The introduction of robotic surgical systems has revolutionized the practice of minimal invasive surgery (MIS). Although little data regarding robotic hepatectomies have been reported, it appears to be similar to conventional laparoscopic approach in terms of blood loss, morbidity rate, mortality rate and hospital stay at least. The application of robotic system in liver surgery was not well evaluated yet, particularly learning curve. Studies were identified by searching MEDLINE and PubMed databases for articles from January 2001 to May 2016 using the keywords “laparoscopic hepatectomy”, “robotic hepatectomy”, and “learning curve”. With the limited data in robotic hepatectomy, the learning curve model of robotic hepatectomy needs to base on the experience of conventional laparoscopic hepatectomy. Based on the learning curve study experience for laparoscopic hepatectomies, the minimal number laparoscopic minor and major hepatectomies to overcome learning curve are 22–64 cases, and 45–75 cases, respectively. Left lateral sectionectomy technique is more standardized, and it is a good start for training of MIS liver surgery. However, the training program required for the robotic liver surgeons still highly depends on the surgeons' experience of previous open and laparoscopic liver surgery, the surgeons' previous experience of other robotic surgeries, the experience of the surgical team including the assistant surgeons and nursing staffs, and the complexity of the diseases. We discourage performance of robotic hepatectomy in the occasional patient by a team that is not well prepared and is not embedded in a specialized center. Knowledge and practical skills are both required in MIS liver surgery and cannot be replaced by newer tools, including the most advanced robotic system.

Keywords: Laparoscopy; hepatectomy; robotic surgery; learning curve; training

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Introduction

The introduction of minimally invasive surgery (MIS) has revolutionized our surgical practice in the past two decades. MIS have been shown to be safe and effective for surgical management of several gastrointestinal pathologies. MIS benefits patients in terms of better cosmetic outcome, less pain and earlier recovery, and medical institutions in terms of the lower cost associated with a shorter hospital stay. Traditionally, liver surgery is considered as one of the most complex surgeries among the abdominal surgical procedures. Its MIS development is lag behind other gastrointestinal organs' surgical development. Recently, there has been increasing interest in the ability to perform complex hepato-biliary surgical procedures using the laparoscopic approach. These advanced techniques require surgeons to have highly experienced laparoscopic skills with a steep learning curve. Therefore, its development is very slow also.

The recent introduction of robot has revolutionized the practice of MIS. It was developed to overcome the disadvantages of conventional laparoscopic surgery. Well-known advantages of the robotic surgery such as improved view via three-dimensional vision, visual magnification, tremor suppression, and the flexibility and dexterity of the instruments have allowed precise operating techniques in a variety of surgical procedures. These special features allow the surgeons to perform delicate dissection and precise intra-corporeal suturing. At the current stage of development, the benefits of robotic surgery in liver surgery have not yet been defined when compared with laparoscopic hepatectomy. Based on the current evidence, robotic surgical approach offers an alternative option to conventional laparoscopic hepatectomy for MIS hepatectomy. Although little data regarding robotic hepatectomy have been reported, robotic hepatectomy appears to be similar to conventional laparoscopic hepatectomy in terms of blood loss, morbidity, mortality rate and hospital stay. Arguments of prolonged operative times and increased costs are among the main criticisms. This lack of demonstrated benefit of robotic versus laparoscopic hepatectomy has led some to argue that teaching robotic hepatectomy should not be a priority for liver surgeons. With more and more studies about robotic liver surgery, its importance and priority will be increased.

This article aimed at reviewing the learning curves of laparoscopic and robotic hepatectomy, and the Hong Kong experience in this area.

Methods

Studies were identified by searching MEDLINE and PubMed databases for articles from January 2001 to May 2016 using the keywords "laparoscopic hepatectomy", "robotic hepatectomy", and "learning curve".

Learning curve

Because of the enhanced surgical dexterity offered by robotic system, robotic hepatectomy may have a shorter learning curve as compared to laparoscopic hepatectomy. Robotic surgery, however, is known to be associated to unique hurdles that require individual and team learning curve. Robotic hepatectomy requires a team approach that should include an experienced laparoscopic surgeon at the patient's bed side to manage the complex instruments and procedures. Complete separation of console surgeon with the operative field, no direct perception of the position of the surgical instruments outside the surgeon's field of endoscopic vision and complete loss of haptic feedback create new operative conditions. However, with any new medical technology, effective training strategies must be developed to ensure competency. Currently, there is not a clear "standard of training" for robotic surgery, particularly robotic hepatectomy. Each individual robotic liver surgery training program relies on their own institutional training guidelines. Formal learning curve study about robotic hepatectomy was almost zero. Tsung *et al.* from University of Pittsburgh Medical Center, United States, analyzed the impact of the learning curve on robotic hepatectomy techniques, robotic cases occurring before January 2010 (n=13) were compared with cases occurring during or after January 2010 (n=44) (1). Significant differences were observed in estimated blood loss (300 *vs.* 100 mL), overall room time (466 *vs.* 314.5 minutes), operation time (381 *vs.* 232 minutes), and length of hospital stay (5 *vs.* 4 days), in favor of robotic hepatectomies performed later. These data demonstrate improvements in surgical and postsurgical outcomes as experience with robotic technology grows.

With the limited data in robotic hepatectomy, the learning curve model of robotic hepatectomy needs to base on the experience of conventional laparoscopic hepatectomy. Vigano *et al.* from Hôpital Henri Mondor-Université Paris 12, Créteil, France, analyzed laparoscopic hepatectomies from 1996 to 2008 (2). Laparoscopic hepatectomies were divided into 3 equal groups of 58 cases, and outcomes were compared. Risk-adjusted Cumulative Sum (CUSUM) model was used for determining the learning curve based on the need for conversion. Of 782 patients, 174 (22.3%) patients underwent laparoscopic hepatectomies. Proportion of laparoscopic hepatectomies progressively increased (17.5%, 22.4%, and 24.2%), such as hepatocellular carcinoma (HCC) (17.6%, 25.6%, and 39.4%), colorectal liver metastases (0%, 6.5%, and 13.1%), major hepatectomies (1.1%, 9.1%, and 8.5%), and right hepatectomies (0%, 13.2%, and 13.1%). Comparing groups, results of laparoscopic hepatectomies significantly improved in terms of conversion rate (15.5%, 10.3%, and 3.4%), operation time (210, 180, and 150 minutes), blood loss (300, 200, and 200 mL), and morbidity (17.2%, 22.4%, and 3.4%). Pedicle clamping was less used over time (77.6%, 62.1%, and 17.2%) and for shorter durations (45, 30, and 20 minutes). Having adjusted for case-mix, the CUSUM analysis demonstrated a learning curve for laparoscopic hepatectomies of 60 cases. Lin *et al.* from Koo Foundation

Sun Yat-Sen Cancer Center, Taipei, Taiwan, analyzed 126 consecutive laparoscopic hepatectomies from May 2008 to December 2014 (3). Their CUSUM analysis demonstrated that the probability of the occurrence of major operative events including operation time >300 minutes, perioperative blood loss >500 mL, and major postoperative complications was increasing in the earlier period of their series prior to the 22nd patient and then decreased gradually. The slope of CUSUM curve reversed after the 22nd consecutive patient. The indication of laparoscopic hepatectomy in this study extended after 60 cases to include tumors located in difficult locations (segments 4a, 7, 8) and major hepatectomy. CUSUM showed that the incidence of major operative events proceeded to increase again, and the second reverse was noted after an additional 40 cases of experience. Location of the tumor in a difficult area emerged as a significant predictor of major operative events. Regarding reasonable operation time, with acceptable perioperative blood loss and smooth postoperative recovery without major complications, Lin *et al.* indicates a learning period of at least 22 cases was need for laparoscopic minor hepatectomies. Cai *et al.* from Sir Run Run Shaw Hospital, Institute of Minimally Invasive Surgery of Zhejiang University, China, retrospectively analyzed 365 patients who underwent a laparoscopic hepatectomy from August 1998 to August 2012 (4). After finishing 15–30, 43, 35, and 28 cases of laparoscopic left hemihepatectomy, left lateral hepatectomy, non-anatomic liver resection, and segmentectomy, respectively, the average operation time, blood loss, and hospitalization were almost the same as the overall mean results. Lee *et al.* from Gyeongsang National University Hospital, Korea, analyzed 96 major and 74 minor laparoscopic hepatectomy (5). The learning curves showed a steady state after 50 cases of laparoscopic major hepatectomy. Because of discordant results in laparoscopic minor hepatectomy, subgroup analyses were performed, showing competency in laparoscopic hepatectomy after cases 25 and 35 for left lateral sectionectomy and tumorectomy, respectively. Hasegawa *et al.* from Iwate Medical University, Japan, retrospectively reviewed data from 245 consecutive patients who underwent pure laparoscopic hepatectomies (6). Patients were divided into 3 groups: Phase 1, the first 64 cases, all minor hepatectomies; Phase 2, cases from the first laparoscopic major hepatectomy case to the midmost of the laparoscopic major hepatectomy cases (n=69, including 22 laparoscopic major hepatectomies); Phase 3, the most recent 112 cases, including 22 laparoscopic major hepatectomies. Patient characteristics and surgical results were evaluated, and the learning curve was analyzed with the CUSUM method. The first laparoscopic major hepatectomy was adopted after sufficient preparatory experience was gained from performing 64 minor hepatectomies. In cases of laparoscopic major hepatectomy, there were no significant differences in the surgical time between Phases 2 and 3 (356 *vs.* 309 minutes), morbidity rate (22.7% *vs.* 31.8%), or major morbidity rate (18.2% *vs.* 9.1%); however, estimated blood loss was significantly reduced from Phase 2 to Phase 3 (236 *vs.* 68 mL). The CUSUM for morbidity also showed similar outcomes through Phases 2 and 3. Hasegawa *et al.* concluded that to maintain a low morbidity rate, 60 laparoscopic minor hepatectomies could provide adequate experience before the adoption of laparoscopic major hepatectomies. Another study by Hasegawa *et al.* also assessed the feasibility and safety of an improved laparoscopic left lateral sectionectomy technique as a training procedure for new surgeons (7). Twenty-four laparoscopic left lateral sectionectomy were retrospectively reviewed. Patients were divided into 3 groups with 8 patients in each: those undergoing surgery by expert surgeons prior to 2008 (Group A); those undergoing surgery by expert surgeons after 2008, when a standardized laparoscopic left lateral sectionectomy technique was adopted (Group B); and those undergoing laparoscopic left lateral sectionectomy by junior surgeons being trained (Group C). The median operation time was significantly shorter for Group B (103 minutes; range, 99–109 minutes) and C (107 minutes; range, 85–135 minutes) patients than for Group A (153 minutes; range, 95–210 minutes) patients. There were no significant differences in blood loss or hospital stay. In Groups B and C, no conversions to open laparotomy or complications occurred. The standardized left lateral sectionectomy procedure was both safe and feasible as a technique for training surgeons in laparoscopic hepatectomy. Nomi *et al.* from Université Paris-Descartes, France, analyzed data for all patients undergoing laparoscopic major hepatectomy from January 1998 to September 2013 using the CUSUM method (8). Of 173 patients undergoing major hepatectomy, left hepatectomy was performed in 28 (16.2%), left trisectionectomy in 9 (5.2%), right hepatectomy in 115 (66.5%), right trisectionectomy in 13 (7.5%) and central hepatectomy in 8 (4.6%). Median duration of surgery was 270 (range, 100–540) minutes and median blood loss was 300 (10–4,500) mL. The learning curve comprised 3 phases: phase 1 (45 initial patients), phase 2 (30 intermediate patients) and phase 3 (the subsequent 98 patients). Although right hepatectomy was most common in phase 1, a significant decrease was observed from phase 1 to 3 in favor of more complex procedures. There were 20 conversions to an open procedure (11.6%), because of hemorrhage (n=11), oncological reasons (n=6) and lack of progress (n=3). The learning curve adjusted for the risk factors of conversion demonstrated that the rate of conversion to open surgery decreased in later years (18%, 20% and 6% in phases 1, 2 and 3, respectively). The median duration of surgery and blood loss decreased significantly between phases 1 and 3 (from 360 to 240 minutes, and from 500 to 200 mL, respectively). A trend toward decreased morbidity was observed. Hospital stay was also slightly shorter during phase 3 (9 days) than in phase 1 (11 days). The data suggest that the learning phase of laparoscopic major hepatectomy included 45 to 75 patients.

Based on the learning curve study experience for laparoscopic hepatectomies, the minimal number laparoscopic minor and major hepatectomies to overcome learning curve are 22–64 cases, and 45–75 cases, respectively. Left lateral sectionectomy is a good start for training surgeons. However, this robotic data lacked still. One of the proposed advantage of robotic surgery is the possibility of shorten learning curve. Although it is unknown whether this laparoscopic data can be directly applied to robotic hepatectomy, this data and experience are still a good reference to liver surgeons.

Hong Kong experience

In Hong Kong, there is still no formal training program for robotic hepatectomy. Its popularization is also limited by its cost, the number of robotic systems and the limited number of qualified robotic liver surgery mentors in Hong Kong. Robotic simulation training machine is lacked also. Therefore, the starting operating surgeons are currently concentrated on those surgeons with specialist qualifications in general surgery and with certain experience in laparoscopic surgery. He must be competent in performance of hepatectomies by the open method. Atlases of laparoscopic anatomy and technique, lectures on procedures from experts in the field and watching of video recordings and/or attending workshops form the initial level. After the recognized instrument training provided by the company, they started to participate as bedside assistant surgeons. After a certain number of operations as bedside assistant surgeons, they began to perform robotic minor hepatectomies with the help and supervision by an already qualified robotic surgery mentors before they can perform robotic hepatectomy individually. Due to the wide spectrum of extent and complexity of hepatectomies, there is still no consensus on the number of minor and major hepatectomies needed for recognized assistant surgeons and surgeons under supervision.

In the authors' center, the first robotic system was installed in the year 2009. However, we have been involved in MIS operations since the early 1990s, making advanced laparoscopic skills immediately available to the development of the robotic program. In addition, the operating surgeons had a sound experience in laparoscopic liver resections before attempting the first robotic hepatectomy (9-15). Thus, we had to mostly understand how to safely apply our open and laparoscopic experience to robotic hepatectomy, and not how to learn the entire process since the beginning. In year 2011, our group analyzed 56 patients with hepatic malignancy underwent laparoscopic hepatectomies from January 1998 to August 2010 (16). The majority of cases were performed by hand-assisted laparoscopic approach, n=31 (55.3%) and the remainder were with pure laparoscopic approach, n=10 (17.9%) and robotic approach, n=15 (26.8%). The median operation time was 150 min (range, 75–307 min). The median blood loss during surgery was 175 mL (range, 5–2,000 mL). Two patients (3.6%) needed open conversion and one patient (1.8%) needed to be converted to hand-assisted laparoscopic approach. The morbidity rate was 14.3%. There was no procedure-related death. 89.3% of patients had R0 resection and 10.7% of patients had R1 resection. The median hospital stay was 6.5 days (range, 2–13 days). The 1-year, 3-year, and 5-year disease-free survival rates for HCC were 85%, 47%, and 38%, respectively. The 1-year, 3-year, and 5-year overall survival rates for HCC were 96%, 67%, and 52%, respectively. The 1-year, and 3-year disease-free survival rates for colorectal liver metastases were 92% and 72%. The 1-year, and 3-year overall survival rates for colorectal liver metastases were 100% and 88%, respectively. In year 2013, the short term survival outcome after robotic hepatectomies for 41 consecutive patients with HCC was reported (17). The mean operation time and blood loss was 229.4 minutes and 412.6 mL, respectively. The R0 resection rate was 93%. The hospital mortality and morbidity rates were 0% and 7.1%, respectively. The mean hospital stay was 6.2 days. The 2-year overall and disease-free survival rates were 94% and 74%, respectively. In the subgroup analysis of minor hepatectomies, when compared with the conventional laparoscopic approach, the robotic group had similar blood loss (mean, 373.4 *vs.* 347.7 mL), morbidity rate (3% *vs.* 9%), mortality rate (0% *vs.* 0%), and R0 resection rate (90.9% *vs.* 90.9%). However, the robotic group had a significantly longer operative time (202.7 *vs.* 133.4 minutes). Recently, we compared the long-term oncological outcomes of robotic (n=100) and conventional laparoscopic hepatectomy (n=35) for HCC (18). Robotic group had a significant higher proportion of major hepatectomies (27% *vs.* 2.9%) and tumors located at or across posterosuperior segments (29% *vs.* 0%) than conventional laparoscopic group. For the perioperative outcomes, robotic group had a significant longer mean operation time (207.4 *vs.* 134.2 minutes). Both groups had similar blood loss (334.6 *vs.* 336 mL). There was no difference in morbidity (14% *vs.* 20%) and mortality rate (0% *vs.* 0%). Concerning oncological outcomes, there was no difference between 2 groups in R0 resection rate (96% *vs.* 91.4%), 5-year overall survival (65% *vs.* 48%), and disease-free survival (42% *vs.* 38%). Robotic approach is an acceptable alternative to laparoscopic hepatectomy for HCC. With the potential advantages of robotic system in performing major hepatectomy and resection of tumor in difficult segments, robotic surgery may have an impact on the therapeutic strategy of HCC.

There were several active MIS liver surgery centers in Hong Kong. Cheung *et al.* from Queen Mary Hospital, The University of Hong Kong, Hong Kong, analyzed 32 patients underwent pure laparoscopic liver resection for HCC between October 2002 and September 2009 (19). Case-matched control patients (n=64) who received open hepatomas for HCC were included for comparison. With the laparoscopic group compared with the open hepatectomy group, operation time was 232.5 *vs.* 204.5 minutes, blood loss was 150 *vs.* 300 mL, hospital stay was 4 *vs.* 7 days, postoperative complication was 2 (6.3%) *vs.* 12 (18.8%), disease-free survival was 78.5 months *vs.* 29 months, and overall survival was 92 *vs.* 71 months. The disease-free survival for stage II HCC was 22.1 *vs.* 12.4 months. Cheung *et al.* concluded that laparoscopic hepatectomy for HCC is associated with less blood loss, shorter hospital stays, and fewer postoperative complications in selected patients with no compromise in survival. Later, Cheung *et al.* also analyzed 24 patients underwent pure laparoscopic left lateral sectionectomy for HCC between January 2004 and September 2014 (20). Twenty-nine patients with case-matched tumor characteristics and liver functions but received open left lateral sectionectomy for HCC were included for comparison. Comparing laparoscopic group to open hepatoma group, the median operation time was 190.5 *vs.* 195 minutes; the median blood loss was 100 *vs.* 300 mL. Hospital stay was 5 days in laparoscopic group *vs.* 6 days in the open group. There was no difference between the two groups in terms of complications. The median survival in laparoscopic group was >115 *vs.* >125 months in the open group. Cheung *et al.* concluded that laparoscopic left lateral sectionectomy for HCC is a safe and simple procedure associated with less blood loss. The survival outcome is comparable with conventional open approach. It is becoming a more favorable treatment option even for patients with HCC and cirrhosis. Chan *et al.* from Kwong Wah Hospital, Hong Kong, analyzed 156 laparoscopic hepatectomies from 2002 to 2014 using the CUSUM analysis of operative time (21). CUSUM analysis showed that operative time improved after the 25th laparoscopic hepatectomy. Beyond that proportion of pure laparoscopic hepatectomies significantly increased (18/25 *vs.* 24/24); Pringle maneuver was not required (4/25 *vs.* 0/24). Blood loss (800 *vs.* 500 mL) and transfusion rate (13/25 to 3/24) significantly improved in latter laparoscopic hepatectomies. Right posterior sectionectomies had significantly more blood loss than anterolateral laparoscopic hepatectomies (500 *vs.* 1,500 mL). Lee *et al.* from Prince of Wales Hospital, The Chinese University of Hong Kong, Hong Kong, analyzed 66 laparoscopic hepatectomies and 70 robotic hepatectomies between November 2003 and January 2015 (22). The 2 groups were comparable in demographic data and disease characteristics except more patient with recurrent pyogenic cholangitis (RPC) occurred in robotic group. More major hepatectomies were performed in robotic group (20.0% *vs.* 3.0%). There was no mortality. No difference was noted in morbidity (4.5% *vs.* 11.4%), conversion rate (12.1% *vs.* 5.7%), median blood loss (100 *vs.* 100 mL) and median length of post-operative hospital stay (5 *vs.* 5 days) but operation time was longer in robotic group (251.5 *vs.* 215 min). There were 29 laparoscopic left lateral sectionectomy and 38 robotic left lateral sectionectomy, and no difference was noted in all perioperative outcomes between the two groups.

Based on the current reported series, the surgical outcome and required learning curves in Hong Kong experiences were similar to international results. Outcomes of comparative studies of minimally invasive liver surgery from various institutions in Hong Kong were shown in *Table 1* (12,18,19,22-25). However, the training program required for the robotic liver surgeons still highly depends on the surgeons' experience of previous open and laparoscopic liver

Table 1 Comparative studies of minimally invasive liver surgery from various institutions in Hong Kong

Study (year)	Study arms	Pathology	n	Operating time (minutes)	Blood loss (mL)	Morbidity rate (%)	Mortality rate (%)	Hospital stay (days)	1-yr OS (%)	3-yr OS (%)	5-yr OS (%)	1-yr DFS (%)	3-yr DFS (%)	5-yr DFS (%)
Lai *et al.* (2009) (12)	Laparoscopic *vs.* open group	HCC	25 *vs.* 33	150 *vs.* 135 (median)	200 (median, all patients)	16 *vs.* 15	0 *vs.* 3	7 *vs.* 9* (median)	92 *vs.* 86	60 *vs.* 60	\	85 *vs.* 84	52 *vs.* 48	\
Lee *et al.* (2011) (23)	Laparoscopic *vs.* open group	HCC	33 *vs.* 50	225 *vs.* 195* (median)	150 *vs.* 240 (median)	6.1 *vs.* 24*	0 *vs.* 0	5 *vs.* 7* (median)	86.9 *vs.* 98	81.8 *vs.* 80.6	76 *vs.* 76.1	78.8 *vs.* 69.2	51 *vs.* 55.9	45.3 *vs.* 55.9
Cheung *et al.* (2013) (24)	Laparoscopic *vs.* open group	Colorectal liver metastasis	20 *vs.* 40	180 *vs.* 210 (median)	200 *vs.* 300* (median)	10 *vs.* 5	0 *vs.* 0	4.5 *vs.* 7* (median)	\	\	54.3 *vs.* 20	\	\	42.3 *vs.* 16
Cheung *et al.* (2013) (19)	Laparoscopic *vs.* open group	HCC	32 *vs.* 64	232.5 *vs.* 204.5 (median)	150 *vs.* 300* (median)	6.3 *vs.* 18.8	0 *vs.* 1.6	4 *vs.* 7* (median)	96.6 *vs.* 95.2	87.5 *vs.* 72.9	76.6 *vs.* 57	87.3 *vs.* 63.5	72.6 *vs.* 50	54.5 *vs.* 44.3
Cheung *et al.* (2016) (25)	Laparoscopic *vs.* open group	HCC	110 *vs.* 330	185 *vs.* 255* (median	150 *vs.* 400* (median	9.1 *vs.* 15.2	0 *vs.* 1.8	4 *vs.* 7* (median	98.9 *vs.* 94	89.8 *vs.* 79.3	83.7 *vs.* 67.4	87.7 *vs.* 75.2	65.8 *vs.* 56.3	52.2 *vs.* 47.9
Lai *et al.* (2016) (18)	Robotic *vs.* laparoscopic group	HCC	100 *vs.* 35	207.4 *vs.* 134.2* (mean)	334.6 *vs.* 336 (mean)	14 *vs.* 20	0 *vs.* 0	7.3 *vs.* 7.1 (mean)	94 *vs.* 90	84 *vs.* 68	65 *vs.* 48	84 *vs.* 79	64 *vs.* 48	42 *vs.* 38
Lee *et al.* (2016) (22)	Robotic *vs.* laparoscopic group	Benign and malignant pathologies	70 *vs.* 66	251.5 *vs.* 215* (median)	100 *vs.* 100 (median)	11.4 *vs.* 4.5	0 *vs.* 0	5 *vs.* 5 (median)	\	\	\	\	\	\

*, P<0.05. OS, overall survival; DFS, disease free survival.

surgery, the surgeons' previous experience of other robotic surgeries, the experiences of the surgical team including the assistant surgeons and nursing staffs, and the complexity of the diseases.

Conclusions

Although little data regarding robotic hepatectomies have been reported, it appears to be similar to conventional laparoscopic approach in terms of blood loss, morbidity rate, mortality rate and hospital stay at least. Its future usage and clinical value will highly depend on the advantages that it can provide over conventional laparoscopic surgery or open surgery.

We discourage performance of robotic hepatectomy in the occasional patient by a team that is not well prepared and is not embedded in a specialized center. Knowledge and practical skills are both required in liver surgery and cannot be replaced by newer tools, including the most advanced robotic system. The essential elements for a qualified robotic surgeon for liver surgery should include: (I) Familiarized with liver anatomy; (II) experience in open liver surgeries and in handling emergency situations; (III) adequate training in laparoscopic surgery; (IV) adequate training in robotic surgery.

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Footnote

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