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Review

Safety and feasibility of laparoscopic liver resection for patients with previous upper abdominal surgery: A systematic review and meta-analysis

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ABSTRACT

Background: Laparoscopic hepatectomy (LH) is technical challenge for patients with previous upper abdominal surgery (UAS), especially for those with previous liver resection. The purpose of this meta-analysis is to assess the safety and feasibility of laparoscopic liver resection for patients with previous UAS, in comparison with primary laparoscopic liver resection which means patients without previous upper abdominal surgery (non-UAS).
Methods: All case-matched articles published from date of inception to 15th April 2018 were identified independently by two reviewers. Perioperative outcomes were analyzed. Data were extracted and calculated by random- or fixed-effect models. In addition, subgroup analysis according to patients with history of liver resection was performed.
Results: A total of 8 non-randomized observational articles were included, with 1625 patients (430 patients in UAS group and 1195 in non-UAS group). The results showed that there was no significant difference between the two groups in perioperative outcomes. In the subgroup analysis of patients with a history of liver resection, however, LH for patients with previous liver resection had longer operative time comparing with patients without previous liver resection (WMD = 33.03, 95% CI 3.16 to 62.90, $P = 0.030$); other perioperative outcomes were similar between UAS and non-UAS groups.
Conclusion: LH is feasible and safe for selected patients with previous UAS comparing with that of primary resection, although LH has longer operative time for patients with previous liver resection.

1. Introduction

Laparoscopic hepatectomy (LH) is widely adopted by surgeons for the treatment of liver malignant or benign diseases, such as hepatocellular carcinoma (HCC), intra-hepatic cholangiocarcinoma (ICC) and hepatolithiasis [1–3]. Compared with conventional open liver resection, the benefits of LH have been widely reported by several studies [4–11]. In addition, a number of studies have reported how to overcome the limitations of LH in terms of underlying liver cirrhosis and tumor locations [12–16]. However, due to severe adhesions after upper abdominal surgery (UAS) which may increase the risk of injury of biliary structures or vascular, LH for patients with previous UAS is limited to highly skilled surgeons or tertiary referral centers. Conventional open liver resection is still a common procedure for patients with previous UAS. So the application of LH to these patients is controversial and data on this topic are scarce. Until now, only few single-centre studies have reported LH for patients with a history of UAS [17–24]. It is still unknown whether LH is feasible and safe for patients with previous UAS, especially for those with previous liver resection. In order to prove LH is feasible and safe for patients with previous UAS, this meta-analysis is made.

2. Methods

2.1. Study selection

Several databases, including PubMed, Web of Science, The Cochrane Library and Ovid, were retrieved with the following combinations of search terms: “laparoscopic,” “laparoscopic assisted,” “minimally invasive,” “redo,” “repeat,” “previous,” “reoperation,” “upper abdominal surgery,” “hepatectomy,” “liver resection,” “hemihepatectomy,” “hepatic resection,” “liver surgery”. The search was updated to 15th April 2018. References of the obtained studies were manually retrieved in order to gain additional studies.

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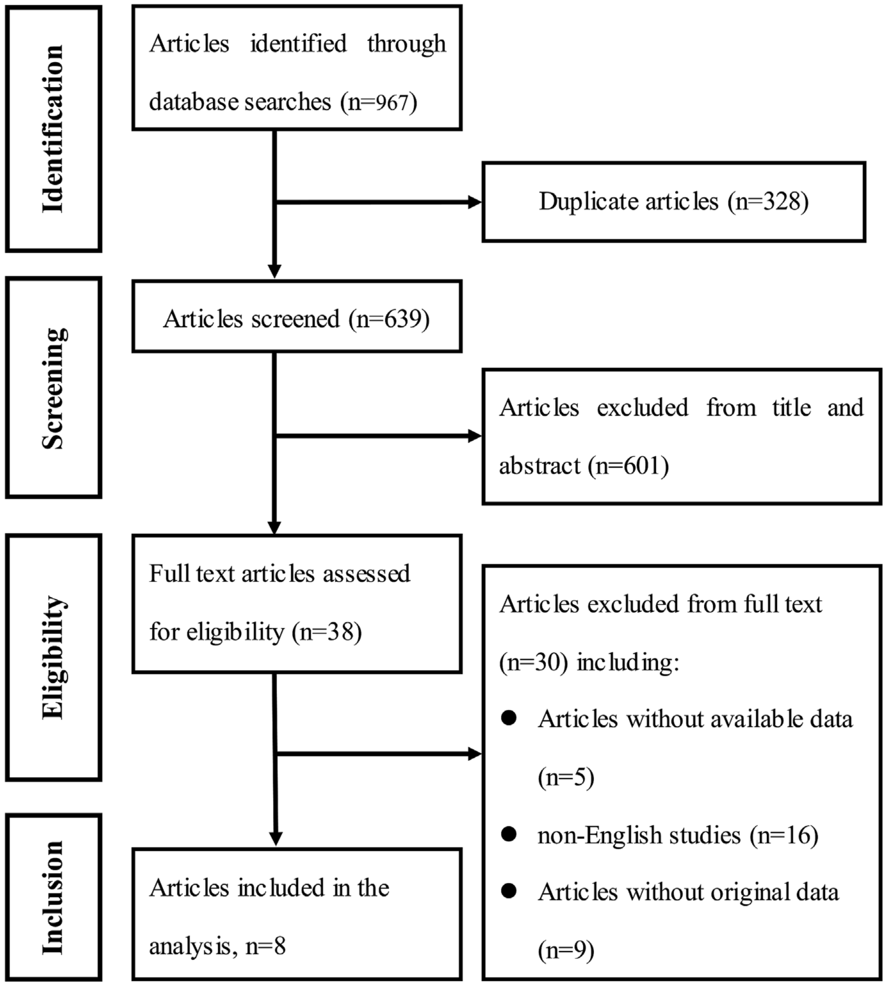


Fig. 1. Flow diagram depicting the process of identifying and selecting studies for inclusion.

The work has been reported in line with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and AMSTAR (Assessing the methodological quality of systematic reviews) Guidelines.

2.2. Inclusion and exclusion criteria

Each acquired study in this meta-analysis must satisfy the following standard: (1) case-matched studies of LH for patients with previous UAS *versus* non-UAS including observational clinical studies (OCSs) or randomized controlled trials (RCTs); (2) at least one interest data should be reported; (3) if the same authors and/or institutions published more than one publication of the same databases, then the study quality, publication year and sample size were considered, and just one article with high quality was included. Exclusion criteria were as follows: (1) editorials, expert opinions, abstracts, letters, case reports and reviews without original data; (2) non-English studies; (3) studies without available data.

2.3. Definition of the surgical procedure

A history of upper abdominal surgery (USA) was defined as a distinct scar above the umbilicus [25] from which the operative procedure involved the upper portion of the peritoneal cavity, hilar area and hepatoduodenal ligament. If a laparoscopic procedure involved above-mentioned area, it was defined as USA regardless of port placement. Therefore, hepatectomy, biliary surgery, pancreatic surgery, splenectomy, radical gastrectomy and surgery involving the small intestine, colon, kidney, and upper abdominal retroperitoneum were included. Major hepatectomy was defined as the resection of three or more contiguous segments [26]. The pathological surgical margin was defined as microscopically positive (R1), or negative (R0) [21–23].

2.4. Data extraction and quality assessment

All candidate articles were independently assessed and extracted by two authors. The following data were used: first author; year of publication; number of patients; gender and age of patients; liver cirrhosis; surgical pathology of included studies; conversion and perioperative outcomes. Inconsistencies were resolved through discussion, or came to an agreement with a third reviewer. If means and standard deviations of continuous variable data were not provided by the selected study in this meta-analysis, we tried to communicate with the corresponding authors of study and get the results as soon so possible. The quality of non-randomized studies was independently assessed by two reviewers using the Newcastle-Ottawa Scale (NOS) [27]. Total scaled scores (0–9 scores) contained three parts: including selection (0–4 scores), outcome assessment (0–3 scores) and comparability (0–2 scores). And high-quality studies were those with scores higher than six.

2.5. Outcomes of interest

Outcomes of interest were separately extracted from the selected non-randomized articles: preoperative outcomes (chronic liver disease, Child-Pugh, BMI, ASA grade), intraoperative outcomes (operative time, type of resection, R0 resection rate, intraoperative blood loss, transfusion and conversion rate) and post-operative outcomes (overall postoperative complications, abdominal collection, ascites, bile leakage, hemorrhage, intra-abdominal effusion or abscess, delayed gastric emptying, postoperative infection, reoperation, mortality and length of hospital stay).

2.6. Statistical analysis

Data analysis was performed using Stata SE 12.0 software. Dichotomous variables were calculated by odds ratio (OR) with 95% confidence interval (CI), nevertheless continuous variables were calculated by standardized mean differences (SMD) with 95%CI. I^2 statistics and chi-square Q test were used to identify the heterogeneity of the acquired data. A *P*h (*P*-value of heterogeneity) < 0.10 or $I^2 > 50\%$ indicated significant heterogeneity among the acquired data, and the random-effects model was selected [28]. Otherwise, a fixed-effect model was used. Furthermore, subgroup analyses according to the type of previous upper abdominal surgery were performed. To assess the effects of any single study, sensitivity analysis was conducted. Publication bias was assessed by Begg's funnel plot and Egger's test. Publication bias was not performed when less than 10 studies were included in meta-analysis. A *P*-value less than 0.05 was considered to indicate statistical significance.

3. Results

A total of 967 published studies were initially found in the article review. The flow of reference selection was outlined in Fig. 1. A total of 8 non-randomized observational articles were included in the present meta-analysis, with 1625 patients (430 patients in UAS group and 1195 in non-UAS group). There were 5 studies from Asia (two from China, two from Japan and one from Korea) and 3 from Europe (Italy, France and UK). The quality assessment scores and study characteristics were outlined in Table 1. In addition, surgical pathology of the included studies was listed in Table 2. Results of the meta-analysis, which were pooled from eligible parameters, were listed in Table 3.

3.1. Preoperative outcomes

As shown in Fig. 2A and Table 3, no significant difference was found between UAS and non-UAS groups in preoperative outcomes of chronic liver disease (OR 0.57, 95%CI 0.22–1.53, $P = 0.265$), but with an I^2 of 82.4% (higher than 50%) and *P*h of 0.001 (lower than 0.1). Although subgroup analysis and sensitivity analysis were performed, the reasons for heterogeneity were not found. Therefore, systematic review was performed. Four studies provided the data of chronic liver disease. No significant difference was observed in the studies reported by Cai et al. [18] (UAS *vs.* non-UAS = 16.7% *vs.* 22.4%; $P = 0.507$), Isetani et al. [20] (UAS *vs.* non-UAS = 37/58 *vs.* 11/22; $P = 0.261$) and Ome et al. [22] (UAS *vs.* non-UAS = 17/33 *vs.* 52/127; $P = 0.519$). However, the study reported by Ahn et al. [17] showed that non-UAS had more patients with chronic liver disease than UAS (UAS *vs.* non-UAS = 18/47 *vs.* 120/155; $P < 0.001$). The main reason was that liver metastases were dominant in UAS group and primary HCC was dominant in non-UAS group [17]. Therefore, non-UAS had more patients with chronic liver disease which were usually associated with HCC.

All the 8 studies reported the type of liver resection (minor liver resection *vs.* major liver resection). The furnishing data indicated that no remarkable difference was observed between both groups (OR 0.71, 95% CI 0.41–1.24, $P = 0.232$; Fig. 2B), but with significant heterogeneity ($I^2 = 70.6\%$; *P*h = 0.001). Subgroup analysis also showed that no obvious difference was found between UAS and non-UAS in the subgroup of patients with previous liver resection (OR 0.46, 95%CI 0.12–1.80, $P = 0.267$) and UAS (OR 0.95, 95%CI 0.61–1.50, $P = 0.831$). Although significant heterogeneity was observed in subgroup of previous liver resection ($I^2 = 80.0\%$; *P*h = 0.002), no obvious heterogeneity was found in UAS subgroup ($I^2 = 44.4\%$; *P*h = 0.126).

3.2. Intraoperative and pathological outcomes

All the eight studies reported operation time, and the furnishing data indicated that no remarkable difference was observed between UAS and non-UAS (WMD 9.27, 95%CI -4.01 to 22.55, $P = 0.171$; Fig. 3A). However, subgroup analysis showed that operation time of patients with a history of liver resection was remarkably longer than that without previous liver resection (WMD 33.03, 95%CI 3.16 to 62.90, $P = 0.030$), but no remarkable difference was observed in the subgroup analysis of UAS (WMD 3.42, 95%CI -11.41 to 18.24, $P = 0.652$). Seven studies [17–19,21–24] reported blood loss, and the furnishing data indicated that no significant difference was found between UAS and non-UAS (WMD 23.75, 95%CI -2.54 to 50.04, $P = 0.077$; Fig. 3B). Subgroup analysis also showed no obvious

Table 1
Characteristics of the included studies.

Authors	Year	Group	No.of patients	Gender (M/F)	Age (yrs)	Conversion (%)	Type of study	Quality scores: Selection	Outcome assessment	Comparability	Total
Ahn et al. [17]	2011	non-UAS	155	95/60	56.0 ± 13.4	7 (4.5)	Retrospective	3	3	2	8
		UAS	47	29/18	58.2 ± 11.7	1 (2.1)					
Cai et al. [18]	2016	non-UAS	294	150/144	54 (16–85)	37 (12.6)	Retrospective	3	2	2	7
		UAS	42	20/22	65 (38–80)	6 (14.3)					
Cipriani et al. [19]	2018	non-UAS	349	185/164	60.2 (20–89)	18 (5.2)	Prospective	3	3	2	8
		UAS	161	179/170	63.4 (31–85)	37 (23)					
Isetani et al. [20]	2015	non-UAS	58	34/24	70 (48–82)	2 (3.4)	Retrospective	2	2	2	6
		UAS	22	12/10	68 (57–81)	0					
Nomi et al. [21]	2016	non-UAS	141	90/51	63 (26–89)	12 (8.5)	Prospective	4	2	2	8
		UAS	67	44/23	62 (34–81) and 67 (43–87)[a]	1 (1.5)					
Ome et al. [22]	2018	non-UAS	127	86/41	69 (39–87)	1 (0.8)	Retrospective	3	2	2	7
		UAS	33	26/7	73 (45–84)	0					
Shelat et al. [23]	2014	non-UAS	19	8/11	57.5 (23–79)	0	Prospective	3	2	1	6
		UAS	20	NA	NA	3 (15)					
Tian et al. [24]	2013	non-UAS	52	18/34	47.7 (21–73)	5 (9.6)	Retrospective	2	3	2	7
		UAS	38	7/31	51.9 (27–77)	4 (10.5)					

M - male, *F* - female, *yrs* - years, *UAS* - upper abdominal surgery, NA - not available.
[a] This study provided age of patients with second and third laparoscopic liver resection.

Table 2
Surgical pathology of included studies.

Authors	Group	Malignant (n)					Benign (n)		
		HCC	ICC	metastasis	Others	Total	Benign tumor	IHD stone	Total
Ahn et al.	non-UAS	86	0	7	0	93	16	46	62
	UAS	4	0	25	0	29	3	15	18
Cai et al.	non-UAS	101	NA	NA	NA	NA	NA	NA	NA
	UAS	10	NA	NA	NA	NA	NA	NA	NA
Cipriani et al.	non-UAS	51	37	227	0	315	34	0	34
	UAS	68	24	53	0	145	16	0	16
Isetani et al.	non-UAS	38	0	11	9	58	0	0	0
	UAS	12	0	8	2	22	0	0	0
Nomi et al.	non-UAS	0	0	141	0	141	0	0	0
	UAS	0	0	67	0	67	0	0	0
Ome et al.	non-UAS	73	7	40	7	127	0	0	0
	UAS	16	2	15	0	33	0	0	0
Shelat et al.	non-UAS	NA	NA	NA	NA	NA	NA	NA	NA
	UAS	2	0	16	0	18	2	0	2
Tian et al.	non-UAS	0	0	0	0	0	0	52	52
	UAS	0	0	0	0	0	0	38	38

HCC hepatocellular carcinoma; *ICC* intra-hepatic cholangiocarcinoma; *IHD* intrahepatic duct; *UAS* upper abdominal surgery; *NA* not available

difference between UAS and non-UAS in the subgroup of patients with previous liver resection (WMD 35.59, 95%CI -1.65 to 72.83, $P = 0.061$) and UAS (WMD 11.99, 95%CI 25.13 to 49.11, $P = 0.527$). Seven studies [17–19,21–24] provided data of intraoperative blood transfusion and no remarkable difference was observed (OR 0.85, 95%CI 0.60–1.21, $P = 0.368$; Fig. 3C). No difference was found in previous liver resection subgroup (OR 0.81, 95% CI 0.20–1.20, $P = 0.760$) and the UAS subgroup (OR 0.85, 95% CI 0.59–1.23, $P = 0.396$).

All the eight studies provided data of conversion to laparotomy. The results showed that no remarkable difference was observed between UAS and non-UAS (OR 1.44, 95% CI 0.62–3.36, $P = 0.401$; Fig. 3D), but with significant heterogeneity ($I^2 = 55.7\%$; $Ph = 0.021$). Then, sensitivity analysis of conversion rate was conducted to assess the effects of any single study. We found that one study reported by Cipriani et al. [19] had great effects on the result of conversion rate. After excluded the study of Cipriani et al., no obvious heterogeneity was found ($I^2 = 0.0\%$; $Ph = 0.816$) and no significant difference was detected between UAS and non-UAS (OR 1.00, 95% CI 0.56–1.81, $P = 0.996$). According to the results of R0 resection rate provided by four studies [18,21–23], no significant difference was observed between UAS and non-UAS (OR 0.89, 95% CI 0.37–2.13, $P = 0.790$; Fig. 3E). Results of surgical pathology were listed in Table 2, and most of the patients were diagnosed with malignant tumors.

3.3. Postoperative outcomes

All the eight studies provided data of postoperative overall complications. According to the pooled data, we found that there was no significant difference between UAS and non-UAS (OR 1.09, 95% CI 0.83–1.43, $P = 0.562$; Fig. 4A). Furthermore, at least three studies provided data of complications, including abdominal collection, ascites, bile leak, hemorrhage and postoperative infection. Then, a meta-analysis of these complications was performed. As shown in Table 3, no significant difference was found between UAS and non-UAS in abdominal collection (OR 1.30, 95%CI 0.62–2.73, $P = 0.491$), ascites (OR 0.97, 95%CI 0.49–1.91, $P = 0.920$), bile leak (OR 1.16, 95%CI 0.61–2.18, $P = 0.654$), hemorrhage (OR 0.62, 95%CI 0.15–2.52, $P = 0.500$) and postoperative infection (OR 0.86, 95%CI 0.39–1.90, $P = 0.711$).

Postoperative hospital stay was reported by seven studies [17–19,21–24]; the result indicated that no significant difference was observed between UAS and non-UAS groups (WMD -0.36, 95%CI -0.87

Table 3
Results of the meta-analysis.

Outcomes of interest	No. of studies	No. of patients	RR or WMD (95% CI)	*P*	Heterogeneity		
					I^2 (%)	*Ph*	Model
Characteristics of preoperative Outcomes							
Chronic liver disease	4	144/634	0.57 (0.22–1.53)	0.265	82.4	0.001	Random effects
Type of liver resection	8	430/1195	0.71 (0.41–1.24)	0.232	70.6	0.001	Random effects
Intraoperative outcomes							
Operation time	8	430/1195	9.27 (−4.01–22.55)	0.269	40.3	0.099	Fixed effects
Blood loss	7	410/1176	23.75 (−2.54–50.04)	0.077	4.2	0.398	Fixed effects
Transfusion	7	410/1176	0.85 (0.60–1.21)	0.368	21.1	0.269	Fixed effects
Conversion	8	430/1195	1.44(0.62–3.36)	0.401	55.7	0.021	Random effects
R0 resection	4	162/581	0.89(0.37–2.13)	0.790	0.0	0.444	Fixed effects
Postoperative outcomes							
Complications	8	430/1195	1.09 (0.83–1.43)	0.562	9.5	0.356	Fixed effects
Abdominal collection	3	246/556	1.30 (0.62–2.73)	0.491	0.0	0.752	Fixed effects
Ascites	3	275/645	0.97 (0.49–1.91)	0.920	0.0	0.671	Fixed effects
Bile leakage	6	366/843	1.16 (0.61–2.18)	0.654	0.0	0.521	Fixed effects
Hemorrhage	3	228/523	0.62(0.15–2.52)	0.500	0.0	0.856	Fixed effects
Postopreative infection	4	313/697	0.86(0.39–1.90)	0.711	0.0	0.411	Fixed effects
Hospital stay	7	408/1137	−0.36 (−0.87–0.14)	0.159	34.1	0.156	Fixed effects
Mortality	8	430/1195	2.54(0.86–7.56)	0.093	0.0	0.785	Fixed effects

OR odds ratio, *WMD* weighted mean difference, *CI* confidence interval, *Ph* *P*-value of heterogeneity.

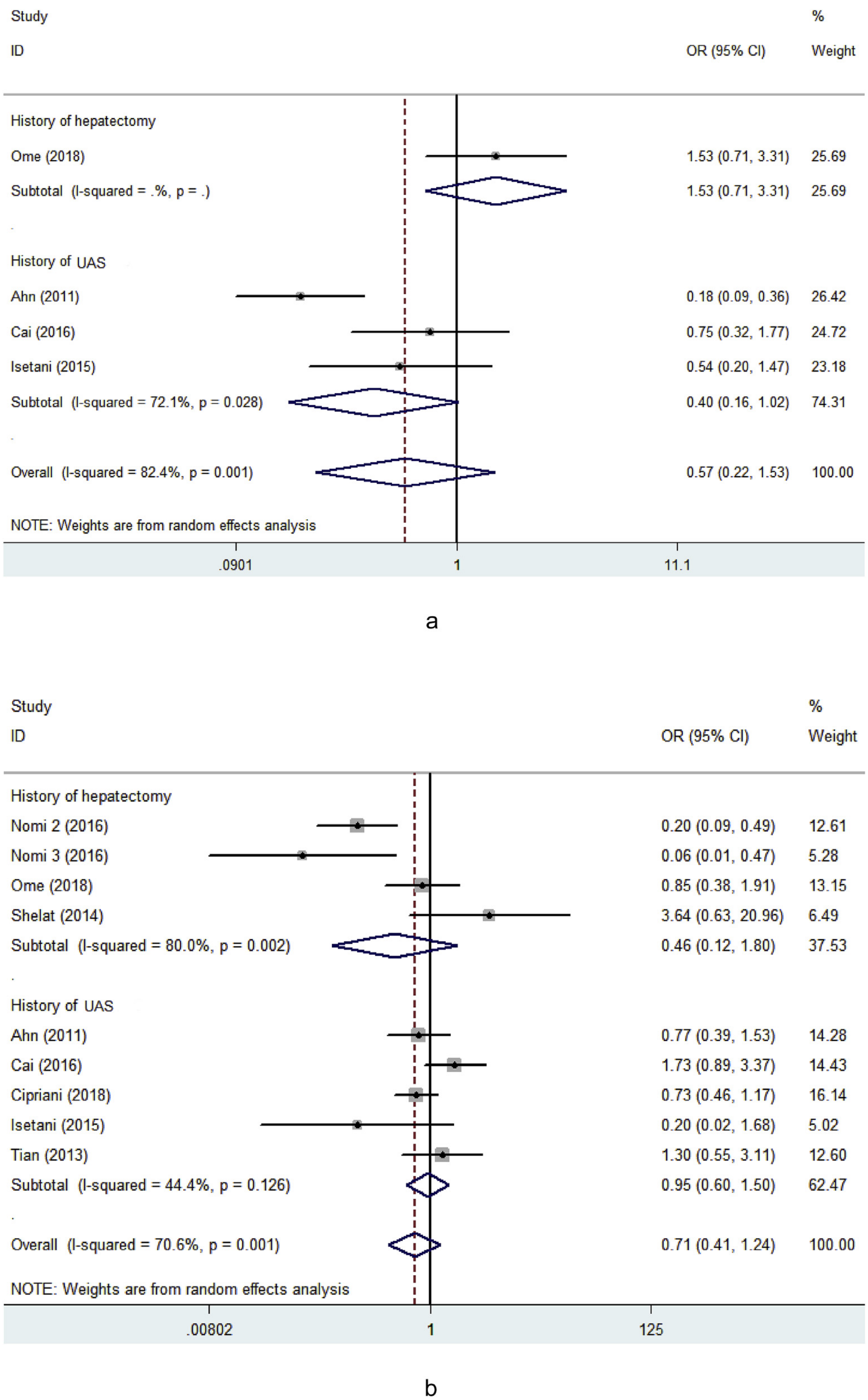


Fig. 2. Forest plots illustrating characteristics of preoperative Outcomes: A chronic liver disease; B type of liver resection.

to 0.14, P = 0.159; Fig. 4B). There was no significant difference in the subgroup of patients with previous liver resection (WMD -0.52, 95%CI -1.48 to 0.44, P = 0.288) and UAS (WMD -0.30, 95%CI -0.89 to 0.29, P = 0.318).

All of the eight studies have reported postoperative mortality, and the furnishing data also indicated that no obvious difference was found between UAS and non-UAS groups (OR 2.54, 95%CI 0.86–7.56, P = 0.093; Fig. 4C). In addition, subgroup analysis also showed no obvious difference between UAS and non-UAS in the subgroup of patients with previous liver resection (OR 2.98, 95%CI 0.57–15.59, P = 0.195) and UAS (OR 2.28, 95%CI 0.54–9.63, P = 0.264).

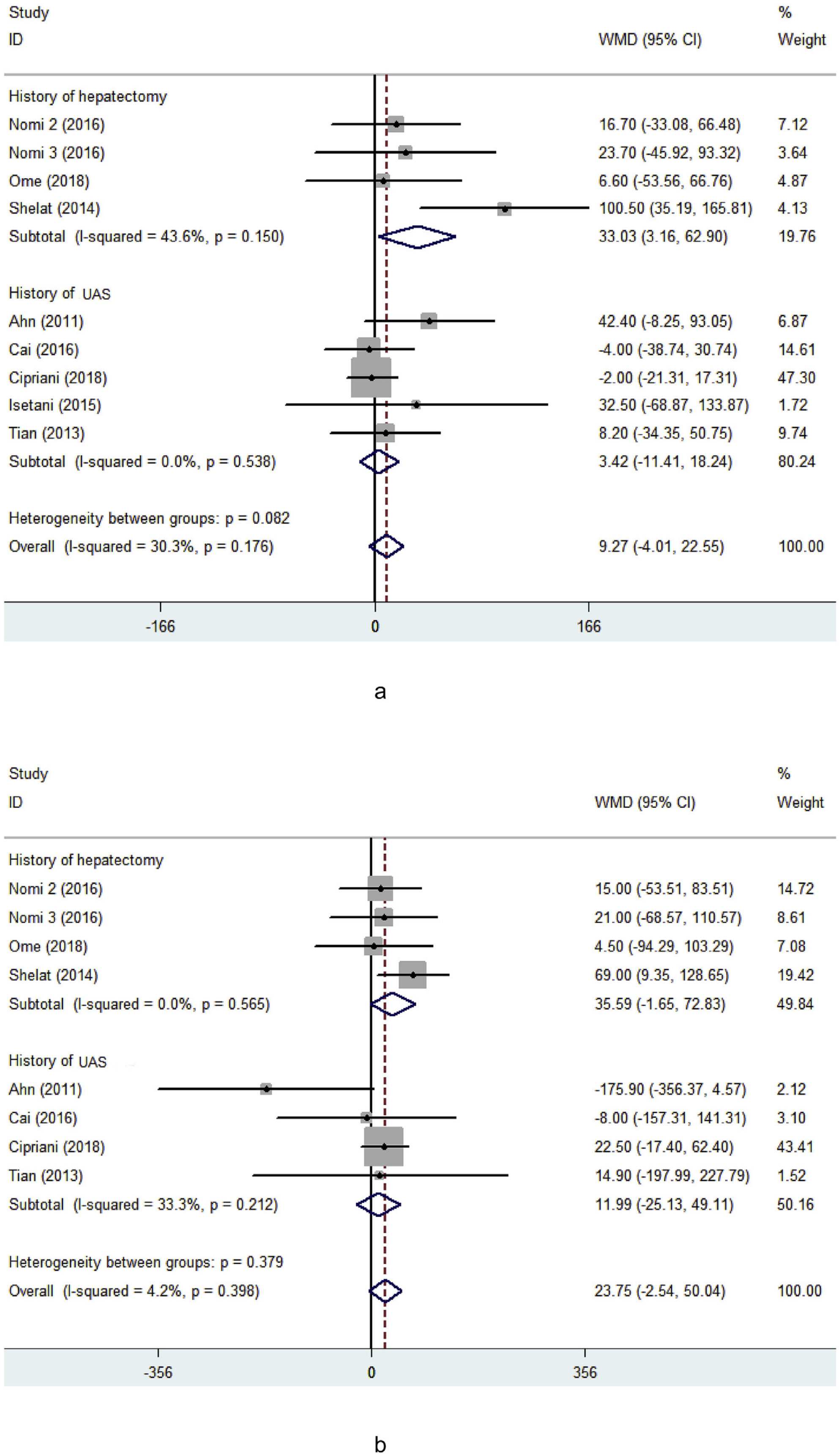
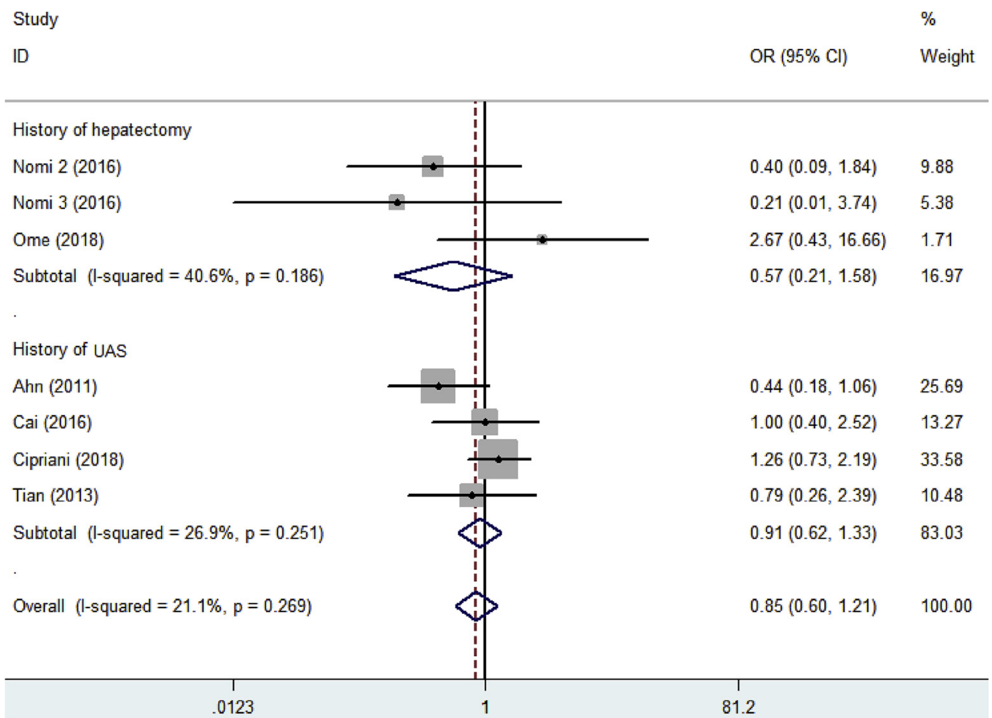


Fig. 3. Forest plots illustrating intraoperative outcomes: A operation time; B blood loss; C intraoperative blood transfusion; D conversion rate; E R0 resection rate.



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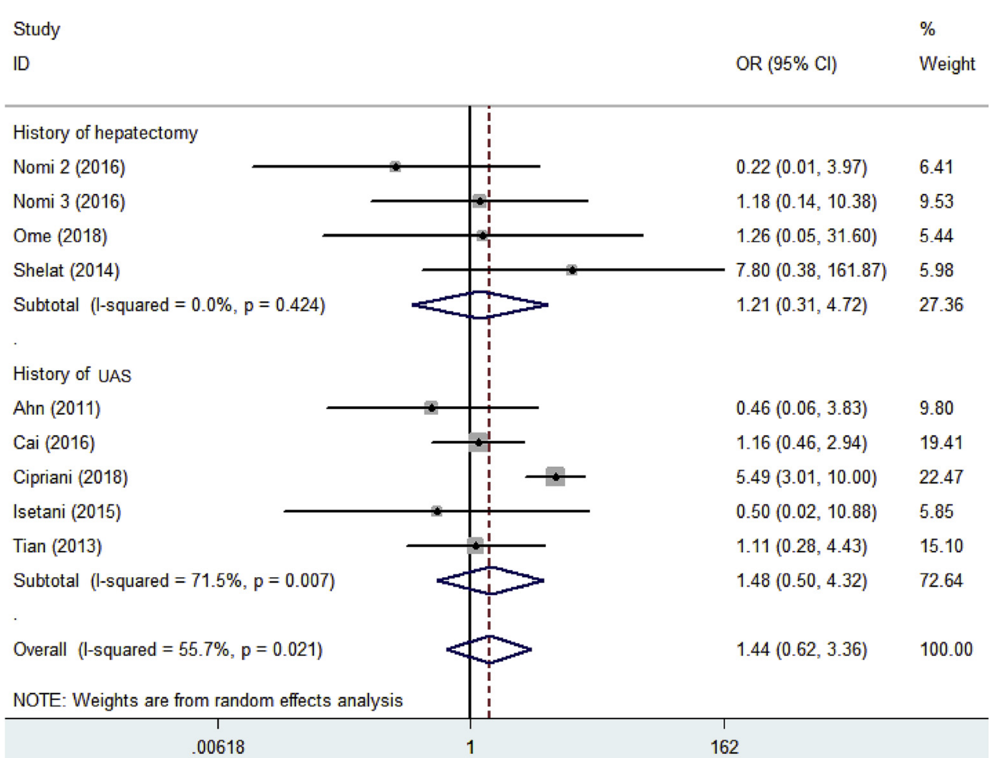

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Fig. 3. (*continued*)

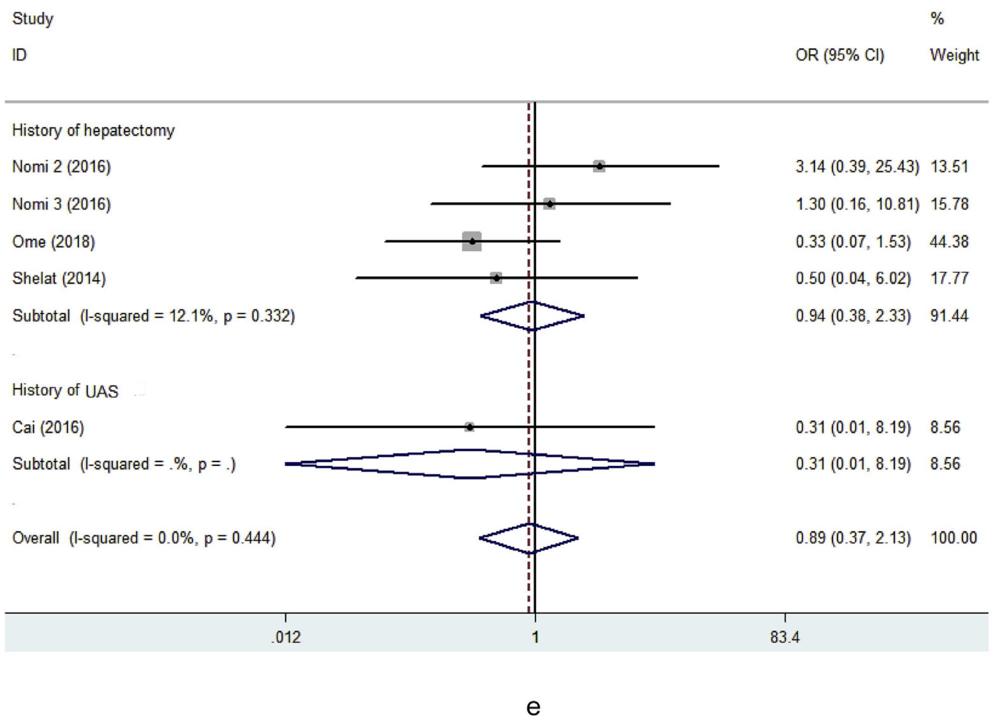


Fig. 3. (*continued*)

3.4. Publication bias

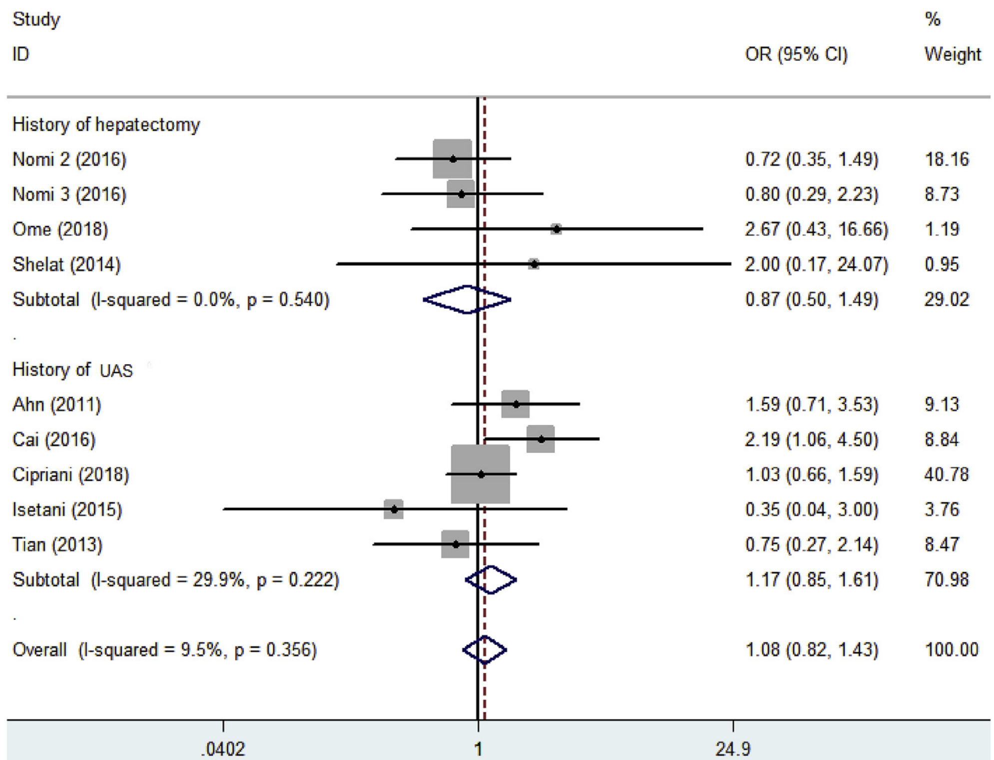
Publication bias was not performed, due to the fact that just eight studies were included.

4. Discussion

Postoperative adhesions can significantly prolong operative time of subsequent liver resection, because of the risk of injury to biliary structures or other organs, intraoperative bleeding and the need for adhesiolysis [29]. For laparoscopic surgery, it also increases the risk of conversion from laparoscopy to laparotomy and intraoperative complications [30]. It has been reported that about 70–95% patients suffered from peritoneal adhesions after surgery [31]. Thus, laparoscopic procedures are once considered as a relative contraindication for patients with previous intra-abdominal surgery. With technical and instrumental improvements, laparoscopic surgeries such as appendectomy, cholecystectomy, gastrectomy and colectomy have been safely applied to patients with previous intra-abdominal surgery [32–34]. However, several factors, such as fibrotic adhesions at the hilar area, chemotherapy-induced liver injury and variations in liver anatomy in the hypertrophied liver remnant, add more stress for an already difficult laparoscopic hepatectomy (LH). Given these factors, only few single-centre studies have reported on LH for patients with a history of upper abdominal surgery (UAS); and no multi-centre RCTs or meta-analysis has been performed on LH for patients with a history of UAS until now. It is still unknown whether LH is feasible and safe for patients with previous UAS. In order to prove that LH is suitable for these patients, this meta-analysis is made. The results showed that LH was feasible and efficient for patients with previous UAS comparing with those without previous surgery, although LH had longer operative time for patients with previous liver resection.

Controlling intraoperative blood loss plays a key role in laparoscopic liver surgery for patients with a history of UAS, due to the changes of postoperative adhesions and rotation in the liver. In addition, increased perioperative blood transfusion and intraoperative blood loss may also play important roles in postoperative lethal complications including liver failure and tumor recurrence after liver resection [35–38]. Uncontrolled intraoperative blood loss is another important reason for causing high conversion rate [17–24]. The results in the current meta-analysis showed that no significant difference was found in the field of intraoperative blood loss and transfusion. Furthermore, no remarkable difference was observed between UAS and non-UAS in conversion rate and R0 resection rate. Although no significant difference was found between UAS and non-UAS in operative time, laparoscopic repeat hepatectomy (LRH) for patients with previous liver resection had longer operative time comparing with those without previous hepatectomy. Fibrotic adhesions at the hilar area, chemotherapy-induced liver injury and variations in liver anatomy in the hypertrophied liver remnant may be the reasons for the significant increase of operative time in LRH [23]. With regard to the data on postoperative outcomes, the present meta-analysis showed that there was no significant difference between UAS and non-UAS in postoperative complications, hospital stay and postoperative mortality. LH is suitable for patients with previous UAS, due to the advanced experience of surgeons and transection devices in laparoscopic surgery [39,40]. In addition, the routine use of auxiliary equipment like intraoperative ultrasound (IOUS) may also play some effects for LH [41]. Based on the results from these limited data, the present meta-analysis proves that the advantages of laparoscopy can also be used to patients with a history of UAS.

There are a number of limitations in the present meta-analysis of non-randomized studies, which should be acknowledged and considered when interpreting the results. Firstly, all the studies included in the meta-analysis are single-centre non-randomized controlled trials (NRCTs) in design, which may be liable to cause selection bias and exaggerate the effect of the approaches. It is a debated topic in the field of meta-analysis to pool data from NRCTs. Nevertheless, several pieces of evidence showed that the results from studies of well-designed NRCTs may be reliable [42,43]. In this meta-analysis, all of the eight included studies are well-designed NRCTs, according to the NOS. Secondly, characteristics of the populations, chronic liver disease, types of liver resection transection devices in laparoscopic surgery, learning curve of the surgeons and definition of the outcomes vary considerably among the included studies, which may bring heterogeneity and impact the reliability of our results. Finally, due to the included studies having



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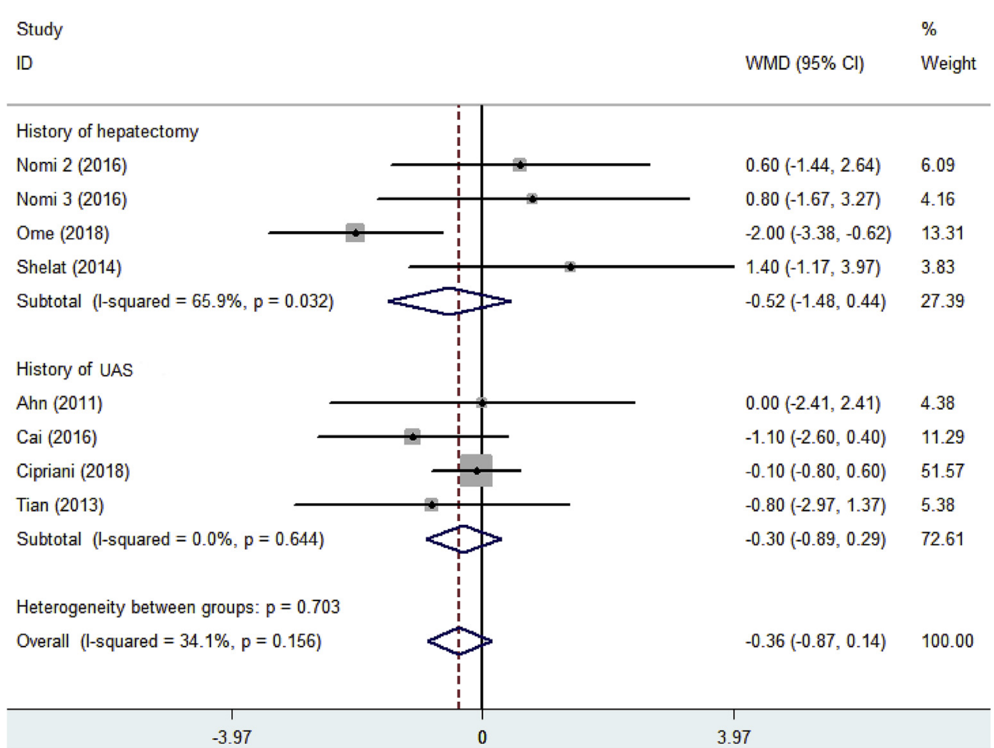
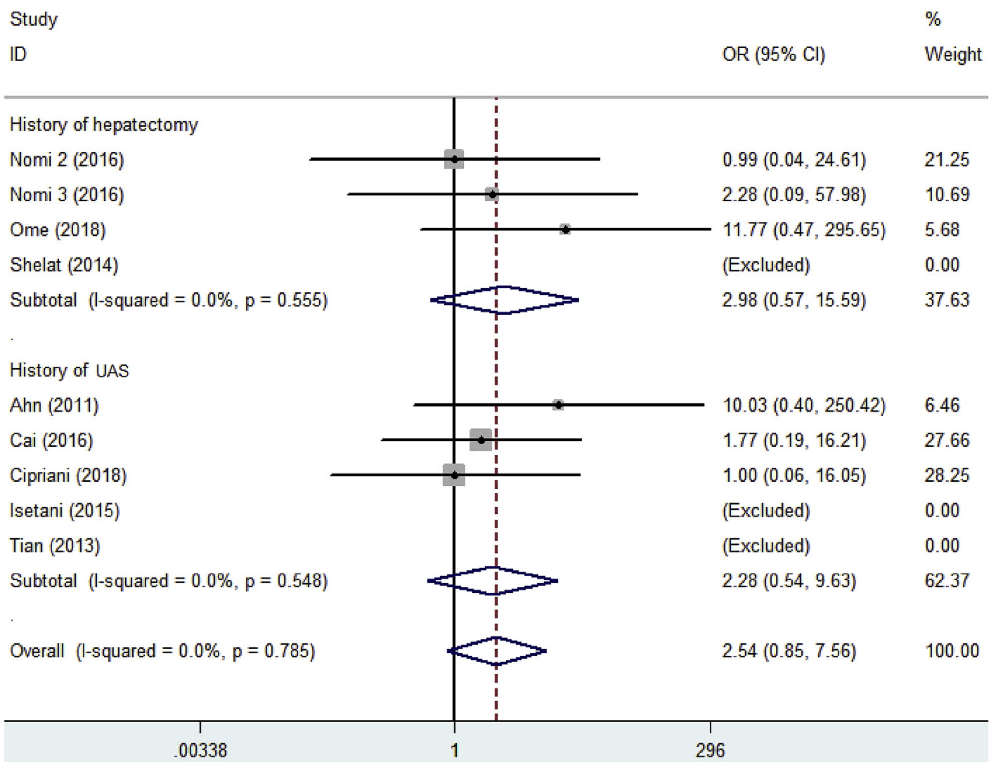


b

Fig. 4. Forest plots illustrating postoperative outcomes: A postoperative overall complications; B postoperative hospital stay; C postoperative mortality.



C

Fig. 4. (*continued*)

limited or nonexistent descriptive statistics, it is impossible to generate more in-depth comparative results, such as the grade of adhesions, costs and short- or long-term oncological outcomes.

In conclusion, the results of our meta-analysis indicate that LH for patients with a history of UAS is as feasible and efficient as those without previous surgery, although LH has longer operative time for patients with previous liver resection. However, because of the small proportion of patients included in this meta-analysis and the lack of high-quality RCTs, the evidence is still limited. Therefore, in order to further define the role of LH for patients with a history of UAS, additional prospective and multi-centre RCTs are needed.

Ethical approval

Not Needed.

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Author contribution

Shengxun Mao conceived the study; Long Peng wrote and edited the paper; all authors collected the data, performed the data analysis, read and approved the final manuscript.

Conflicts of interest

The authors declare that they have no completing interests.

Research Registration number

Reviewregistry565.

Guarantor

Shengxun Mao is the guarantor.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Data statement

We would like to declare that the work described was original research that has not been published previously, and not under consideration for publication elsewhere, in whole or in part. The data of our meta-analysis is accurate.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.03.021.

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