Viewpoint

Improving performance of robotic liver resections with high technical complexity by Robo-Lap approach

Francesca Ratti[1,2], **Rebecca Marino**[1], **Luca Aldrighetti**[1,2]

[1]Hepatobiliary Surgery Division, IRCCS Ospedale San Raffaele, Milan, Italy; [2]Vita-Salute San Raffaele University, Milan, Italy

Correspondence to: Francesca Ratti, MD. Hepatobiliary Surgery Division, IRCCS Ospedale San Raffaele, Milan, Italy; Vita-Salute San Raffaele University, Via Olgettina 60, 20132, Milan, Italy. Email: ratti.francesca@hsr.it.

Submitted Jul 27, 2023. Accepted for publication Oct 17, 2023. Published online Nov 15, 2023.
doi: 10.21037/hbsn-23-378
View this article at: https://dx.doi.org/10.21037/hbsn-23-378

Introduction

The hybrid robotic-laparoscopic technique has been described—in the field of hepatic surgery—in order to overcome procedural challenges related to the lack of the robotic ultrasonic dissector (1-4): Robo-Lap approach hence combines the use of the robotic platform (specifically robotic bipolar forceps for coagulation and scissors) with the laparoscopic dissector handled by the surgeon at the table. This technique aims to enhance surgical performance by combining wherewithal of both approaches, addressing the issue—already reported—of the poor efficacy, precision and reproducibility of the pure robotic transection with parenchymal crushing performed with the robotic bipolar forceps.

The purpose of the analysis was to verify the impact of the Robo-Lap approach in anatomical resections with a high profile of technical complexity: in this setting indeed, perioperative surgical results directly arise from the possibility of following and respecting the anatomical planes identified by vascular landmarks (particularly portal pedicles and hepatic vessels), being significantly impacted by the parenchymal transection phase.

Methods

To fulfill this endpoint, the Robo-Lap approach (n=65) and the pure robotic approach (n=28) were compared in patients undergoing resections with complexity scores >7 according to the Iwate criteria (5) in the time period between January 2022 and May 2023 (after acquisition of the learning curve in robotic approach to avoid bias related to the learning phase of the technique). All resections were performed after the 25th case of the overall series of robotic resections by three senior surgeons, each with extensive experience in both open and minimally invasive liver hepatectomies and having received a full training both as console and table surgeons. All minimally invasive resections were performed at IRCCS San Raffaele Hospital, Milan. The center, originally established as a high-volume laparoscopic center (conducting more than 50 laparoscopic liver resections per year), smoothly transitioned to incorporating the robotic approach into daily practice.

In all cases, a highly experienced junior attending physician, skilled in minimally invasive techniques, served as the bedside assistant for both purely robotic and Robo-Lap procedures, ensuring consistent expertise and support throughout.

Robo-Lap technique is reported in *Figure 1*. A diagram illustrating port placement, emphasizing the location of the laparoscopic trocar relative to the robotic trocars is shown in *Figure 2*.

Briefly, laparoscopic ultrasonic dissection is performed by the bedside surgeon, with vessels coagulation, cutting and vascular dissection performed by robotic instruments (monopolar scissors and bipolar forceps) handled by the surgeon at the console.

In the pure robotic approach, the branches of bipolar forceps were employed in a Kellyclasia-like fashion to revisit the clamp-crush technique for parenchymal transection. Vascular and biliary structures were sealed or closed between clips, according to the caliber.

The two groups are temporally consecutive (i.e., Pure robotic from July 2021 to January 2022 and Robo-Lap from February 2022 on) as the Robo-Lap technique was

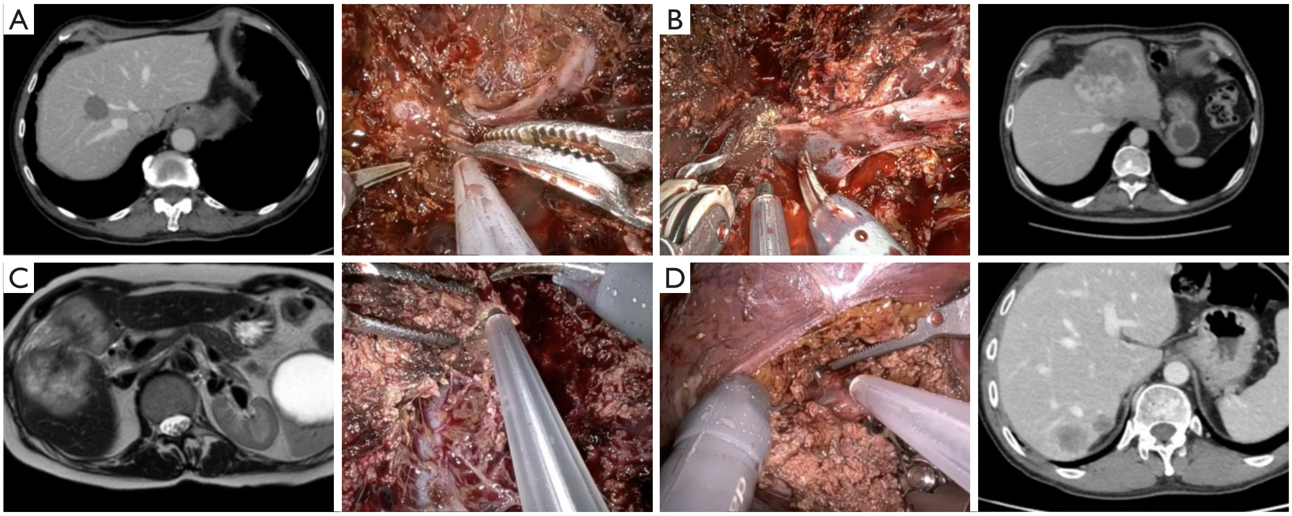

Figure 1 Robo-Lap approach in anatomical resections with high degree of technical complexity. (A) Anatomical Sg8 resection. (B) Left hepatectomy. (C) Right hepatectomy. (D) Anatomical Sg7 resection.

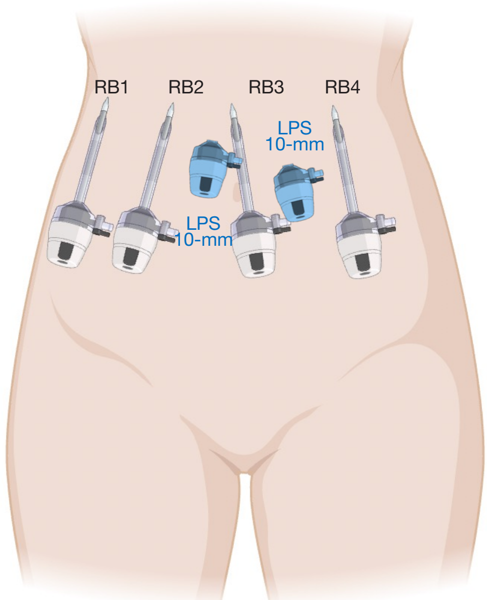

Figure 2 The Da Vinci X platform was utilized for all procedures. The first surgeon operated the console, assisted by the bed-side surgeon positioned between the patient's legs. A 10-mm laparoscopic trocar was inserted infraumbilically in a right pararectal position to create pneumoperitoneum (LPS 10-mm). Four robotic trocars were placed in a standardized configuration: one on the right flank (RB 1), one along the mid-clavicular line (RB 2), one in the midline (RB 3), and one in the left hypochondrium (RB 4). The robotic platform was docked and positioned in a reverse Trendelenburg stance. A second laparoscopic access was added following the docking of robotic arms. This was done to prevent any potential interference between laparoscopic and robotic instruments and to enhance ergonomic efficiency. Standard robotic instruments were used, including prograsp forceps, Maryland bipolar forceps or long bipolar forceps, monopolar scissors, and a robotic clip applier. A camera was positioned on arm 2 (mid-clavicular line) to ensure the line of transection was in view of both the first surgeon and the assistant. LPS, laparoscopic.

implemented later than the adoption of the pure robotic technique and since then was adopted as the standard modality for liver transection. All cases of perihilar cholangiocarcinoma were intentionally excluded due to the distinct surgical techniques applied and expected perioperative outcomes.

Statistical analysis

All variables were compared using the χ^2 or Fisher's exact test for categorical data, the Mann-Whitney *U* test for non-normally distributed continuous data, and Student's *t*-test for normally distributed continuous variables. Significance was defined as P<0.05.

Results

The groups were found to be comparable in terms of patient characteristics and liver disease burden. While the two groups showed similar intraoperative bleeding, periprocedural transfusion rates, conversion rates, and complications, the Robo-Lap group demonstrated a reduction in parenchymal transection time (170±65 *vs.* 248±51 min; P=0.025), a decrease in the risk of Satava grade III complications [0 (0.0%) *vs.* 2 (7.1%); P=0.029] (6), and a reduction in the use of sutures to repair vascular and/or small biliary damages during the parenchymal transection phase [13 (46.4%) *vs.* 3 (4.6%); P<0.001] (*Table 1*). In the robotic group, sutures were utilized in 7 cases to repair

Table 1 Comparison between pure robotic and Robo-Lap approach for procedures with high degree of technical complexity

Approach	Pure robotic (n=28)	Robo-Lap (n=65)	P
Previous interventional procedures			0.846
Portal vein embolization	1 (3.6)	2 (3.1)	
Hepatic deprivation	5 (17.9)	8 (12.3)	
Biliary drainage	3 (10.7)	9 (13.8)	
Indication			0.07
Malignant	25 (89.3)	59 (90.8)	
Colorectal cancer metastases	9 (32.1)	15 (23.1)	
Non-colorectal cancer metastases	0	1 (1.5)	
Hepatocellular carcinoma	12 (42.9)	15 (23.1)	
Intrahepatic cholangiocarcinoma	4 (14.3)	28 (43.1)	
Benign	3 (10.7)	6 (9.2)	
Adenoma	1 (3.6)	1 (1.5)	
Hemangioma	1 (3.6)	3 (4.6)	
Hepatolitiasis	1 (3.6)	2 (3.1)	
Size (cm)	6.7±3.4	6.4± 3.1	0.258
Tumor number			0.151
Single	16 (57.1)	47 (72.3)	
Multiple	12 (42.9)	18 (27.7)	
Type of resection			0.998
Right hepatectomy	7 (25.0)	14 (21.5)	
Left hepatectomy	5 (17.9)	12 (18.5)	
Sg7 segmentectomy	6 (21.4)	13 (20.0)	
Sg8 segmentectomy	6 (21.4)	16 (24.6)	

Table 1 *(continued)*

Table 1 *(continued)*

Approach	Pure robotic (n=28)	Robo-Lap (n=65)	P
Right posterior sectionectomy	2 (7.1)	5 (7.7)	
Right anterior sectionectomy	2 (7.1)	5 (7.7)	
Pringle manoeuvre			0.514
Not performed	1 (3.6)	1 (1.5)	
Performed	27 (96.4)	64 (98.5)	
Length of surgery (min)	355±85	365±65	0.101
Length of parenchymal transection (min)	248±51	170±65	0.025
Blood loss (mL)	420±210	310±100	0.065
Surgical margin			1.000
R0	27 (96.4)	63 (96.9)	
R1	1 (3.6)	2 (3.1)	
Intraoperative complications	13 (46.4)	20 (30.8)	0.147
Intraoperative complications according to Satava			
Grade I	8 (28.6)	14 (21.5)	0.462
Grade II	3 (10.7)	6 (9.2)	0.823
Grade III	2 (7.1)	0	0.029
Conversion	3 (10.7)	5 (7.7)	0.693
Surgical margin (mm)	115	107	0.386
Intraoperative blood transfusions			0.719
No	26 (92.9)	58 (89.2)	
Yes	2 (7.1)	7 (10.8)	
Need for haemostatics	19 (67.9)	25 (38.5)	0.009
Need for stitches during parenchymal transection	13 (46.4)	3 (4.6)	<0.001
Morbidity	9 (32.1)	26 (40.0)	0.475
Grade of complications			
Minor			
Grade I	0	1 (1.5)	0.577
Grade II	6 (21.4)	19 (29.2)	
Major			
Grade IIIa	2 (7.1)	5 (7.7)	0.583
Grade IIIb	1 (3.6)	0	
Grades IV–V	0	1 (1.5)	
Mortality	0	1 (1.5)	>0.99
Length of stay (days)	6 [4–20]	5 [4–30]	0.684

Data are presented as n (%), mean ± standard deviation, or median [range]. R0, negative resection margin; R1, positive resection margin; NA, not assessable.

minor defects in secondary or tertiary biliary branches, and in 1 case to address a minor injury to adjacent organs. The remaining cases involved the use of sutures to repair small tangential vascular breaches. Conversely, in the Robo-Lap group, only 2 cases necessitated sutures for vascular repair. A decrease in the need for hemostatic agents for temporary and definitive hemostasis was also reported [19 (67.9%) *vs.* 25 (38.5%); P=0.009]. When considering the achievement of optimal intraoperative outcomes, the probability of uneventful surgery for technically complex resections was more frequent in the Robo-Lap group than in the pure Robotic group.

Discussion

Provided the need for an expert surgeon to use the laparoscopic dissector, Robo-Lap allows overall optimization of the intraoperative course of liver resection, reducing the number of potentially dangerous events at risk of conversion. This accuracy allows to reduce the time required for parenchymal transection in procedures with time-consuming and complex resection surfaces hence optimizing surgical time and improving operative planning (2). It is likely that a difference between the two approaches in terms of major events (conversion, postoperative morbidity and bleeding) is not detectable because the robotic platform—thanks to its intrinsic characteristics i.e., images magnification and dexterity of instruments—allows to correct errors and intraoperative problems in most cases, without switching to the open approach and therefore negatively impacting the patient's course.

Advantages of this technique are based on two prerequisites: the expertise and shared-leadership of the two operating surgeons who perform parenchymal transection in a combined and synergistic way and a careful preoperative patient selection. Indeed, this use of resources is overestimated in resections with a low profile of complexity where the benefits of robotics are less remarkable (7). Preoperative stratification of patients based on the level of complexity may therefore play a role in the choice of intraoperative technique.

In summary, the Robo-Lap approach offers several benefits that leverage the cornerstones of minimally invasive liver resections. It enhances precision liver resections by deepening the understanding of segmental and subsegmental anatomy, leading to lower numbers of iatrogenic damages and intraoperative complications. This approach ensures the necessary expertise in dissection techniques to safely perform challenging parenchymal sparing resections, with the expert table surgeon skillfully utilizing the laparoscopic dissector.

Moreover, the Robo-Lap approach maximizes the well-known advantages of decreased intraoperative bleeding in minimally-invasive liver resections by reducing transection time. Although transient hepatic vascular inflow occlusion is easy to perform, it can lead to adverse effects such as ischemic-reperfusion injury and splanchnic congestion. However, the Robo-Lap approach mitigates these effects by potentially minimizing the overall number of clamping instances during surgery. This improvement is achieved through better control of transecting bleeding, facilitated by the laparoscopic dissector.

The determination of the superior robotic approach in liver resection surgery requires further investigation, especially as more surgical centers gain expertise in robotic techniques. The Robo-Lap approach aligns with Gumbs *et al.*'s concept of "Handled Robotics" (8), combining the preservation of haptics while retaining the benefits of the cavitron ultrasonic surgical aspirator (CUSA). Additionally, it stands as a valuable platform for rapid skill acquisition, enabling the development of autonomous actions guided by the operating surgeon. This evolutionary pathway holds promise for the progression towards a fully autonomous robotic approach, where the robotic system is trained to interpret and utilize haptic feedback efficiently.

Limitations

Given the retrospective design and the limited patient cohort, interpreting the findings is influenced by these limitations. Future multi-institutional studies, involving tertiary centers with extensive experience in minimally invasive liver surgery techniques, are crucial to better evaluate the potential benefits of the Robo-Lap approach.

Conclusions

In conclusion, the Robo-Lap approach for complex anatomical resections has the potential to enhance intraoperative outcomes by optimizing the execution of an uneventful parenchymal transection phase.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was a standard submission to the journal. The article has undergone external peer review.

Peer Review File: Available at https://hbsn.amegroups.com/article/view/10.21037/hbsn-23-378/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://hbsn.amegroups.com/article/view/10.21037/hbsn-23-378/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Ratti F, Cipriani F, Ingallinella S, et al. Robotic Approach for Lymphadenectomy in Biliary Tumors: The Missing Ring Between the Benefits of Laparoscopic and Reproducibility of Open Approach? Ann Surg 2023;278:e780-8.
2. Aldrighetti L, Cipriani F, Fornoni G, et al. Robo-Lap Approach for Anatomical Resections of Postero-Superior Liver Segments by Indocyanine Green Fluorescence: Intraoperative Navigation Based on Vascular Landmarks. Chirurgia (Bucur) 2023;118:170-9.
3. Aldrighetti L, Catena M, Ratti F. Maximizing Performance in Complex Minimally Invasive Surgery of the Liver: the RoboLap Approach. J Gastrointest Surg 2022;26:1811-3.
4. Perrakis A, Rahimli M, Gumbs AA, et al. Three-Device (3D) Technique for Liver Parenchyma Dissection in Robotic Liver Surgery. J Clin Med 2021;10:5265.
5. Ban D, Tanabe M, Ito H, et al. A novel difficulty scoring system for laparoscopic liver resection. J Hepatobiliary Pancreat Sci 2014;21:745-53.
6. Kazaryan AM, Røsok BI, Edwin B. Morbidity assessment in surgery: refinement proposal based on a concept of perioperative adverse events. ISRN Surg 2013;2013:625093.
7. Cipriani F, Fiorentini G, Magistri P, et al. Pure laparoscopic versus robotic liver resections: Multicentric propensity score-based analysis with stratification according to difficulty scores. J Hepatobiliary Pancreat Sci 2022;29:1108-23.
8. Gumbs AA, Abu-Hilal M, Tsai TJ, et al. Keeping surgeons in the loop: are handheld robotics the best path towards more autonomous actions? (A comparison of complete vs. handheld robotic hepatectomy for colorectal liver metastases). Art Int Surg 2021;1:38-51.

Cite this article as: Ratti F, Marino R, Aldrighetti L. Improving performance of robotic liver resections with high technical complexity by Robo-Lap approach. HepatoBiliary Surg Nutr 2023;12(6):981-986. doi: 10.21037/hbsn-23-378

