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Review Article

Meta-analysis of perioperative outcomes between obese and non-obese patients on minimally invasive partial nephrectomy

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Abstract: Purpose: The safety and efficacy of minimally invasive partial nephrectomy (MIPN) on obese patients is controversial. The existing evidence lacks details about the differences in perioperative outcomes between obese and non-obese patients. This study aims to unveil the relationship between obesity and perioperative outcomes in MIPN. Methods: We conducted a systemic review and meta-analysis to clarify this relationship. Relevant studies were identified in four databases (PubMed, Cochrane Library, Web of Science and Embase), and twelve studies were included, with nine studies regarding laparoscopic partial nephrectomy (LPN) and four studies regarding robot-assisted laparoscopic partial nephrectomy (RLPN). Intraoperative outcomes included the operative duration (OD), estimated blood loss (EBL), warm ischemia time (WIT), transfusion rate, length of stay (LOS) and conversion to open surgery rate. Postoperative outcomes included the complication rate and the presence of positive margins. Results: The results showed that the obese group exhibited a longer OD, larger EBL, longer WIT and LOS, and higher ratio of total and minor complications than those of the non-obese group in RLPN ($p<0.05$). The results also demonstrated that the obese group had a larger EBL and higher ratio of total and minor complications than the non-obese group in LPN ($p<0.05$). Other outcomes did not demonstrate significant differences ($p>0.05$). Conclusions: MIPN could be performed in obese patients with numerous advantages, but some perioperative outcomes need to be considered with discretion.

Keywords: Obesity, perioperative outcomes, body mass index, minimally invasive partial nephrectomy

Introduction

Renal cell carcinoma (RCC) is the most common kidney neoplasm in adults, and its incidence increases by nearly 2% per year over the last two decades [1, 2]. Although some patients with renal masses remain asymptomatic until the late stages of the disease, the majority of renal cell carcinoma cases are detected incidentally when abdominal ultrasound or computed tomography is carried out for physical examination or other medical reasons. Small renal masses (SRMs) are defined as contrast-enhancing masses of 4 cm or less on abdominal imaging [3]. Minimally invasive partial nephrectomy (MIPN) is one of the standards of care for the management of SRMs, and it includes pure laparoscopic partial nephrectomy (LPN) and robot-assisted laparoscopic partial nephrectomy (RLPN) [4].

Obesity has been a global medical problem for decades. It is associated with an increased risk of many chronic diseases and several types of cancer [5-7]. Obesity was also reported as one of the etiological factors for RCCs [8]. However, whether obesity influences the perioperative outcomes of MIPN still remains unclear.

Previous meta-analyses reported that the incidence of major complication was higher in obese patients than non-obese patients who underwent LPN [9]. However, similar issues with RLPN have not been illustrated by high

levels of evidence, such as systematic reviews or meta-analyses. We aimed to perform a Cochrane level, systematic review of the literature with a meta-analysis comparing the perioperative outcomes of obese and non-obese patients who underwent MIPN, performing the first evidence-based medical research of this topic on RLPN as well as updating the previous meta-analyses on LPN.

Materials and methods

Information sources and search strategies

A literature search was performed by all the authors on March 26, 2018 using PubMed, the Cochrane Library, the Web of Science and Embase. Meshed search headings with combined keywords were searched for in the (Title/Abstract) section that included the words "obesity", "body mass index", "nephrectomy", "laparoscopy", "partial nephrectomy", "laparoscopic partial nephrectomy" and "robot-assisted partial nephrectomy". The related article functions were used to broaden the search, and they were searched for papers published in all available years of each database. All studies and abstracts were reviewed irrespective of language. Internet search was accompanied with the manual search of the reference lists of all retrieved studies, reviews, and conference abstracts. The search terms will be adapted with other bibliographic databases in combination with database-specific filters. There were no language, regional or publication status restrictions. Likewise, there were no restrictions regarding the types of study design eligible for inclusion.

The protocol and methods of this meta-analysis were conducted according to the recommendations of the Cochrane Collaboration and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [10]. The protocol was registered in PROSPERO as International prospective registration of systematic review (Registration number: CRD42016046906) [11].

Inclusion criteria

Based on the principle of PICOS (participant, intervention, comparison, outcomes and study design) [10], the following criteria were used for study selection. 1. Participants with small renal masses (of any nationality and ethnicity) who required minimally invasive partial nephrectomy, including laparoscopic partial nephrectomy or robotic-assisted partial nephrectomy, were included. 2. Obesity was defined as a BMI ≥30 kg/m^2, while non-obesity was defined as a BMI <30 kg/m^2. 3. The measured outcomes included several perioperative indexes and parameters.

Exclusion criteria

1. Studies were excluded when full information was unavailable, and could not be obtained from the authors. 2. Animal experiments, conference abstracts and irrelevant studies were likewise excluded from analysis. 3. Studies reporting combined data from MIPN and other kinds of nephrectomy were also excluded. 4. Patients who underwent radical nephrectomy, simple nephrectomy and open surgery were not included.

Data extraction

Intraoperative outcomes: The operative duration (OD), estimated blood loss (EBL), warm ischemia time (WIT), transfusion rate, length of stay (LOS) and conversion to open surgery rate were measured as intraoperative outcomes.

Postoperative outcomes: The total complications, major complications, minor complications and presence positive margins were recorded as postoperative outcomes.

Three authors independently screened the studies, read the full articles, and extracted the following data from the included studies using a pre-standardized data extraction form. The study inclusion criteria and sample size, methods of sampling and grouping, types of participants, interventions/comparisons, outcome measures, and statistical methods of the studies were recorded on this form. All data were checked twice by these three authors, and any discrepancy was resolved by the adjudicating senior author. In cases of missing data, we made attempts to contact the study investigators for further information. For continuous variables, the standard deviations (SDs) and means were estimated when the studies only provided sample sizes, ranges, and medians

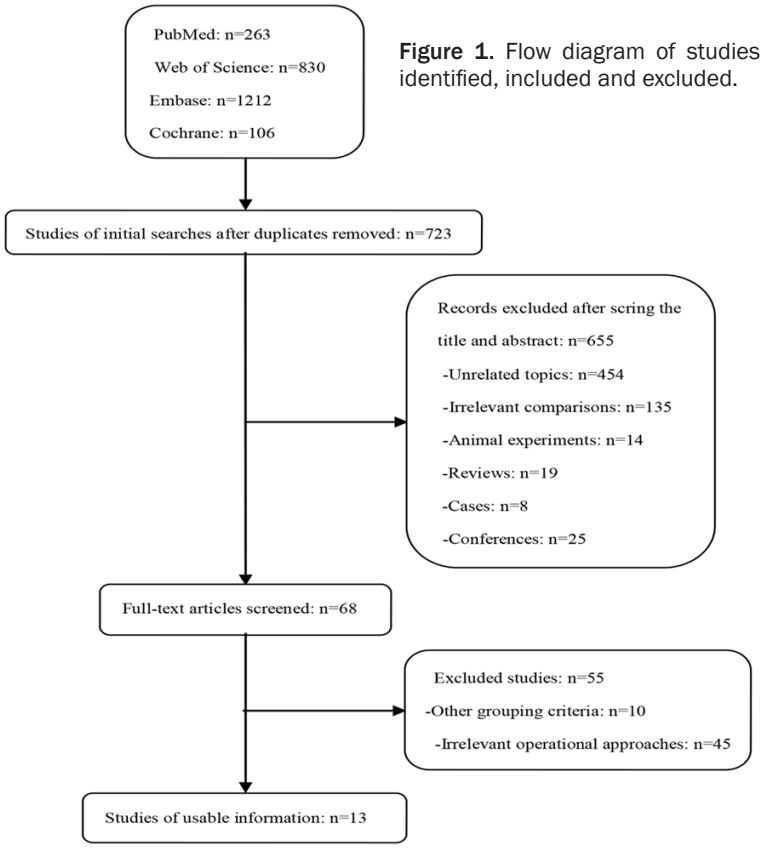


Figure 1. Flow diagram of studies identified, included and excluded.

[12, 13]; SDs of absolute changes from baseline were inputted and we used a correlation of r = 0.5 as described in the Cochrane Handbook for Systematic Reviews of Interventions. The consolidation of data from different BMI groups was based on equations from published materials [14].

Methodological quality assessment

According to the World Health Organization classification, all subjects in these reports could be divided into three BMI groups: the normal group (BMI <25 kg/m^2), the overweight group (25≤ BMI <30 kg/m^2), and the obese group (BMI ≥30 kg/m^2). Based on the Clavien-Dindo grading system, postoperative complications were classified into five grades. Grade I and II were regarded as minor complications, which required pharmacological treatment but no invasive or radiological interventions. Major complications included grade III, IV and V complications. Grade III and IV complications needed the interventions mentioned in the minor complications and even ICU management for life-threatening complications. A grade V complication involved a patient death [15]. The methodological quality of included studies was assessed using the Newcastle-Ottawa Scale (NOS) [16, 17], which contained three aspects of study design: patient selection, comparability of the study groups, and assessment of outcomes. A score of 0 to 9 (allocated as stars) was allocated to each study. Studies with a score of ≥6 stars were regarded as high-quality studies.

Statistical analysis

All meta-analyses were performed by Review Manager Version 5.3 (Cochrane Collaboration, Oxford, UK). The weighted mean difference (WMD) was used to analyze continuous variables, and odds ratios (ORs) were used to analyze dichotomous outcomes.

An OR of more than 1 indicated a higher risk in the obese groups. The estimation of OR was considered to be statistically significant if P was less than 0.05 and the 95% CI did not include a value of 1. All results were reported with a 95% confidence interval (CI).

Heterogeneity was quantified using the I^2 statistic, and statistical heterogeneity was evaluated by the chi-square test with significance set at P<0.10. The assumption of homogeneity between studies was regarded as invalid if the *p* value was less than 0.1 and the random-effects models were reported after exploring the causes of heterogeneity. Otherwise, the fixed-effects models were reported. A two-tailed *p* value of less than 0.05 was considered statistically significant.

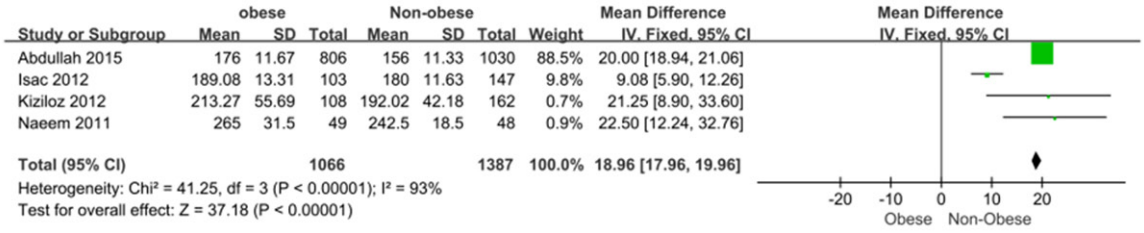
Sensitivity analyses were performed for high-quality studies. Studies with six or more stars on the modified Newcastle-Ottawa scale were included in sensitivity analysis. Funnel plots were used to screen for potential publication bias. Revman 5.3 were used to conduct funnel plots in this study.

Table 1. Characteristics of included studies

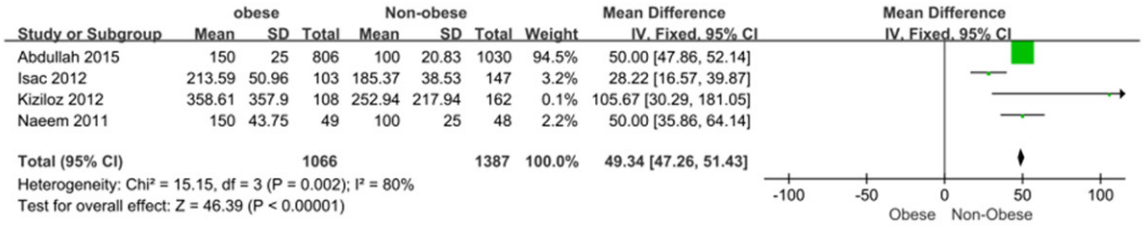
Surgery procedures	Authors	Year	Country	BMI, kg/m^2		Study design	Patients, n.		Mean [SD] age, years	Mean [SD] BMI, kg/m^2	Mean [SD] tumor size, cm	Right: Left, n	Malignant, n	Matching*	Quality score
							Non-Obesity	Obesity							
RLPN															
	Abdullah N	2015	US	<30	>30	R	1030	806	61 [2.83] vs 59 [2.33]	26 [0.83] vs 33.8 [1.07]	2.5 [0.28] vs 2.9 [0.33]	NA	NA	1, 2, 3, 6, 8	★★★★★
	Isac WE	2012	US	<30	>30	R	147	103	59.49 [12.2] vs 57.66 [11.2]	NA	2.44 [0.27] vs 3.09 [0.47]	NA	NA	1, 2, 3, 4, 6, 8	★★★★★★
	Kiziloz H	2012	US	<30	>30	R	162	108	61 [12.21] vs 57.42 [10.45]	25.93 [2.66] vs 34.68 [4.05]	2.83 [1.19] vs 3.08 [1.35]	NA	94 vs 73	1, 3, 8, 9	★★★★
	Naeem N	2011	US	<30	>30	RP	48	49	60.2 [13.25] vs 58.9 [9]	25.7 [2.3] vs 36.2 [4.68]	2.3 [1.8] vs 2.5 [1.28]	20:28 vs 19:30	40 vs 46	1, 2, 3, 4, 5, 6, 7, 8, 9	★★★★★★★★★
Total							1387	1066							
LPN															
	Anast JW	2004	US	<30	>30	R	32	12	NA	NA	NA	21:11 vs 8:4	NA	1, 2, 3, 4, 5, 6, 7, 8, 9	★★★★★★★★★
	Bensalah K	2008	US	<30	>30	R	33	28	56 [12] vs 58 [12]	NA	2.4 [0.9] vs 3 [1.4]	NA	NA	1, 2, 3, 6, 8, 9	★★★★★★
	Colombo JR Jr	2007	US	<30	>30	R	238	140	60.2 [13.5] vs 57.6 [11.2]	25.7 [2.6] vs 35.7 [6.4]	2.8 [1.3] vs 2.8 [1.1]	131:107 vs 76:64	139 vs 92	1, 2, 3, 4, 6, 8, 9	★★★★★★★
	Eaton SH	2011	US	<30	>30	R	77	48	55.61 [12.26] vs 54.02 [12.16]	NA	2.64 [2] vs 2.74 [1.37]	27:50 vs 21:27	NA	1, 2, 3, 4, 6, 8	★★★★★★
	George AK	2015	US	<30	>30	R	254	181	58.69 [9.75] vs 58.9 [9.17]	25.83 [2.75] vs 35.7 [6.75]	3.25 [1.99] vs 3 [1.97]	NA	NA	1, 2, 3, 6, 7, 8, 9	★★★★★★★
	Romero FR	2008	US	<30	>30	R	56	56	58 [11] vs 55.4 [10.8]	25.5 [2.5] vs 36.6 [7.2]	3.1 [0.9] vs 3.1 [1.2]	28:28 vs 30:26	42 vs 45	1, 3, 4, 5, 6, 8, 9	★★★★★★★
	Sharma V	2014	US	<30	>30	R	1126	892	NA	NA	NA	NA	NA	1, 2, 3, 6	★★★★
	Gong EM	2006	US	<30	>30	RP	47	38	NA	NA	NA	NA	NA	1, 2, 3, 4, 7, 8	★★★★★★
	Wiens EJ	2017	Canada	<30	>30	NA	85	102	59.72 [9.6] vs 56.2 [11.8]	NA	2.97 [1.1] vs 3.42 [1.4]	NA	NA	1, 2, 3, 6, 7, 8	★★★★★★
Total							1948	1497							

R = retrospective; RP = retrospective design, prospective data collection; NA = not available; *Matching: 1 = age; 2 = gender; 3 = body mass index; 4 = tumor side; 5 = clinical stage; 6 = American Society of Anesthesiologists score; 7 = previous abdominal surgery history; 8 = tumor size; 9 = The pathological nature.

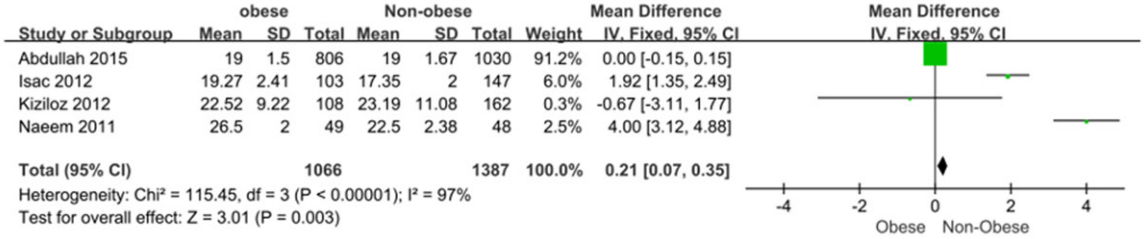
A Forest plot of Operative duration.



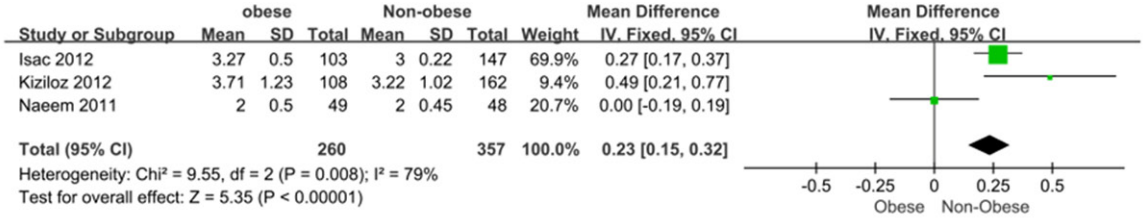
B Forest plot of Estimated blood loos.



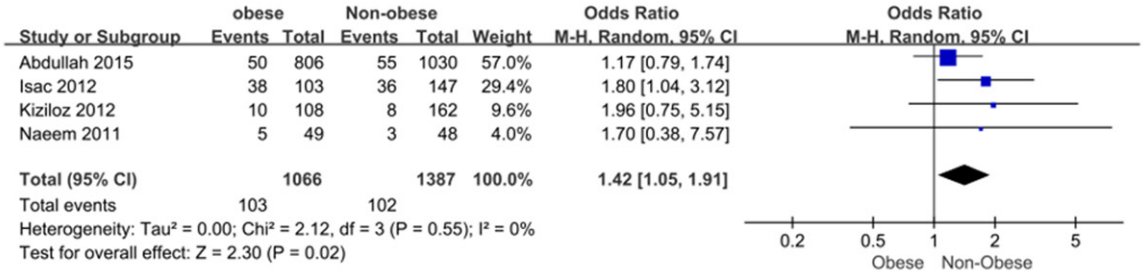
C Forest plot of Warm ischamia time.



D Forest plot of Length of stay.



E Forest plot of Total complications.



F Forest plot of Minor complications..

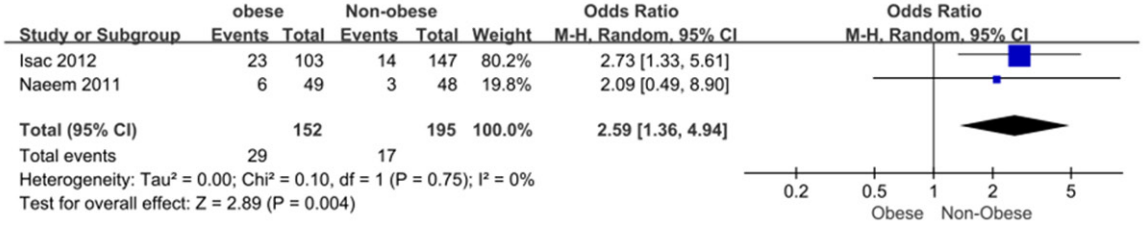


Figure 2. Forest plots of obese versus non-obese patients following robot-assisted laparoscopic partial nephrectomy in terms of intraoperative outcomes. A. Operative duration. B. Estimated blood loss. C. Warm ischemia time. D. Length of stay. E. Total complications. F. Minor complications. Squares are the point estimates of the treatment effect [OR, WMD], with 95% CI indicated by horizontal bars. Diamonds are the summary estimate from the pooled studies with 95% CI.

Results

Results of data mining and characteristics of inclusions

1688 studies were found in initial search after removal of duplication. The search strategy was demonstrated in a flow diagram (**Figure 1**). For LPN, the results were updating a previous meta-analysis in 2011, and the inclusions of LPN were expanded from 4 studies to 9 studies [9]. 5898 participants were enrolled, with 2563 patients in the obese group and 3335 patients in the non-obese group. No randomized controlled trial (RCT) was included. 2 studies were retrospective with prospective data collection [18, 19], and 10 studies were retrospective [20-29]. All inclusion characteristics and quality scores are represented in **Table 1**. The results of every outcome were analyzed in the LPN and RLPN subgroup, respectively.

Outcomes in robot-assisted laparoscopic partial nephrectomy

The operation duration was longer in the obese group (P<0.05, WMD 18.96 min, 95% CI 17.96 to 19.96) (**Figure 2A**), and the estimated blood loss was also larger in the obese group (P< 0.05, WMD 49.34 ml, 95% CI 47.26 to 51.43) (**Figure 2B**). Warm ischemia time was longer in obese group (P<0.05, WMD 0.21 min, 95% CI 0.07 to 0.35) (**Figure 2C**). Only three studies reported the length of stay (LOS) [19, 21, 22], and the LOS was longer in the obese group (P<0.05, WMD 0.23 days, 95% CI 0.15 to 0.32) (**Figure 2D**). The total complication rate was higher in the obese group (P<0.05, OR 1.42, 95% CI 1.05 to 1.91) (**Figure 2E**). Minor complications were only reported in two studies [19, 21], and they were higher in the obese group (P<0.05, OR 2.59, 95% CI 1.36 to 4.94) (**Figure 2F**). The statistical difference (shown in Supplementary RLPN) was not significant for the transfusion rate (P = 0.47, OR 1.17, 95% CI 0.77 to 1.78), conversion to open surgery rate (P = 0.64, OR 1.30, 95% CI 0.43 to 3.99), major complication rate (P = 0.3, OR 1.26, 95% CI 0.81 to 1.95), or presence of positive margins (P = 0.36, OR 1.28, 95% CI 0.76 to 2.15) (**Table 2**).

Outcomes in laparoscopic partial nephrectomy

The estimated blood loss (EBL) was reported by six studies [23, 25-28, 30], and the EBL in the obese group was larger than that in the non-obese group (P<0.05, WMD 60.58 ml, 95% CI 25.99 to 95.17) (**Figure 3A**). The total complication rate was higher in obese group (P<0.05, OR 1.34, 95% CI 1.08 to 1.67) (**Figure 3B**). Five studies reported the minor complication rate [18, 23, 26, 27, 29], which was higher in the obese group than in the non-obese group (P<0.05, OR 1.34, 95% CI 1.02 to 1.76) (**Figure 3C**). Other outcomes (shown in Supplementary LPN) showed no significant difference between the two groups in terms of the operative duration (P = 0.06, WMD 7.49 min, 95% CI -0.36 to 15.34), warm ischemia time (P = 0.34, WMD -0.51 min, 95% CI -1.54 to 0.53), transfusion rate (P = 0.58, OR 1.33, 95% CI 0.48 to 3.64), length of stay (P = 0.43, WMD -0.10 days, 95% CI -0.34 to 0.14), conversion to open surgery rate (P = 0.05, OR 4.17, 95% CI 1.02 to 17.14), major complication rate (P = 0.1, OR 1.39, 95% CI 0.94 to 2.04), and presence of positive margins (P = 0.63, OR 1.63, 95% CI 0.22 to 11.98] (**Table 2**).

Sensitivity analysis and publication bias

Ten studies [18, 19, 21, 23-28, 30] with six or more stars on the modified Newcastle-Ottawa scale were included in sensitivity analysis (**Table 3**). No changes in significance of all outcomes was found except total complications in RLPN that was show to be no significantly (OR: 1.37; 95% CI, 1.00 to 1.88; p = 0.05), and minor complications in LPN that was show to be no significantly (OR: 1.26; 95% CI, 0.80 to 2.00; p = 0.32). These two subcategories showed no significant statistical difference between obese and non-obese group. The sensitivity analysis of conversion rate was not available with only one study.

Figure 4 showed two funnel plots of inclusions in this meta-analysis. The funnel plot for total

Table 2. Results of Meta-analysis Comparison of Obese and Non-Obese under MIPN

Outcomes of interest	Surgery procedures	Studies, No	Patients, n.		WMD/OR, [95% CI]	*p* value	Study heterogeneity			
			Obesity	Non-Obesity			X^2	df	I^2, %	*p* value
	RLPN									
Operative duration [min]		4	1066	1387	18.96† [17.96, 19.96]	<0.00001	41.25	3	93	<0.00001
Estimated blood loss [ml]		4	1066	1387	49.34† [47.26, 51.43]	<0.00001	15.15	3	80	0.002
Warm Ischemia Time [min]		4	1066	1387	0.21† [0.07, 0.35]	0.003	115.45	3	97	<0.00001
Transfusion rate		2	909	1177	1.17* [0.77, 1.78]	0.47	0.21	1	0	0.64
Length of stay [days]		3	260	357	0.23† [0.15, 0.32]	<0.00001	9.55	2	79	0.008
Conversion rate		2	914	1192	1.30* [0.43, 3.99]	0.64	NA	NA	NA	NA
Total complications		4	1066	1387	1.42* [1.05, 1.91]	0.02	2.12	3	0	0.55
Major complications		3	958	1225	1.26* [0.81, 1.95]	0.3	0.11	2	0	0.95
Minor complications		2	152	195	2.59* [1.36, 4.94]	0.004	0.1	1	0	0.75
Positive Margins		2	855	1078	1.28* [0.76, 2.15]	0.36	0.04	1	0	0.85
	LPN									
Operative duration [min]		5	437	657	7.49† [-0.36, 15.34]	0.06	5.03	4	21	0.28
Estimated blood loss [ml]		6	539	742	60.58† [25.99, 95.17]	0.0006	3.97	5	0	0.55
Warm Ischemia Time [min]		5	527	710	-0.51† [-1.54, 0.53]	0.34	2.3	4	0	0.68
Transfusion rate		4	381	601	1.33* [0.48, 3.64]	0.58	5.17	3	42	0.16
Length of stay [days]		7	567	775	-0.10† [-0.34, 0.14]	0.43	14.61	6	59	0.02
Conversion rate		3	208	326	4.17* [1.02, 17.14]	0.05	0.14	1	0	0.71
Total complications		8	1395	1863	1.34* [1.08, 1.67]	0.008	5.31	7	0	0.62
Major complications		5	1171	1536	1.39* [0.94, 2.04]	0.1	1.49	4	0	0.83
Minor complications		5	1171	1536	1.34* [1.02, 1.76]	0.03	2.86	4	0	0.58
Positive Margins		1	48	77	1.63* [0.22, 11.98]	0.63	NA	NA	NA	NA

Abbreviations: NA = not available; OR = odds ratio; WMD = weighted mean difference; CI = confidence interval; df = degrees of freedom; *OR; †WMD.

complication rate of RLPN was shown in **Figure 4A**, and outcomes were within the 95% CIs and symmetrically distributed, showing no evidence of publication bias. The funnel plot for total complication rate of LPN was shown in **Figure 4B**, the outcomes were also within the 95% CIs and symmetrically distributed, showing no evidence of publication bias.

Discussion

This article is a meta-analysis of 13 studies with 5898 enrolled subjects. In LPN, the current research expanded the study inclusion of previous meta-analysis and challenged previous research on this topic by Aboumarzouk et al. [9]. We found there was a significant difference in the estimated blood loss, total complication rate and minor complication rate between the obese group and non-obese group, and no difference in other outcomes. It is implied that not only were major complications higher in obese patients as a previous meta-analysis reported, the total complication rate was also higher in the obese group.

In RLPN, our results indicated a great difference between the two groups in many outcomes for the first time, including the operative duration, estimated blood loss, warm ischemia time, length of stay, and total and minor complication rates, which could demonstrate what might occur during the management of obese patients who underwent RLPN. In robotic laparoscopy, obese individuals can pose a challenge for two reasons in peritoneal access. First, surface anatomical landmarks can vary significantly in relation to the underlying anatomy. For example, the distortion of the umbilicus, a landmark and access point for the laparoscopic procedure, is common in morbidly obese individuals, in whom the thickness of the abdominal wall limits the method of access. The greater depth of the wound also requires larger incisions. Furthermore, the trocar length and external interference also become issues in morbidly obese or super-obese patients. All in all, obesity and distorted surface anatomy not only makes initial peritoneal access more challenging but also increase the risk of intraperitoneal and retroperitoneal injuries [31].

Numerous studies have reported adverse effects or necessary considerations for MIPN patients with high BMI [32-36]. Oh T et al. reported increased BMI was associated with a higher

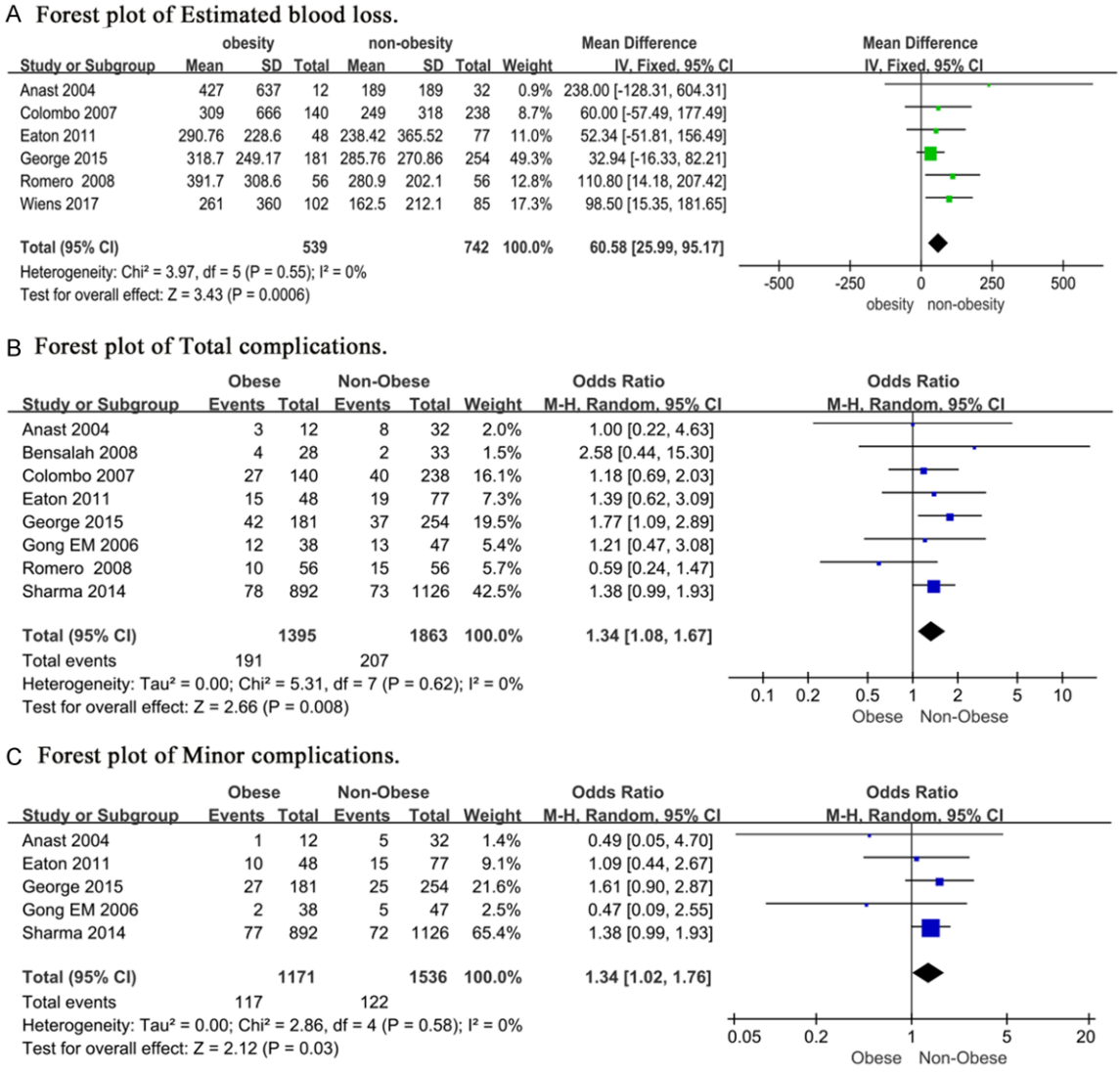


Figure 3. Forest plots of obese versus non-obese patients following laparoscopic partial nephrectomy in terms of intraoperative outcomes. A. Estimated blood loss. B. Total complications. C. Minor complications. Squares are the point estimates of the treatment effect [HR, OR, WMD], with 95% CI indicated by horizontal bars. Diamonds are the summary estimate from the pooled studies with 95% CI.

estimated blood loss in patients undergoing simple or radical laparoscopic nephrectomy [34]. For patients undergoing radical nephrectomy with concomitant IVC thrombectomy for RCC, obesity was reported to represent an adverse prognosticator for operative blood loss [36]. Kurzer et al. have quantified the risk of complications in laparoscopic renal surgeries for obese patients, and found that with every unit increases in the BMI, the risk of a major complication increases by 14% [33]. Hua X et al. reported that patients were more likely to experience complications after nephrectomy as BMI increases, and metabolic disorders, such as obesity, hypertension and diabetic mellitus were closely related to a greater number of complications of varying degrees after nephrectomy [32]. Richards KA et al. reported that the BMI was an independent risk factor for worsening kidney function following MIPN [35].

Other studies emphasized the benefits and feasibility of MIPN for obese patients [4, 37-41]. Klingler HC et al. demonstrated that patients with a higher BMI benefited more from laparoscopy in respect to postoperative pain and morbidity, but did not experience more complications [39]. Christopher Reynolds et al. founded

Table 3. Sensitivity analysis comparison of obese and non-obese patients undergone MIPN

Outcomes of interest	Surgery procedures	Studies, No	Patients, n.		WMD/OR, [95% CI]	*p* value	Study heterogeneity			
			Obesity	Non-Obesity			X^2	df	I^2, %	*p* value
	RLPN									
Operative duration [min]		3	958	1225	18.94† [17.94, 19.94]	<0.00001	41.11	2	95	<0.00001
Estimated blood loss [ml]		3	958	1225	49.30† [47.22, 51.39]	<0.00001	13	2	85	0.002
Warm Ischemia Time [min]		3	958	1225	0.22† [0.08, 0.36]	0.002	114.94	2	98	<0.00001
Conversion rate		1	806	1030	NA	NA	NA	NA	NA	NA
Length of stay [days]		2	152	195	0.21† [0.12, 0.30]	<0.00001	6.04	1	83	0.01
Total complications		3	958	1225	1.37* [1.00, 1.88]	0.05	1.64	2	0	0.44
	LPN									
Total complications		7	503	737	1.31* [0.99, 1.75]	0.06	5.26	6	0	0.51
Major complications		4	279	410	1.76* [0.99, 3.13]	0.06	0.32	3	0	0.96
Minor complications		4	279	410	1.26* [0.80, 2.00]	0.32	2.76	3	0	0.43

Abbreviations: NA = not available; OR = odds ratio; WMD = weighted mean difference; CI = confidence interval; df = degrees of freedom; *OR; †WMD.

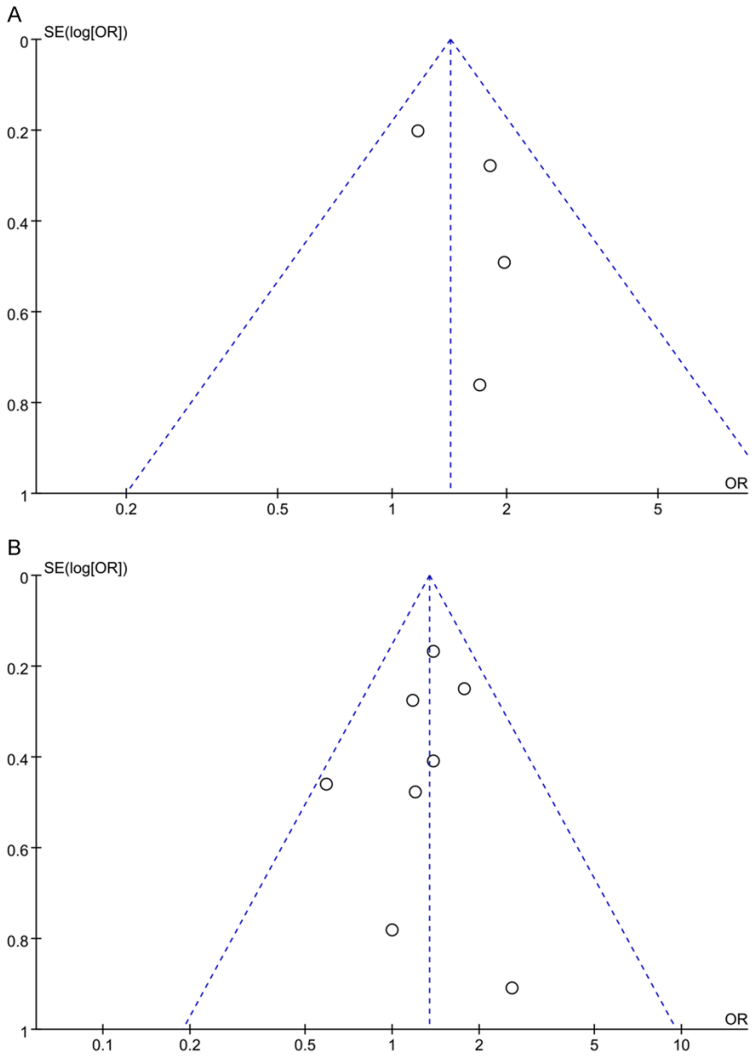


Figure 4. Funnel plots for assessing publication bias (A). Funnel plot showing approximation symmetry indicative of no evidence of publication bias for total complication rate of RLPN and (B). Funnel plot showing symmetry indicative of no evidence of publication bias for total complication rate of LPN.

out that increasing nephrometry score was the sole variable associated with perioperative complications rather than BMI [4]. Nita G et al. suggested that proper trocar site selection and greater insufflation pressures were critical for successful MIPN for obese patients [41]. Additionally, a number of researchers also reported obesity was related to less-aggressive disease profiles for RCC and superior cancer-specific survival [42-44]. Even though it warrants further exploration, this association suggests that surgeons should pay more attentions to the topic.

Once MIPN has failed, the procedure is converted to an open partial nephrectomy (OPN), which has been the main surgical operation for RCC in the 20th century. OPN served as the last approach for all kinds of difficulties and that is why we do not compare those outcomes under OPN. The fact that MIPN has many advantages over OPN in obese patients was reported in numerous studies. MIPN resulted in a significantly decreased blood loss, shorter operating time, and quicker return

of bowel function, lower analgesic requirements, shorter convalescence and reduced hospital stay in treating obese patients with RCC when compared with those of OPN [28, 29, 37, 45-47]. In addition to medical outcomes, obesity could influence the costs in some patients who underwent OPN [24]. The length of stay seems to be the main determinants of economic costs in renal surgery.

However, there were some limitations in this analysis. First, all the inclusion studies were retrospective, and no randomized controlled trials were included. Retrospective studies might have selective bias from the subjects by the researchers. Second, even if we expanded inclusions for LPN compared with previous analysis and conducted the first meta-analysis of RLPN on this topic, more studies with larger samples would still be required for solid and detailed clinical outcomes and conclusion. Third, a thorough understanding of one operation and its indications not only needs perioperative outcomes but also relies on long term postoperative and oncological outcomes and prognoses. None of the included studies provided prognosis or long-time postoperative outcomes on this topic.

Conclusion

For LPN, obese patients have a higher likelihood of total and minor complications and a larger EBL. For RLPN, obese patients have a longer OD, WIT, and LOS. They also have a larger EBL and higher likelihood of total and minor complications than non-obese patients. For this reason, MIPN should be performed on obese patients with caution.

Disclosure of conflict of interest

None.

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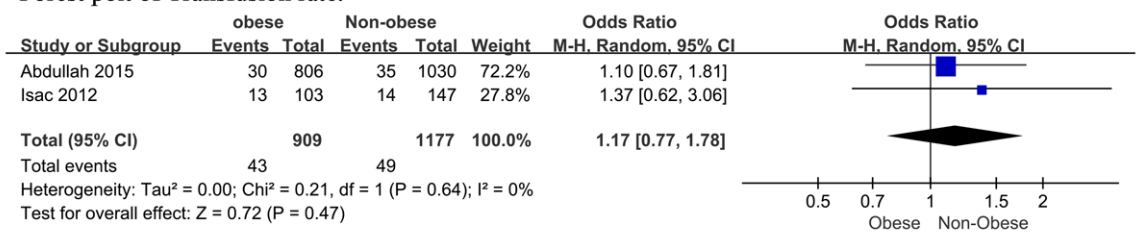
A



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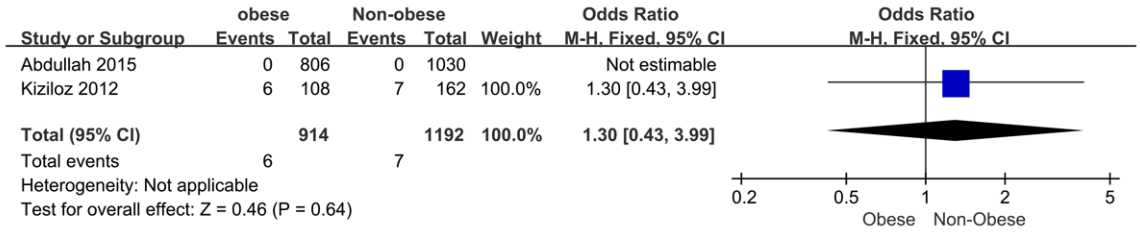

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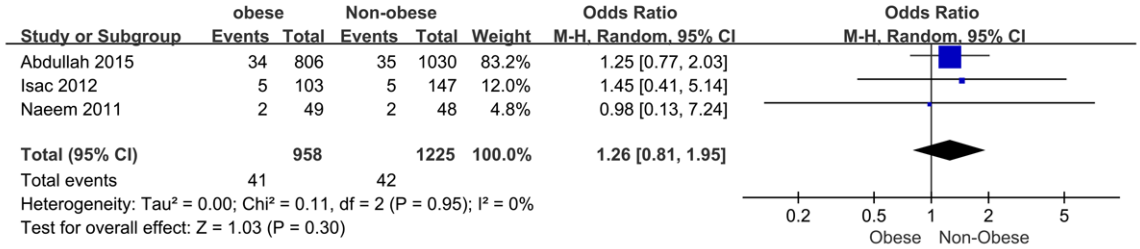

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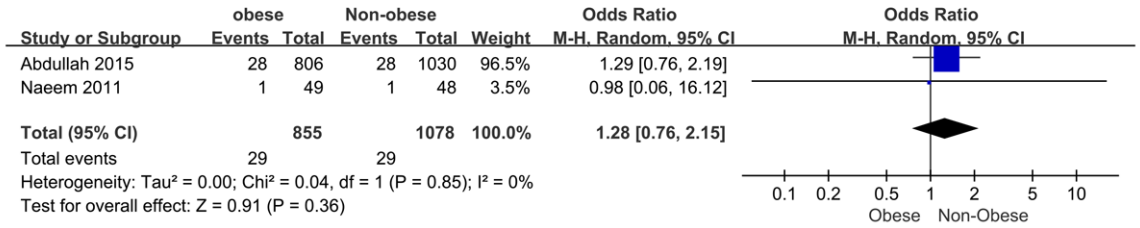


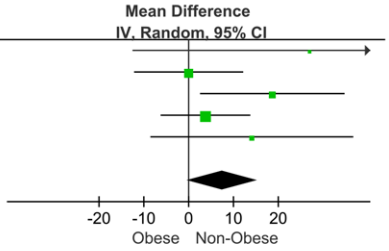
Supplementary RLPN. Forest plots of obese versus non-obese patients following robot-assisted laparoscopic partial nephrectomy in terms of intraoperative outcomes. A. Transfusion rate. B. Conversion rate. C. Major complications. D. Positive margins.

A

Forest plot of Operative duration.

Study or Subgroup	Obese Mean	SD	Total	Non-Obese Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Anast 2004	260	51	12	233	78	32	3.8%	27.00 [-12.53, 66.53]
Colombo 2007	205.2	57.9	140	205.2	59.1	238	29.0%	0.00 [-12.18, 12.18]
Eaton 2011	220.16	46.38	48	201.49	42.02	77	19.0%	18.67 [2.54, 34.80]
George 2015	142.5	46.17	181	138.74	60.27	254	37.5%	3.76 [-6.25, 13.77]
Romero 2008	195.2	59.8	56	181.1	62.4	56	10.7%	14.10 [-8.54, 36.74]
Total (95% CI)			**437**			**657**	**100.0%**	**7.49 [-0.36, 15.34]**

Heterogeneity: Tau² = 16.71; Chi² = 5.03, df = 4 (P = 0.28); I² = 21%
Test for overall effect: Z = 1.87 (P = 0.06)

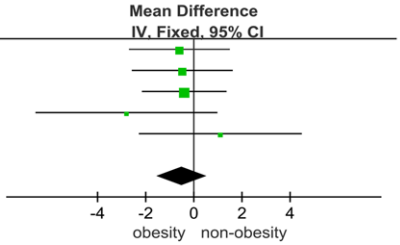


B

Forest plot of Warm ischemia time.

Study or Subgroup	obesity Mean	SD	Total	non-obesity Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Colombo 2007	31.7	10	140	32.3	10.1	238	24.3%	-0.60 [-2.70, 1.50]
Eaton 2011	29.33	6.27	48	29.81	5	77	24.3%	-0.48 [-2.58, 1.62]
George 2015	16.7	8.83	181	17.1	9.75	254	34.5%	-0.40 [-2.16, 1.36]
Romero 2008	28.2	10.5	56	31	9.9	56	7.5%	-2.80 [-6.58, 0.98]
Wiens 2017	27.24	13.4	102	26.14	10.2	85	9.3%	1.10 [-2.29, 4.49]
Total (95% CI)			**527**			**710**	**100.0%**	**-0.51 [-1.54, 0.53]**

Heterogeneity: Chi² = 2.30, df = 4 (P = 0.68); I² = 0%
Test for overall effect: Z = 0.96 (P = 0.34)

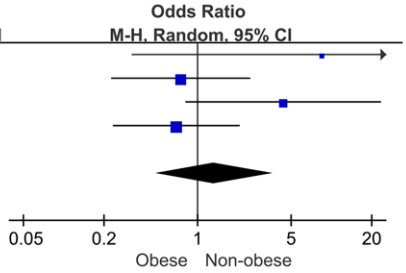


C

Forest plot of Transfusion rate.

Study or Subgroup	Obese Events	Total	Non-obese Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Anast 2004	1	12	0	32	8.2%	8.48 [0.32, 223.18]
Colombo 2007	4	140	9	238	33.1%	0.75 [0.23, 2.48]
Eaton 2011	5	48	2	77	22.8%	4.36 [0.81, 23.45]
George 2015	5	181	10	254	35.9%	0.69 [0.23, 2.06]
Total (95% CI)		**381**		**601**	**100.0%**	**1.33 [0.48, 3.64]**
Total events	15		21			

Heterogeneity: Tau² = 0.43; Chi² = 5.17, df = 3 (P = 0.16); I² = 42%
Test for overall effect: Z = 0.55 (P = 0.58)

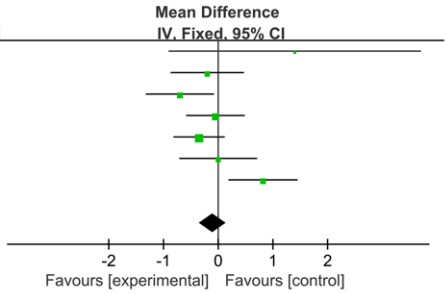


D

Forest plot of Length of stay.

Study or Subgroup	obesity Mean	SD	Total	non-obesity Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Anast 2004	4.5	3.7	12	3.1	2.8	32	1.1%	1.40 [-0.91, 3.71]
Bensalah 2008	2.3	1.5	28	2.5	1.1	33	12.7%	-0.20 [-0.87, 0.47]
Colombo 2007	2.8	1.5	140	3.5	4.5	238	14.7%	-0.70 [-1.32, -0.08]
Eaton 2011	3.72	1.05	48	3.77	2	77	19.9%	-0.05 [-0.59, 0.49]
George 2015	2.3	2.17	181	2.65	2.82	254	26.0%	-0.35 [-0.82, 0.12]
Romero 2008	3.2	2.2	56	3.2	1.6	56	11.3%	0.00 [-0.71, 0.71]
Wiens 2017	4.11	2.9	102	3.29	1.35	85	14.3%	0.82 [0.19, 1.45]
Total (95% CI)			**567**			**775**	**100.0%**	**-0.10 [-0.34, 0.14]**

Heterogeneity: Chi² = 14.61, df = 6 (P = 0.02); I² = 59%
Test for overall effect: Z = 0.79 (P = 0.43)

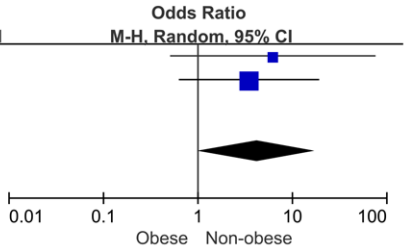


E

Forest plot of Conversion rate.

Study or Subgroup	Obese Events	Total	Non-obese Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Anast 2004	2	12	1	32	31.8%	6.20 [0.51, 75.84]
Colombo 2007	4	140	2	238	68.2%	3.47 [0.63, 19.20]
Romero 2008	0	56	0	56		Not estimable
Total (95% CI)		**208**		**326**	**100.0%**	**4.17 [1.02, 17.14]**
Total events	6		3			

Heterogeneity: Tau² = 0.00; Chi² = 0.14, df = 1 (P = 0.71); I² = 0%
Test for overall effect: Z = 1.98 (P = 0.05)



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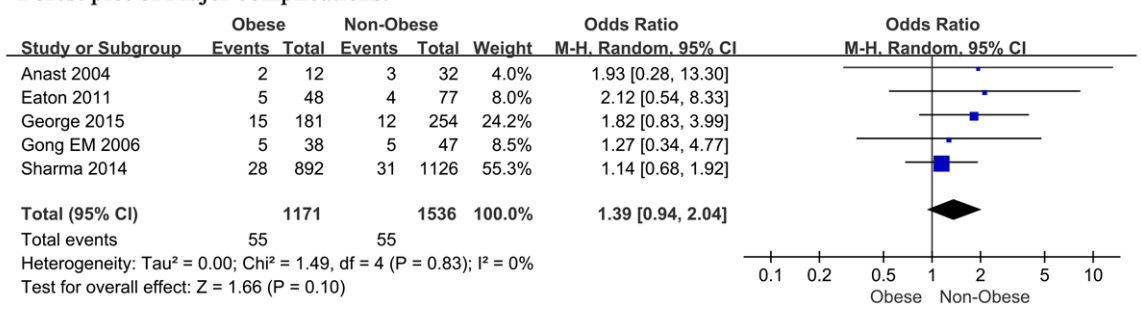

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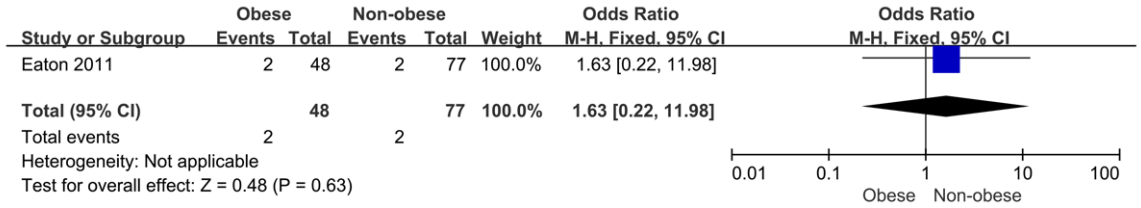

Supplementary LPN. Forest plots of obese versus non-obese patients following laparoscopic partial nephrectomy in terms of intraoperative outcomes. A. Operative duration. B. Warm ischemia time. C. Transfusion rate. D. Length of stay. E. Conversion rate. F. Major complications. G. Positive margins.