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Original Article

Laparoscopic and open hemihepatectomy procedures: a literature review and meta-analysis

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Abstract: *Background:* The laparoscopic approach has been widely performed by surgeons, worldwide, in recent years. However, previous studies were conducted with a retrospective nature and small sample sizes. Thus, it has been difficult to reach a consensus concerning whether laparoscopic hemihepatectomy (LHH) procedures were superior to open hemihepatectomy (OHH) procedures. This review aimed to compare the results of LHH and OHH procedures. *Materials and methods:* PubMed, Cochrane Library, EMBASE, and Medline databases were searched for relevant studies. All calculations were performed using Review Manager version 5.3. Mean differences (MDs) with 95% confidence intervals (CI) were calculated for continuous variables, while dichotomous variables were calculated using odds ratios (OR) or random ratios (RR) with 95% CIs. *Results:* A total of 8 eligible studies, involving 666 patients, were included. There were 307 cases in the LHH group and 359 cases in the OHH group. LHH was related to less intraoperative blood loss (MD = -157.36 mL, 95% CI: -202.97 to -111.75, P < 0.00001), shorter hospital stays after surgery (MD = -4.06d, 95% CI: -5.31 to -2.80, P < 0.00001), and decreased postoperative morbidity (OR = 0.46, 95% CI: 0.29 to 0.72, P = 0.0008), compared to the OHH group. However, operative times in the LHH group were significantly longer than those in the OHH group (MD = 38.11 min, 95% CI: 11.87 to 64.35, P < 0.00001). *Conclusion:* Current results suggest that, compared to the open technique, LHH appears to be safer, providing improved patient outcomes.

Keywords: Laparoscopic hemihepatectomy, open hemihepatectomy, meta-analysis

Introduction

Since Reynolds first performed a laparoscopic cholecystectomy in 1985 [1], laparoscopic surgery has developed rapidly, having a tremendous impact on surgical outcomes. Laparoscopic procedures are now extensively used in most surgeries, including splenectomy [2], hernia repair [3], adrenalectomy [4], appendicectomy [5], colorectal resections [6], and anti-reflux surgery [7]. The applicability of laparoscopy in liver surgery was first reported in 1993 [8]. Since the first International Consensus Conference on Laparoscopic Liver Surgery was held in 2008, the number of laparoscopic hepatectomies has increased dramatically. Many studies have reported that laparoscopic hepatectomy procedures produced less intraoperative blood loss, lower postoperative complication rates, and shorter hospital stays after surgery, compared to the open procedure [9-12]. A recent meta-analysis showed that laparoscopic hepatectomy procedures produce better outcomes for hepatolithiasis than open hepatectomy procedures [13]. Most previous laparoscopic studies were conducted mainly for solitary lesions located in peripheral hepatic segments 2-6 [12, 14]. Laparoscopic hemihepatectomy (LHH) procedures, often associated with a high risk of uncontrollable bleeding and conversion, have been rarely performed. With the rapid development of laparoscopic devices and surgical experience, some centers have gradually attempted to perform LHH for various liver diseases. Both safety and efficacy levels have been observed. However, all previous studies were based on a retrospective nature with small sizes. Thus, reaching a consensus concerning whether LHH is superior to OHH has been difficult. Therefore, the current meta-analysis was conducted, aiming to provide comprehensive evidence concerning outcomes following LHH, compared with OHH.

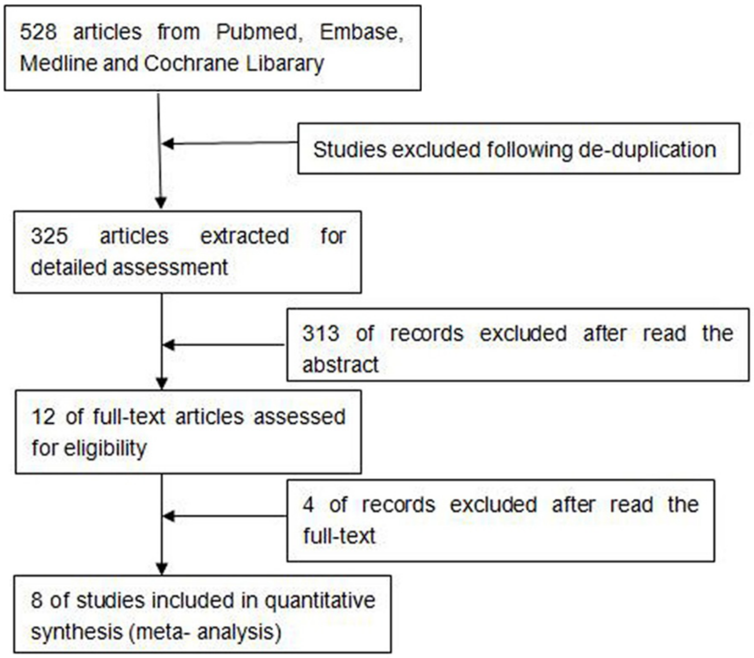

Figure 1. Flow chart illustrating the screening and selection process.

Materials and methods

Search strategy

A systematic search was performed using PubMed, EMBASE, Cochrane Library, and Medline databases, up to November 2017. Only studies written in English were included. Search terms included left hepatectomy, left lobe resection, right lobe resection, right hepatectomy, hemihepatectomy, open resection, laparotomy, and laparoscopic. References of identified articles and relevant reviews were also reviewed.

Study selection

Abstracts and full texts were reviewed by two reviewers, independently. Articles were included based on abstracts containing information concerning comparisons of complication rates after surgery with LHH, despite the study design or underlying disease. Observational studies, clinical controlled trials, and randomized clinical trials, with a control group, were considered suitable for this review. Studies evaluating techniques other than conventional laparoscopy (robotic surgery and hand-assisted laparoscopy) were excluded. Studies on animals and living donor hepatectomy procedures were also excluded. Unavailable data was acquired by contacting the authors via email.

Data extraction

Available studies were independently assessed by two reviewers. Any differences were resolved by discussion with a third author. Extracted data included name of first author, country, publication year, total number of cases and controls, sex, age, disease, blood loss, operative time, postoperative hospital stays, and complications. Unavailable data was by contacting the authors via email.

Quality assessment

The Newcastle-Ottawa quality assessment tool was used to assess the quality of observational studies. Three major domains, including selection of the study groups, comparability, and assessment of outcomes, were evaluated. The maximum score was 9 stars. Scale components for each study were independently assessed by two authors. Discrepancies between the authors were resolved by discussion until an agreement was reached.

Statistical analysis

Intraoperative and postoperative outcomes were assessed. Intraoperative measures included operation times and volume of blood loss. Postoperative measures included length of stays in the hospital and complication rates. Meta-analysis was performed using odds ratios (OR) or risk ratios (RRs) for dichotomous variables and mean differences (MDs) for continuous variables. Polled estimates are presented with 95% confidence intervals (CIs). Fixed or random-effects models were used in this review [15]. When substantial heterogeneity was high ($I^2 > 50\%$), subgroup analyses were conducted based on left or right hemihepatectomy procedures. To screen for publication bias, funnel plots were generated. Results are considered statistically significant with two-sided p-values < 0.05. The current meta-analysis

Table 1. Summary of characteristics of included studies (left and righthemihepatectomy)

Study (year)	Country	Study type	Scale	No. of patients		Age		Gender (M/F)		Major disease	
				(OHH)	(LHH)	(OHH)	(LHH)	(LHH)	(OHH)	(OHH)	(LHH)
Cai (2009)	China	CM	Left	19	19	53 ± 10	55 ± 9	7/12	7/12	HL	HL
Ibrahim (2009)	France	CM	Right	22	50	60.9 ± 2.8	61.1 ± 2.2	9/13	25/25	CRCLM/LC	CRCLM/LC
Mohammed (2011)	UK	CCM	Right	36	34	64 (26-82)	63 (25-84)	18/18	18/16	CRCLM/LC	CRCLM/LC
Jin (2015)	China	C	Left	96	105	51.7 ± 10.9	52.8 ± 11.2	27/69	26/79	HL	HL
Ye (2015)	China	C	Left	46	51	54 (37-74)	55 (41-74)	16/30	18/33	HL	HL
Zhang* (2016)	China	C	Left	20	25	47 ± 8.5	52 ± 10.5	12/8	15/10	LC	LC
Zhang (2016)	China	C	Right	35	42	58 ± 9.5	63 ± 10.5	25/10	26/16	LC	LC
Yoon (2017)	Korea	CM	Right	33	33	56.03 ± 7.02	57.33 ± 6.88	23/10	26/7	LC	LC

Note: LHH Laparoscopic hemihepatectomy, OHH Open hemohepatectomy, CM Corhot with case-matched controls, CCM Case-control study matched, C Corhot comparison, CRCLM Colon rectal cancer liver metastasis, LC Liver cancer, HL Hepatolithiasis. *Zhang et al. published two syudies in the same year, thus * indicates a difference.

Table 2. Summary of the Newcastle-Ottawa quality assessment scale

Study	Quality of selection	Quality of comparability	Quality of outcome/exposure	Total stars(*)
Cai	2	2	2	6
Ibrahim	2	2	2	6
Mohammed	2	2	3	7
Jin	3	0	2	5
Ye	2	1	2	5
Zhang*	3	1	2	6
Zhang	3	1	2	6
Yoon	3	2	2	7

was performed using Review Manager (RevMan) 5.3.

Results

Study characteristics

Search results are shown in **Figure 1**. A total of 528 potential studies were initially presented. A total of 8 studies were finally included for meta-analysis after a review of the abstracts and full texts. All studies were single center non-randomized control trails. Four were matched studies. A total of 666 patients (LHH 307, OHH 359) were included. No significant differences in patient demographics between the two groups were found (**Table 1**).

Quality of included studies

The Newcastle-Ottawa Scale was used to assess study quality for cohort or case-control studies. Characteristics of the selected studies are presented in **Table 2**. Results of quality evaluations showed that two out of the eight studies received 7 stars, four studies received 6 stars, and two studies received 5 stars.

Operative times

Patients undergoing LHH had longer operative times than those undergoing OHH (MD = 38.11 min, 95% CI: 11.87 to 64.35, $P < 0.00001$, $I^2 = 86\%$) (**Figure 2**).

Blood loss

Blood loss during the operation in the laparoscopic group was significantly lower than that in the open group (MD = -157.36 ml, 95% CI: -202.97 to -111.75, $P < 0.00001$, $I^2 = 73\%$) (**Figure 3**).

Hospital stays after surgery

Postoperative stays were shorter with LHH by 4.06 days (MD = -4.06d, 95% CI: -5.31 to -2.80, $P < 0.00001$). However, the heterogeneity of results was high ($I^2 = 84\%$, $P < 0.01$) (**Figure 4**).

Complication rates

Compared to the open group, complication rates of the laparoscopic group were significantly lower (OR = 0.46, 95% CI: 0.29 to 0.72, $P = 0.0008$, $I^2 = 8\%$) (**Figure 5**).

Subgroup and sensitivity analyses

Subgroup analysis of left and right hemihepatectomy procedures showed a significant benefit for laparoscopic surgery. For right hemihepatectomy procedures, blood loss was less (MD = -131.38 mL, 95% CI: -222.59 to -40.16, $P = 0.0003$, $I^2 = 88\%$) and length of hospital stays (MD = -4.77d, 95% CI: -5.95 to -43.59, $P < 0.00001$, $I^2 = 73\%$) was shorter, compared to

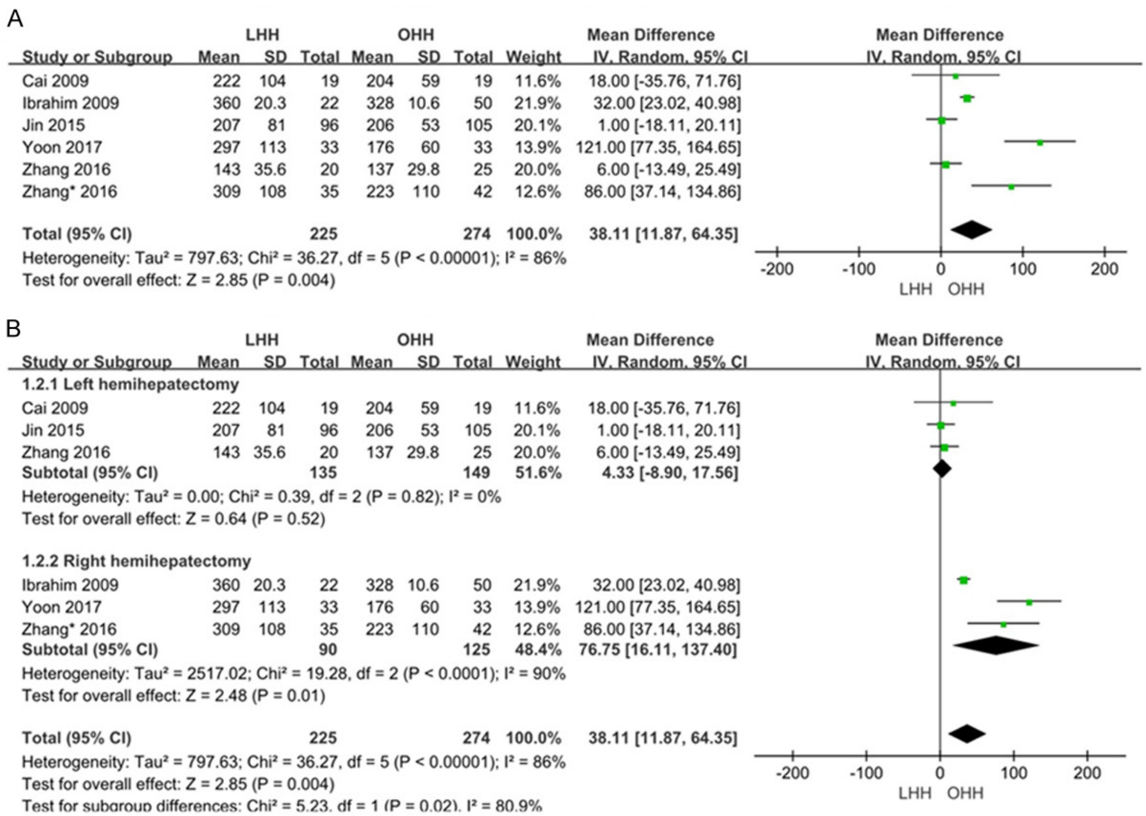

Figure 2. A. Forest plots depicting operative times in included studies. MDs are shown with 95% Cis; B. Subgroup analysis for operative times.

the open group. Additionally, the surgical duration did increase (MD = -76.75 min, 95% CI: 16.11 to 137.40, P = 0.01, I^2 = 90%). For left hemihepatectomy procedures, only blood loss was different, compared with open surgery (MD = -171.59 mL, 95% CI: -198.96 to -144.21, P < 0.00001, I^2 = 3%) (**Figures 2-4**).

Sensitivity analyses showed no alterations in main outcomes after the elimination of each study.

Publication bias

A funnel plot was constructed for postoperative complications. It was used to assess publication bias (**Figure 6**). The funnel plot was basically inverted and funnel-shaped, with no presence of obvious asymmetry.

Discussion

Laparoscopic hepatectomies are more often performed for malignant lesions, although they were initially prescribed for benign and peripheral lesions [16]. An increasing number of centers are now performing laparoscopic major resections, including left and right hepatectomies. A recent meta-analysis showed that laparoscopic hepatectomy procedures were superior to the open approach for hepatolithiasis, in both the right and left sides of the liver [13]. Results of a large series have been recently reported, worldwide, confirming the technical feasibility, postoperative benefits, and oncological safety of this technique [17, 18]. However, no randomized controlled trails (RCTs) regarding this special technique have been published. Existing data has not been systematically reviewed. Thus, the roles of LHH remain unclear. The current meta-analysis was conducted to provide comprehensive evidence concerning outcomes of LHH. Based on this study, LHH showed superior surgical outcomes, compared with OHH.

Intraoperative bleeding, a major problem in hepatectomy procedures, has been considered a risk factor for postoperative death. It has

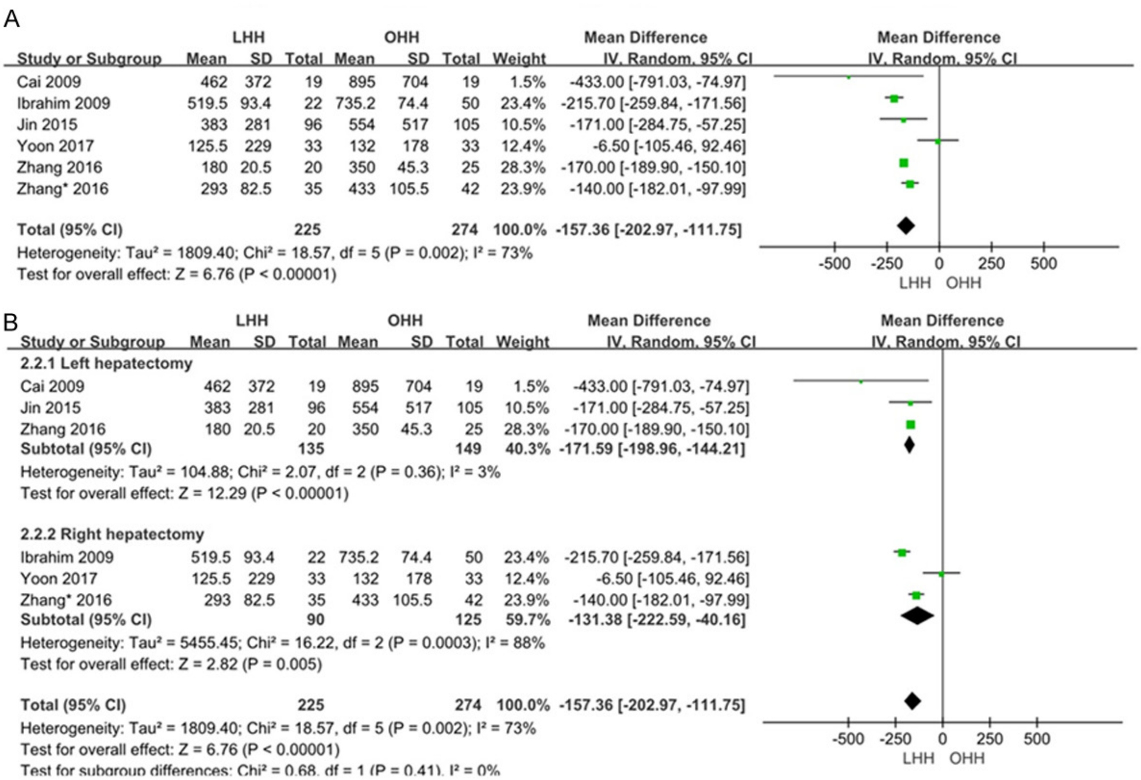

Figure 3. A. Forest plots depicting blood loss during surgery in included studies. MDs are shown with 95% Cis; B. Subgroup analysis for blood loss during surgery.

been shown that blood loss has a deleterious impact on both short- and long-term outcomes. Technical difficulties in controlling hemorrhaging from intrahepatic vessels and maintaining hemostasis at the transection plane have directly delayed the application of laparoscopy to hepatectomies [19, 20]. The introduction of equipment modifications, such as intraoperative ultrasonography, ultrasonic dissection, argon beam coagulators, and microwave coagulators, as well as the introduction of laparoscopic coagulation shears and endoscopic linear staplers, have played an important part in maintaining hemostasis in hepatectomy procedures [21, 22]. Pooled estimates of the current meta-analysis showed that blood loss was significantly decreased in LHH, compared with OHH (MD = -157.36 mL, 95% CI: -202.97 to -111.75, $P < 0.00001$, $I^2 = 73\%$). This may be associated with the laparoscopy allowing for smaller incisions to complete an operation, as well as the development of high-definition laparoscopic equipment. These magnify the surgical field, enabling surgeons to acquire a suitable view for completing hemostasis [23].

Regarding other intraoperative outcome measurements, operative times of LHH were longer than OHH. This was consistent with the meta-analysis performed by Mirnezami et al. [24]. Included studies in the current meta-analysis mainly enrolled a small number of cases of LHH. This serves as a critical explanation for relatively longer operative duration times. In the future, it is believed that LHH will take less time as experience with LHH increases.

Results showed reduced lengths of stay and reduced morbidity rates. Thus, postoperative recovery appeared to be quicker in the LHH cohort, compared to open resections. Present results might be related to a reduction in postsurgical pain experience and rapid wound recovery for patients that underwent LHH. The open procedure usually has a larger and longer incision than LHH, bringing about intense postoperative pain and longer recovery times. Postoperative morbidity rates in the LHH group were less, although morbidity was present only in a small number of included studies. However, it was indeed significantly decreased in laparo-

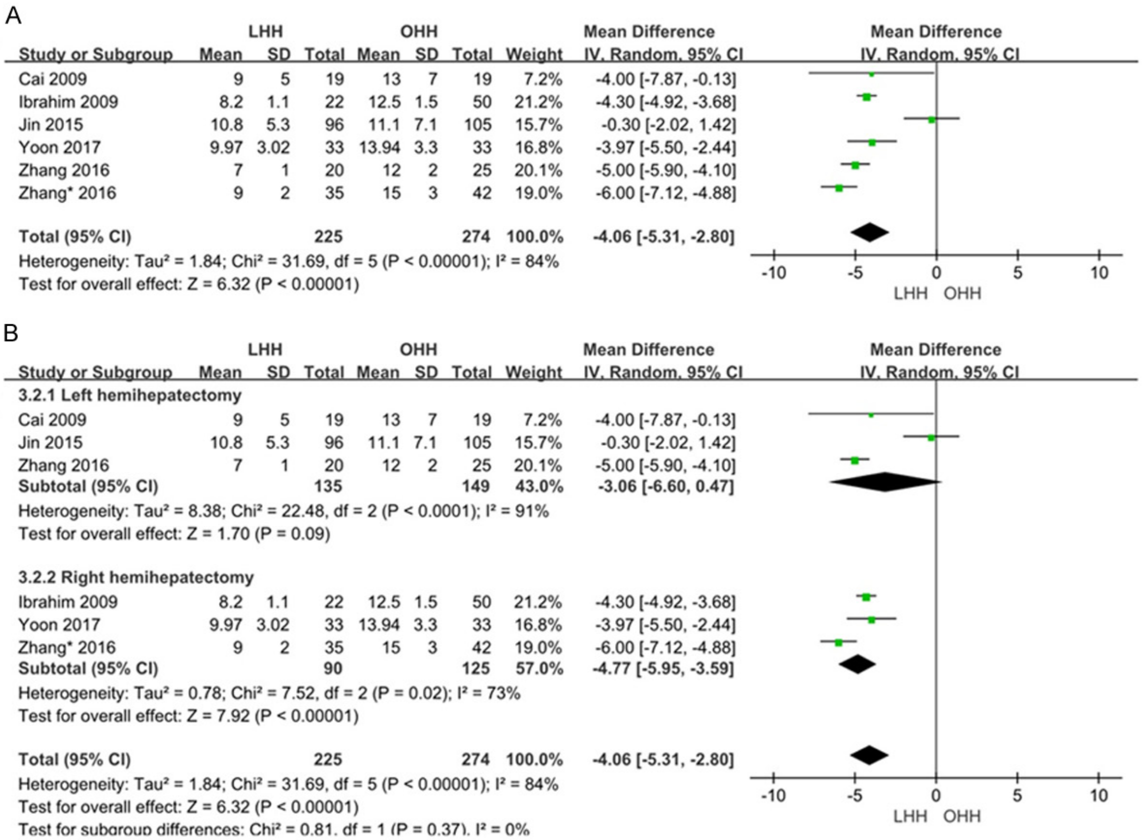

Figure 4. A. Forest plots depicting hospital stays after surgery in included studies. MDs are shown with 95% Cis; B. Subgroup analysis for hospital stays after surgery.

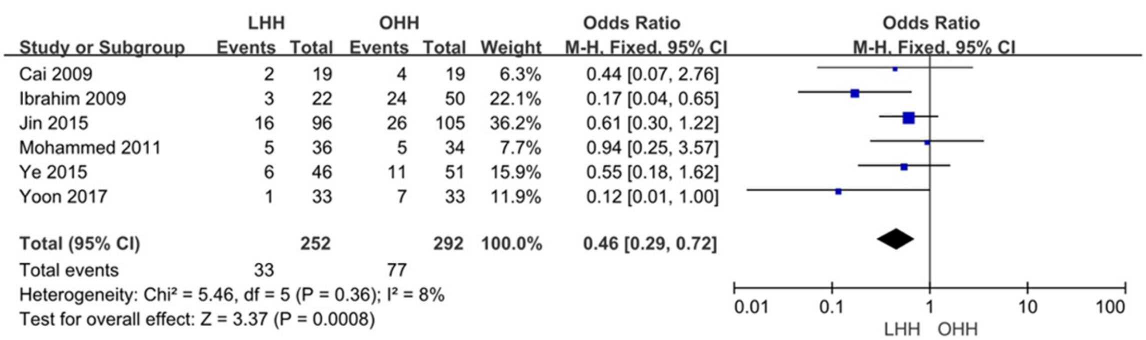

Figure 5. Forest plots depicting complications after surgery in included studies. ORs are shown with 95% CIs.

scopic procedures, according to pooled results. Furthermore, intraoperative bleeding was shown to be independent risk factor for postoperative morbidity, according to previously established evidence. Less blood loss in the LHH group may also play as an important role in the decreased postoperative complication rates [25-27].

However, there were several limitations to the current study. It was limited to English abstracts and the number of studies comparing LHH with OHH published was small. Moreover, there was a lack of randomized trials. The cohort samples were relatively small, leading to reduced quality of conclusions. The quality of included studies, assessed using the Newcastle-Ottawa Scale,

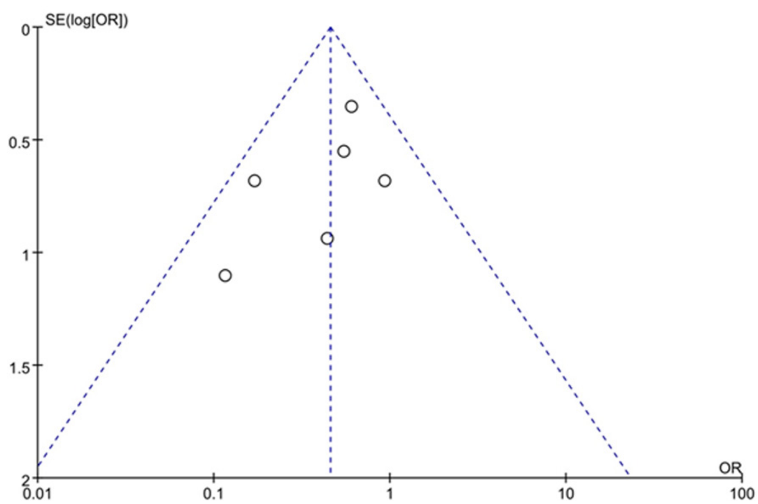

Figure 6. Funnel plot of postoperative complication analysis of publication bias.

was moderate. All included studies were non-randomized cohorts from single centers. An element of surgeon and selection bias may have affected the potential generalizability of results.

Although higher quality data is required, the current data demonstrates that LHH is safer than OHH and may offer better outcomes for patients. Laparoscopic and minimally-invasive surgical procedures have become the gold standard for most surgeries.

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Disclosure of conflict of interest

None.

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