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Meta-Analysis of Laparoscopic Pyelolithotomy versus Percutaneous Nephrolithotomy as a Treatment of Large Kidney Stones

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Abstract

BACKGROUND: Percutaneous nephrolithotomy (PCNL) is considered as a gold standard management for treating large kidney stones. However, laparoscopic approach has been considered as an alternative management to treat such cases.

AIM: The goal of this study is to assess the safety and efficacy of laparoscopic stone removal or laparoscopic pyelolithotomy and PCNL for patients with large kidney stone/s whether they were single or multiple.

METHODS: Authors searched literatures from Medline, EMBASE, Science Direct, Cochrane Library, and Google Scholar published from inception to March 2019. The studies related to laparoscopic pyelolithotomy regardless of the approach and PCNL for the treatment of kidney stones. Meta-analysis was performed following data extraction and quality assessment. Data analysis was performed using Review Manager 5.3.

RESULTS: Sixteen studies with a total of 1044 patients comprised of 501 and 543 patients treated with laparoscopic pyelolithotomy and PCNL, respectively. Operative time was longer in laparoscopic group (Mean difference [MD], 35.45 (95% confidence interval [CI] 13.12–57.79), p = 0.002, I^2 = 98%). Stone free rate was higher in laparoscopic than PCNL (RR, 1.17 (95% CI 1.09–1.25), p < 0.0001, I^2 = 59%) group. Moreover, patients in laparoscopic group benefited from lesser overall complication (RR, 0.71 (95% CI 0.55–0.93), p = 0.01, I^2 = 0%), drop in hemoglobin (MD, −0.89 (95% CI −1.14– (−0.65)), p < 0.00001, I^2 = 53%), blood transfusion rate (Risk ratio [RR], 0.33 (95% CI 0.16–0.66), p = 0.002, I^2 = 0%), post-operative fever (RR, 0.45 (95% CI 0.28–0.72), p = 0.0009, I^2 = 15%), and the need for additional intervention (RR, 0.35 (95% CI 0.19–0.62), p = 0.0004, I^2 = 0%). In addition, there were no significance in post-operative hospital stay (MD, 0.45 (95% CI −0.14–1.03), p = 0.13, I^2 = 90%) and prolonged urine leakage (RR, 1.76 (95% CI 0.90–3.42), p = 0.10, I^2 = 0%) between two groups.

CONCLUSION: Laparoscopic stone removal provided higher stone free rate and lower post-operative complications than PCNL. Laparoscopic approach could stand as a main treatment option in large kidney stone/s beside PCNL. Moreover, further Randomized controlled trial studies needed to justify the outcomes of this study.

Introduction

For several decades, percutaneous nephrolithotomy (PCNL) is being considered as a gold standard management for most large kidney stone cases. Despite the flourishing advances in PCNL technique, several concerns still reside about its complications such as post-operative bleeding, injury to the neighboring organs, and the parenchymal loss [1]. Some literatures reported that there was no significant effect on glomerular filtration rate and no parenchymal injury related to PCNL [2], [3]. However, more studies have to be performed regarding this issue.

Alternative managements, such as laparoscopic kidney stone surgery, have been considered approachable especially where kidney stones exist with concomitant ureteropelvic junction obstruction [4], [5]. Laparoscopic stone removal, either performed retroperitoneoscopic or transperitoneal has been reported in several studies [4], [5], [6].

Some studies have assessed the beneficial of laparoscopic stone removal in cases of large kidney stones [7], [8], [9]. However, the effectiveness of laparoscopic stone removal compared to PCNL in treating large or multiple kidney stones still has to be validated. Two meta-analysis has been reported the comparison of laparoscopic approach and PCNL in treating kidney stones and found the comparable results between those two managements. At present, several clinical trials have been performed since the last meta-analysis study comparing laparoscopic approach and PCNL for removal of kidney stones. Therefore, we conducted an update meta-analysis to compare the effectiveness and safety of laparoscopic pyelolithotomy and PCNL in the treatment for large and/or multiple kidney stones.

Methods

Literature selection

Literatures from Medline, EMBASE, Science Direct, Cochrane Library, and Google Scholar databases published from inception to March 2019 were assessed using keywords related to laparoscopic pyelolithotomy, PCNL, and kidney stones. All eligible studies were addressed by tested the strategies and modified them if necessary. We use "related article" feature on Medline to obtain any additional and grey literatures. We also assessed all the citations of any relevant articles to broaden our search. Study searches were restricted by adult patients and English language.

Inclusion and exclusion criteria

The inclusion criteria for this study were: (1) randomized controlled trials (RCTs), case control or cohort studies that compare the outcomes of laparoscopic pyelolithotomy with PCNL, (2) Cases with large kidney stone burden (>1.5 cm), single or multiple. We excluded literatures other than English, meta-analysis studies, studies included ureteral stones, and studies with pediatric populations.

Data extraction, quality assessment, and outcomes

First author assessed and screened the literatures according to inclusion and exclusion criteria. Author screened the title, abstract and eventually the full paper of potentially relevant studies. The following outcomes were extracted from included studies: Operation time, post-operative hospital stay, stone-free status, overall complications, post-operative bleeding (hemoglobin drop and the rate of blood transfusion), post-operative fever, prolonged urine leakage, and additional interventions. The quality of eligible studies was assessed using the Newcastle-Ottawa Scale.

Data analysis

Statistical analysis used a risk ratio (RR) for dichotomous data, whereas mean difference (MD) was used for continuous data. Fixed or random effects model was used based on the *p* value of heterogeneity. The data heterogeneity was assessed by calculating the degree of inconsistency (I^2). The heterogeneity was determined low (I^2 = 25-50%), moderate (I^2 = 51–75%), and high (I^2 > 75%). The effects of pooled data were determined by test for overall effect (Z-test), and p < 0.05 was considered significant. All calculations were performed using Review Manager version 5.3.

Results

A thorough search identified 731 studies. After comprehensive assessment, authors identified 16 publications that met inclusion criteria. Thirteen citations were full papers and three were conference publications. Therefore, these 16 studies were included in our meta-analysis which involved 1044 cases: 501 cases underwent laparoscopic pyelolithotomy and 543 cases for PCNL. The flowchart for literature searching and selection process is shown in Figure 1. Authors analyzed 9 outcomes: Operation time in 16 studies, post-operative hospital stay in 13 studies, stone-free rate in 13 studies, overall post-operative complications in 13 studies, prolonged urine leakage in 10 studies, post-operative fever in 9 studies, drop in hemoglobin, blood transfusion rate, and additional intervention in 8, 12, and 6 studies, respectively.

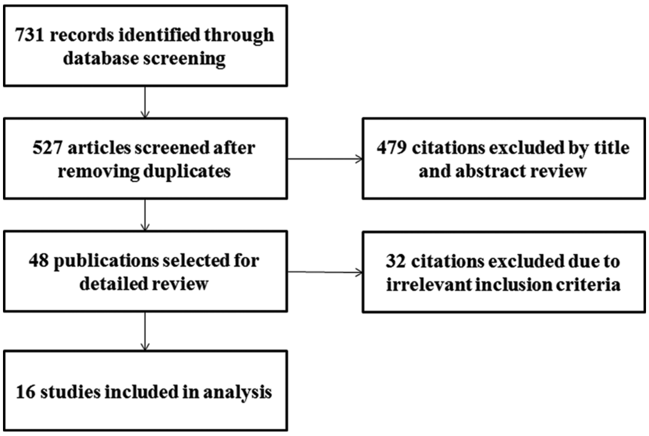

Figure 1: Flowchart of studies searching

Baseline characteristics and summary of findings included in this study were presented in Tables 1 and 2. Eight studies were RCTs and another eight studies were non-RCTs. The imaging modalities used in the studies were plain X-ray of kidney-ureter-bladder, ultrasonography, fluoroscopy, computed tomography, and nephrostography.

Operation time and post-operative hospital stay

All studies reported the operative time that included 1044 patients, 501 patients in laparoscopic group and 543 patients in PCNL group (Figure 2). High level of heterogeneity was showed in the analysis (I^2 = 98%). Analysis of the data showed that laparoscopic pyelolithotomy had significantly longer operative time than PCNL (MD, random-effect 35.45, 95% CI 13.12–57.79, p = 0.002).

The length of post-operative hospital stay was reported in 13 studies, with the total of 479 patients in laparoscopic group and 521 patients in PCNL group (Figure 3). No significantly difference was found

Table 1: Characteristics of studies included in the review

First author	Year	Study design	Treatments approach	Patients number	Age (years)	Percentage of males	BMI (kg/m^2)	Stone burden	Types of stones	NOS score
Agrawal [10]	2015	RCT	Lap	18	40	66.7	NA	3.70 ± 0.55 cm^2	Pelvis	4
			PCNL	20	41.2	70	NA	3.90 ± 0.60 cm^2		
Al-Hunayan [9]	2011	RCT	Lap	55	41.2 ± 11.7	58.2	NA	2.40 ± 0.40 cm	Pelvis	6
			PCNL	50	38.5 ± 11.9	56	NA	2.50 ± 0.40 cm		
Aminsharifi [11]	2013	RCT	Lap	60	44.5 ± 14.8	61.7	NA	3.59 ± 0.73 cm	Pelvis	5
			PCNL	30	43.8 ± 15.0	66.7	NA	3.53 ± 0.73 cm		
Basiri [12]	2014	RCT	Lap	30	38.5 ± 15.9	NA	26.10 ± 6.70	3.6 (2.8-4.4) cm	Pelvis, staghorn	6
			PCNL	30	42.1 ± 14.3	NA	25.80 ± 7.30	3.3 (2.7-4.2) cm		
Fawzi [13]	2015	RCT	Lap	30	42.4 ± 12.1	NA	NA	3.20 ± 0.60 cm	Pelvis	4
			PCNL	30	44.6 ± 11.4	NA	NA	3.40 ± 0.50 cm		
Gaur [14]	2001	Non-RCT	Lap	42	39.1 (8–65)	NA	NA	2.0 (1.0–4.8) cm	Pelvis, multiple, calyx	4
			PCNL	47	34.4	NA	NA	2.9 (2.0–3.8) cm		
Goel [7]	2003	Non-RCT	Lap	16	38.9 (21–60)	62.5	NA	3.6 (3.2–4.5) cm	Pelvis	5
			PCNL	12	41.4 (20–62)	66.7	NA	4.1 (3.5–5.2) cm		
Haggag [15]	2013	Non-RCT	Lap	10	38.8 ± 12.2	50	NA	6.50 ± 1.20 cm^2	Pelvis	4
			PCNL	42	42.0 ± 13.2	73.8	NA	4.19 ± 2.03 cm^2		
Lee [16]	2014	Non-RCT	Lap	45	56.0 ± 13.7	73.3	24.90 ± 3.80	4.93 ± 3.03 cm	Pelvis, staghorn, multiple	6
			PCNL	39	54.3 ± 13.0	71.8	25.10 ± 4.10	4.63 ± 1.65 cm		
Li [17]	2014	RCT	Lap	89	55.6 ± 10.9	NA	23.29 ± 3.37	2.93 ± 1.02 cm	Pelvis, staghorn	6
			PCNL	89	53.2 ± 11.5	NA	22.67 ± 3.19	3.00 ± 0.96 cm		
Meria [8]	2005	Non-RCT	Lap	16	42 (21–63)	NA	NA	2.5 (2.0–3.3) cm	Pelvis	5
			PCNL	16	45 (24–69)	NA	NA	2.6 (2.0–4.0) cm		
Perlin [18]	2011	Non-RCT	Lap	5	NA	NA	NA	>2 cm	Pelvis	5
			PCNL	20	NA	NA	NA	>2 cm		
Singh [19]	2014	RCT	Lap	22	45.6 ± 14.2	NA	NA	>3 cm	Pelvis	6
			PCNL	22	44.9 ± 13.8	NA	NA	>3 cm		
Tefekli [20]	2012	Non-RCT	Lap	26	36.5 ± 11.1	NA	25.34 ± 3.55	7.46 ± 2.25 cm^2	Pelvis	6
			PCNL	26	37.1 ± 10.0	NA	25.25 ± 3.03	7.18 ± 1.51 cm^2		
Tepeler [21]	2009	Non-RCT	Lap	16	41.2 ± 16.8	NA	NA	8.82 ± 3.20 cm^2	Pelvis	4
			PCNL	16	43.9 ± 14.1	NA	NA	8.49 ± 2.60 cm^2		
Xiao [22]	2018	RCT	Lap	51	55.3 ± 14.8	68.7	24.95 ± 4.57	13.77 ± 5.18 cm^2	Pelvis, staghorn, multiple	6
			PCNL	54	53.7 ± 12.5	72.2	25.80 ± 4.70	12.59 ± 6.58 cm^2		

RCT: Randomized controlled trial, *Lap*: laparoscopic pyelolithotomy, PCNL: Percutaneous nephrolithotomy, BMI: Body mass index, NA: Not available, NOS: Newcastle-Ottawa Scale; Age, BMI and stone burden were shown as mean ± SD or mean (minimum-maximum).

regarding the length of post-operative hospital stay between the two groups (MD, random-effect 0.45, 95% CI −0.14–1.03, p = 0.13, I^2 = 90%).

Stone-free rate

Thirteen studies assessed the stone-free rate between laparoscopic group and PCNL group. Total of 986 patients were analyzed comprising 471 patients in laparoscopic group and 515 patients in PCNL group (Figure 4). We found that laparoscopic had more significant benefit on stone-free rate than PCNL (RR, random-effect 1.17, 95% CI 1.09–1.25, p < 0.0001). Moreover, moderate heterogeneity was found in this analysis (I^2 = 59%).

Overall complications

Thirteen studies reported the overall complications after surgery. Total of 435 patients in

Table 2: Summary of findings included in meta-analysis

Study, year	Treatments	Operative time (minutes)	Drop in Hb (g/dL)	Hospital stay (days)	Stone free (%)	Post-operative complications (%)	Urine leakage (%)	Post-operative fever (%)	Post-op blood transfusion (%)	Additional intervention (%)
Agrawal, 2015	Lap	145.88 ± 35.54	NA	4.50 ± 2.47	NA	22.22	NA	16.67	0.00	NA
	PCNL	76.20 ± 9.21	NA	3.50 ± 1.33	NA	15	NA	10.00	0.00	NA
Al-Hunayan, 2011	Lap	130.60 ± 38.70	NA	4.50 ± 1.90	100	16.36	5.45	5.45	5.45	NA
	PCNL	108.5 ± 18.70	NA	4.40 ± 1.40	96	24	0.00	18.00	6.00	NA
Aminsharifi, 2013	Lap	120.5 ± 39.94	1.38 ± 0.88	4.00 ± 0.70	100	3.33	0.00	NA	3.33	NA
	PCNL	98.10 ± 23.38	1.76 ± 0.94	3.50 ± 0.70	76.67	16.67	10.00	NA	6.67	NA
Basiri, 2014	Lap	149.00 ± 31.00	0.85 ± 0.50	3.40 ± 1.20	88	13.33	0.00	NA	3.33	10.00
	PCNL	107.00 ± 26.00	1.88 ± 1.20	2.16 ± 0.70	64	20	10.00	NA	13.33	13.33
Fawzi, 2015	Lap	132.70 ± 33.40	1.10 ± 0.56	4.10 ± 1.70	100	20	10.00	6.67	0.00	NA
	PCNL	85.40 ± 16.20	1.80 ± 1.20	3.40 ± 1.50	90	16.67	3.33	13.33	10.00	NA
Gaur, 2001	Lap	116.25 ± 10.00	NA	3.90 ± 1.00	100	30.95	NA	2.38	0.00	0.00
	PCNL	152.00 ± 10.00	NA	5.40 ± 1.00	82.98	40.43	NA	10.64	12.77	12.77
Goel, 2003	Lap	142.20 ± 58.75	NA	3.80 ± 2.25	NA	31.25	6.25	0.00	NA	NA
	PCNL	71.60 ± 12.50	NA	3.00 ± 0.75	NA	25	0.00	8.33	NA	NA
Haggag, 2013	Lap	131.00 ± 22.11	NA	2.30 ± 0.64	80	30	0.00	30.00	0.00	NA
	PCNL	51.19 ± 24.39	NA	3.70 ± 1.40	78.57	35.71	2.38	21.43	4.76	NA
Lee, 2014	Lap	163.70 ± 78.20	NA	4.64 ± 3.34	91	NA	NA	NA	NA	NA
	PCNL	116.80 ± 44.40	NA	4.76 ± 1.60	64.10	NA	NA	NA	NA	NA
Li, 2014	Lap	90.87 ± 33.40	0.90 ± 0.50	4.50 ± 2.30	97.75	6.74	3.37	3.37	0.00	0.00
	PCNL	116.80 ± 44.40	1.70 ± 1.30	4.30 ± 1.30	89.89	16.85	0.00	13.48	1.12	2.25
Meria, 2005	Lap	129.00 ± 37.50	0.60 ± 0.30	8.25 ± 3.00	87.50	25	12.50	NA	0.00	12.50
	PCNL	75.00 ± 26.25	1.80 ± 1.10	7.00 ± 1.75	81.25	18.75	0.00	NA	6.25	18.75
Perlin, 2011	Lap	143.00 ± 10.00	NA	8.50 ± 1.00	100	NA	NA	NA	NA	NA
	PCNL	116.00 ± 10.00	NA	6.20 ± 1.00	90	NA	NA	NA	NA	NA
Singh, 2014	Lap	91.82 ± 16.51	NA	NA	95.45	9.09	NA	9.09	0.00	4.55
	PCNL	87.27 ± 23.84	NA	NA	72.72	9.09	NA	9.09	0.00	27.27
Tefekli, 2012	Lap	138.40 ± 51.19	1.00 ± 0.57	3.90 ± 2.50	100	7.69	3.85	NA	0.00	NA
	PCNL	57.92 ± 21.12	1.70 ± 1.12	2.30 ± 0.50	88.46	7.69	0.00	NA	3.85	NA
Tepeler, 2009	Lap	126.40 ± 34.80	3.07 ± 3.86	3.20 ± 1.60	NA	NA	NA	NA	NA	NA
	PCNL	95.80 ± 37.80	6.08 ± 4.51	3.00 ± 2.10	NA	NA	NA	NA	NA	NA
Xiao, 2018	Lap	135.70 ± 35.50	0.40 ± 0.30	5.30 ± 1.80	88.24	21.57	11.75	5.88	3.92	11.77
	PCNL	101.90 ± 41.20	1.70 ± 1.30	4.70 ± 2.40	64.82	38.89	3.70	20.37	12.96	31.48

Lap: Laparoscopic pyelolithotomy, PCNL: Percutaneous nephrolithotomy, NA: Not available; Operative time, drop in Hb and hospital stay were presented as mean ± SD

Study or Subgroup	Lap Mean	Lap SD	Lap Total	PCNL Mean	PCNL SD	PCNL Total	Weight	Mean Difference IV, Random, 95% CI
Agrawal 2015	145.88	35.54	18	76.2	9.21	20	6.3%	69.68 [52.77, 86.59]
Al-Hunayan 2011	130.6	38.7	55	108.5	18.7	50	6.4%	22.10 [10.63, 33.57]
Aminsharifi 2013	120.5	39.94	30	98.1	23.28	30	6.3%	22.40 [5.86, 38.94]
Basiri 2014	149	31	30	107	26	30	6.3%	42.00 [27.52, 56.48]
Fawzi 2015	132.7	33.4	30	85.4	16.2	30	6.4%	47.30 [34.02, 60.58]
Gaur 2001	116.25	10	42	152	10	47	6.5%	-35.75 [-39.91, -31.59]
Goel 2003	142.2	58.75	16	71.6	12.5	12	5.8%	70.60 [40.96, 100.24]
Hagagg 2013	131	22.11	10	51.19	24.39	42	6.3%	79.81 [64.25, 95.37]
Lee 2014	163.7	78.2	45	110	54.6	39	5.9%	53.70 [25.14, 82.26]
Li 2014	90.87	33.4	89	116.8	44.4	89	6.4%	-25.93 [-37.47, -14.39]
Meria 2005	129	37.5	16	75	26.25	16	6.1%	54.00 [31.57, 76.43]
Perlin 2011	143	10	5	116	10	20	6.4%	27.00 [17.20, 36.80]
Singh 2014	91.82	16.51	22	87.27	23.84	22	6.4%	4.55 [-7.57, 16.67]
Tefekli 2012	138.4	51.19	26	57.92	21.12	26	6.1%	80.48 [59.19, 101.77]
Tepeler 2009	126.4	34.8	16	95.8	37.8	16	6.0%	30.60 [5.42, 55.78]
Xiao 2018	135.7	35.5	51	101.9	41.2	54	6.3%	33.80 [19.11, 48.49]
Total (95% CI)			**501**			**543**	**100.0%**	**35.45 [13.12, 57.79]**

Heterogeneity: Tau² = 1994.89; Chi² = 739.75, df = 15 (P < 0.00001); I² = 98%
Test for overall effect: Z = 3.11 (P = 0.002)

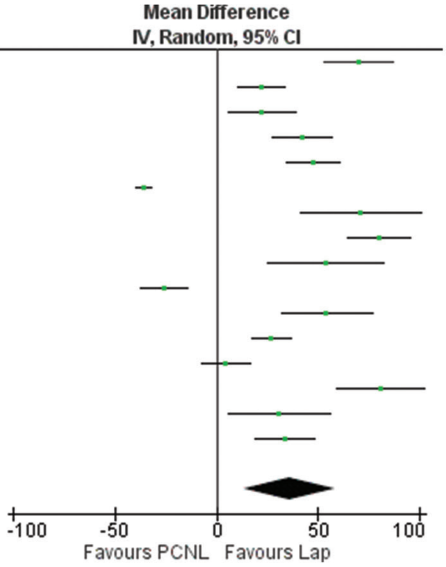

Figure 2: Forest plot of the length of operative time between laparoscopic and Percutaneous nephrolithotomy

laparoscopic group and 468 patients in PCNL groups was analyzed (Figure 5). The meta-analysis revealed that PCNL had significantly higher complications than laparoscopic (RR, fixed-effect 0.71, 95% CI 0.55 – 0.93, $p = 0.01$, $I^2 = 0\%$).

Post-operative bleeding

The outcomes observed were post-operative drop of hemoglobin and the need for blood transfusion post-operatively. Eight studies reported post-operative hemoglobin drop, comprising 288 patients in laparoscopic group and 291 patients in PCNL group (Figure 6). Moderate heterogeneity was observed in the analysis ($I^2 = 53\%$). The result of analysis showed that laparoscopic pyelolithotomy had a significant lower hemoglobin drop than PCNL (MD, random-effect −0.89, 95% CI −1.14–(−0.65), $p < 0.00001$).

Twelve publications reported regarding blood transfusion. However, two studies reported that no blood transfusion needed on both groups; therefore, the analysis on these two studies was not estimable. Ten studies with the total of 875 patients (419 patients in laparoscopic group and 456 patients in PCNL group) were analyzed (Figure 7). We found that laparoscopic had a significantly lower blood transfusion than PCNL (RR, fixed-effect 0.33, 95% CI 0.16–0.66, $p = 0.002$, $I^2 = 0\%$).

Post-operative fever and urine leakage

There were nine studies including total of 699 patients to be included in the analysis of post-operative fever (Figure 8). There was higher incidence of post-operative fever in PCNL group than laparoscopic group (RR, fixed-effect 0.45, 95% CI 0.28–0.72, $p = 0.0009$, $I^2 = 15\%$).

Study or Subgroup	Lap Mean	Lap SD	Lap Total	PCNL Mean	PCNL SD	PCNL Total	Weight	Mean Difference IV, Random, 95% CI
Agrawal 2015	4.5	2.47	18	3.5	1.33	20	5.7%	1.00 [-0.28, 2.28]
Al-Hunayan 2011	4.5	1.9	55	4.4	1.4	50	7.3%	0.10 [-0.53, 0.73]
Aminsharifi 2013	4	0.7	30	3.5	0.7	30	7.7%	0.50 [0.15, 0.85]
Basiri 2014	3.4	1.2	30	2.16	0.7	30	7.5%	1.24 [0.74, 1.74]
Fawzi 2015	4.1	1.7	30	3.4	1.5	30	6.9%	0.70 [-0.11, 1.51]
Gaur 2001	3.9	1	42	5.4	1	47	7.6%	-1.50 [-1.92, -1.08]
Goel 2003	3.8	2.25	16	3	0.75	12	6.0%	0.80 [-0.38, 1.98]
Hagagg 2013	2.3	0.64	10	3.7	1.4	42	7.4%	-1.40 [-1.98, -0.82]
Lee 2014	4.64	3.34	45	4.76	1.6	39	6.2%	-0.12 [-1.22, 0.98]
Li 2014	4.5	2.3	89	4.3	1.3	89	7.4%	0.20 [-0.35, 0.75]
Meria 2005	8.25	3	16	7	1.75	16	4.7%	1.25 [-0.45, 2.95]
Perlin 2011	8.5	1	5	6.2	1	20	6.5%	2.30 [1.32, 3.28]
Tefekli 2012	3.9	2.5	26	2.3	0.5	26	6.5%	1.60 [0.62, 2.58]
Tepeler 2009	3.2	1.6	16	3	2.1	16	5.7%	0.20 [-1.09, 1.49]
Xiao 2018	5.3	1.8	51	4.7	2.4	54	6.9%	0.60 [-0.21, 1.41]
Total (95% CI)			**479**			**521**	**100.0%**	**0.45 [-0.14, 1.03]**

Heterogeneity: Tau² = 1.11; Chi² = 144.61, df = 14 (P < 0.00001); I² = 90%
Test for overall effect: Z = 1.50 (P = 0.13)

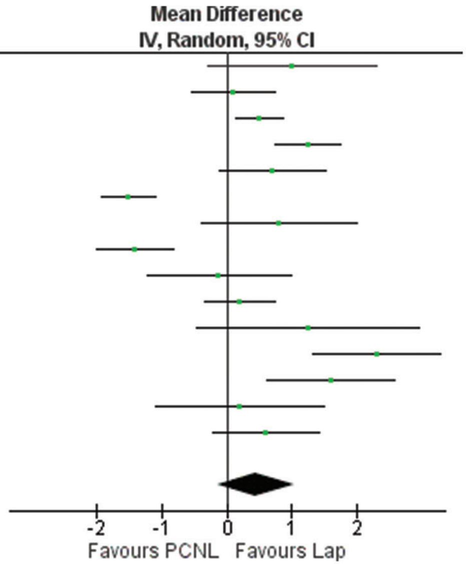

Figure 3: Forest plot of post-operative hospital stay between laparoscopic and Percutaneous nephrolithotomy

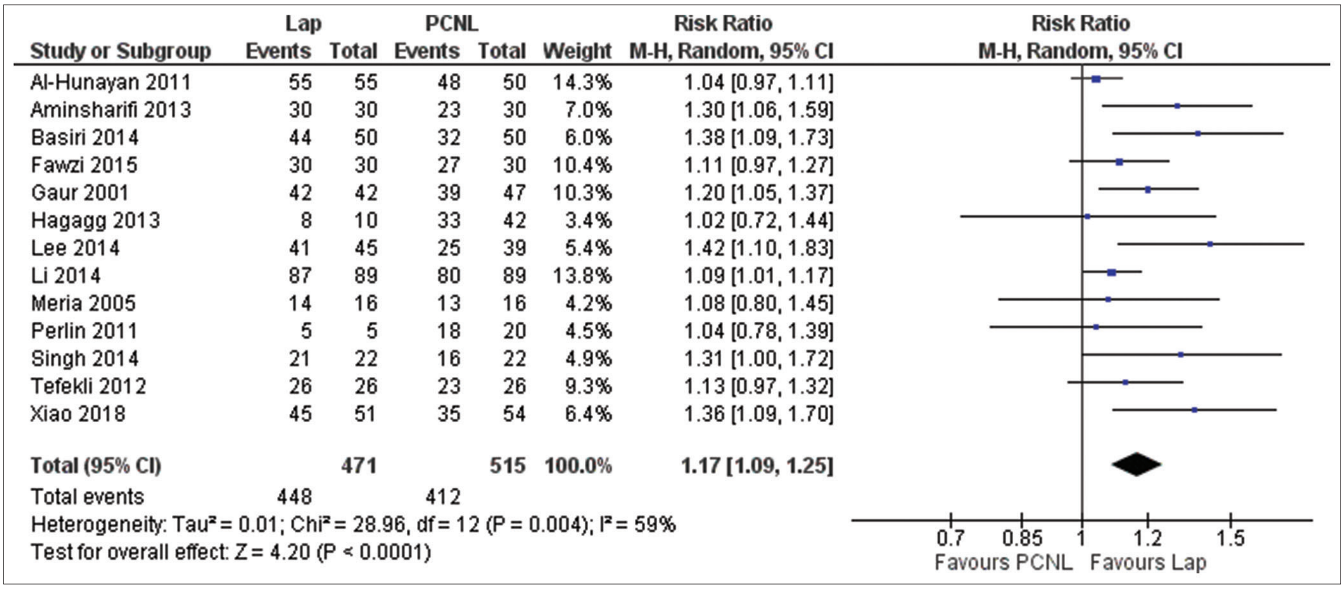

Figure 4: Forest plot of stone free rate between laparoscopic and Percutaneous nephrolithotomy

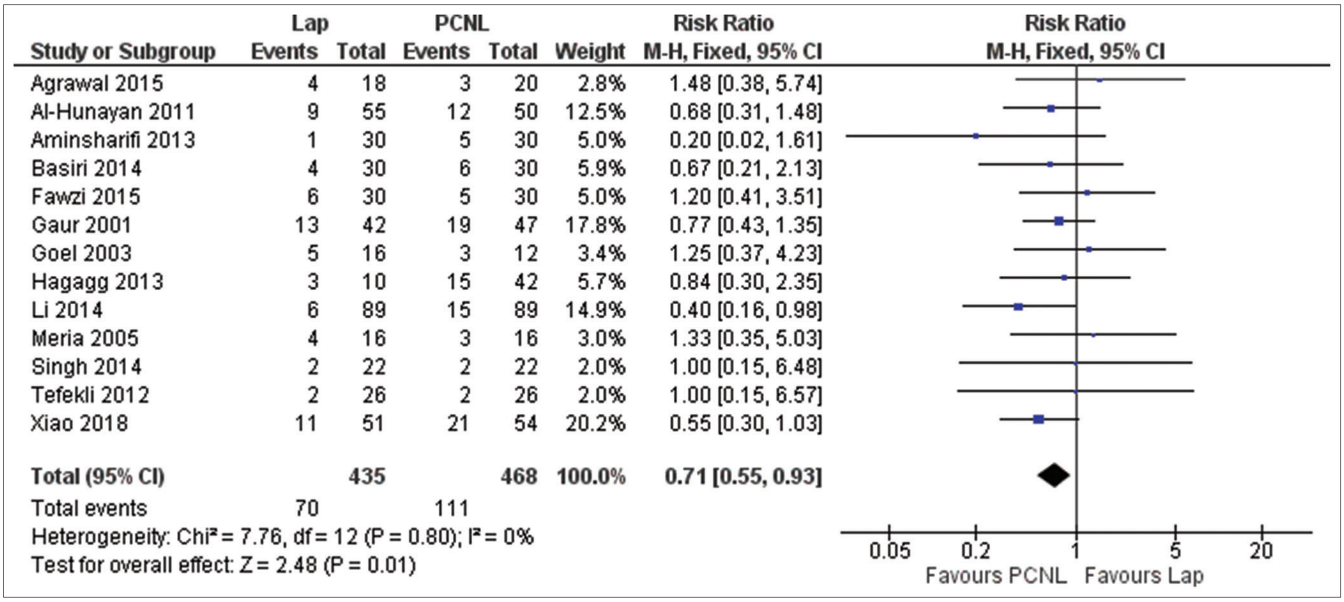

Figure 5: Forest plot of overall post-operative complications between laparoscopic and Percutaneous nephrolithotomy

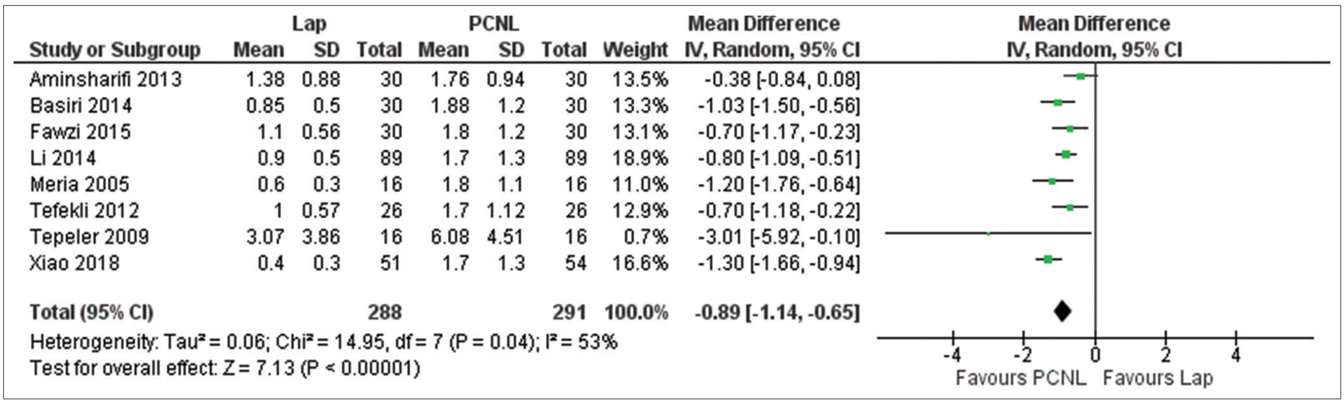

Figure 6: Forest plot of drop in hemoglobin between laparoscopic and Percutaneous nephrolithotomy

Ten studies reported regarding prolonged urine leakage after surgery with the total of 732 patients (353 in laparoscopic group and 379 in PCNL group) (Figure 9). We found that there were no significantly

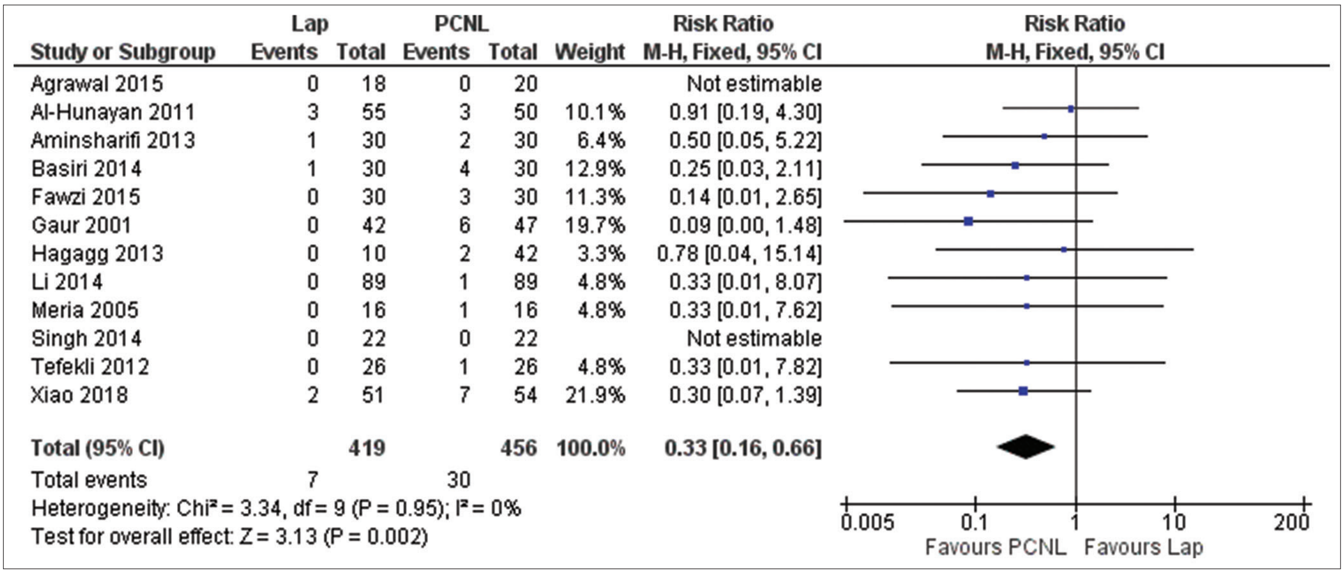

Figure 7: Forest plot of post-operative blood transfusion between laparoscopic and P Percutaneous nephrolithotomy

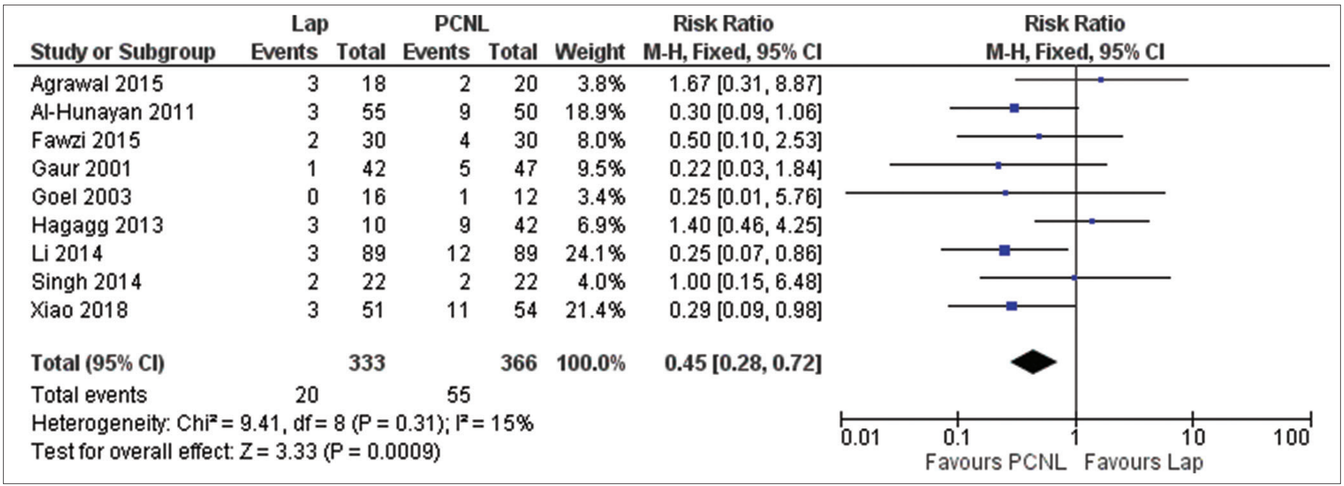

Figure 8: Forest plot of post-operative fever between laparoscopic and Percutaneous nephrolithotomy

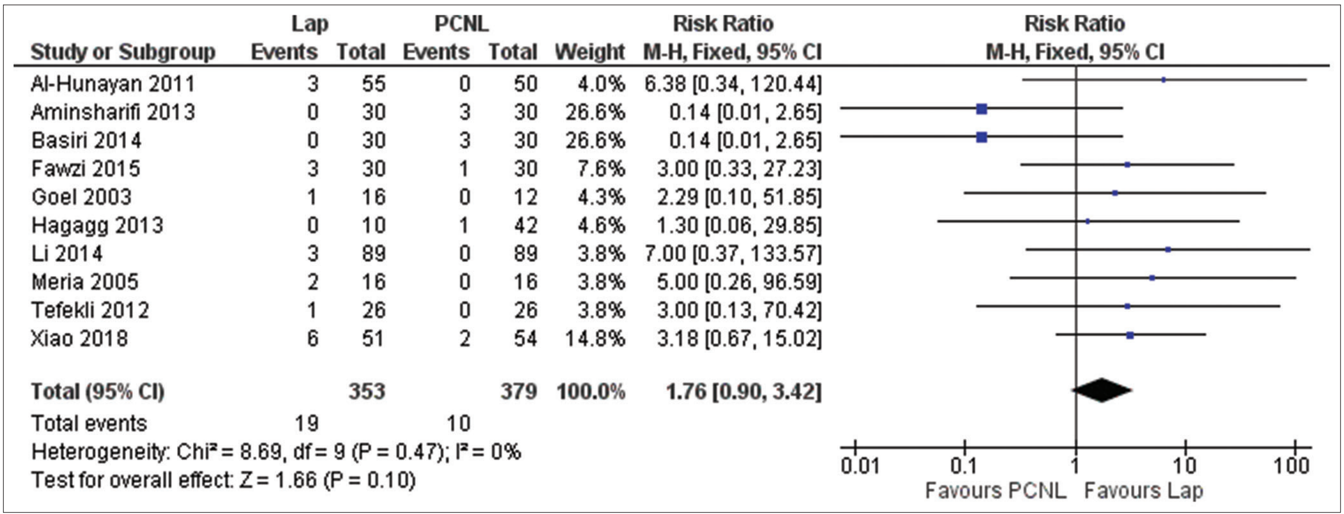

Figure 9: Forest plot of prolonged urine leakage between laparoscopic and Percutaneous nephrolithotomy

differences between two groups regarding post-operative urine leakage (RR, fixed-effect 1.76, 95% CI 0.90–3.42, p = 0.10, I^2 = 0%).

Additional interventions

The data from total of 508 patients from 6 studies, including 250 from laparoscopic and 258 from PCNL were pooled into analysis (Figure 10). Twelve patients out of 250 patients in laparoscopic group were needing additional procedures, whereas 38 from 258 patients in PCNL group need additional interventions. PCNL showed a significantly higher additional interventions rate than laparoscopic (RR, fixed-effect 0.35, 95% CI 0.19–0.62, p = 0.0004, I^2 = 0%).

Discussion

At present, PCNL is considered as a gold standard and recommended as the first choice of management for kidney stones above 2 cm and also for complex renal stones. However, laparoscopic kidney stone removal, either retroperitoneal or transperitoneal, has gained wide attention since the first report by Gaur *et al*. [23]. They recommended laparoscopic stone removal for stones not successfully treated to shockwave lithotripsy or PCNL. Meta-analysis comparing laparoscopic pyelolithotomy and PCNL for treating patients with large kidney stones have been performed previously [24], [25]. However, some randomized studies obtained different results. We carried out this meta-analysis with several additional literatures for further validation.

This study showed that laparoscopic approach achieved a higher stone-free rate than PCNL. In solitary stone, this could possible due to the stone can be removed clearly using laparoscopic approach, meanwhile in PCNL the stones or the fragmented stones could move into smaller calyces and make it harder to reached. The additional interventions might be needed due to the residual stone. This could be explained on why the additional treatment rate was higher in PCNL group than laparoscopic group. Previous study suggested the more advance additional technical approaches needed to improve stone free rate [26]. Some studies evaluated the effect of laparoscopic approach on single kidney stone cases and showed insightful results as laparoscopic approach had comparable results to PCNL for single pyelum kidney stones [8], [9]. However, laparoscopic approach might be better option for cases with complex kidney stones, such as multiple calyceal stones and complex staghorn stones.

Most included studies showed PCNL group has less operative time than laparoscopic approach. However, Gaur *et al*. and Li *et al*. reported conflicting results [14], [17]. They showed that PCNL was associated with longer operative time than laparoscopic approach. Some factors may affect operative time, including operator's experience, option of approach, armamentarium used, and variability among patient's anatomy [17]. Previous study showed the superiority of laparoscopic retroperitoneal approach as this approach less involving the vascular area than those with PCNL [17].

Laparoscopic group was associated with lower incidence of post-operative complications compared to PCNL. A decrease in hemoglobin and blood transfusion rate were more detected in PCNL group. This issue might happen due to the fact that kidney parenchymal was disturbed and invaded during the procedure. This could relate to the higher rate of complications following PCNL as compared to those in laparoscopic group. While most of the included studies reported lower estimated blood loss in laparoscopic group, Goel *et al*. and Agrawal *et al*. found the opposite findings. They reported greater blood loss in the laparoscopic group compared with PCNL group, although not statistically significant [7], [10]. There was a higher incidence of post-operative fever in PCNL group compared with laparoscopic group. However, there was a comparable result between two approaches in terms of prolonged urine leakage postoperatively.

The main drawback of laparoscopic technique is the requirement of more advance expertise as well as the learning curve of the surgeon performing it. This study showed the longer operation time in laparoscopic technique than PCNL. Nevertheless, outweighed by several beneficial outcomes in laparoscopic group, this technique is worth doing not only as an alternative management, but also as a main treatment options for large kidney stone cases.

Study or Subgroup	Lap Events	Lap Total	PCNL Events	PCNL Total	Weight	Risk Ratio M-H, Fixed, 95% CI
Basiri 2014	3	30	4	30	10.5%	0.75 [0.18, 3.07]
Gaur 2001	0	42	6	47	16.1%	0.09 [0.00, 1.48]
Li 2014	0	89	2	89	6.6%	0.20 [0.01, 4.11]
Meria 2005	2	16	3	16	7.9%	0.67 [0.13, 3.47]
Singh 2014	1	22	6	22	15.7%	0.17 [0.02, 1.27]
Xiao 2018	6	51	17	54	43.3%	0.37 [0.16, 0.87]
Total (95% CI)		**250**		**258**	**100.0%**	**0.35 [0.19, 0.62]**
Total events	12		38			

Heterogeneity: Chi² = 3.34, df = 5 (P = 0.65); I² = 0%
Test for overall effect: Z = 3.52 (P = 0.0004)

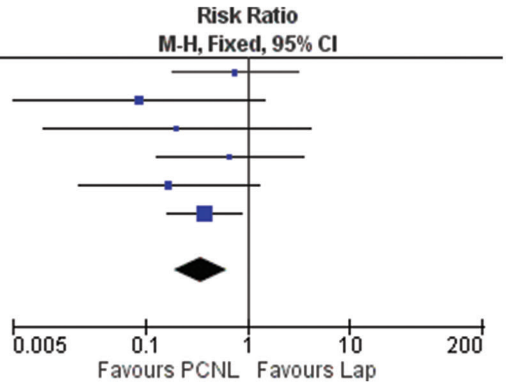

Figure 10: Forest plot regarding additional intervention between laparoscopic and Percutaneous nephrolithotomy

This study might have some possible drawbacks that should well thought of: (1) Not all of the studies included were RCTs, this might lead to some biases. More RCTs surely needed to confirm the outcomes of this meta-analysis. (2) Some data were extracted from conference abstract [13], [18], [21] that we cannot justify their methods in detail. However, these data were valuable to be included in this study.

Conclusion

Laparoscopic stone removal provided higher stone free rate and lower post-operative complications than PCNL. Laparoscopic approach could stand as a main treatment option in large kidney stone/s beside PCNL. Nevertheless, more large volume RCTs studies needed to justify the outcomes of this study.

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