An Update on Supine Versus Prone Percutaneous Nephrolithotomy: A Meta-analysis

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Purpose: To compare results of studies on supine and prone percutaneous nephrolithotomy (PCNL) techniques to find the best position for treating kidney stones.

Materials and Methods: A systematic literature review was done in April 2016 using PubMed, Scopus, and Web of Science databases to identify the relevant studies. Article selection was based on the preferred reporting elements of systematic reviews and meta-analysis criteria. A subgroup analysis was done comparing standard prone and supine PCNLs separately.

Results: Twenty studies were selected for the analysis including 7733 PCNL cases: 2110 cases were (27.3%) in supine and 5623 cases were (72.7%) in prone position. Supine and prone PCNL had a similar stone-free rate (OR: 0.95; 95% CI: 0.70-1.27; $P = .73$), operation time (difference in means = -0.01, 95% CI: -0.07 to 0.03; $P = .53$), hospital stay (difference in means = -0.01, 95% CI: -0.07 to 0.03; $P = .52$), complication rate (OR: 0.88; 95% CI: 0.76-1.02; $P = .09$) and urinary leakage (OR: 1.14; 95% CI: 0.50-2.59; $P = .75$). However, patients received less blood transfusion (OR: 0.72; 95% CI: 0.55-0.94; $P = .01$) and had less fever rates (OR: 0.65; 95% CI: 0.52-0.80; $P < 0.001$) in supine PCNL.

Conclusion: Supine PCNL has similar stone-free rate, operation time, and hospital stay relative to prone PCNL. However, the supine position has the advantage of less fever and need for blood transfusion. Although both prone and supine PCNLs are suggested for treatment, supine PCNL may have advantages especially in patients with comorbidity.

Keywords: complication; hospital stay; operative time; prone; percutaneous nephrolithotomy; stone free rate; supine

INTRODUCTION

In the past two decades nearly all open surgeries have been converted to minimally invasive procedures in patients with kidney stones because of the progress in endourology surgical techniques[1]. Percutaneous nephrolithotomy (PCNL) is now the standard procedure for the treatment of large kidney stones[2], but its higher stone-free rate is associated with potentially more complication[3]. PCNL has been routinely performed in the prone position. However, after Valdivia introduced the supine position for PCNL in the late 1980s, this position became a routine in many centers[1]. Both supine and prone positions have their own advantages and complications. For example, although prone position makes a wider area for device management, i.e. more space for puncture site, theoretically it requires turning the patient and there is a chance of nerve, neck, nose and limb injuries. Also, the prone position is associated with an increased radiological hazard to the surgeon and needs additional personnel for changing intraoperative position. Moreover, diseases like severe spine disease or ankylosing spondylitis are relative contraindications for prone PCNL. The prone position may be problematic for patients with severe cardiopulmonary disease and morbid obesity[4,5]. While , a study has reported less complications in the prone position[6]. In supine position, the kidney is in anatomical region that requires less mobility, resulting in easier puncture and dilatation. Fluoroscopy is less demanding in supine position with less X-ray exposure for the surgeon. Because of gravity and fewer intra-calyceal forces, stone residue clearance is also higher[7,8]. A recent meta-analysis had compared supine versus prone PCNL[9]. Based on our experience in supine PCNL, we added two publications of our center to this analysis. Furthermore, two randomized clinical trials and one new prospective study were added to update the mentioned meta-analysis. Assessing the effectiveness and complications of endourologic procedures is challenging. Studies in this area have evaluated different techniques, preoperative care, intraoperative instruments and postoperative management. We designed this meta-analysis to systematically describe the most newly available data of adults who had undergone PCNL in supine and prone positions to compare their stone free rate, operation time, hospital stay and complications.

MATERIALS AND METHODS

This systematic literature review was done in April

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Table 1: Characteristics and quality assessment scoring studies included in our meta-analysis

Author	Year	Study design	Number of patient (prone/supine)	Male/Female	Age(years)	Quality score
Ashraf A	2013	RCT	60 (30/30)	29/31	35	5
Al-Dessoukey A	2014	RCT	203 (102/101)	136/67	36	9
Basiri A	2013	RCT	89 (46/43)	61/28	45	8
De Sio M	2008	RCT	75 (36/39)	33/42	39	6
Falahatkar S	2011	RCT	33 (15/18)	25/8	48	9
Falahatkar S	2008	RCT	80 (40/40)	41/39	44	8
Falahatkar S	2012	RCT	110 (50/60)	57/53	45	8
Karami H	2013	RCT	100 (50/50)	65/35	43	9
Llanes L	2013	Retrospective	317 (183/134)	198/119	53	7
Mazzucchi E	2012	Retrospective	42 (12/30)	14/28	46	7
McCahy P	2013	Retrospective	72 (36/36)	-	53	7
Mehrabi S	2014	RCT	60 (31/29)	31/29	41	6
Sanguedolce F	2013	Retrospective	117 (52/65)	69/48	51	9
Sesmero A	2008	Retrospective	104 (54/50)	53/51	54	8
Shoma A	2002	Retrospective	130 (77/53)	77/53	46	5
Sofer M	2016	Prospective	45 (20/25)	31/14	51	5
Valdivia J	2011	Retrospective	5775 (4637/1138)	3256/2519	49	8
Wang Y	2012	Retrospective	122 (62/60)	62/60	43	8
Wang Y	2013	RCT	18 (12/6)	12/6	44	7
Zhan H	2013	RCT	109 (56/53)	74/35	44	8

Abbreviation: RCT, randomized clinical trial.

2016 using PubMed, Scopus, and Web of Science databases to identify relevant studies. Searches were restricted to Studies published after year 2000 in English and Farsi (contemporary Persian) languages which were on adults who had undergone PCNL. Separate searches were done with the following search terms: supine percutaneous nephrolithotomy, prone percutaneous nephrolithotomy, supine PCNL, and prone PCNL.

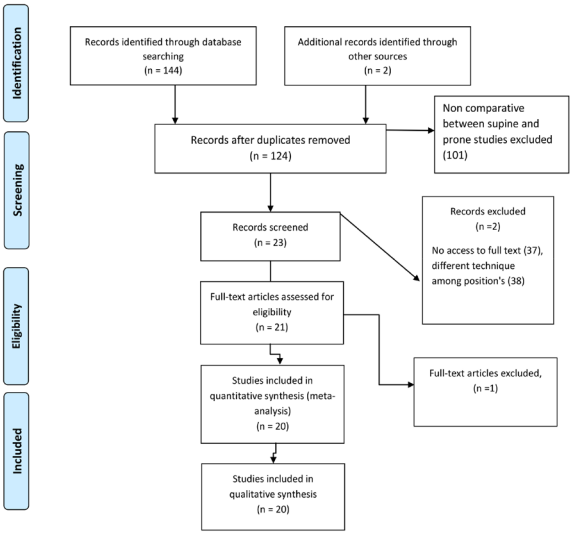

Figure 1: Flowchart of the study

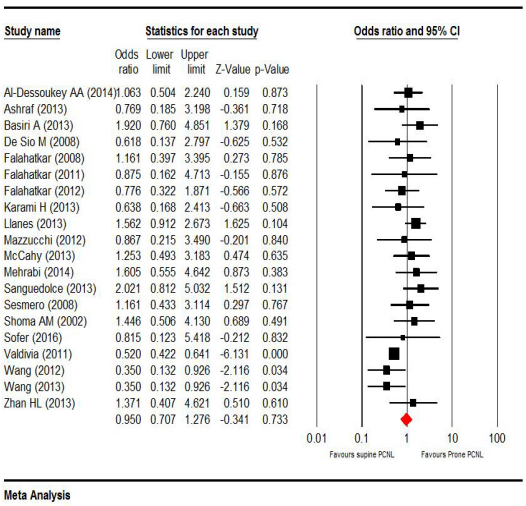

Figure 2. Stone free rate in supine versus prone positions of percutaneous nephrolithotomy.

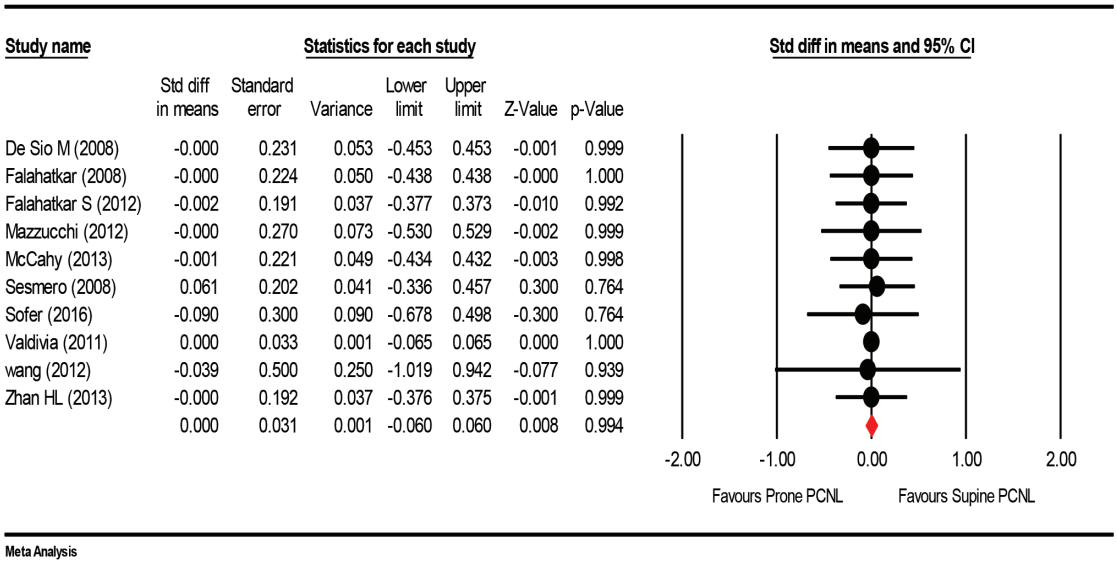

Figure 3. Operation time in supine versus prone positions of percutaneous nephrolithotomy

Article selection proceeded according to the search strategy of Preferred Reporting Items for Systematic Reviews and Meta-analysis criteria (www.prisma-statement.org). Only studies comparing supine and prone PCNLs were included for further screening. The cited references from the selected articles that were retrieved in the search were also assessed for finding significant papers. We also included retrospective studies that met our outcome. Our center has published three articles, two of which were in the same time but with different populations. We also included modified supine PCNL, and a study that compared mini-PCNL in supine and prone positions. Conference abstracts were not included because they were not deemed to be methodologically appropriate. (**Figure 1**)

Assessment of study quality

Two reviewers (urologists with expertise in supine and prone PCNLs and research strategies) reviewed the full texts of all studies and scored their quality. Any disagreements were settled by consensus. We compared preoperative demographic characteristics as well as perioperative and postoperative outcomes between the two procedures.

Statistical analysis

A meta-analysis was done to assess the overall outcomes of supine PCNL compared with prone PCNL. Extracted data for the analysis included operation time, estimated blood loss, duration of hospital stay, stone free and postoperative complication rates. Odds ratio (OR) was used for binary variables, and mean difference or standardized mean difference was used for the continuous parameters. We performed our meta-analysis by comprehensive Meta-Analysis software (version 2.2.064). Effect size and statistical analysis methods were selected according to data type. For continuous variables we used standardized mean difference. For categorical variables, statistical analysis was done by OR and 95% confidence interval (CI). Heterogeneity among the studies was measured using chi-squared statistics (P = .05), fixed effect models were considered for homogeneous data, and random effects analysis was calculated for heterogeneous data. The results of the meta-analysis were presented by forest graphs. We

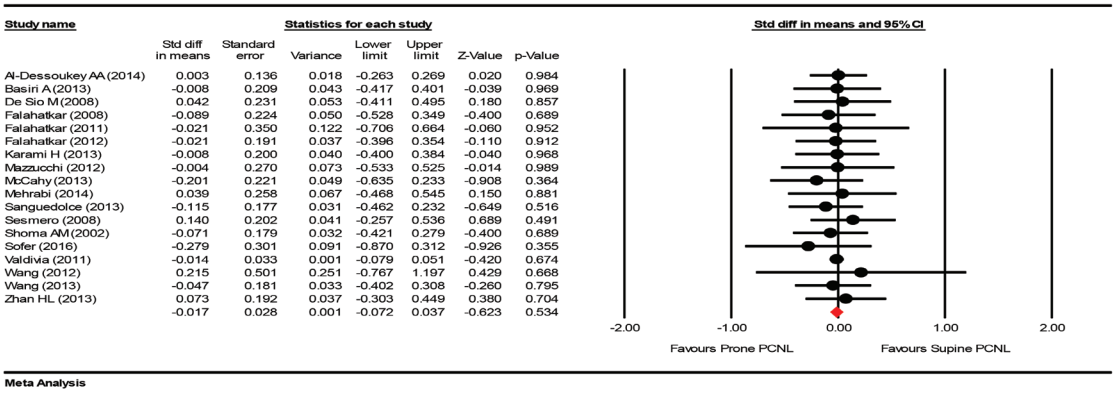

Figure 4. Hospital stay in supine versus prone positions of percutaneous nephrolithotomy

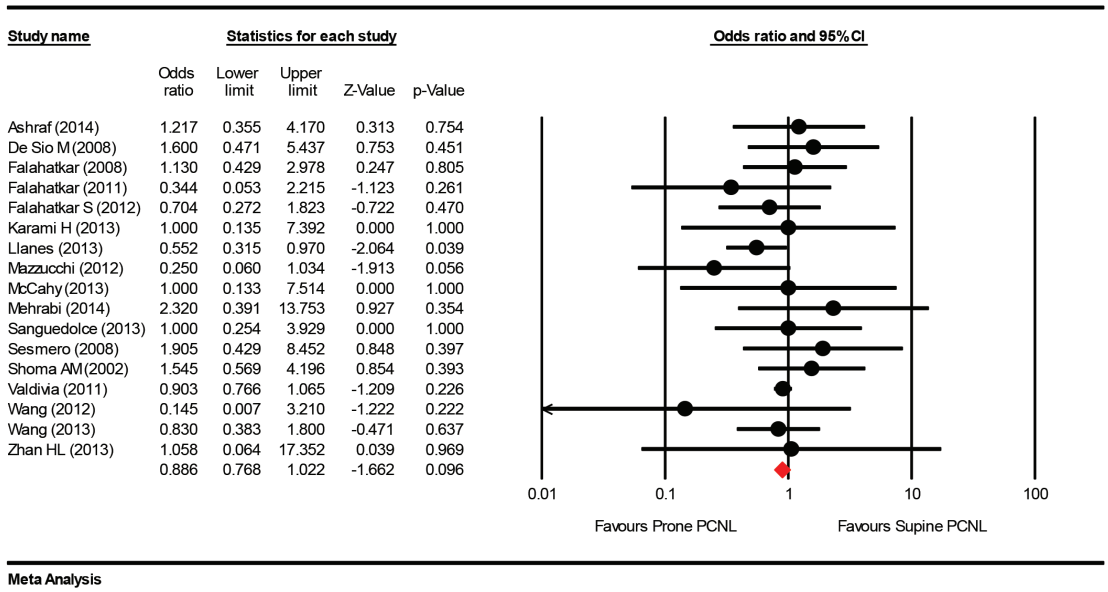

Figure 5. Complication rate in supine versus prone positions of percutaneous nephrolithotomy

analyzed possible publication bias by generating funnel plots of the studies which was used for all of the evaluated comparisons of outcomes. In case of any doubt, we used Egger's regression model for confirmation.

RESULTS

In our primary search, 144 references were identified from the searched medical journal databases. On examination of the abstracts, 124 articles were rejected based on the criteria outlined in **Figure 2**. Accordingly, 11 non duplicated randomized clinical trials, eight retrospective studies and one prospective non-randomized study that compared supine with prone PCNL were included in the meta-analysis. Twenty studies were selected for the analysis including 7733 PCNL cases: 2110 cases (27.3%) were in supine and 5623 cases (72.7%) were in prone positions.

Subgroup analysis of standard PCNL

Stone free rate

Among 7733 patients, 4335 were included in the stone free rate comparison (only supine and prone patients of Valdivia and colleagues[6] study were included). 1138 cases (74.8%) among 1522 patients in supine position and 2117 cases (78%) among 2713 patients in prone position were reported as stone free. Supine PCNL had a similar stone-free rate to prone PCNL (OR: 0.95; 95% CI: 0.70-1.27; $P = 0.73$) (**Figure 2**). Because of heterogonous data (I-square = 52.48 and $P = .00$) we used random effect analysis but we had no publication bias (Egger bias = 1.24, 95% CI = 0.26 to 2.21, $P = 001$).

Operation time

Mean operation times in supine and prone positions were 81 and 99 minutes, respectively. Thus, operation time was similar in both positions (standard dif-

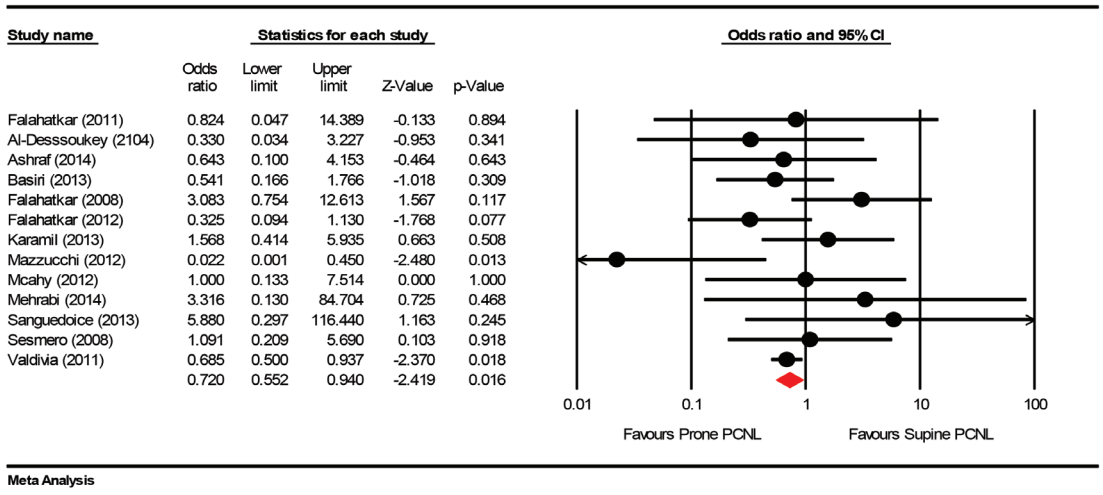

Figure 6. Blood transfusion in supine versus prone positions of percutaneous nephrolithotomy

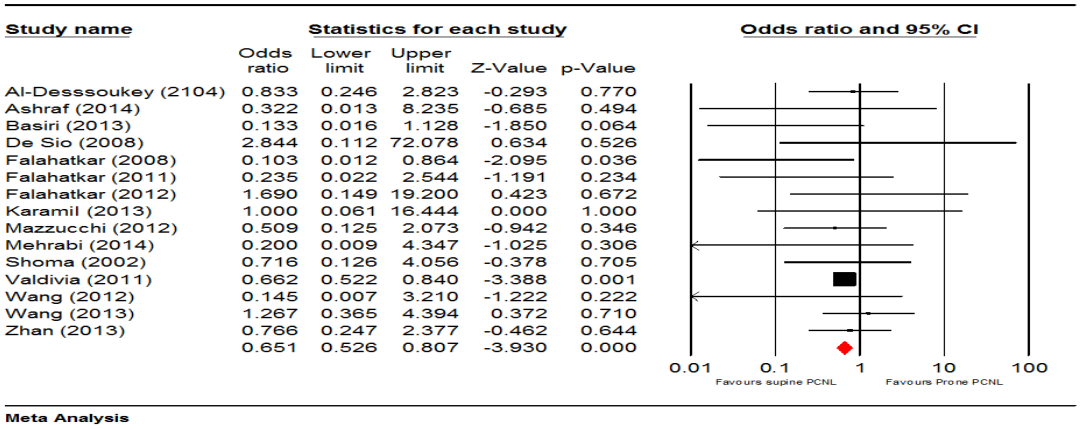

Figure 7. Fever frequency in supine versus prone positions of percutaneous nephrolithotomy

ference in means = -0.01, 95% CI = -0.07 to 0.03; *P* = .53). Because of non-homogenous data (I-squared = 0.00 and *P* = 1.00) we used fixed effect analysis. We observed no publication bias (Egger bias = -0.05, 95% CI = -0.14 to -0.37, *P* = .35) (**Figure 3**).

Hospital stay

Means of hospital stay in supine and prone positions were 92 and 96 hours, respectively. Thus, hospital stay was similar in both positions (standard difference = -0.01, 95% CI = -0.07 to 0.03; *P* = 0.053). Because of non-homogenous data (I-squared = 0.00 and *P* = 0.99) we used fixed effect analysis. Again we observed no publication bias (Egger bias = -0.08, 95% CI = -0.43 to 0.27, *P* = .31) (**Figure 4**).

Overall complication rate

Supine and prone PCNL had a similar complication rate (OR: 0.88; 95% CI: 0.76-1.02; P = .09). Because of homogenous data (I-squared = 0.00 and P = 0.66) we used fixed effect analysis. No publication bias was observed (Egger bias = -0.03, 95% CI=-0.60 to 0.60, P = .46) (**Figure 5**).

Subgroup analysis of complications in standard PCNL

Blood Transfusion

Totally, 84 cases (5%) among 1675 patients in supine position and 322 cases (6.3%) among 5100 patients in prone position underwent blood transfusion after PCNL. Patient in supine PCNL had less blood transfusion rate (OR: 0.72; 95% CI: 0.55-0.94; *P* = .01) (**Figure 6**). Because of non-heterogonous data (I squared = 25.01 and *P* = 0.19) we used fixed effect analysis. We observed had no publication bias (Egger bias = 0.20, 95% CI: -0.84 to 1.24; *P* = .34).

Fever

A number of 120 cases (6.9%) among 1738 patients in supine position and 564 cases (10.8%) among 5204 patients in prone position experienced fever after PCNL. Patients in prone PCNL had more fever rate (OR: 0.65; 95% CI, 0.52–0.80; *P* < .001) (**Figure 7**). Because of non-heterogonous data (I-squared = 0.00 and *P* = 0.67) we used fixed effect analysis. No publication bias was observed (Egger bias = -0.30, 95% CI = -0.95 to 0.34, *P* = 0.16).

Urinary leakage

Totally, 16 cases (4.3%) among 366 patients in supine position and 13 cases (3.5%) among 373 patients in prone position had urinary leakage after PCNL. Thus, both positions had a similar urinary leakage rate (OR:

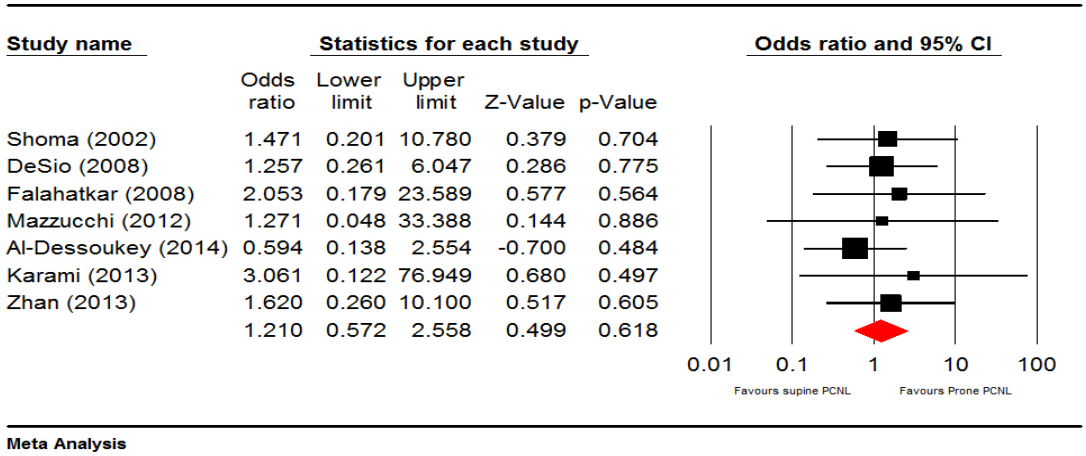

Figure 8. Urinary leakage in supine versus prone positions of percutaneous nephrolithotomy

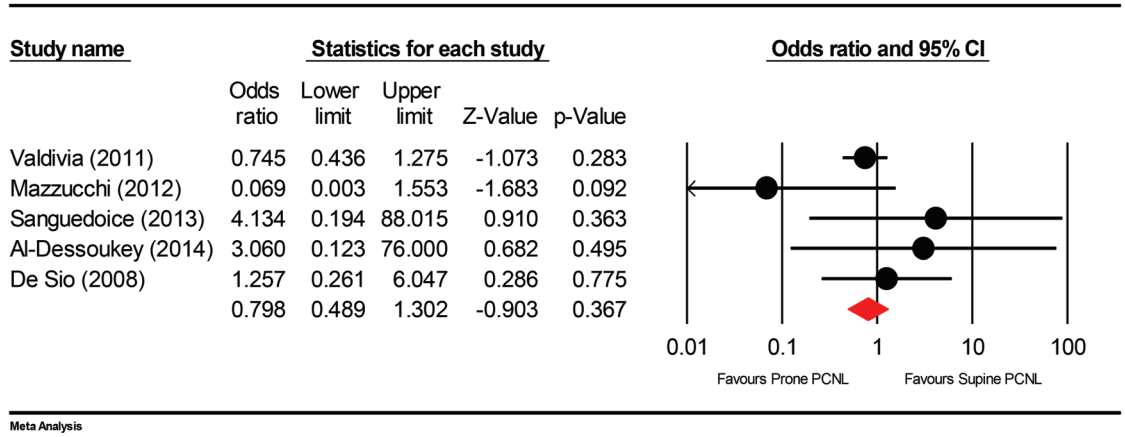

Figure 9. Pleural effusion in supine versus prone positions of percutaneous nephrolithotomy

1.21; 95% CI: 0.57-2.55; P = .61) (**Figure 8**). Because of heterogonous data (I-squared = 0.00 and P = 0.92) we used fixed effect analysis. Again we had no publication bias (Egger bias = 1.18, 95% CI: -0.39 to 2.76, *P* = .05).

Pleural effusion

A number of 23 cases (1.6%) among 1361 patients in supine position and 92 cases (1.9%) among 4787 patients in prone position had pleural effusion after PCNL. Thus, both positions had a similar pleural effusion rate (OR: 0.79; 95% CI: 0.48-1.30; *P* = .36) (**Figure 9**). Because of non-heterogonous data (I-squared = 11.93 and *P* = 0.33) we used fixed effect analysis. We perceived no publication bias (Egger bias = 0.30, 95% CI: -2.31 to 2.92, *P* = .36).

DISCUSSION

PCNL is currently a standard of care for treating kidney stones[10]. It is safe and feasible by various techniques. Clinical Research Office of the Endourology Society's (CROES) PCNL global study[6] and a recent meta-analysis by Yuan and colleagues[9] published data about better stone free rate of prone PCNL. They have stated some advantages of supine position, but mentioned that the technique should be personalized for each patient. Until now, there has been no consensus on the best position. Our meta-analysis showed that prone and supine PCNLs have a similar stone free rate. We found different stone free rates in studies about supine PCNL. The mean stone free rate in these studies was 81% (ranging from 62%[8] to 95%[11]). Stone free rate has a great role in selecting a surgical technique. Although some researchers have presented stone burden as the best predictor of stone free rate, additional issues related to it are case volume, previous stone treatment, staghorn stone, stone location and stone count[12]. Many studies which compared stone free rate had the same preoperative patient demographic data in supine and prone positions[13-17]. A study is in favor of prone PCNL by Valdivia and colleagues[6] reported a critical demographic difference at the start of study that could significantly change its outcome. Another study by Zhan and colleagues[18] which was done by a minimally invasive technique showed that stone composition can affect the result of stone free rate. However, we found no other study in this regard. Stone free rate definition and its technique and assessment time vary in different studies. In our study and most other studies, stone free rate was confirmed if kidneys-ureters-bladder radiography and

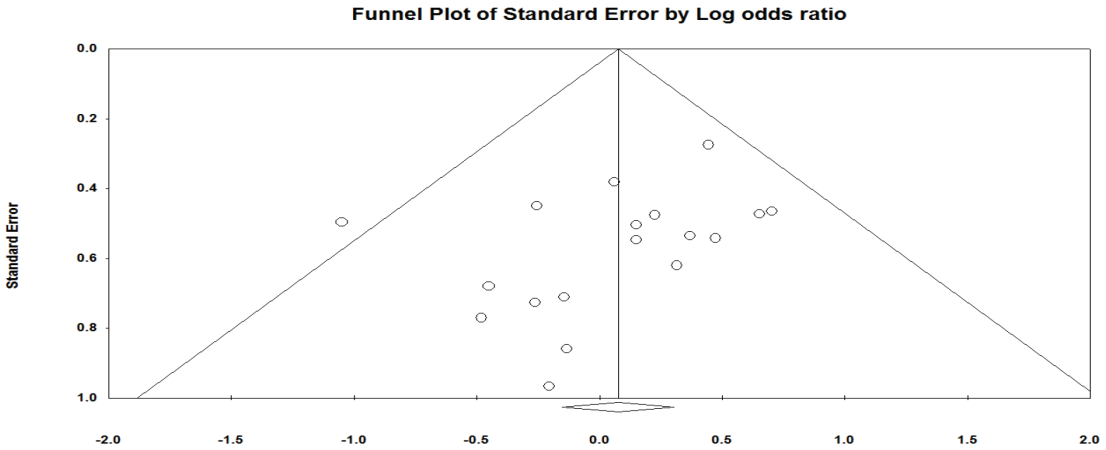

Figure 10. Funnel plot of standard error by log odds ratio

ultrasound showed no remaining stone or residual stone fragments < 4 mm on postoperative imaging. Two earlier meta-analyses by Liu and colleagues[19] and Wu and colleagues[20] showed no difference in stone free rate in these positions. However, Yuan and colleagues[9] found better stone free rate in prone PCNL. So for now it seems that both prone and supine PCNLs have similar stone free rates until more randomized clinical trials are done. Prolonged operation time is frequently associated with increased complication rate and thus is a crucial factor for choosing a surgical technique. Patient repositioning after anesthesia and before recovery certainly elongates anesthesia time. Yuan and colleagues[9] found that supine position PCNL has less operation time significantly. Although our findings showed less operation time in supine PCNL, it was not significant. In our study, operation time was the same in both groups. Two previous meta-analyses are in agreement with our finding[9,21]. Shorter hospital stay can lessen costs of procedures. Admission time varies according to patient risk factors and surgeons' practice. Admission duration has been widely reported from an overnight stay to 11 days[22,23] Durations of hospital stay are similar in different PCNL positions. Because of similar complications in both positions, this can elongate patient admission in both groups equally. According to our results, hospital stay of patients was the same in supine and prone PCNLs. This is in agreement with Sofer and colleagues' study[5] and some other previous meta-analyses[9,21]. Despite of complication in about one third of patients in both positions, PCNL remains a standard surgery for kidney stones[24,25]. Prone and supine PCNLs have the same complication rate. All three previous meta-analyses had reported similar blood transfusion and complication rates for prone and supine PCNLs[9,19,21]. Complication rate was different between different studies and it seems to be related to underlying diseases, previous medical history, age, body mass index, transfusion level, and administrated prophylactic antibiotic regimens. Patient follow up protocols that were not evidently definite make reporting complication more difficult. Theoretically, it seems that prone PCNL has an extra risk of complications such as nerve entrapment, neck injuries during repositioning and insufficient authority of anesthesiologist. Studies have reported complication rate with different definitions. This made judgment harder for us. There were 0 to 15% blood loss in this meta-analysis which seems to be related to other technical issues other than patient's position, including intraoperative imaging, dilation instrument, site and number of access sites, sheath size, lithotripters types, nephrostomy tube placement and its type and size, and ureteric stent placement and its type and size. Also, background history like chronic kidney failure can increase bleeding. Finally, the surgeon's experience is very important in this regard. After bleeding, fever and urinary tract infection were the common complications. There are factors such as Foley catechization duration, antimicrobial prophylaxis, stone type which are determinative. We found more fever in prone PCNL that can be because of atelectasis[9]. Higher calyceal pressure also seems to increase urinary infection and urinary leakage. The overall complication rates were not significantly different when comparing supine with prone PCNL. However, complication rate in a specific patient might differ regarding PCNL position. For example, a recent study by Martov and colleagues suggested supine PCNL for morbid obese patients[26] because prone PCNL in an obese patient can increase morbidity[27] .Modified Clavien system was presented to classify complications according to life-threatening events, interventions, and disability[28]. According to some researches[29,30] who used this system for reporting of complications, no statistically significant difference was observed in different PCNL positions. Furthermore the modified Clavien system like Guy's stone scoring system[31] or 'STONE' nephrolithometry score, did not consider position as an extra risk factor[32]. Many studies which have assessed PCNL risk factors never recognized position as a risk factor[30,33]. In another study, multivariate analysis showed that kidney dysfunction, lack of remarkable hydronephrosis, anatomic upper urinary tract anomaly, numerous tracts, anemia before surgery, and blood loss can result in major complications[34]. Kamphuis and colleagues showed that bleeding is related to dilatation size. He said that elderly people are at greater risk of complications and extended hospital stay. In patients with body mass index more than 40 there are more severe complications[33]. In spite of wide practice of different PCNL positions worldwide, data are insufficient for choosing the best position. However, recent definition and risk classification has provided more rigorous data. Our study included comparative studies which had used different techniques and approaches, surgeons' experience and definitions for outcome and their follow up. These limitations made our study more puzzling but we hope this meta-analysis releases updated material in this subject and can further complete the existing literature.

CONCLUSIONS

Supine and prone PCNLs have a similar stone-free rate, operation time, and hospital stay. However, supine position is associated with less fever and blood transfusion. Although both prone and supine PCNLs are suggested for treatment, supine PCNL may have advantages especially in patients with comorbidity. In case of the surgeon's preference, the approach should be tailored for each patient accordingly. More well-designed clinical trials are still required to find the best PCNL positions.

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CONFLICTS OF INTEREST

None declared.

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