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Maturation of robotic liver resection during the last decade: A systematic review and meta-analysis

Tomohiro Ishinuki, Shigenori Ota, Kohei Harada, Makoto Meguro, Masaki Kawamoto, Goro Kutomi, Hiroomi Tatsumi, Keisuke Harada, Koji Miyanishi, Ichiro Takemasa, Toshio Ohyanagi, Thomas T Hui, Toru Mizuguchi

ORCID number: Tomohiro Ishinuki 0000-0003-3225-9781; Shigenori Ota 0000-0003-3123-9172; Kohei Harada 0000-0002-3245-6980; Makoto Meguro 0000-0002-9170-6919; Masaki Kawamoto 0000-0002-2800-6207; Goro Kutomi 0000-0003-4557-5126; Hiroomi Tatsumi 0000-0002-9688-6154; Keisuke Harada 0000-0002-7497-6191; Koji Miyanishi 0000-0002-6466-3458; Ichiro Takemasa 0000-0003-1595-2453; Toshio Ohyanagi 0000-0001-8335-3087; Thomas T Hui 0000-0003-2717-3983; Toru Mizuguchi 0000-0002-8225-7461.

Author contributions: Ishinuki T and Ota S developed the study concept and designed the systematic review; Ishinuki T, Meguro M, and Ohyanagi T searched for and screened the articles; Kawamoto M, Harada K, and Tatsumi H assessed the articles for eligibility; Miyanishi K carried out the statistical analyses; Takemasa I supervised and audited the preparation of the manuscript; Hui TT and Mizuguchi T drafted the initial manuscript; Mizuguchi T finalized the manuscript; All of the authors reviewed and approved the final submitted manuscript.

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Tomohiro Ishinuki, Toru Mizuguchi, Department of Nursing, Surgical Sciences, Sapporo Medical University, Sapporo 0608556, Hokkaido, Japan

Shigenori Ota, Ichiro Takemasa, Departments of Surgery, Surgical Science and Oncology, Sapporo Medical University, Sapporo 0608543, Hokkaido, Japan

Kohei Harada, Division of Radiology, Sapporo Medical University, Sapporo 060-8543, Hokkaido, Japan

Makoto Meguro, Departments of Surgery, Sapporo Satozuka Hospital, Sapporo 0048686, Japan

Masaki Kawamoto, Departments of Surgery, Nemuro City Hospital, Nemuro 0878686, Hokkaido, Japan

Goro Kutomi, Department of Surgery, School of Medicine, Sapporo Medical University, Sapporo 0608543, Hokkaido, Japan

Hiroomi Tatsumi, Department of Intensive Care Medicine, Sapporo Medical University Hospital, Sapporo 0608543, Hokkaido, Japan

Keisuke Harada, Department of Emergency Medicine, Sapporo Medical University, Sapporo 0606543, Hokkaido, Japan

Koji Miyanishi, Department of Medical Oncology, Sapporo Medical University, Sapporo 0608543, Hokkaido, Japan

Toshio Ohyanagi, Department of Liberal Arts and Sciences, Center for Medical Education, Sapporo Medical University, Sapporo 0608556, Hokkaido, Japan

Thomas T Hui, Department of Surgery, Division of Pediatric Surgery, Stanford University School of Medicine, Stanford, CA 94598, United States

Corresponding author: Toru Mizuguchi, MD, PhD, Professor, Department of Nursing, Surgical Sciences, Sapporo Medical University, S1, W17, Chuo-ku, Sapporo 0608556, Hokkaido, Japan. tmizu@sapmed.ac.jp

Abstract

BACKGROUND

Minimally invasive hepatectomy techniques have developed rapidly since 2000.

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Pure laparoscopic liver resection (LLR) has become the primary approach for managing liver tumors and procuring donor organs for liver transplantation. Robotic liver resection (RLR) has emerged during the last decade. The technical status of RLR seems to be improving.

AIM

To conduct a systematic review and meta-analysis comparing the short-term clinical outcomes of LLR and RLR over two 5-year periods.

METHODS

A systematic literature search was performed using PubMed and Medline, including the Cochrane Library. The following inclusion criteria were set for the meta-analysis: (1) Studies comparing LLR *vs* RLR; and (2) Studies that described clinical outcomes, such as the operative time, intraoperative bleeding, intraoperative conversion rate, and postoperative complications.

RESULTS

A total of 25 articles were included in this meta-analysis after 40 articles had been subjected to full-text evaluations. The studies were divided into early ($n = 14$) and recent ($n = 11$) groups. In the recent group, the operative time did not differ significantly between LLR and RLR ($P = 0.70$), whereas in the early group the operative time of LLR was significantly shorter than that of RLR ($P < 0.001$).

CONCLUSION

The initial disadvantages of RLR, such as its long operation time, have been overcome during the last 5 years. The other clinical outcomes of RLR are comparable to those of LLR. The cost and quality-of-life outcomes of RLR should be evaluated in future studies to promote its routine clinical use.

Key Words: Hepatectomy; Laparoscopy; Robot; Operation time

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Core Tip: A systematic review and meta-analysis comparing the clinical outcomes of laparoscopic liver resection (LLR) and robotic liver resection (RLR) was conducted. A total of 25 studies were included in the meta-analysis. In the recent studies, operative time did not differ significantly between LLR and RLR ($P = 0.70$), whereas in the early studies LLR was associated with significantly shorter operative times than RLR ($P < 0.001$). The initial disadvantages of RLR have been overcome during the last 5 years.

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INTRODUCTION

Surgery is a curative treatment for liver tumors[1]. The development of surgical devices has promoted minimally invasive surgery (MIS), including minimally invasive liver resection[2]. Therefore, the concept of 'big surgeons, big incision' has become a myth[3]. Minimal skin wounds are preferable, and patients who undergo laparoscopic liver resection (LLR) recover faster without somatic pain than those that undergo open liver resection[1,4].

MIS has significant clinical benefits, *e.g.*, it results in faster recovery, less pain, and shorter hospital stays[5]. On the other hand, long operation times and the associated higher costs were reported as disadvantages of the MIS approach[4,5]. However, the disadvantages of the MIS approach might be ameliorated as surgeons gain experience

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[6]. Initially, LLR was reported to have various clinical benefits but result in longer operation times[4].

Robotic surgery has gained popularity since 2000[7]. Although robotic towers occupy space in the operating room, the skill of surgeons can be enhanced by robotic technology, such as "wristed instruments", "tremor cancellation", "enhanced dexterity", and "3D vision"[8,9]. These technologies are considered to reduce 93% of errors associated with human skill[8].

Total robotic liver resection (RLR) is limited to minor liver resection, which does not require the liver to be mobilized[10]. Furthermore, the robotic approach is only used for parenchymal dissection during laparoscopic surgery[11]. Therefore, the clinical outcomes of LLR and RLR should be similar[5,12]. We systematically reviewed the literature in which the clinical outcomes of LLR and RLR were compared. We divided the studies according to the year of publication to determine how the clinical outcomes of these techniques have changed over time. Early studies were defined as those published in 2016 or earlier. Recent studies were defined as those published in 2017 or later. We also examined the current status of RLR through a meta-analysis.

MATERIALS AND METHODS

Literature search

The Preferred Reporting Items for Systematic Reviews And Meta-Analyses (PRISMA) statement guidelines were followed when obtaining and reporting the meta-analysis data[13]. The PICOS scheme was employed when reporting the inclusion criteria. A systematic literature search of PubMed and MEDLINE, including the Cochrane Library, was performed independently by two authors (Ishinuki T and Ota S). The search was limited to human studies whose findings were reported in English. No restriction was set with regard to the type of publication, the publication date, or publication status. Patients of any age or sex who underwent liver resection for any hepatic lesion were considered, as outlined in the PICOS scheme. The search strategy was based on different combinations of words for each database. For the PubMed database the following combination was used: ("hepatectomy"[MeSH Terms] OR "hepatectomy"[All Fields] OR ("liver"[All Fields] AND "resection"[All Fields]) OR "liver resection"[All Fields]) AND ("laparoscopy"[All Fields] OR "laparoscopy"[MeSH Terms] OR "laparoscopy"[All Fields] OR "laparoscopies"[All Fields]) AND ("robot"[All Fields] OR "robot s"[All Fields] OR "robotically"[All Fields] OR "robotics"[MeSH Terms] OR "robotics"[All Fields] OR "robotic"[All Fields] OR "robotization"[All Fields] OR "robotized"[All Fields] OR "robots"[All Fields]). For the MEDLINE database, including the Cochrane Library database, the following combination was used: #1. liver.mp. [mp=title, abstract, full text, caption text], #2. resection.mp. [mp=title, abstract, full text, caption text], #3. robot.mp. [mp=title, abstract, full text, caption text], #4. 1 and 2 and 3.

Selecting policy of the studies

The independent authors have read the primary studies searched in the database. Similar studies and unrelated studies were excluded. The inclusion criteria for the statistical analysis were following: (1) Studies comparing LLR and RLR; (2) Studies reporting at least one clinical result or variable; and (3) If any institution reported multiple studies, only the recent and the excellent study was selected. The policies of the exclusion were following: (1) The studies dealing with liver transplantation; (2) Reviews, opinions, comments, letters, and case reports; and (3) The studies were impossible to reproduce. The Cohen kappa statistic was used to quantify assess the agreement among the researchers.

PROSPERO was used for the protocol registration (#CRD42021234405).

Data extraction

The independent authors extracted the following initial data: (1) The name of authors, year, and quality of study; (2) The etiology of the disease; and (3) The period of the evaluations.

Bias assessment

The publication bias was assessed by the Newcastle–Ottawa Scale: NOS (<http://www.ohri.ca/>), as they included observational studies. The NOS consists of domains for the patient selection, comparability of study groups, and outcome

Table 1 Frequency of each type of liver resection in the studies published in 2016 or earlier

Ref.		Laparoscopic liver resection					Robotic liver resection				
		Seg	LLS	LH	RH	EH	Seg	LLS	LH	RH	EH
Berber <i>et al</i> [17], 2010	Case	12	11				6	3			
Ji <i>et al</i> [18], 2011	Case	9	7	3	1		1	4	6	2	1
Lai <i>et al</i> [19], 2011	Cohort	6	4				6	3			
Lai <i>et al</i> [20], 2012	Cohort	9	8				12	17	2	1	
Packiam <i>et al</i> [21], 2012	Case		18					11			
Troisi <i>et al</i> [9], 2013	Case	149	39	16	17	2	38	2			
Spampinato <i>et al</i> [22], 2014	Case			9	15	1			8	16	1
Tranchart <i>et al</i> [23], 2014	Case	22	5	1			22	5	1		
Tsung <i>et al</i> [12], 2014	Case	72		21			36		21		
Wu <i>et al</i> [24], 2014	Case	28	31	8	2		8	24	7	12	1
Yu <i>et al</i> [25], 2014	Case		6	11				10	3		
Croner <i>et al</i> [26], 2016	Case	ND					ND				
Kim <i>et al</i> [27], 2016	Case		31					12			
Lai <i>et al</i> [28], 2016	Cohort	25	9		1		45	29	6	20	1
Lee <i>et al</i> [29], 2016	Case	34	30	2			17	39	10	4	
Montalti <i>et al</i> [30], 2016	Case	72					36				

EH: Extended hemi-hepatectomy; LH: Left hepatectomy; LLS: Left lateral segmentectomy; ND: Not properly described; RH: Right hepatectomy; Seg: Segmentectomy.

assessment. The low risk of bias results in a score of 9 points. We considered studies that scored ≥ 7 , 4-6, and < 4 to be high, moderate, and low quality, respectively[14].

Statistical analyses

RevMan software (version 5.3.; The Cochrane Collaboration) was used for the meta-analysis. For continuous variables, the differences between groups were compared using the inverse-variance method. On the other hand, dichotomous outcomes were compared using the Mantel-Haenszel method. The Egger's test for publication bias was performed using EZR (version 1.54; <https://www.softpedia.com/get/Science-CAD/EZR.shtml>)[15].

The χ^2 test was used to evaluate heterogeneity, and the Cochran Q and I^2 statistics were reported. The I^2 value describes the percentage variation between studies in degrees of freedom. Low, moderate, and high heterogeneity were defined based on cut-off values of 25%, 50%, and 75%, respectively[16].

All results were considered significant at P values of < 0.05 .

RESULTS

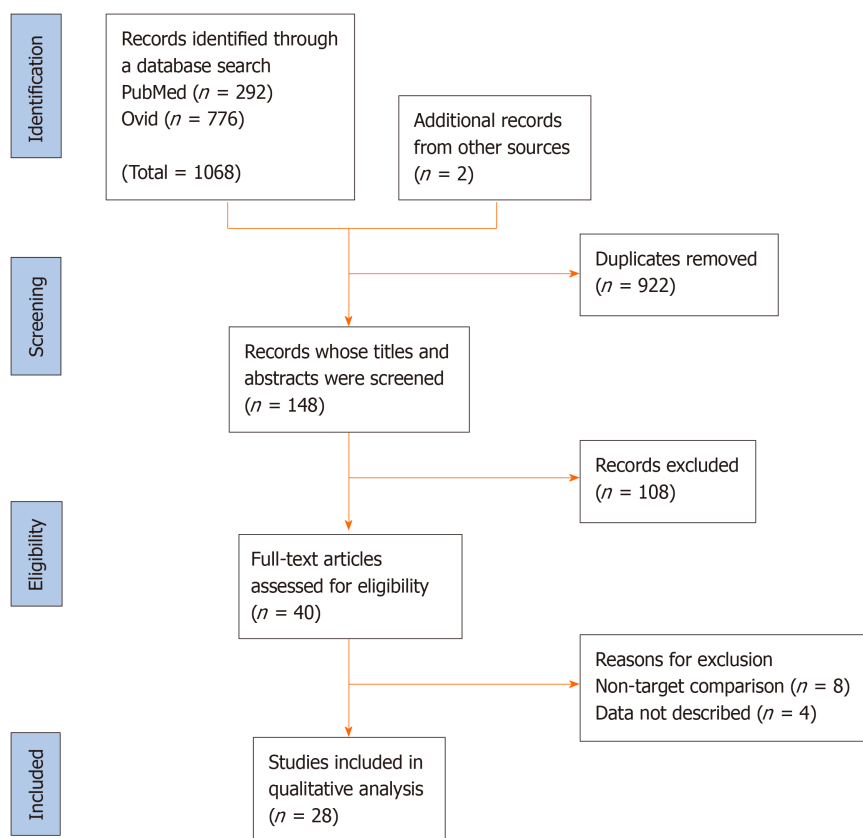
The PRISMA flow diagram for this study is shown in Figure 1. The database search for relevant studies resulted in 1,068 studies being identified. We excluded 922 studies because of duplication, and the titles and abstracts of the remaining 148 studies were screened. As a result, we reviewed 40 full-text articles to evaluate their eligibility further. We excluded 8 studies for which the outcome involved a non-target comparison, and 4 studies for which the data were not available. Finally, we included 28 studies in our meta-analysis.

The data regarding the frequency of each type of liver resection in the selected studies are shown in Tables 1 and 2. Table 1 shows the data for the studies published in 2016 or earlier[9,12,17-30]. Table 2 shows the data for the studies published in 2017 or later[31-42]. No randomized controlled trials (RCT) comparing the clinical outcomes of LLR and RLR were identified. All of the selected publications related to observa-

Table 2 Frequency of each type of liver resection in the studies published in 2017 or later

Ref.		Laparoscopic liver resection					Robotic liver resection				
		Seg	LLS	LH	RH	EH	Seg	LLS	LH	RH	EH
Efanovet al[31], 2017	Cohort	ND					ND				
Magistri et al[32], 2017	Case	24					14	6		2	
Salloumet al[33], 2017	Case	ND					ND				
Fruscone et al[34], 2019	Case	48		22	46		17		20	20	
Marino et al[35], 2019	Cohort				20					14	
Huet al[36], 2019	Case		54					58			
Lee et al[37], 2019	Case		7	3				8	5		
Limet al[38], 2019	Case	ND					ND				
Wang et al[39], 2019	Case			29	19				48	44	
Chonget al[40], 2020	Case	47	40	3	1		34	39	12	6	
Mejia et al[41], 2020	Case	ND					ND				
Rahim et al[42], 2020	Case	ND					ND				

EH: Extended hemi-hepatectomy; LH: Left hepatectomy; LLS: Left lateral segmentectomy; ND: Not properly described; RH: Right hepatectomy; Seg: Segmentectomy.

**Figure 1** PRISMA flow diagram for this study.

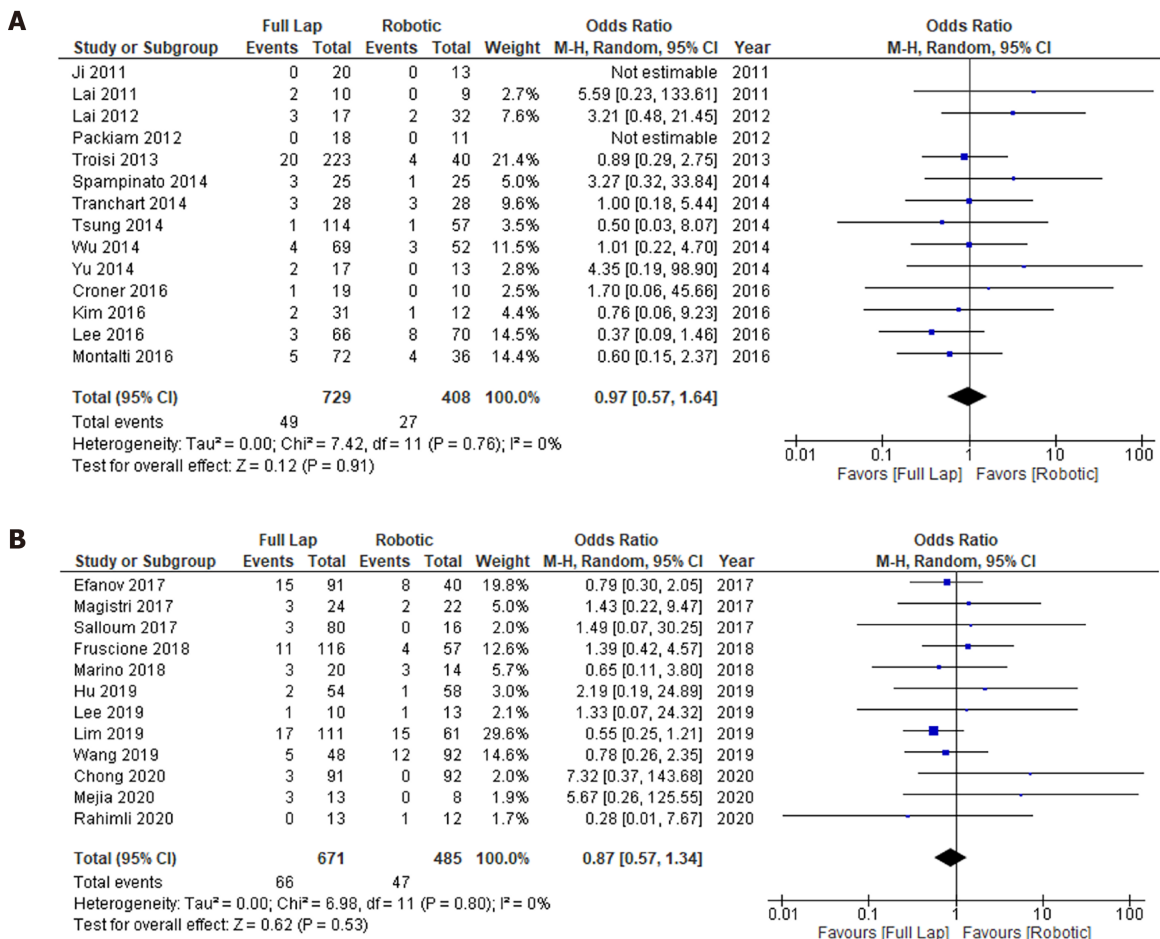


Figure 2 Frequency of Clavien-Dindo grade 3/4 complications. A: 2010-2016; B: 2017-2020.

tional studies. The types of liver resection performed did not differ significantly between the early (Table 1) and recent (Table 2) studies.

Frequency of Clavien-Dindo grade 3/4 complications

The data regarding complications of grade ≥ 3 according to the Clavien-Dindo (CD) classification are shown in Figure 2. There was no significant difference in the frequency of such complications between LLR and RLR in the early or recent studies. Scores of I^2 in both analyses were 0%, which indicated no heterogeneity. The funnel plots were shown in Supplementary Figure 1.

Intraoperative conversion rate

The data regarding the intraoperative conversion rate are shown in Figure 3. There was no significant difference in the intraoperative conversion rate between LLR and RLR in the early or recent studies. Score of I^2 in the early studies was 20% and the one in the recent studies was 44%. The heterogeneities were acceptable in the both analyses. The funnel plots were shown in Supplementary Figure 2.

Intraoperative blood loss

The data regarding intraoperative blood loss are shown in Figure 4. Although LLR tended to cause less intraoperative blood loss than RLR in the early studies, no marked difference in intraoperative blood loss between LLR and RLR was seen in the recent studies. Scores of I^2 in the early and recent studies were 88% and 94%, respectively. Severe heterogeneities were observed in both the early and recent analyses. The funnel plots were shown in Supplementary Figure 3.

Operation time

The data regarding the operation time are shown in Figure 5. Although in the early studies the operation time of LLR was significantly shorter than that of RLR ($P < 0.0001$), there was no significant difference between the operation times of LLR and

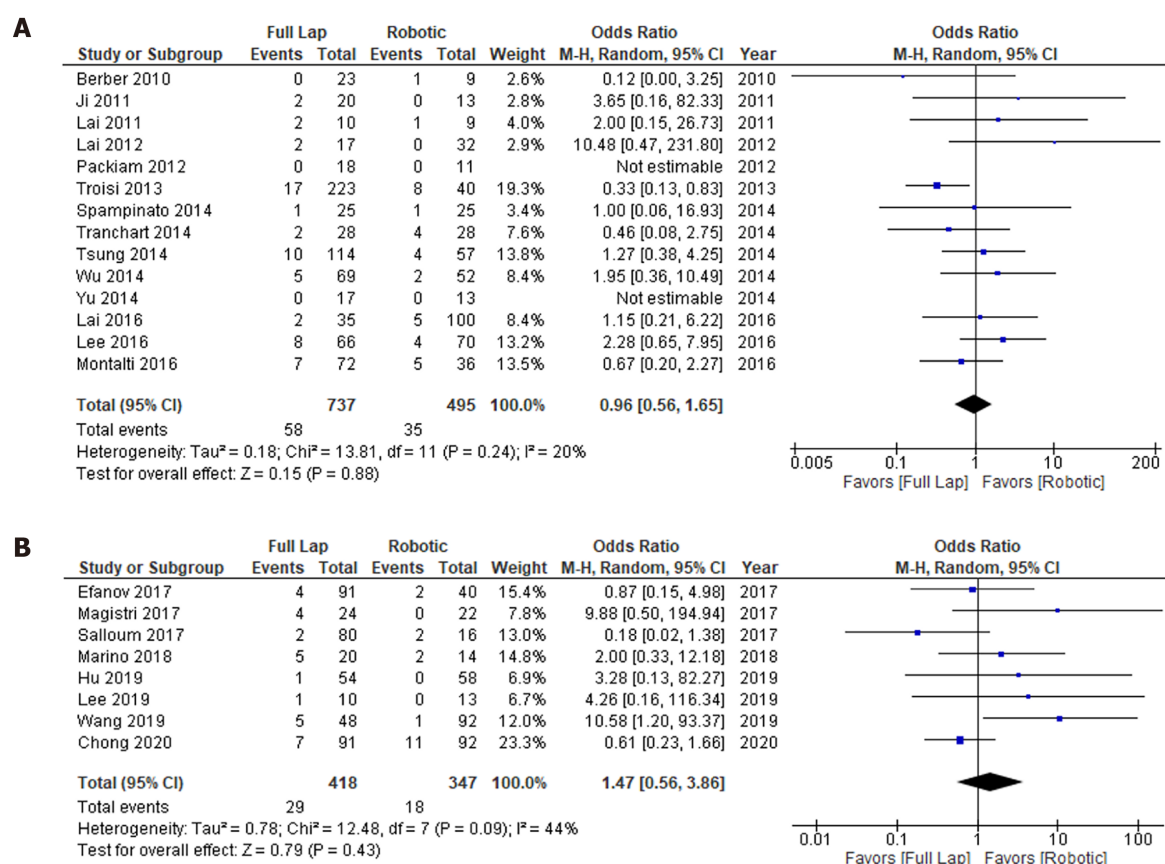


Figure 3 Intraoperative conversion rate. A: 2010-2016; B: 2017-2020.

RLR in the recent studies. Scores of I^2 in the early and recent studies were 81% and 93%, respectively. Severe heterogeneities were observed in both the early and recent analyses. The funnel plots were shown in [Supplementary Figure 4](#).

Quality assessment of the bias

The quality assessment was conducted using the NOS score ([Supplementary Table 1 and 2](#)). There was no significant difference in the NOS score between the early and recent studies, although the quality of the studies varied. Summary of the publication bias in each analysis was shown in [Supplementary Table 3](#).

DISCUSSION

MIS has become the standard approach for liver resection[1,4]. The initial disadvantages of RLR were that it involves large amounts of intraoperative blood loss and a long operation time. The recent studies examined in this review indicated that these initial disadvantages have been ameliorated. This finding strongly indicates that a new era of MIS may be upon us.

The CD classification is the standard grading system for surgical complications[43]. The definitions of the grades in the CD classification are based on how the complications are managed, *e.g.*, with pharmacological interventions, surgical interventions, or intensive care. These are indirect signs of complications. Furthermore, the grading system is divided into 5 grades plus 2 sub-grades. We did not find any difference in the types of complications encountered according to the CD classification between LLR/RLR or the early/recent period. This may have been because the CD classification is not suitable for identifying differences between clinical studies due to its use of indirect definitions and a relatively large number of grades. Ideally, surgical complications should be analyzed based on direct symptoms of the actual complications and a simple grading system[44].

LLR and RLR exhibited similar intraoperative conversion rates in both periods. The background data for each study varied, as they were all observational studies. The selection criteria for LLR and RLR were also unclear. Therefore, we could not conclude

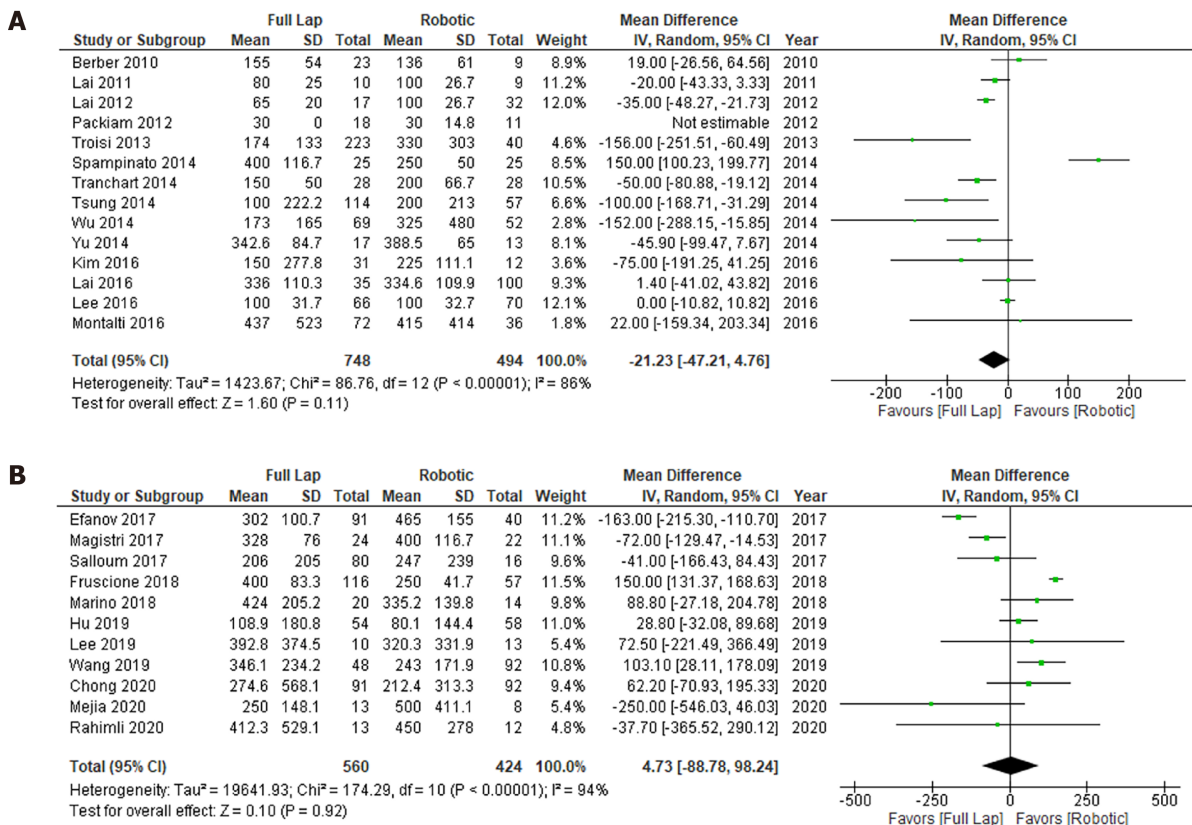


Figure 4 Intraoperative blood loss. A: 2010-2016; B: 2017-2020.

which type of surgery was safer. The maximum intraoperative conversion rate of LLR was about 25% among the recent studies. The maximum intraoperative conversion rate of RLR was about 20% among the early studies, although the mean conversion rate was $< 10\%$ in both study periods. In future, these rates could be used as standard clinical goals in order to ensure that surgical quality is maintained.

In the early studies, LLR tended to result in less intraoperative blood loss than RLR, although no marked differences in intraoperative blood loss were seen between LLR and RLR in the recent studies. Several strategies can reduce blood loss during pneumoperitoneum, such as using the head-up position, inducing a high peritoneal pressure, reducing the intratracheal pressure to increase the respiration time, reducing the respiratory volume, using a low central venous pressure, and employing inflow blood control based on the Pringle maneuver[2,45,46]. In addition, it is easier to change the body positions of patients during LLR than during RLR, which could help to control bleeding from veins. Various hemostatic devices are available, such as ultrasonic dissectors, and various hemostatic surgical devices were used for RLR in the recent studies, which may have counteracted the positional disadvantages of RLR. In addition to technical improvements associated with experience, various surgical devices can be used to reduce blood loss during RLR.

In the early studies, the operation time of the RLR was longer than that of the LLR. This is reasonable because it takes time to install robotic towers for robotic procedures. However, the difference in the operation time between the surgical procedures disappeared in the recent studies. It could be that the surgeons became familiar with the robotic procedures, which reduced the time required to set up the robot. Visual support and human-error-canceling functions could also have reduced the operation time[8]. Therefore, the initial disadvantages of RLR have recently been ameliorated.

One advantage of RLR is that it can be used to approach the dorsal segment and caudate lobe of the liver[47,48]. In addition, RLR is superior to LLR for bile duct reconstruction[49]. Therefore, separate tumor location- and surgical procedure-dependent indications need to be developed for RLR and LLR. The differences in the cost and quality-of-life outcomes of RLR and LLR should also be elucidated in the future.

This study had several limitations. First, all of the included studies were observational studies, and no RCT were identified. In addition, the indications for each procedure were not described clearly. The number of subjects recruited for each study

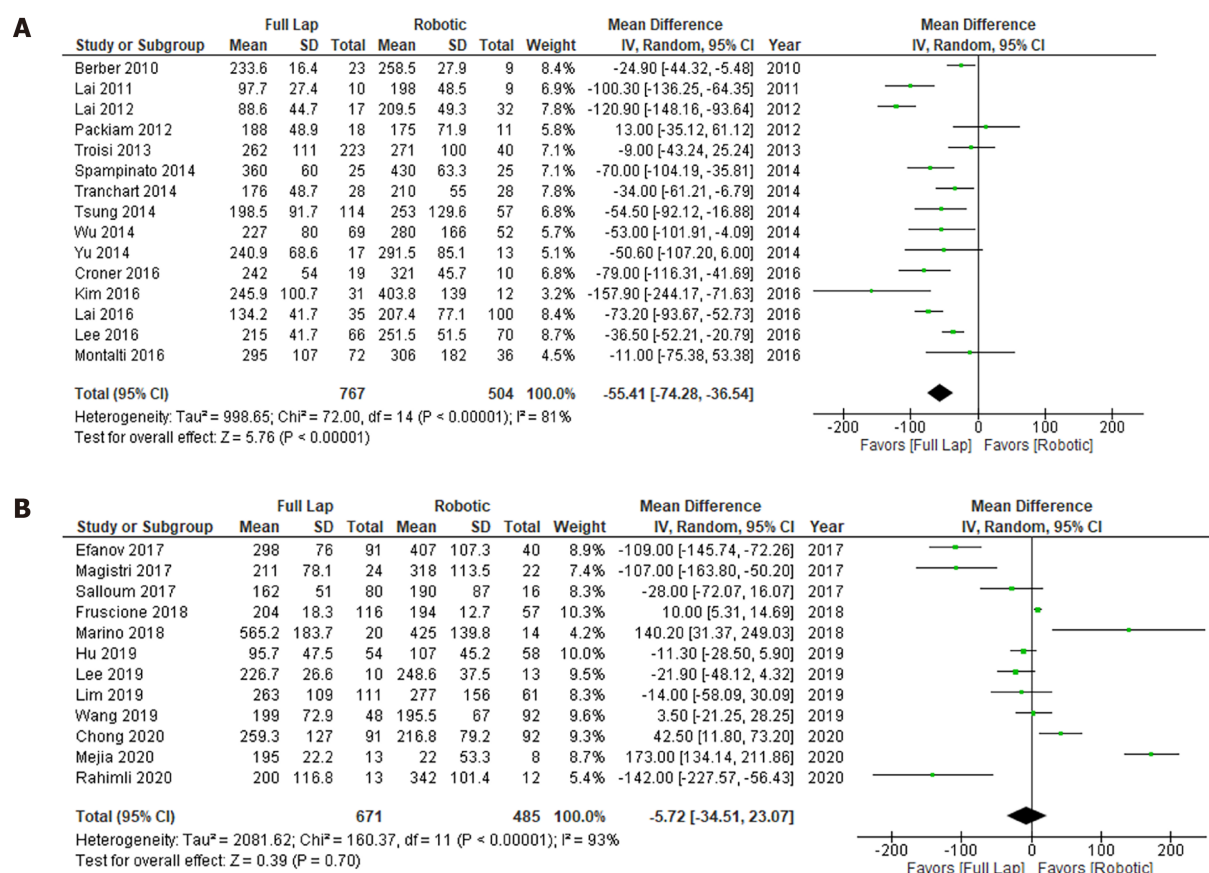


Figure 5 Operation time. A: 2010-2016; B: 2017-2020.

varied, as did the quality of each study. In addition, the clinical backgrounds of the studies differed. Although a few studies involved prospective protocols, at present there is no international registration system for such studies.

CONCLUSION

In conclusion, the initial disadvantages of RLR have been ameliorated. The clinical outcomes of LLR and RLR are comparable. Separate indications for each approach should be developed based on their cost and quality-of-life outcomes. A reliable international registration system for such cases needs to be established.

ARTICLE HIGHLIGHTS

Research background

Robotic liver resection (RLR) has emerged during the last decade. But the clinical outcome of the RLR has been debated.

Research motivation

Clinical outcomes among the laparoscopic liver resection (LLR) and RLR should be compared regarding merit and demerit.

Research objectives

The objective of this study was to conduct a systematic review and meta-analysis comparing the clinical outcomes of LLR and RLR over two 5-year periods.

Research methods

A systematic literature search was performed using PubMed and Medline, including the Cochrane Library.

Research results

A total of 25 articles were included in this meta-analysis after 40 articles had been subjected to full-text evaluations.

Research conclusions

The initial disadvantages of RLR, such as its long operation time, have been overcome during the last 5 years. The other clinical outcomes of RLR are comparable to those of LLR.

Research perspectives

The cost and quality-of-life outcomes of RLR should be evaluated in future studies to promote its routine clinical use.

REFERENCES

- 1 **Meguro M**, Mizuguchi T, Kawamoto M, Ota S, Ishii M, Nishidate T, Okita K, Kimura Y, Hirata K. Clinical comparison of laparoscopic and open liver resection after propensity matching selection. *Surgery* 2015; **158**: 573-587 [PMID: [26120070](#) DOI: [10.1016/j.surg.2015.02.031](#)]
- 2 **Mizuguchi T**, Kawamoto M, Nakamura Y, Meguro M, Hui TT, Hirata K. New technique of extracorporeal hepatic inflow control for pure laparoscopic liver resection. *Surg Laparosc Endosc Percutan Tech* 2015; **25**: e16-e20 [PMID: [25533749](#) DOI: [10.1097/SLE.0b013e3182a4c0f4](#)]
- 3 **Ogiso S**, Hatano E, Nomi T, Uemoto S. Laparoscopic liver resection: Toward a truly minimally invasive approach. *World J Gastrointest Endosc* 2015; **7**: 159-161 [PMID: [25789085](#) DOI: [10.4253/wjge.v7.i3.159](#)]
- 4 **Mizuguchi T**, Kawamoto M, Meguro M, Shibata T, Nakamura Y, Kimura Y, Furuhashi T, Sonoda T, Hirata K. Laparoscopic hepatectomy: a systematic review, meta-analysis, and power analysis. *Surg Today* 2011; **41**: 39-47 [PMID: [21191689](#) DOI: [10.1007/s00595-010-4337-6](#)]
- 5 **Swaid F**, Geller DA. Minimally Invasive Primary Liver Cancer Surgery. *Surg Oncol Clin N Am* 2019; **28**: 215-227 [PMID: [30851824](#) DOI: [10.1016/j.soc.2018.11.002](#)]
- 6 **Chua D**, Syn N, Koh YX, Goh BKP. Learning curves in minimally invasive hepatectomy: systematic review and meta-regression analysis. *Br J Surg* 2021; **108**: 351-358 [PMID: [33779690](#) DOI: [10.1093/bjs/znaa118](#)]
- 7 **Buess GF**, Schurr MO, Fischer SC. Robotics and allied technologies in endoscopic surgery. *Arch Surg* 2000; **135**: 229-235 [PMID: [10668887](#) DOI: [10.1001/archsurg.135.2.229](#)]
- 8 **Moorthy K**, Munz Y, Dosis A, Hernandez J, Martin S, Bello F, Rockall T, Darzi A. Dexterity enhancement with robotic surgery. *Surg Endosc* 2004; **18**: 790-795 [PMID: [15216862](#) DOI: [10.1007/s00464-003-8922-2](#)]
- 9 **Troisi RI**, Patriti A, Montalti R, Casciola L. Robot assistance in liver surgery: a real advantage over a fully laparoscopic approach? *Int J Med Robot* 2013; **9**: 160-166 [PMID: [23526589](#) DOI: [10.1002/rcs.1495](#)]
- 10 **Giulianotti PC**, Bianco FM, Daskalaki D, Gonzalez-Ciccarelli LF, Kim J, Benedetti E. Robotic liver surgery: technical aspects and review of the literature. *Hepatobiliary Surg Nutr* 2016; **5**: 311-321 [PMID: [27500143](#) DOI: [10.21037/hbsn.2015.10.05](#)]
- 11 **Zhang L**, Yuan Q, Xu Y, Wang W. Comparative clinical outcomes of robot-assisted liver resection vs laparoscopic liver resection: A meta-analysis. *PLoS One* 2020; **15**: e0240593 [PMID: [33048989](#) DOI: [10.1371/journal.pone.0240593](#)]
- 12 **Tsung A**, Geller DA, Sukato DC, Sabbaghian S, Tohme S, Steel J, Marsh W, Reddy SK, Bartlett DL. Robotic vs laparoscopic hepatectomy: a matched comparison. *Ann Surg* 2014; **259**: 549-555 [PMID: [24045442](#) DOI: [10.1097/SLA.0000000000000250](#)]
- 13 **Liberati A**, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med* 2009; **6**: e1000100 [PMID: [19621070](#) DOI: [10.1371/journal.pmed.1000100](#)]
- 14 **Islam MM**, Iqbal U, Walther B, Atique S, Dubey NK, Nguyen PA, Poly TN, Masud JH, Li YJ, Shabbir SA. Benzodiazepine Use and Risk of Dementia in the Elderly Population: A Systematic Review and Meta-Analysis. *Neuroepidemiology* 2016; **47**: 181-191 [PMID: [28013304](#) DOI: [10.1159/000454881](#)]
- 15 **Kanda Y**. Investigation of the freely available easy-to-use software 'EZR' for medical statistics. *Bone Marrow Transplantation* 2013; **48**: 452-458 [PMID: [23208313](#) DOI: [10.1038/bmt.2012.244](#)]
- 16 **Higgins JP**, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ* 2003; **327**: 557-560 [PMID: [12958120](#) DOI: [10.1136/bmj.327.7414.557](#)]
- 17 **Berber E**, Akyildiz HY, Aucejo F, Gunasekaran G, Chalikhonda S, Fung J. Robotic vs laparoscopic resection of liver tumours. *HPB (Oxford)* 2010; **12**: 583-586 [PMID: [20887327](#) DOI: [10.1111/j.1477-2574.2010.00234.x](#)]
- 18 **Ji WB**, Wang HG, Zhao ZM, Duan WD, Lu F, Dong JH. Robotic-assisted laparoscopic anatomic hepatectomy in China: initial experience. *Ann Surg* 2011; **253**: 342-348 [PMID: [21135692](#) DOI: [10.1097/SLA.0b013e3182a4c0f4](#)]

- 10.1097/SLA.0b013e3181ff4601]
- 19 **Lai EC**, Tang CN, Yang GP, Li MK. Multimodality laparoscopic liver resection for hepatic malignancy--from conventional total laparoscopic approach to robot-assisted laparoscopic approach. *Int J Surg* 2011; **9**: 324-328 [PMID: 21334468 DOI: 10.1016/j.ijsu.2011.02.004]
 - 20 **Lai EC**, Tang CN, Li MK. Conventional laparoscopic and robot-assisted laparoscopic liver resection for benign and malignant pathologies: a cohort study. *J Robot Surg* 2012; **6**: 295-300 [PMID: 27628468 DOI: 10.1007/s11701-011-0311-6]
 - 21 **Packiam V**, Bartlett DL, Tohme S, Reddy S, Marsh JW, Geller DA, Tsung A. Minimally invasive liver resection: robotic vs laparoscopic left lateral sectionectomy. *J Gastrointest Surg* 2012; **16**: 2233-2238 [PMID: 23054901 DOI: 10.1007/s11605-012-2040-1]
 - 22 **Spampinato MG**, Coratti A, Bianco L, Caniglia F, Laurenzi A, Puleo F, Ettorre GM, Boggi U. Perioperative outcomes of laparoscopic and robot-assisted major hepatectomies: an Italian multi-institutional comparative study. *Surg Endosc* 2014; **28**: 2973-2979 [PMID: 24853851 DOI: 10.1007/s00464-014-3560-4]
 - 23 **Tranchart H**, Ceribelli C, Ferretti S, Dagher I, Patriti A. Traditional vs robot-assisted full laparoscopic liver resection: a matched-pair comparative study. *World J Surg* 2014; **38**: 2904-2909 [PMID: 24984879 DOI: 10.1007/s00268-014-2679-8]
 - 24 **Wu YM**, Hu RH, Lai HS, Lee PH. Robotic-assisted minimally invasive liver resection. *Asian J Surg* 2014; **37**: 53-57 [PMID: 24642128 DOI: 10.1016/j.asjsur.2014.01.015]
 - 25 **Yu YD**, Kim KH, Jung DH, Namkoong JM, Yoon SY, Jung SW, Lee SK, Lee SG. Robotic vs laparoscopic liver resection: a comparative study from a single center. *Langenbecks Arch Surg* 2014; **399**: 1039-1045 [PMID: 25366357 DOI: 10.1007/s00423-014-1238-y]
 - 26 **Croner RS**, Perrakis A, Hohenberger W, Brunner M. Robotic liver surgery for minor hepatic resections: a comparison with laparoscopic and open standard procedures. *Langenbecks Arch Surg* 2016; **401**: 707-714 [PMID: 27207697 DOI: 10.1007/s00423-016-1440-1]
 - 27 **Kim JK**, Park JS, Han DH, Choi GH, Kim KS, Choi JS, Yoon DS. Robotic vs laparoscopic left lateral sectionectomy of liver. *Surg Endosc* 2016; **30**: 4756-4764 [PMID: 26902613 DOI: 10.1007/s00464-016-4803-3]
 - 28 **Lai EC**, Tang CN. Long-term Survival Analysis of Robotic Versus Conventional Laparoscopic Hepatectomy for Hepatocellular Carcinoma: A Comparative Study. *Surg Laparosc Endosc Percutan Tech* 2016; **26**: 162-166 [PMID: 27031650 DOI: 10.1097/SLE.0000000000000254]
 - 29 **Lee KF**, Cheung YS, Chong CC, Wong J, Fong AK, Lai PB. Laparoscopic and robotic hepatectomy: experience from a single centre. *ANZ J Surg* 2016; **86**: 122-126 [PMID: 26423216 DOI: 10.1111/ans.13339]
 - 30 **Montalti R**, Scuderi V, Patriti A, Vivarelli M, Troisi RI. Robotic vs laparoscopic resections of posterosuperior segments of the liver: a propensity score-matched comparison. *Surg Endosc* 2016; **30**: 1004-1013 [PMID: 26123328 DOI: 10.1007/s00464-015-4284-9]
 - 31 **Efanov M**, Alikhanov R, Tsvirkun V, Kazakov I, Melekhina O, Kim P, Vankovich A, Grendal K, Berelavichus S, Khatkov I. Comparative analysis of learning curve in complex robot-assisted and laparoscopic liver resection. *HPB (Oxford)* 2017; **19**: 818-824 [PMID: 28599892 DOI: 10.1016/j.hpb.2017.05.003]
 - 32 **Magistri P**, Tarantino G, Guidetti C, Assirati G, Olivieri T, Ballarin R, Coratti A, Di Benedetto F. Laparoscopic vs robotic surgery for hepatocellular carcinoma: the first 46 consecutive cases. *J Surg Res* 2017; **217**: 92-99 [PMID: 28641762 DOI: 10.1016/j.jss.2017.05.005]
 - 33 **Salloum C**, Lim C, Lahat E, Gavara CG, Levesque E, Compagnon P, Azoulay D. Robotic-Assisted Versus Laparoscopic Left Lateral Sectionectomy: Analysis of Surgical Outcomes and Costs by a Propensity Score Matched Cohort Study. *World J Surg* 2017; **41**: 516-524 [PMID: 27743071 DOI: 10.1007/s00268-016-3736-2]
 - 34 **Fruscione M**, Pickens R, Baker EH, Cochran A, Khan A, Ocun L, Iannitti DA, Vrochides D, Martinie JB. Robotic-assisted vs laparoscopic major liver resection: analysis of outcomes from a single center. *HPB (Oxford)* 2019; **21**: 906-911 [PMID: 30617001 DOI: 10.1016/j.hpb.2018.11.011]
 - 35 **Marino MV**, Shabat G, Guarasi D, Gulotta G, Komorowski AL. Comparative Study of the Initial Experience in Performing Robotic and Laparoscopic Right Hepatectomy with Technical Description of the Robotic Technique. *Dig Surg* 2019; **36**: 241-250 [PMID: 29539603 DOI: 10.1159/000487686]
 - 36 **Hu M**, Liu Y, Li C, Wang G, Yin Z, Lau WY, Liu R. Robotic vs laparoscopic liver resection in complex cases of left lateral sectionectomy. *Int J Surg* 2019; **67**: 54-60 [PMID: 31121328 DOI: 10.1016/j.ijsu.2019.05.008]
 - 37 **Lee SJ**, Lee JH, Lee YJ, Kim SC, Hwang DW, Song KB, Shin SH, Kwon JW, Park GS, Park YJ, Park KM. The feasibility of robotic left-side hepatectomy with comparison of laparoscopic and open approach: Consecutive series of single surgeon. *Int J Med Robot* 2019; **15**: e1982 [PMID: 30636179 DOI: 10.1002/rcs.1982]
 - 38 **Lim C**, Salloum C, Tudisco A, Ricci C, Osseis M, Napoli N, Lahat E, Boggi U, Azoulay D. Short- and Long-term Outcomes after Robotic and Laparoscopic Liver Resection for Malignancies: A Propensity Score-Matched Study. *World J Surg* 2019; **43**: 1594-1603 [PMID: 30706105 DOI: 10.1007/s00268-019-04927-x]
 - 39 **Wang ZZ**, Tang WB, Hu MG, Zhao ZM, Zhao GD, Li CG, Tan XL, Zhang X, Lau WY, Liu R. Robotic vs laparoscopic hemihepatectomy: A comparative study from a single center. *J Surg Oncol* 2019; **120**: 646-653 [PMID: 31313324 DOI: 10.1002/jso.25640]
 - 40 **Chong CCN**, Lok HT, Fung AKY, Fong AKW, Cheung YS, Wong J, Lee KF, Lai PBS. Robotic vs

- laparoscopic hepatectomy: application of the difficulty scoring system. *Surg Endosc* 2020; **34**: 2000-2006 [PMID: [31312961](#) DOI: [10.1007/s00464-019-06976-8](#)]
- 41 **Mejia A**, Cheng SS, Vivian E, Shah J, Oduor H, Archarya P. Minimally invasive liver resection in the era of robotics: analysis of 214 cases. *Surg Endosc* 2020; **34**: 339-348 [PMID: [30937618](#) DOI: [10.1007/s00464-019-06773-3](#)]
 - 42 **Rahimli M**, Perrakis A, Schellerer V, Gumbs A, Lorenz E, Franz M, Arend J, Negrini VR, Croner RS. Robotic and laparoscopic liver surgery for colorectal liver metastases: an experience from a German Academic Center. *World J Surg Oncol* 2020; **18**: 333 [PMID: [33353551](#) DOI: [10.1186/s12957-020-02113-1](#)]
 - 43 **Dindo D**, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004; **240**: 205-213 [PMID: [15273542](#) DOI: [10.1097/01.sla.0000133083.54934.ae](#)]
 - 44 **Ishii M**, Mizuguchi T, Harada K, Ota S, Meguro M, Ueki T, Nishidate T, Okita K, Hirata K. Comprehensive review of post-liver resection surgical complications and a new universal classification and grading system. *World J Hepatol* 2014; **6**: 745-751 [PMID: [25349645](#) DOI: [10.4254/wjh.v6.i10.745](#)]
 - 45 **Otsuka Y**, Katagiri T, Ishii J, Maeda T, Kubota Y, Tamura A, Tsuchiya M, Kaneko H. Gas embolism in laparoscopic hepatectomy: what is the optimal pneumoperitoneal pressure for laparoscopic major hepatectomy? *J Hepatobiliary Pancreat Sci* 2013; **20**: 137-140 [PMID: [23001192](#) DOI: [10.1007/s00534-012-0556-0](#)]
 - 46 **Pan YX**, Wang JC, Lu XY, Chen JB, He W, Chen JC, Wang XH, Fu YZ, Xu L, Zhang YJ, Chen MS, Lai RC, Zhou ZG. Intention to control low central venous pressure reduced blood loss during laparoscopic hepatectomy: A double-blind randomized clinical trial. *Surgery* 2020; **167**: 933-941 [PMID: [32216964](#) DOI: [10.1016/j.surg.2020.02.004](#)]
 - 47 **Zhao ZM**, Yin ZZ, Meng Y, Jiang N, Ma ZG, Pan LC, Tan XL, Chen X, Liu R. Successful robotic radical resection of hepatic echinococcosis located in posterosuperior liver segments. *World J Gastroenterol* 2020; **26**: 2831-2838 [PMID: [32550758](#) DOI: [10.3748/wjg.v26.i21.2831](#)]
 - 48 **Vanbrugghe C**, Fara R, Camerlo A. Robotic anatomical resection of segment 7 by caudate lobe approach for colorectal metastasis (with video). *Surg Oncol* 2021; **37**: 101548 [PMID: [33773283](#) DOI: [10.1016/j.suronc.2021.101548](#)]
 - 49 **Giulianotti PC**, Sbrana F, Bianco FM, Addeo P. Robot-assisted laparoscopic extended right hepatectomy with biliary reconstruction. *J Laparoendosc Adv Surg Tech A* 2010; **20**: 159-163 [PMID: [20201685](#) DOI: [10.1089/lap.2009.0383](#)]



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