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A meta analysis of the lateral decubitus position and prone position percutaneous nephrolithotomy

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Abstract
Objective To analyzed the safety and efficacy of percutaneous nephrolithotomy (PCNL) in lateral decubitus position and prone position for upper ureteral calculi. Methods Databases including PubMed, Springer, ScienceDirect, Wiley Online Library, CNKI, CSPD and VIP were searched for clinical controlled studies involved with lateral decubitus position and prone position PCNL from their establishment to November 2023.Studies were enrolled according to inclusion and exclusion criteria. the dates were compared by Review Manager 5.4 software. Results seven studies were eligible, including 807 cases. The Meta-analysis showed that, blood loss and perioperative complication rate of lateral decubitus position PCNL group were significantly different from those of the prone position PCNL group ($P < 0.05$). There was no significant difference between the two groups regarding hospital time, operative time, channel establishment time and stone-free rate ($P > 0.05$).Conclusions The lateral decubitus position can reduce blood loss and perioperative complication rate. The lateral decubitus position PCNL is safe and effective for upper ureteral calculi which was deserved clinical popularizing use.

Keywords Lateral decubitus positio, Prone position, Percutaneous nephrolithotomy, Meta-analysis

Percutaneous nephrolithotomy (PCNL) has emerged as a pivotal minimally invasive surgical approach for the management of upper urinary tract stones, owing to its merits such as minimally invasive, expeditious convalescence, and high stone-free rate. The conventional PCNL is executed in a prone position, albeit this posture is beset with drawbacks including time-consuming and laborious repositioning of the body and a substantial impact on cardiopulmonary function. Consequently, numerous domestic and foreign investigations have postulated that performing PCNL in a lateral decubitus position can also confer favorable therapeutic outcomes. In this study, we employed evidence-based medicine methodology to collate controlled studies on lateral decubitus and prone percutaneous nephrolithotomy from both local and international sources, to scrutinize the safety and efficacy of Lateral decubitus position percutaneous nephrolithotomy (PCNL), thereby furnishing an evidence-based medical rationale for the selection of PCNL body position.

Materials and methods

Inclusion criteria

① Study type: randomized controlled trial (RCT), controlled clinical trial (CCT), retrospective controlled study; ② Research subjects: patients with kidney or upper ureteral calculi diagnosed at home and abroad, who underwent PCNL in the lateral decubitus or prone

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position before surgery, and did not have urinary tract infection before surgery or had controlled infection; ③ Interventions: the experimental group underwent PCNL in the lateral decubitus position, while the control group underwent PCNL in the prone position; (4) The results of the study included indicators such as stone-free rate.

Exclusion criteria

① Research subjects with abnormal"1.2 Exclusion criteria: ① Research subjects with abnormal anatomical structures of the urinary system, pregnancy, age < 18 years old, and patients with contraindications for PCNL surgery, as well as patients with kidney stones and/or ureteral stones accompanied by severe infection; ② Patients who did not undergo PCNL in the lateral decubitus or prone position; ③ Patients who underwent non-tubectomized PCNL; ④ Studies that did not mention outcome indicators or were unable to extract corresponding values.".

Evaluation indicators

Operative time, hospital time, channel establishment time, blood loss, stone-free rate, perioperative complication rate.

Data collection

Computer retrieval of PubMed, Springer, ScienceDirect, Wiley Online Library, China National Knowledge Infrastructure (CNKI), Wanfang Chinese Journal Database (CSPD), and VIP Chinese Science and Technology Journal Database to collect all controlled studies comparing lateral decubitus position and prone percutaneous nephrolithotomy (PCNL) for the treatment of upper urinary tract stones at home and abroad. The search terms were "Lateral decubitus", "flank", "Percutaneous nephrolithotomy", "Nephrolithotomies", "Percutaneous", and "Percutaneous Nephrolithotomies". The retrieval time was from the establishment of the database to November 2023.

Data extraction and methodological evaluation

Two researchers independently selected and extracted data from the included studies. In case of disagreement, they discussed or sought the judgment of a third researcher for analysis. The methodological quality assessment of the controlled studies was conducted according to the Cochrane Collaboration's Handbook for Systematic Reviews. The main items include concealment of grouping methods, appropriateness of randomized grouping methods, correct use of blinding methods, intention-to-treat analysis, completeness of reporting data results, comparability of baseline data, and number of lost to follow-up. The quality of the literature was evaluated using the Newcastle-Ottawa Scale (a total of 9 points).

Statistical analysis

Meta-analysis was performed using Revman5.4 software provided by the Cochrane Collaboration. Heterogeneity was first assessed, and the x^2 test and I^2 test were used to evaluate heterogeneity. When $P > 0.1$ and $I^2 < 50\%$, it indicates low heterogeneity and a fixed-effects model was used. Otherwise, a random-effects model was applied. For continuous variables with the same measurement units, mean difference (MD) was used, while for variables with different measurement tools or units, standardized mean difference (SMD) was employed. For categorical variables, the odds ratio (OR) was used. All meta-analyses provided 95% confidence intervals (95%CI) and P values. A statistically significant difference was considered when $P < 0.05$.

Conclusions

General information of included studies

After retrieval and application of inclusion and exclusion criteria, a total of 7 studies [1–7] were finally included, including 5 randomized controlled trials [2,3,5–7] and 2 controlled clinical trials [1, 4]. The Newcastle-Ottawa Scale score of all included studies was greater than 5, indicating the high quality of the literature. Details are shown in Table 1.

Quality assessment of the included studies

Among the 5 randomized controlled trials [2,3,5–7] included, all used randomized grouping methods. Wang Xingyuan [2], Meng Qingze [3], and Moahmmad [7] mentioned specific random allocation schemes, while Hossein2010 [5] and Hossein2012 [6] did not mention a specific random allocation scheme. Blinding was not mentioned in any of the studies. There were no losses to follow-up or dropouts, and an intention-to-treat analysis was not performed. The data reports were relatively comprehensive, and the baseline comparability was good. Both controlled clinical trials [1, 4] did not mention blinding, had no losses to follow-up or dropouts, and did not perform intention-to-treat analysis. The data reports were relatively comprehensive, and the baseline comparability was good.".

Results of meta-analysis

Stone-free rate

A total of 7 studies [1–7] were included, all of which mentioned detailed stone-free rates. Among them, 2 studies [1, 4] only mentioned stone-free rates without mentioning the judgment index; 1 study [2] mentioned stone-free rates and judgment criteria (careful KUB examination of patients on postoperative days 3–5, with effective stones diameter < 4 cm); 1 study [2] mentioned stone-free rate and judgment criteria (KUB examination of patients on postoperative month 1, with effective stone

Table 1 Characteristics of included literature

Included studies	Study type	Group	Number of cases	Mean age (years)	Male/Female	Surgical outcome stone-free rate	operative time (min)	blood loss (ml)	hospital time (d)	channel establishment time (min)	perioperative complication rate	Literature quality score
Liu [1]	Case-control study	Lateral decubitus position; prone position	63	41.5 ± 6.7	34/29	53(84.1)	64.50 ± 33.80	—	—	—	4(6.34)	6
			69	44.3 ± 8.2	32/37	55(79.1)	59.60 ± 29.50	—	—	—	6(8.70)	
Wang [2]	Case-control study	Lateral decubitus position; prone position	65	55.15 ± 5.18	38/27	60(92.31)	108.54 ± 20.13	82.13 ± 11.74	7.03 ± 1.48	—	2(3.08)	7
			65	54.58 ± 5.32	39/26	48(73.85)	132.48 ± 18.61	99.70 ± 16.15	9.04 ± 2.01	—	15(23.08)	
Meng [3]	Case-control study	Lateral decubitus position; prone position	50	40.24 ± 7.55	31/19	45(90.0)	152.92 ± 19.33	47.98 ± 5.86	28.85 ± 8.12	6.10 ± 1.30	7(14.00)	7
			50	43.67 ± 10.49	28/22	40(80.0)	169.72 ± 21.23	55.60 ± 8.01	14.68 ± 5.24	7.00 ± 1.62	11(22.00)	
Hu [4]	Case-control study	Lateral decubitus position; prone position	45	42.8 ± 4.5	26/19	43 (95.6)	78.30 ± 7.80	81.60 ± 60.50	6.20 ± 0.50	—	1 (2.20)	6
			40	43.5 ± 4.8	23/17	32 (80.0)	82.80 ± 8.40	115.80 ± 62.90	7.10 ± 0.80	—	2 (5.00)	
Hossein [5]	Case-control study	Lateral decubitus position; prone position	30	40.8 ± 6.9	18/12	26(86.7)	44.7 ± 6.4	—	2.7 ± 0.3	14.5 ± 2.6	3(10.00)	7
			30	39.4 ± 10.6	19/11	27(90.0)	34.9 ± 5.1	—	2.9 ± 0.3	9.4 ± 2.3	2(6.70)	
Hossein 2012	Case-control study	Lateral decubitus position; prone position	50	40.7 ± 8.4	31/19	44(88.0)	74.4 ± 26.9	—	2.6 ± 0.6	10.8 ± 4.1	8(16.00)	7
			50	41.5 ± 8.8	31/19	46(92.0)	68.7 ± 37.4	—	2.6 ± 0.6	6.9 ± 4.2	6(12.00)	
Moahmmad [7]	Case-control study	Lateral decubitus position; prone position	100	42.34 ± 6.62	61/39	85(85.0)	61.4 ± 6.4	—	3.41 ± 0.52	11.8 ± 4.2	5(5.00)	7
			100	44.03 ± 7.22	54/46	87(87.0)	59.2 ± 7.8	—	3.24 ± 0.72	12.6 ± 3.2	8(8.00))	

length ≤ 5 mm); 1 study [5] mentioned stone-free rate and judgment criteria (abdominal X-ray or renal ultrasound examination of patients on postoperative month 1, with effective stone size < 4 mm); 1 study [6] mentioned stone-free rate and judgment criteria (abdominal CT examination of patients on postoperative month 1, with effective stone size ≤ 3 mm); 1 study [7] mentioned stone-free rate and judgment criteria (ultrasound and KUB examination of patients on postoperative week 2, with effective stone size < 4 mm). The overall stone clearance rate was: 88.34% in the lateral decubitus position group (356/403), and 82.92% in the prone position group (335/404). A heterogeneity test was first performed. According to the level of heterogeneity testing, the chi-square test indicated that there was a heterogeneity difference among the studies on stone clearance rate (P=0.09, I^2 = 45%), and a random effects model (Random-effects model, RE) should be used for this Meta analysis, with OR as the combined statistical index. The results of Meta analysis showed that there was no significant difference in stone-free rate between the lateral decubitus PCNL group and the prone PCNL group [OR = 1.55, 95%CI (0.86,2.78), P = 0.14], P > 0.05, and there was no statistically significant difference in stone-free rate between lateral decubitus PCNL and prone PCNL (Fig. 1). The funnel plot (Fig. 2) shows that the literature is evenly distributed on both sides of the vertical line in the funnel plot, indicating that there is no obvious publication bias for including this outcome indicator.

Operative time

A total of 7 studies [1–7] with detailed operative time were included. A total of 403 cases in the lateral decubitus and 404 cases in the prone position were included. The heterogeneity test was first performed. According to the level of heterogeneity testing, the chi-square test indicated that there was a heterogeneity difference among the studies on stone (P < 0.00001, I^2 = 95%), and a random effects model should be used for this Meta analysis, with MD as the combined statistical index. The results of Meta analysis showed that there was no significant difference in operative time between the lateral decubitus PCNL group and the prone PCNL group [MD=-3.37, 95%CI (-10.81,4.08), P = 0.38], P > 0.05, and there was no statistically significant difference in operative time between the lateral decubitus PCNL and prone PCNL (Fig. 3). The funnel plot (Fig. 4) shows that the literature is evenly distributed on both sides of the vertical line in the funnel plot, indicating that there is no obvious publication bias for including this outcome indicator.

Blood loss

A total of 3 studies [3–5] with reported surgical blood loss were included. A total of 160 cases in the lateral

Study or Subgroup	the lateral decubitus position Events	Total	the prone position Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Hossein 2010	26	30	27	30	9.6%	0.72 [0.15, 3.54]
Hossein 2012	44	50	46	50	12.2%	0.64 [0.17, 2.41]
Hu 2020	43	45	32	40	9.4%	5.38 [1.07, 27.04]
Liu 2013	53	63	55	69	18.5%	1.35 [0.55, 3.30]
Meng 2019	45	50	40	50	14.4%	2.25 [0.71, 7.14]
Moahmmad 2021	85	100	87	100	20.3%	0.85 [0.38, 1.89]
Wang 2018	60	65	48	65	15.7%	4.25 [1.46, 12.35]
Total (95% CI)		**403**		**404**	**100.0%**	**1.55 [0.86, 2.78]**
Total events	356		335			

Heterogeneity: Tau² = 0.27; Chi² = 10.98, df = 6 (P = 0.09); I² = 45%
Test for overall effect: Z = 1.46 (P = 0.14)

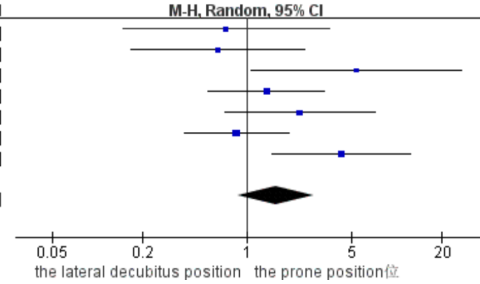

Fig. 1 Forest plot comparing stone-free rate of lateral decubitus and prone PCNL

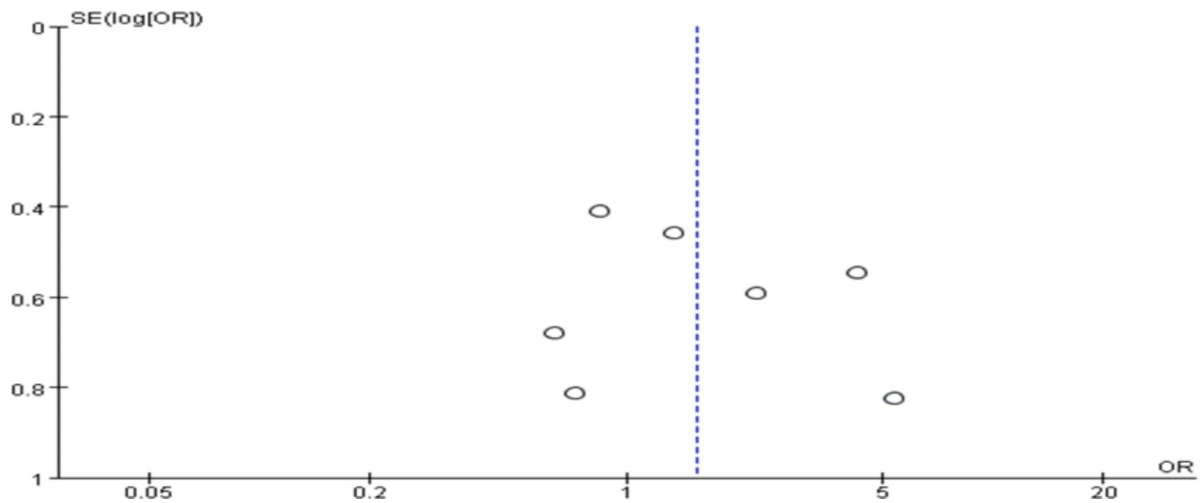

Fig. 2 Funnel plot of publication bias for comparison of stone-free rate between lateral decubitus and prone PCNL

Study or Subgroup	the lateral decubitus position Mean	SD	Total	the prone position Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Hossein 2010	44.7	6.4	30	34.9	5.1	30	16.1%	9.80 [6.87, 12.73]
Hossein 2012	74.4	26.9	50	68.7	37.4	50	11.1%	5.70 [-7.07, 18.47]
Hu 2020	78.3	7.8	45	82.8	8.4	40	15.9%	-4.50 [-7.96, -1.04]
Liu 2013	64.5	33.8	63	59.6	29.5	69	12.2%	4.90 [-5.97, 15.77]
Meng 2019	152.92	19.33	50	169.72	21.23	50	13.9%	-16.80 [-24.76, -8.84]
Moahmmad 2021	61.4	6.4	100	59.2	7.8	100	16.3%	2.20 [0.22, 4.18]
Wang 2018	108.54	20.13	65	132.48	18.61	65	14.6%	-23.94 [-30.60, -17.28]
Total (95% CI)			**403**			**404**	**100.0%**	**-3.37 [-10.81, 4.08]**

Heterogeneity: Tau² = 87.60; Chi² = 119.78, df = 6 (P < 0.00001); I² = 95%
Test for overall effect: Z = 0.89 (P = 0.38)

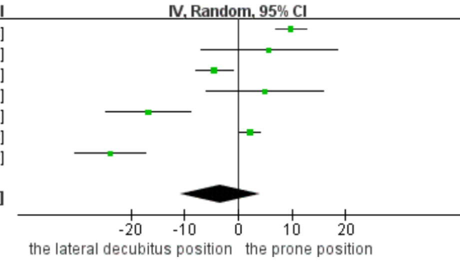

Fig. 3 Forest plot comparing operative time between lateral decubitus and prone PCNL

decubitus position and 155 cases in the prone position were included. The heterogeneity test was first performed. According to the level of heterogeneity testing, the chi-square test indicated that there was a heterogeneity difference among the studies on stone (P=0.0004, I^2=87%), and a random effects model should be used for this Meta analysis, with MD as the combined statistical index. The results of Meta analysis showed that there was a significant difference in blood loss between the lateral decubitus PCNL group and the prone PCNL group [MD=-14.77, 95%CI (-24.60, -4.93), P=0.003], P<0.05, and there was a statistically significant difference in blood loss between lateral decubitus PCNL and prone PCNL (Fig. 5), with less blood loss in lateral decubitus PCNL than in prone PCNL. The funnel plot (Fig. 6) shows that the literature is evenly distributed on both sides of the vertical line in the funnel plot, indicating that there is no obvious publication bias for including this outcome indicator.

Hospital time

A total of 6 studies [2–7] with detailed hospital time were included. A total of 340 cases in the lateral decubitus position and 335 cases in the prone position were included. The heterogeneity test was first performed. According to the level of heterogeneity testing, the

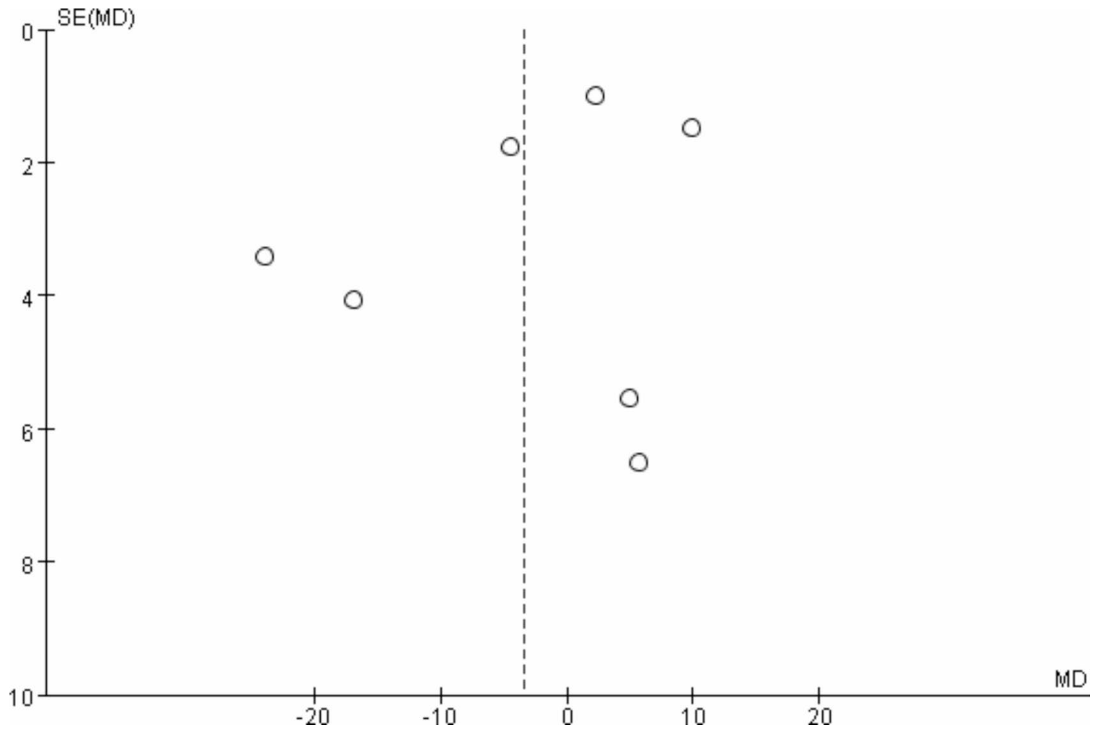

Fig. 4 Funnel plot for publication bias in the comparison of operative time between lateral decubitus and prone PCNL

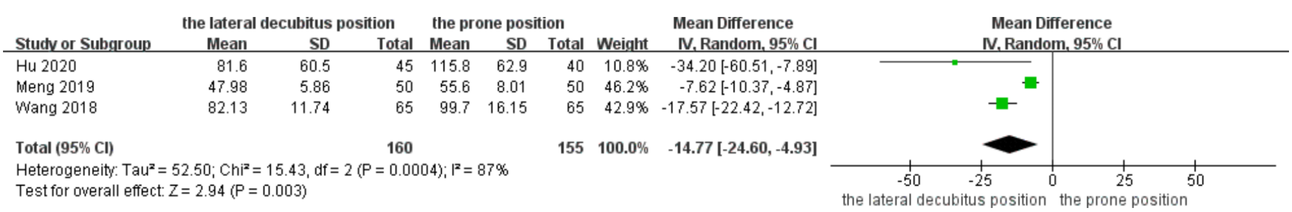

Fig. 5 Forest plot comparing the blood loss during PCNL surgery between lateral decubitus and prone positions

chi-square test indicated that there was a heterogeneity difference among the studies on stone ($P<0.00001$, $I^2=97\%$), and a random effects model should be used for this Meta analysis, with MD as the combined statistical index. The results of Meta analysis showed that there was no significant difference in hospital time between the lateral decubitus PCNL group and the prone PCNL group [MD=0.17, 95%CI (0.51,0.85), $P=0.63$], $P>0.05$, and there was no statistically significant difference in hospital time between lateral decubitus PCNL and prone PCNL (Fig. 7). The funnel plot (Fig. 8) shows that the literature is evenly distributed on both sides of the vertical line in the funnel plot, indicating that there is no obvious publication bias for including this outcome indicator.

Channel establishment time

A total of 4 studies [3, 5–7] with detailed channel establishment time were included. A total of 230 cases in the lateral decubitus position and 230 cases in the prone position were included. The heterogeneity test was first performed. According to the level of heterogeneity testing, the chi-square test indicated that there was a heterogeneity difference among the studies on stone ($P<0.00001$, $I^2=97\%$), and a random effects model should be used for this Meta analysis, with MD as the combined statistical index. The results of Meta analysis showed that there was no significant difference in channel establishment time between the lateral decubitus PCNL group and the prone PCNL group [MD=1.78, 95%CI (-1.15,4.70), $P=0.23$], $P>0.05$, and there was no statistically significant difference in channel establishment time between lateral decubitus PCNL and prone PCNL (Fig. 9). The funnel plot (Fig. 10) shows that the literature is evenly distributed on both sides of the vertical line in the funnel plot, indicating that there is no obvious publication bias for including this outcome indicator.

Perioperative complication rate

A total of 7 studies [1–7] provided data on perioperative complication rates, including fever, bleeding, infection,

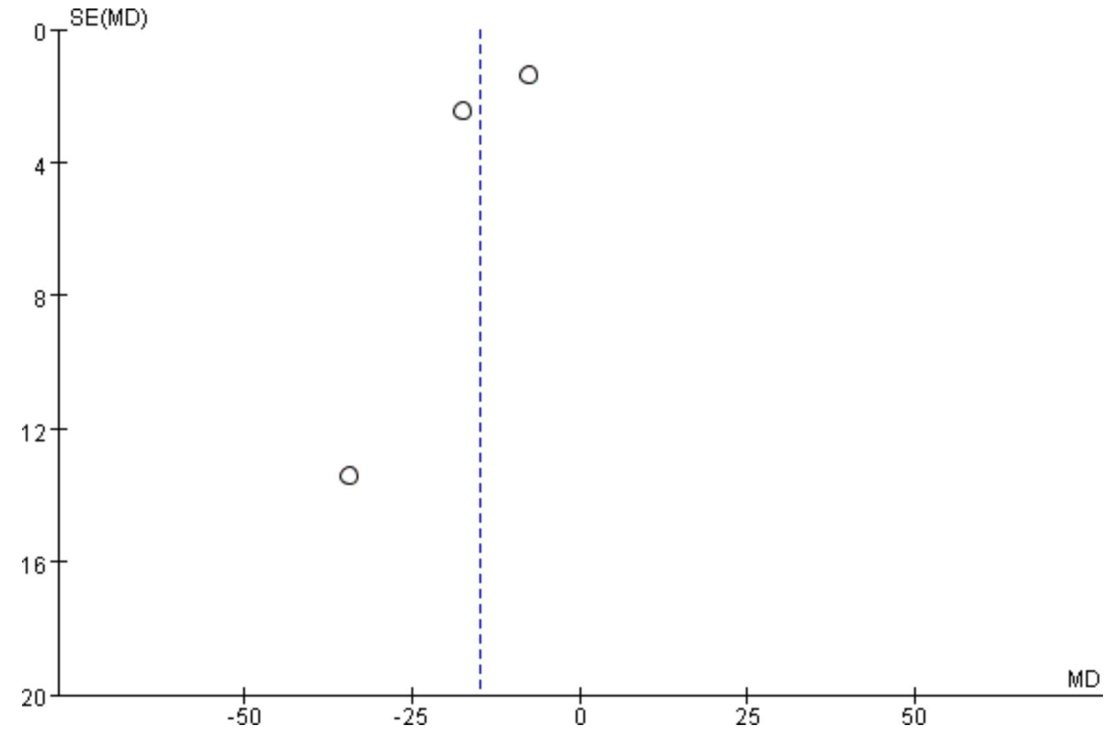

Fig. 6 Funnel plot comparing the publication bias for the comparison of blood loss during PCNL surgery between lateral decubitus and prone positions

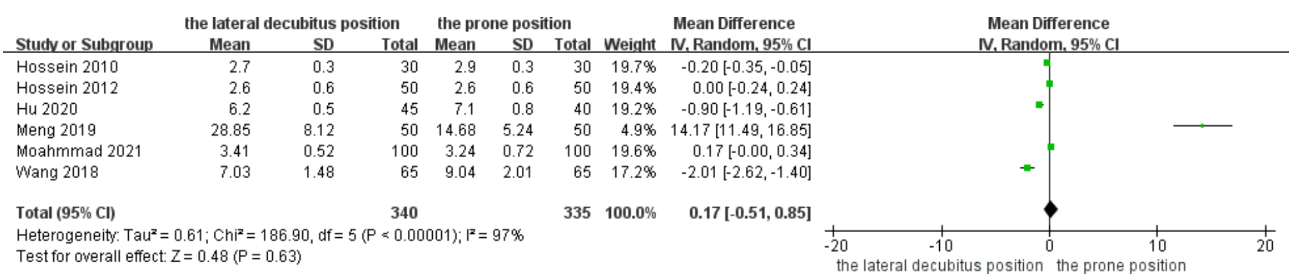

Fig. 7 Forest plot comparing hospital time between lateral decubitus and prone PCNL positions

kidney and surrounding organ injury, chills, pleural effusion, dyspnea, etc. A total of 403 cases in the lateral decubitus position and 404 cases in the prone position were included. The heterogeneity test was first performed. According to the level of heterogeneity testing, the chi-square test indicated that there was no significant heterogeneity among the studies on stone ($P=0.21$, $I^2=28\%$), and a fixed effects model should be used for this Meta analysis, with OR as the combined statistical index. The results of Meta analysis showed that there was a significant difference in the perioperative complication rates, between the lateral decubitus PCNL group and the prone PCNL group [OR=0.57, 95%CI (0.35,0.92), $P=0.02$], $P<0.05$, and there was a statistically significant difference in the comparison of perioperative complication rates between lateral decubitus PCNL and prone PCNL (Fig. 11), with a lower complication rate in lateral decubitus PCNL than in prone PCNL. The funnel plot (Fig. 12) shows that the literature is evenly distributed on both sides of the vertical line in the funnel plot, indicating that there is no obvious publication bias for including this outcome indicator.

Discussion

Upper urinary tract stone disease is a common disease in urology. Currently, percutaneous nephrolithotomy has gradually become the gold standard for the treatment of upper urinary tract stones. The prone position is the earliest and most classic surgical position used in PCNL, but it can cause compression of the heart, lungs, and abdomen, leading to hemodynamic and ventilatory dysfunction and an increased risk of cardiovascular accidents [8]. The prone position is also contraindicated for anesthesia management, and if respiratory or circulatory problems occur, it is difficult to implement emergency treatment due to the limitations of the body position. Additionally,

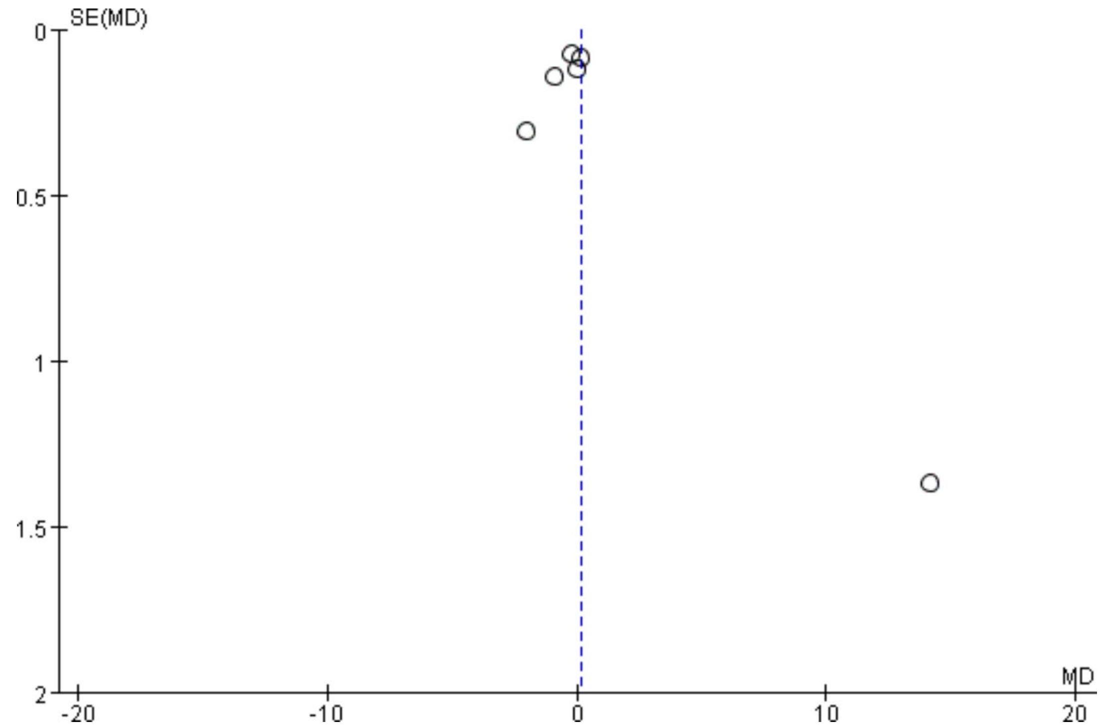

Fig. 8 Funnel plot comparing publication bias for the comparison of hospital time duration between lateral decubitus and prone positions for PCNL

Study or Subgroup	the lateral decubitus position Mean	SD	Total	the prone position Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Hossein 2010	14.5	2.6	30	9.4	2.3	30	24.9%	5.10 [3.86, 6.34]
Hossein 2012	10.8	4.1	50	6.9	4.2	50	24.1%	3.90 [2.27, 5.53]
Meng 2019	6.1	1.3	50	7	1.62	50	25.8%	-0.90 [-1.48, -0.32]
Moahmmad 2021	11.8	4.2	100	12.6	3.2	100	25.2%	-0.80 [-1.83, 0.23]
Total (95% CI)			**230**			**230**	**100.0%**	**1.78 [-1.15, 4.70]**

Heterogeneity: Tau² = 8.57; Chi² = 97.18, df = 3 (P < 0.00001); I² = 97%
Test for overall effect: Z = 1.19 (P = 0.23)

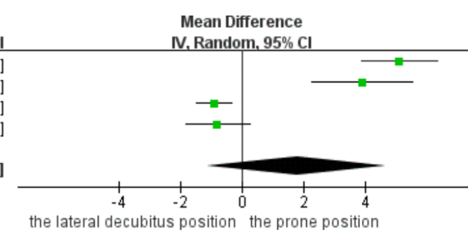

Fig. 9 Forest plot comparing the channel establishment time between lateral decubitus and prone positions for PCNL

changing the patient's position requires cooperation from multiple people and is inconvenient [9–10]. The lateral decubitus position is also the most commonly used position in many urological surgeries. In recent years, many hospitals have adopted this position for PCNL and have conducted numerous clinical comparative studies with the traditional prone position. Compared with the prone position, this position has the following advantages: ① It can elevate the healthy side of the patient's waist with the aid of a lumbar bridge, expanding the surgical puncture area and operating space; ② By adjusting the patient's head-up, foot-down position, the kidney can be moved down, reducing the rate of pleural injury caused by puncture through the 11th intercostal space to the 12th intercostal space; ③ During the lateral decubitus position, the patient's intestines hang down to the opposite side, which also reduces the risk of intestinal injury; ④ The lateral decubitus position can also move the peritoneum forward, protecting the patient's peritoneum from injury [11]; ⑤ The lateral decubitus position can raise the patient's stone location, which can promote small stones to fall into the renal pelvis under the impact of stone crushing and gravity, making it easier to remove them; ⑥ If massive bleeding or other risks occur during the operation, there is no need to change the patient's position, and immediate conversion to an open procedure can be performed to save the patient's life; ⑦ This position has little effect on the patient's respiratory and circulatory function during surgery, is beneficial for anesthesia, and is suitable for high-risk patients (ASA score III or higher) [12], as well as obese patients. For patients with kidney stones combined with spinal deformities, using the lateral decubitus position for PCNL can also achieve good therapeutic results [13]. Therefore, using the lateral decubitus position for PCNL can improve the patient's intraoperative adaptability and tolerance, reduce the impact on the patient's cardiopulmonary function, and is especially suitable for obese, elderly, and cardiopulmonary insufficient patients with kidney stones, expanding the indications for minimally invasive percutaneous

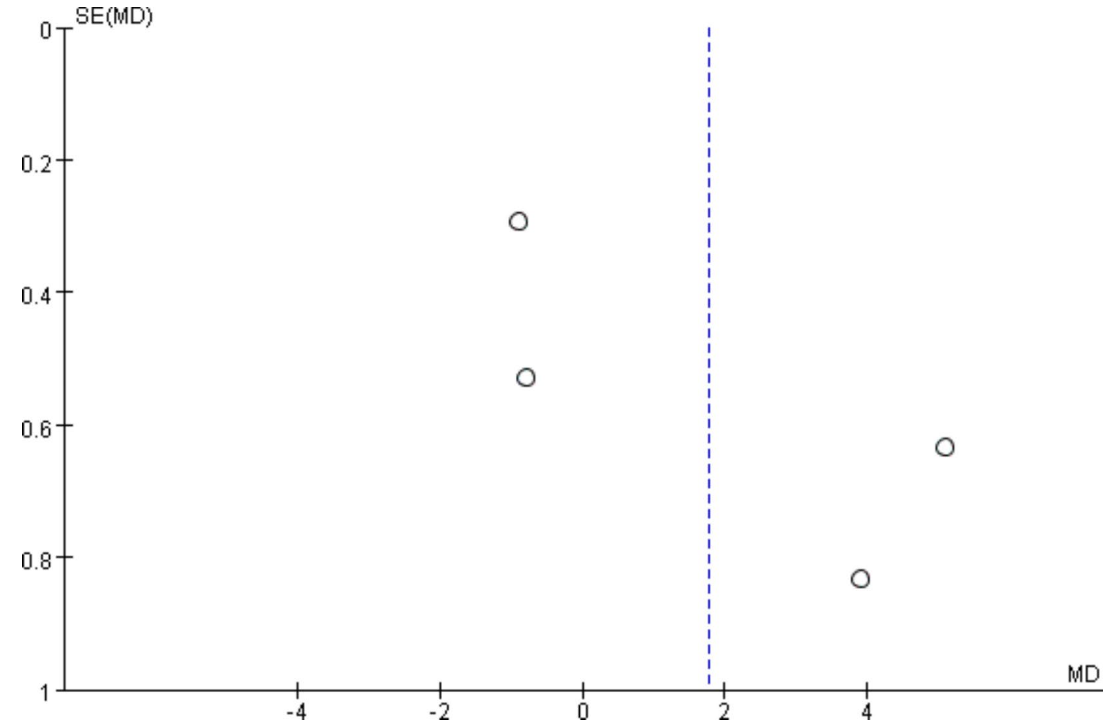

Fig. 10 Funnel plot comparing publication bias for the comparison of the channel establishment time between lateral decubitus and prone positions for PCNL

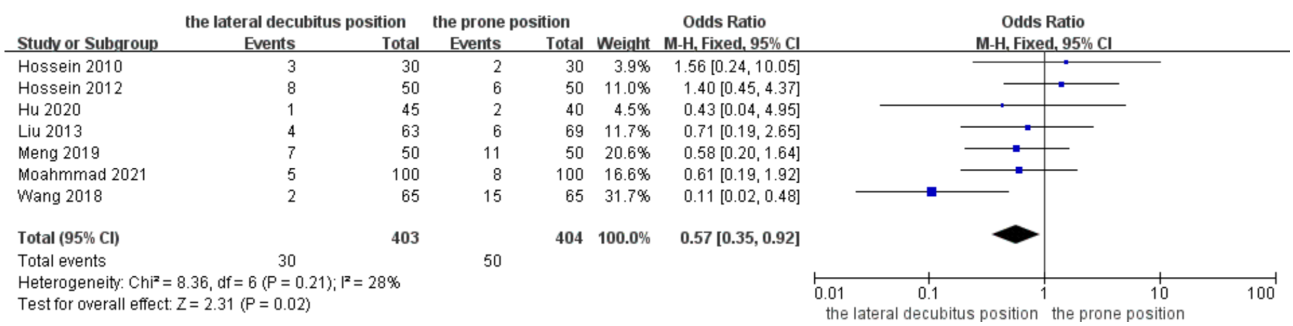

Fig. 11 Forest plot comparing the total perioperative complication rate between lateral decubitus and prone positions for PCNL

nephrolithotomy [14–15]. At the same time, when using the lateral decubitus position for PCNL, it can avoid related adverse events risks, facilitate anesthesia monitoring, shorten the operation time, reduce blood loss, and improve surgical safety [16]. This study collected and analyzed all randomized controlled trials of lateral decubitus and prone positions for PCNL in the treatment of upper urinary tract stones published between database establishment and November 2023. After strict screening, a total of six clinical randomized controlled trials with six research indicators and a total of 807 cases were included in the Meta analysis. The results of this Meta analysis showed that compared with prone PCNL, lateral decubitus PCNL had advantages in terms of blood loss and perioperative complication rates ($P<0.05$), while there was no significant difference in terms of hospital time、operative time、channel establishment time and stone-free rate ($P>0.05$). This indicates that the lateral decubitus position for PCNL is safe and effective and has more advantages than the prone position for PCNL. It is worth promoting in clinical practice.

There was no statistically significant difference in operative time, hospital time, and channel establishment time between lateral decubitus position PCNL and prone position PCNL. When performing heterogeneity analysis of the included literature, it was indicated that the heterogeneity of the literature was significant, which was respectively: $I^2=95\%$, $I^2=97\%$, $I^2=97\%$. Due to the high heterogeneity, sensitivity analysis was conducted for operative time, hospital time, and channel establishment time by eliminating studies one by one respectively, and it was found that the reduction of heterogeneity was not

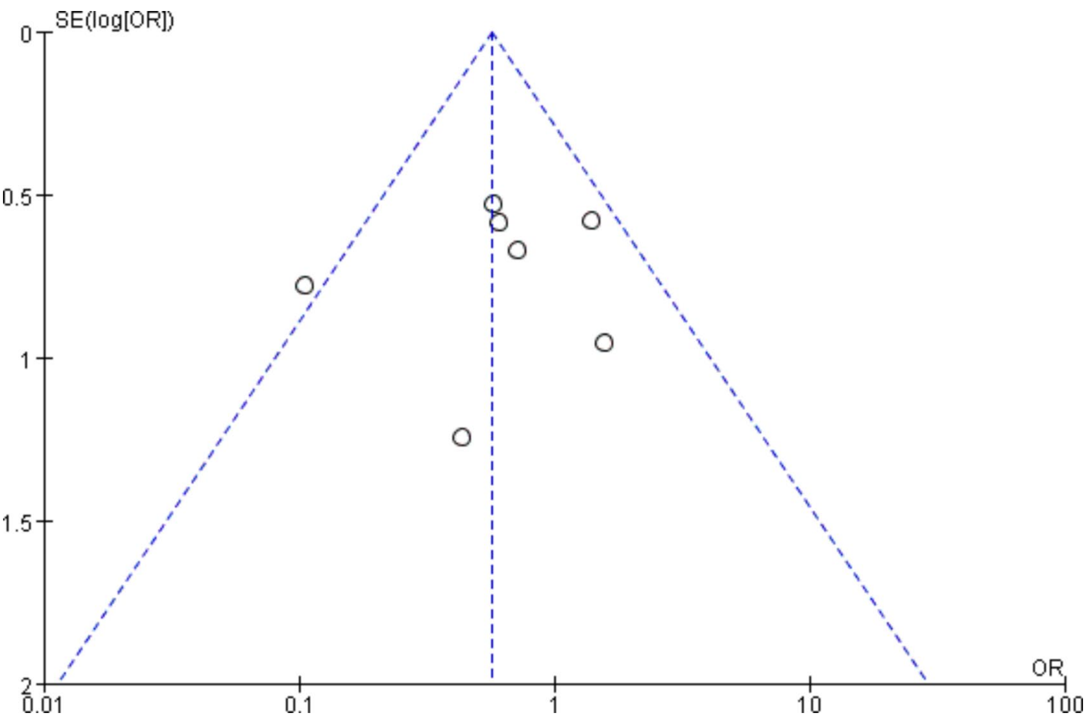

Fig. 12 Funnel plot comparing publication bias for the comparison of total perioperative complication rate during the perioperative period between lateral decubitus and prone positions for PCNL

obvious. Considering the heterogeneity of hospital time, it may result from the fact that the included literature did not strictly stipulate the discharge conditions of patients, thus leading to differences in discharge criteria among different literature. The source of heterogeneity in operation time may be: (1) Different complexities of stones; (2) Differences in the size of the channel used in percutaneous nephrolithotomy; (3) The learning curve effect. In PCNL surgery, different operators have different techniques and proficiency levels, which will lead to certain differences in the time of lithotripsy and stone removal. (4) Different ways of puncture positioning, including ultrasound and fluoroscopy. Different positioning methods require different times. The heterogeneity of hospital time may result from the fact that the included literature did not strictly stipulate the discharge conditions of patients, thus leading to differences in discharge criteria among different literature. In terms of channel establishment time, the following sources of heterogeneity may exist: (1) Different puncture positioning methods, including different positioning methods such as ultrasound and fluoroscopy, and the time required for establishing the channel will also be different; (2) Differences in the size of the channel for percutaneous nephrolithotomy. In the included literature, the size of the channel selected for percutaneous nephrolithotomy was inconsistent, which would affect the time for establishing the channel; (3) Differences in the technical level and proficiency of the operator may lead to different times required for puncture and establishment of the surgical channel.

This meta-analysis has several limitations. Firstly, the limited number of literatures included in the analysis, which come from multiple medical centers, may cause some differences in the quantification of the outcome indicators and introduce a certain degree of heterogeneity in the statistical results. Secondly, only 5 randomized controlled trials were included in this meta-analysis study, and the rest were non-randomized controlled trials, which inevitably introduced bias. Therefore, we look forward to more multi-center randomized controlled clinical studies with a larger number of cases in the future to explore the safety and effectiveness of the two position surgical methods in the clinic more deeply. This will provide more accurate and reliable theoretical basis for better selection of PCNL positions and better guide clinical work.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Author contributions

YYD.SPC.CSY. searched the literature, YYD. wrote the manuscript, YYD. and CSY. revised the manuscript, and all authors reviewed the final version of the manuscript.

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Data availability
Data is provided within the manuscript.

Declarations

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This study does not involve "ethical approval and consent to participate".

Consent for publication
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The authors declare no competing interests.

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