

ORIGINAL ARTICLE

Is robotic liver resection feasible in patients with lesions in close proximity to major vessels? A propensity score matching analysis

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Abstract

Introduction: Robotic surgery is widely diffused in the surgical field and is becoming increasingly prevalent, however several aspects need more detailed assessment. One of them concerns the role of robotic liver surgery for lesions in contact with major vascular (CMV) pedicles. The aim of our study is to evaluate and compare intra and post operative outcomes in patients undergoing robotic liver resections between lesions in contact or free from major vessels.

Methods: A multicentric retrospective study was performed including 1030 patients who underwent robotic liver resection. Patients were divided into two groups according to vascular contact. Intra and post-operative outcomes were compared between the groups before and after Propensity Score Matching.

Results: After propensity score matching 889 patients were included in the study. Among these lesions, 595 were not in contact with major vessels (NCMV) and 294 were in contact with major vessels (CMV). Use of Pringle Manoeuvre was more associated with CMV resections (49.8 % vs 31.2 %, $p = 0,0001$). No differences in terms of operative time, conversion rate, morbidity and type of complications were observed after PSM.

Conclusion: The presents study shows how robotic surgery is a valid and safe technique also for resection of tumors close to vascular pedicles.

Received 8 July 2024; accepted 25 September 2024

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* Author's didn't use AI and AI-assisted technologies in the writing process. The authors received no funding for this study.

Introduction

In recent years, the introduction of more robotic platforms helped to increase diffusion of robotic surgical procedures.

Due to the improved range of movements that robotic arms and instruments are able to perform, researcher's attention was gradually drawn on robotic-assisted liver surgery.¹

Compared to open resection, robotic liver surgery shows a reduced incidence of intraoperative haemorrhage, this is probably due to greater visualization of the surgical field and the possibility of performing complex movements with greater agility.

This results in fewer postoperative complications and a quicker postoperative recovery, assuming the same surgical margin status.²

Robotic liver surgery seems to be superior to the laparoscopic approach especially considering complex hepatectomies, such as posterosuperior resection, hilar dissection, and bilio-enteric anastomoses.³ The robotic approach might, also, lead to slightly higher Textbook Outcomes in Liver Surgery (TOLS) rates than laparoscopic Surgery.⁴

Despite the diffusion of robotic surgery and the growing focus of researchers, several aspects still need to be discussed. One of these concerns the role of robotic liver surgery for lesion in contact with or in close proximity to major vascular (CMV) pedicles.

To our knowledge, in literature there are no studies reporting outcomes concerning this specific scenario.

The aim of our study is to evaluate and compare intra and post operative outcomes in patients undergoing robotic liver resections (RLR) between lesions in contact or free from major vessels.

Methods

A multicentric retrospective study was performed including 1030 patients who underwent robotic liver resection. Among them, we included in the study 889 patients who underwent liver resection for malignancies.

Surgery was performed from January 2011 to March 2022 at 12 European tertiary hepatobiliary surgery centers.

Each center received both approval from its own ethics committee and the informed consent to collect individual patient clinical data.

Patient demographic data and preoperative variables were collected: Age, BMI, American Society of Anesthesiologists (ASA) score; comorbidities; cause of cirrhosis; Child-Pugh and the model for end-stage liver disease (MELD) scores; previous surgery and indications to surgery.

All patients were staged preoperatively considering computer tomography of the chest-abdomen-pelvis and/or abdominal magnetic resonance.

The diagnosis was based on radiological findings (CT and/or MRI) and biopsy was used for unclear radiological diagnosis. In

addition, each patient's case was discussed with a multidisciplinary team.

The collected tumor data included: number of lesions, size, location in the liver (anterior or posterior segments), vascular contact, type of surgical resection and Iwate score.

Patients were divided into two groups according to tumor contact or distance from vessels. Vascular contact was defined as radiological evidence, at pre-operative staging, of portal branch or hepatic vein contact without radiological signs of infiltration (<1 mm) confirmed by surgeons at IOUS. Tumor without vascular contact were defined as a minimum distance of at least 1 mm between the mass and vascular pedicles with an evident plane of transition without sign of contact/infiltration (Figs. 1–3).

All hepatic resections were performed by expert hepato-biliary surgeons using DaVinci XI platform.

The Couinaud classification was used to define liver segmentation and the Brisbane 2000 terminology was used to determine the liver resections.^{5,6} Tumors involving segments VI-VII, VII, VIII were defined as located in the postero-superior segments.⁷ Major hepatectomy was defined as the resection of three or more segments.⁶

Intraoperative results analysed were: operative time, Pringle maneuver, intra-operative blood transfusion, estimated blood loss, conversion, and reason for conversion (anesthesiological problems, bleeding, adhesion, oncological radicality).

Post-operative data considered were: post-operative complications (biliary leak, haemorrhage, post-operative infection) according to Clavien-Dindo classification,⁸ median hospital stay, 90 days re-admission, 90 days mortality, and R0 resection.

Peri-operative data were retrospectively analyzed and compared in both groups before propensity score matching (b-PSM) and after 1:1 propensity score matching (a-PSM).

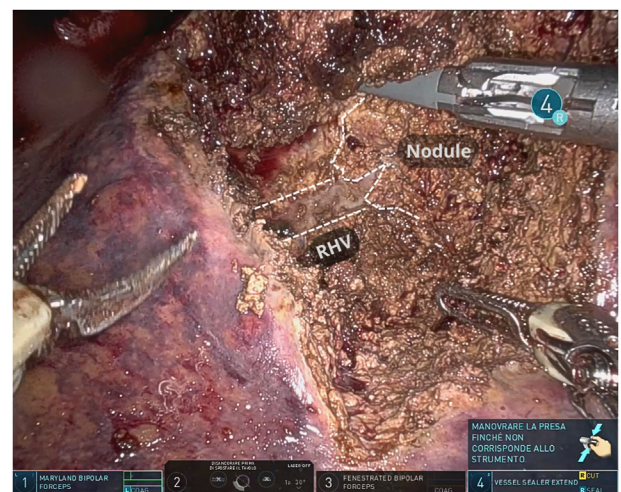


Figure 1 Intraoperative view of lesion in contact with major vascular pedicle. RHV = Right hepatic vein

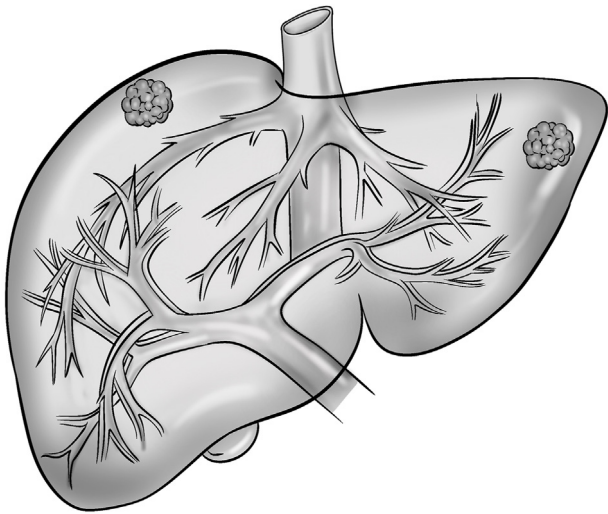


Figure 2 Schematic view of lesions not in contact with major vascular pedicles

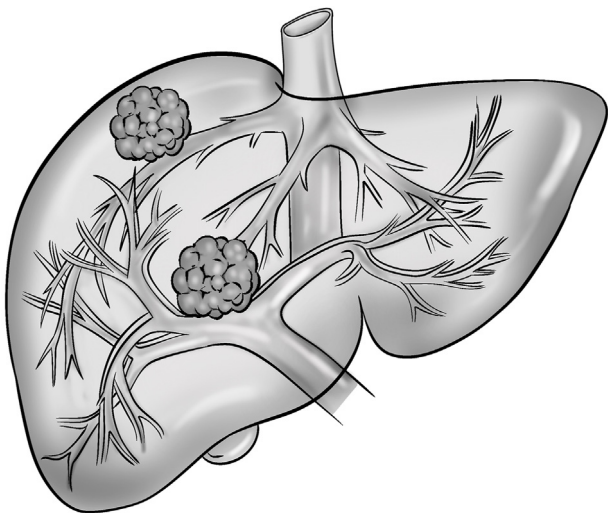


Figure 3 Schematic view of lesions in contact with major vascular pedicles

Statistical analysis

Data are reported as median with interquartile range for continuous variables or numbers (percentages) of patients for categorical variables.

The Student's t-test was used to compare continuous variables. Associations between categorical variables were evaluated by using Chi-squared test or Fisher test as appropriate. We assessed a propensity score-matched cohort by using an automated procedure to pair patients according to lesion distance from vessels.

The propensity score was based on a multivariable logistic regression model including: Age, BMI, ASA>2, Previous surgery, Comorbidities >2, Cirrhosis, Number of tumors, tumor size, anatomical resection, major resection, Iwate >7. Matching was performed in a 1:1 ratio using a caliper width of 0.25 of the

standard deviation of the linear predictor of the estimated propensity score.⁹ Variables were compared before and after matching using a test for paired data. A p value < 0.05 was considered statistically significant. All analyses were conducted using STATA software, version 16 (Stata-Corp LP, College Station, Tex).

Results

The study included 889 patients. Among them, 595 lesions were free from contact with major vessels (NCMV) and 294 were in contact with major vessels (CMV). HCC were the most common tumor's type (39.5 %), followed by colorectal liver metastasis (38.2 %). 294 lesions were in contact with major vessels; 127 (43.2 %) with portal vein (PV), 118 (40.1 %) with hepatic vein (HV) and in 49 (16.7 %) cases lesions were in contact with both vascular structures. Mean tumor's size was 32 ± 19 mm. Anatomical resection was performed in 48.4 % of cases. Major hepatectomies were 12.7 % while Iwate score was ≥ 7 in 27.1 % of the surgical procedures.

Patient characteristics and perioperative outcomes in the overall cohort, before PSM

Baseline characteristics of patients in the overall cohort, before propensity score matching, shows in both groups a predominance of male patients (63.2 % and 60.5 %), with a mean age of 66 years old in both groups. Patients in the NCMV group were frailer with more comorbidities (ASA>2 50.3 % vs 32.7 %, $p = 0.001$). Patients in the NCMV group were more likely to have undergone previous surgery (56.4%vs46.8 %, $p = 0.009$). Cirrhosis and therefore HCC, were more observed in the NCMV group, (cirrhosis 42.9 % vs 30.8 %; HCC 42.7 % vs 33 %). Instead, intrahepatic cholangiocarcinoma was more prevalent in the CMV group (16.7%vs6.2, $p = 0.001$). Other tumor types were equally observed between the two groups. No difference was observed in grade of cirrhosis (Child Pugh A grade 96.1 % vs 98 %), while mean MELD score were higher in NCMV (7.8 ± 2.6 vs 6.9 ± 1.5). No differences were observed between locations and number of lesions. In the CMV group larger tumor size (mean size 39 ± 22 vs 29 ± 16 , $p = 0.001$), higher rate of anatomical resections (60.9 % vs 42.2 %, $p = 0.0001$) and major hepatectomies (26.9 % vs 5.7 %, $p = 0.0001$) and lower rate of wedge resections (38.4 % vs 57 %, $p = 0.0001$) were observed. Resections in the CMV group were more complex, so their Iwate score was ≥ 7 in 34.7 % vs 23 % ($p = 0.002$) in the NCMV group. In the CMV group the mean operative time was longer (264 ± 106 vs 239 ± 107 , $p = 0.001$) and a higher rate of conversion was observed (10.2 % vs 4.7, $p = 0.002$). No difference was found between the two groups regarding conversion's reasons except for adhesions (32 % NCMV vs 10 % CMV $p = 0.002$). No differences were found in terms of blood loss and blood transfusions. More Pringle maneuvers were performed in the CMV group (55.8 % vs 33.2 %, $p = 0.0001$). Regarding post operative outcomes, no differences were found in terms of morbidity (17.8 vs 18.3 %), instead severe morbidity (Clavien Dindo III/IV) was more common in the CMV group,

even if it didn't show any statistical significance (7 % vs 11.8, $p = 0.064$). No differences were observed when comparing types of complications. Reoperation rate was similar between the two groups, the same is true for length of stay, RO rate, readmission at 90-days and 90-days mortality. Re-hepatectomy rate was higher in the CMV group (8.3 % vs 5 %), without, however, achieving statistical significance ($p = 0.058$). All the results are shown in [Table 1](#).

Patient characteristics and perioperative outcomes in the overall cohort, after PSM

After propensity score matching, NCMV and CMV groups both included 216 patients. NCMV group no longer exhibited

a higher rate of patients with ASA>2 and with more comorbidities, however it was still associated with several patients who had already undergone previous surgery (56.7 % vs 47.1 %, $p = 0.035$). Between the two groups, no further differences were observed in terms of cirrhosis, MELD score and tumor's type. Only non-colorectal liver metastasis were more represented in the NCMV group without, however, reaching statistical significance ($p = 0.071$). Tumor sizes were now similar between the two groups. Anatomical resection and major hepatectomy rate were found to be comparable. All these preoperative characteristics are in [Table 1](#). The rate of complex resections (Iwate score ≥ 7) was comparable between the two groups. No differences were observed in

Table 1 Preoperative characteristics before and after propensity matching, according to vessel contact

	Before PSM (n:889)			After PSM (n:432)		
	No Contact vessels (n:595)	Contact vessels (n:294)	P value	NO Contact Vessels (n:216)	Contact vessels (n:216)	P value
Male n (%)	375 (63.2 %)	178 (60.5 %)	0.436	129 (59.7 %)	138 (63.9 %)	0.371
Age (yr) median (range)	66 ± 11	66 ± 12	0.538	66 ± 10	66 ± 12	0.563
BMI (kg/cm ²) median (range)	26.3 ± 3.9	26.4 ± 4.0	0.570	26.3 ± 3.5	26.4 ± 3.9	0.988
ASA ≥ 2 n (%)	298 (50.3 %)	96 (32.7 %)	0.001	78 (36.3 %)	82 (38.1 %)	0.663
Previous surgery (%)	332 (56.4 %)	125 (46.8 %)	0.009	118 (56.7 %)	98 (47.1 %)	0.035
Cirrhosis n (%)	251 (42.9 %)	89 (30.8 %)	0.001	62 (30.1 %)	65 (31.6 %)	0.729
Child Pugh n(%)						
A	240 (96.1 %)	87 (98 %)	0.340	60 (96.1 %)	64 (99 %)	0.531
B	11 (3.9 %)	2 (2 %)		2 (3.9 %)	1 (1 %)	
MELD median (range)	7.8 ± 2.6	6.9 ± 1.5	0.002	7.1 ± 2.1	6.9 ± 1.6	0.938
Histological tumor's type n(%)						
HCC	254 (42.7 %)	97 (33 %)	0.005	67 (31 %)	73 (33.8 %)	0.522
CRLM	220 (37 %)	120 (40.8 %)	0.268	90 (41.7 %)	93 (43.1 %)	0.761
NCRLM	67 (11.3 %)	24 (8.2 %)	0.152	28 (13.0 %)	17 (7.9 %)	0.071
iCCA	37 (6.2 %)	49 (16.7 %)	0.001	23 (10.6 %)	29 (13.4 %)	0.366
pCCA	1 (0.2 %)	0 (0 %)	1.000	1 (0.5 %)	0 (0 %)	1.000
Gallbladder	16 (2.7 %)	4 (1.4 %)	0.209	7 (3.2 %)	4 (1.9 %)	0.549
Benign	0	0		0 (0 %)	0 (0 %)	
Tumors number n(%)						
Single	417 (70.3 %)	202 (68.7 %)	0.622	154 (71.6 %)	152 (70.7 %)	0.831
Multinodular	176 (29.7 %)	92 (31.3 %)	0.622	61 (28.4 %)	63 (29.3 %)	0.830
Tumors size biggest lesion (mm) median (SD)	29 ± 16	39 ± 22	0.001	35 ± 18	35 ± 16	0.980
Type of vein's contact n (%)						
Portal Vein	/	127 (43.2 %)		/	104 (48.1 %)	
Hepatic Vein	/	118 (40.1 %)		/	81 (37.5 %)	
Both	/	49 (16.7 %)		/	31 (14.4 %)	
Tumor locations n (%)						
Anterior	455 (77.9 %)	225 (77.6 %)	0.913	159 (76.8 %)	152 (73.4 %)	0.453
Posterior	331 (56.7 %)	178 (61.4 %)	0.185	127 (61.4 %)	119 (57.5 %)	0.454

The numbers in bold are the significant values.

operative time and conversion rate after PSM. Use of Pringle Maneuver remained more associated with CMV resections (49.8 % vs 31.2 %, $p = 0,0001$). No difference in terms of morbidity and type of complications was observed between the two groups. Re-hepatectomy remained higher in in CMV

group although it didn't reach statistical significance (8.8 % vs 4.4 %, $p = 0.093$). Reoperation rate stayed similar in the two groups, the same occurred for length of stay, R0 rate, readmission at 90-days and 90-days mortality. All results are shown in [Table 2](#).

Table 2 Perioperative characteristic before and after propensity score matching

	Before PSM (n:889)			After PSM (n:432)		
	No Contact vessels (n:595)	Contact vessels (n:294)	P value	No Contact vessels (n:216)	Contact vessels (n:216)	P value
Iwate score ≥ 7	94 (23 %)	77 (34.7 %)	0.002	34 (29.8 %)	29 (25.4 %)	0.475
Major resection	34 (5.7 %)	79 (26.9 %)	0.001	25 (11.6 %)	30 (13.9 %)	0.383
Anatomical resection	251 (42.2 %)	179 (60.9 %)	0.001	114 (52.8 %)	114 (52.8 %)	1.000
Type of hepatectomy (%)						
Wedge	331 (57 %)	111 (38.4 %)	0.001	95 (46.3 %)	94 (45.9 %)	0.914
Segmenctectomy	133 (22.9 %)	58 (20.1 %)	0.344	42 (20.5 %)	51 (24.9 %)	0.299
Left Lateral sectorectomy	60 (10.3 %)	30 (10.4 %)	0.980	27 (13.2 %)	22 (10.7 %)	0.456
Right Posterior sectorectomy	11 (1.9 %)	12 (4.2 %)	0.050	7 (3.4 %)	10 (4.9 %)	0.629
Right Anterior sectorectomy	2 (0.3 %)	1 (0.3 %)	1.000	1 (0.5 %)	1 (0.5 %)	1.000
Other sectorectomy	18 (3.1 %)	6 (2.1 %)	0.386	9 (4.4 %)	6 (2.9 %)	0.607
Left hepatectomy	20 (3.4 %)	42 (14.5 %)	0.001	17 (8.3 %)	19 (9.3 %)	0.839
Right hepatectomy	14 (2.4 %)	36 (12.5 %)	0.001	8 (3.9 %)	9 (4.4 %)	1.000
Central hepatectomy	0 (0 %)	1 (0 %)	0.332	0 (0 %)	1 (0.5 %)	1.000
Rehepatectomy	29 (5.0 %)	22 (8.3 %)	0.058	9 (4.4 %)	18 (8.8 %)	0.093
Operative time (min) median (SD)	239 \pm 107	264 \pm 107	0.001	250 \pm 117	262 \pm 108	0.144
Conversion	28 (4.7 %)	30 (10.2 %)	0.002	12 (5.6 %)	21 (9.7 %)	0.106
Reasons of conversion						
Anesthesiological problems	3 (12 %)	7 (24 %)	0.309	0 (0 %)	0 (0 %)	/
Adhesions	8 (32 %)	3 (10 %)	0.049	1 (100 %)	0 (0 %)	/
Bleeding	6 (24 %)	8 (28 %)	0.764	0 (0 %)	1 (0 %)	/
Oncological radicality	8 (32 %)	11 (38 %)	0.649	0 (0 %)	0 (0 %)	/
Estimated blood loss (mL) (SD)	215 \pm 239	231 \pm 181	0.323	225 \pm 202	222 \pm 182	0.725
Blood transfusion n (%)	43 (30 %)	5 (12 %)	0.03	9 (4.5 %)	6 (3 %)	0.607
Pringle Manoeuvre n (%)	196 (33.2 %)	164 (55.8 %)	0.001	67 (31.2 %)	107 (49.8 %)	0.001
Postoperative complication n(%)	104 (17.8 %)	53 (18.3 %)	0.856	41 (19.7 %)	32 (15.4 %)	0.249
Dindo Clavien III-IV n (%)	33 (7 %)	18 (11.8 %)	0.064	5 (5 %)	8 (8 %)	0.549
Type of complication n(%)						
Ascites	28 (5.5 %)	15 (5.4 %)	0.964	6 (3.5 %)	9 (5.2 %)	0.581
Biliary leakage	12 (2.1 %)	9 (3.1 %)	0.349	7 (3.3 %)	5 (2.4 %)	0.774
Hemorrhage	10 (2 %)	9 (3.3 %)	0.265	3 (1.8 %)	3 (1.8 %)	1.000
Pulmonary infection	32 (6.3 %)	17 (6.2 %)	0.942	13 (7.6 %)	10 (5.8 %)	0.648
Other infection	26 (5.2 %)	16 (5.9 %)	0.684	9 (5.3 %)	10 (5.9 %)	1.000
Reoperation n(%)	6 (1.2 %)	5 (1.8 %)	0.532	2 (1.2 %)	5 (2.9 %)	0.453
Length of hospital stay median (SD)	5.9 \pm 3.2	6 \pm 4.5	0.757	5.6 \pm 2.8	5.7 \pm 3.6	0.932
Resection R1 n(%)	42 (7.1 %)	26 (8.9 %)	0.464	16 (7.4 %)	11 (4.9 %)	0.754
Readmission at 90-days	25 (4.5 %)	13 (6.2 %)	0.352	6 (4 %)	8 (5.3 %)	0.791
Mortality 90 days n(%)	2 (1.8 %)	1 (1.6 %)	1.000	0 (0 %)	0 (0 %)	/

The numbers in bold are the significant values.

Discussion

Robotic surgery is gaining increasing acceptance in liver surgery, even for complex cases.^{10–12} However, the role of robotic surgery in the resection of lesions in contact with major vascular (CMV) pedicles remains controversial and no data on this specific aspect have been reported in the literature. To our knowledge, this is the first study reporting the results of the robotic approach in this specific scenario. Our results showed no difference in terms of short-term outcomes between lesions distant from vessels (NCMV) and lesions in contact with vessels (CMV) when using the robot (Table 2). After propensity score matching, the robotic approach allowed complex resections without sacrificing additional parenchyma due to its increased capacity for “vessel sparing” surgery. This resulted in comparable rates of major liver resection between the two groups (13.9 % vs 11.6 %) (Table 2). Despite involving lesions in contact with vascular structures, so with a high risk of bleeding, no difference in terms of blood loss, transfusions, open conversion and operating time was observed (Table 2.) This could be attributed to the robotic platform’s enhanced precision, able to facilitate complex maneuvers such as hemorrhage control and suturing. It should be noted that there was a higher rate of Pringle maneuver in the vessel-contact group (49.8 % vs 31.2 %, $p = 0.001$). Although we don’t have transaminase curves in the postoperative period, the absence of differences in hospital stay and postoperative course suggests that the increased use of Pringle didn’t lead to postoperative effects in terms of cytolysis or liver failure (Table 2). As mentioned above, no differences were observed in post-operative complications (19.7 % vs 15.4 %, $p = 0.249$). Regarding short-term outcomes, it’s worth noting that re-intervention rate, hospital stay and readmissions within 90 days were similar in the two groups. No mortality was reported in both groups. In addition, the oncological radicality of resections was comparable (R1 resection 7.4 % vs 4.9 %, 0.754). It’s important to highlight that the NCMV group had a significantly higher proportion of patients that had already undergone surgery (56.7 % vs 47.1 %, $p = 0.035$). However, it’s noteworthy that the rate of re-hepatectomy is higher and almost statistically significant in favor of the CMV group (4.4 % vs. 8.8 %, $p = 0.093$) showing how robotic surgery may facilitate resections even in complex scenarios like re-hepatectomies. Therefore, there was no difference between the two groups in terms of lesion location (anterior vs posterior). A well-established finding in minimally invasive liver surgery literature is the significant difference in difficulty between resecting lesions located in the posterior versus anterior sectors. This difference is so important that it is included into several difficulty scores,^{13–16} so this aspect deserves careful analysis. The IWATE score, a widely recognized critical score for stratifying the difficulty of a liver resection, considers among its variables factors such as precise tumor location and proximity to vessels.¹⁷ The result of our study shows how robotic surgery somehow revolutionizes this concept of difficulty, questioning

the validity of the score for robotic surgery.¹⁵ This aspect was analyzed by several authors who compared the main difficulty scores (IWATE, IMM and Southampton) for robotic resections.¹⁸ IWATE and IMM systems can predict certain outcomes, such as intra-operative complications and unplanned conversions, with reasonable accuracy. However, overall performance across all assessed metrics was suboptimal, as evidenced by AUCs below the 700 benchmark. The Southampton model showed the highest accuracy for predicting Clavien - Dindo \geq III complications, however this accuracy didn’t consistently extend to other categories.¹⁸ So, as mentioned by *Lamberty et al.* in their study, the IWATE score remains a valid tool for assessing preparatory difficulty, planning resection, and training young surgeons, however it may be less accurate regarding robotic surgery.¹⁹ Therefore, “Tampa” a specific robotic difficult score was recently proposed by *Sucandy I. et al.* To fill this critical gap.²⁰ It not only includes but uniquely uses factors that are important in robotic hepatectomy, such as the need for radical portal lymphadenectomy and extra-hepatic biliary resection with Roux-en-Y reconstruction. By incorporating these specific robotic surgery considerations, the Tampa Difficulty Score provides a more accurate and predictive tool for assessing the complexity of robotic hepatectomies compared to laparoscopic-focused scoring systems like IWATE, IMM, and Southampton.²⁰ Had we considered the tampa score in our study, we would have noticed how in both groups, the scores would probably have been lower because >70 % of the lesions are located in the anterior site (score 1–3) and about 50 % are wedge resection (+0 points). However, a significant proportion of cases would still have been classified as complex resections considering that they were all neoplastic lesions >3 cm (6 points), >20 % complex resections (right hepatectomies, left hepatectomies, sectorectomies (12 points) and in 13 % of cases they needed a lymphadenectomy (12 points). Thus, while laparoscopy remains the more commonly used surgical approach for minimally invasive hepatectomy, its inherent technical limitations including straight, fixed, handheld instruments with restricted range of motion, can hinder the resection of nonanatomic anterolateral and peripheral liver tumors. Robotic surgery seems to overcome some of these limitations, expanding the technical applications and complexity level of liver operations.^{21,22} To our knowledge, in literature, there are no studies reporting a series of robotic resections of lesions in contact with vessels. There are sporadic case reports that nevertheless show these advantages of robotic surgery. *Song et al.* report the robotic resection of a voluminous hepatocarcinoma with inferior vena cava thrombosis, *Machado et al.* report a Robotic Right Hepatectomy with Portal Vein Thrombectomy for Colorectal Liver Metastasis, and finally *Magistri P. et al* report a series of robotic resections in the setting of cholangiocarcinomas (from type I to type IV according to Bismuth-Corlette classifications) including portal vein en-bloc resection at the confluence with end-to-end reconstruction.^{23–25} Further prospective randomized studies of the various

techniques will help to precisely define the role of robotic platform in liver surgery. Indeed, if robotic complex vessels sparing resection might be feasible from a technical point of view, data on oncological validity are still preliminary. Certainly, there are also some limitations of this technique. First, the limited availability of robotic systems, often restricted to one maximum two consoles per hospital shared among all the sub-specialties. Secondly, the learning curve associated with robotic surgery, often influenced by infrequent use due to limited access, is very steep, even for surgeons who already have experience in laparoscopic liver surgery.²⁶ Bernandi et al. declare that to overcome the learning curve it is necessary to carry out at least 40 robotic resections of low and intermediate difficulty, which is still not a properly low number.²⁷ This study has several limitations, first, it is a retrospective study, although with application of propensity score matching; second, all centers included in the study are tertiary centers for minimally invasive liver surgery, so it may not be reproducible in other contexts; third, a comparison with the laparoscopic technique, but especially with the open technique, is lacking. Indeed, the robotic technique still suffers from the economic limitation and from longer operative times compared to open surgery, despite achieving the same oncologic outcomes. However, the big advantage of the robotic approach could prove to be precisely in complex scenarios, (such as lesions in contact with vessels) overcoming the technical limitations of laparoscopy but maintaining the advantages of short-term outcomes over open surgery.^{28–30}

Conclusion

In conclusion, robotic surgery proves to be a valid and safe technique for resections also for tumors close to vascular pedicles. Further randomized studies are expected to discuss this emerging issue. In the future, it is hoped that there will be studies comparing this technique with laparoscopic and open surgery in this specific setting.

Conflict of interest

The authors have no conflict of interest to declare.

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