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Effect of Obesity on Outcomes of Percutaneous Nephrolithotomy in Renal Stone Management: A Systematic Review and Meta-Analysis

Keywords

Renal stones · Percutaneous nephrolithotomy ·
Obesity · Complications · Stone-free rate · Operative time ·
Length of hospital stay

Abstract

Background: Percutaneous nephrolithotomy (PCNL) has been widely used to treat renal stones. The application of PCNL in obese patients results in the emergence of a number of challenges. This study compared the effect of obesity on the outcomes of PCNL in kidney stone treatment. **Methods:** Eligible studies were searched in PubMed, Web of Science, and Cochrane Library databases. Data were analyzed using RevMan statistical software, weighted mean differences, ORs, and 95% CIs were calculated. **Results:** Seven studies involving 2,720 normal-weight, 1,686 obese, and 286 super-obese individuals were included in this meta-analysis. A pooled analysis of safety revealed that no obvious differences in terms of complication rates after treatment existed between obese and normal-weight individuals (OR 0.97, 95% CI 0.80–1.16, $p = 0.73$), and between super-obese and normal-weight individuals (OR 0.88, 95% CI 0.61–1.27, $p = 0.49$). A pooled analysis of effectiveness revealed that no obvious difference in terms of stone-free rate after treatment existed between obese and normal-weight individuals (OR 0.98, 95% CI 0.84–1.15, $p = 0.79$), and between super-obese and normal-weight individuals (OR 1.20, 95% CI 0.88–1.63, $p = 0.25$). Moreover, no obvious differences in terms of

length of hospital stay after treatment existed between super-obese and normal-weight individuals (95% CI –0.15 to 0.37, $p = 0.39$). Additionally, no obvious differences in terms of operation time existed between obese and normal-weight individuals (95% CI –3.36 to 1.17, $p = 0.34$). However, the operation time was longer among super-obese individuals than among normal-weight individuals (95% CI –22.64 to –1.40, $p = 0.03$), and the length of hospital stay was shorter among obese patients than among normal-weight patients (95% CI 0.04–0.34, $p = 0.01$). No publication bias was observed in this work. **Conclusion:** The PCNL performed in normal-weight, obese, and super-obese individuals for kidney stone treatment showed similar outcomes, except that operation time was longer among super-obese individuals and the hospital stay was shorter in obese individuals than in other groups. Thus, PCNL is a safe and efficacious treatment for renal stones in patients of all sizes.

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Introduction

The prevalence of obesity is increasing in the global context. The number of obese individuals has rapidly increased in recent years both in developed and developing countries [1]. The prevalence of overweight and

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obesity ranged from 25 to 81.9% between 1990 and 2011 among adults in the Eastern Mediterranean Region [2]. Among Iranian children and adolescents, the prevalence of obesity ranged from 1 to 16.1% between 1990 and 2013 [3]. Moreover, obesity has increased the risk of kidney stones formation because obesity is closely related to comorbid health conditions, such as diabetes mellitus, hypertension, and metabolic syndromes [4–6].

The most common current treatments for renal stones include extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), and retrograde intrarenal surgery (RIRS) [7]. The application of ESWL among obese patients is limited because of patient weight, difficulty in stone localization, and long skin-to-stone distance [8]. RIRS is a safe and effective approach for renal stone treatment in obese individuals, except that RIRS requires long operation time depending on the size, number, and location of stones and on the experience of the surgeon [9]. PCNL is the gold standard first-line treatment for renal stones larger than 2 cm; the use of ultrasonographic access is recommended for PCNL [10]. PCNL is a particularly important therapeutic modality for obese individuals. Studies have assessed the intra- and postoperative outcomes of PCNL in obese patients [11–14]. They noted stone-free rate, and complications, length of stay equivalent to those in individuals of normal weight except with longer operative times. The Clinical Research Office of the Endourological Society collected data from 5,803 patients treated with PCNL; data demonstrated that PCNL can be safely performed in obese patients, although the operation time is extended and the stone-free rate is inferior [15]. Whether outcomes of PCNL are affected by obese is a matter that remains controversial. To conduct an updated study and to provide more lines of evidence that will serve as bases in clinical decision making, we collected published studies on the treatment of renal stones through PCNL and performed a meta-analysis to evaluate the outcomes of this modality.

Materials and Methods

Data Sources and Search Strategy

Articles were searched in PubMed, Web of Science, and Cochrane Library databases. Eligible studies were searched in these databases by using combinations of the following keywords: percutaneous nephrolithotomy or PCNL, body mass index or BMI, obese, super obese, and morbid obesity. The literature search was limited to human subjects. The titles and abstracts of the

potentially relevant studies identified through computerized search were reviewed. The reference lists of the retrieved studies were also assessed to identify additional relevant articles.

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: (1) the study included outpatients of either gender and aged 18–70 years; (2) outcomes included complication, stone-free rate, operative time, and hospital stay at least; (3) patients were treated with PCNL; and (4) patients were stratified into 3 or 4 groups according to the scheme used by the World Health Organization (WHO) to classify BMI, namely, <25 kg/m² (average), 25–29.9 kg/m² (overweight), 30–39.9 kg/m² (obese), and >40 kg/m² (super obese). The exclusion criteria were as follows: (1) data description or sample information was insufficiently clear; (2) other treatments were performed, (3) patients below 18 years old, and (4) BMI classification is inconsistent with the WHO classification system.

Assessment of Extracted Data

Two coauthors (X.Z. and X.S.) of this study independently reviewed all of the titles and abstracts of the searched papers. The full texts of potentially qualified papers that met the inclusion criteria were examined to determine their eligibility. Data extracted from the eligible studies included period, study design, sample size, mean age, stone characteristics, and relevant outcomes.

Outcomes

In each study, the primary outcome was safety as assessed on the basis of complication rate, and the secondary outcome was effectiveness as assessed on the basis of stone-free rate. Stone free rate was determined by ultrasound, CT scan, or a kidney, ureter, and bladder X-ray after the initial procedure; stone-free rate was accepted as an indication of complete clearance of stone and presence of residual fragments. Complication rate was measured by the overall complication rate. Operative time and length of hospital stay were also assessed.

Statistical Analysis

A meta-analysis was conducted using the Review Manager 5.3 software. For dichotomous outcomes, the OR and 95% CI were calculated, whereas for continuous outcomes, the standardized mean difference and 95% CI were used. The Cochrane Handbook's Q test and I^2 statistic were used to determine the heterogeneity among the studies. In the presence of significant heterogeneity ($p < 0.05$, $I^2 > 50\%$), a random-effects model was used. Otherwise, fixed-effects models were applied ($p \geq 0.05$, $I^2 \leq 50\%$).

Results

Data Extraction

Of the 333 citations identified based on the title and summary of the studies, 92 duplicate articles and 223 irrelevant articles were excluded. Eighteen full-text articles were assessed for eligibility. Finally, 7 clinical studies satisfied the inclusion requirements. Figure 1 shows a detailed flow diagram of this study.

Fig. 1. Flowchart showing the study selection procedure.

Table 1. Characteristics of studies included in the meta-analysis

Author	Year	Subgroup	Mean age, years	Patients, <i>n</i>	Stone size/ burden, mm/cm/mm ²	Complications, <i>n</i>	Stone free rate, %	Operative time, min	Length of stay, days
Koo et al. [22]	2004	Normal weight	50±18	65	17 (8–85)	11	79	75.2±32.3	6.5±3.3
		Obese	56±14	67	18 (10–45)	16	79	68.5±29.7	6.1±2.8
		Super obese	51±14	12	23 (8–45)	3	83	81.4±31.2	5.8±1.9
El-Assmy et al. [13]	2007	Normal weight	46.5±10.9	270	10–45	17	83.7	69.8±32.4	3.4±2.6
		Obese	46.9±10.5	468	10–45	26	84.8	68.5±29.6	3.3±2.5
		Super obese	46.5±10	92	11–45	7	84.7	77.2±32.4	3.1±2
Bagrodia et al. [14]	2008	Normal weight	58 (21–69)	26	17 (8–85)	7	57.7	NA	3
		Obese	53 (30–63)	51	18 (10–45)	10	64.7	NA	3
		Super obese	45 (24–55)	29	23 (8–45)	5	62.1	NA	2
Fuller et al. [15]	2012	Normal weight	46.1±14.9	1,394	362.6±366.4	262	77.5	82.1±48.3	4.3±3.6
		Obese	55.5±12.9	650	429.1±399.8	120	78.9	84.9±44.8	4.0±2.9
		Super obese	55.3±12.1	97	345.0±340.9	22	65.6	112.2±56.4	4.5±4.3
Alyami et al. [23]	2013	Normal weight	55 (2.6)	39	2.3±0.14	4	90	44.6 (2.4)	1.6 (0.3)
		Obese	60 (2.2)	41	2.2±0.16	5	90	47 (2.6)	1.5 (0.2)
		Super obese	53 (4.1)	10	2.4±0.39	2	80	55 (8.2)	1.7 (0.3)
Faruk et al. [11]	2014	Normal weight	38.19±14.8	849	7.6±5.70	51	83	64.44±26.93	2.86±1.56
		Obese	49.52±12.8	334	8.17±6.00	28	80	66.13±28.42	2.70±1.58
		Super obese	50.22±11.1	36	8.15±5.92	3	86	68.2±24.66	2.81±0.98
Torrecilla Ortiz et al. [12]	2014	Normal weight	51.9±15.8	77	9.2±10.5	24	76.6	101.7±48.1	5.2±3.4
		Obese	54.7±12.1	75	8.2±7.2	22	78.7	110.2±46.2	5.2±4.6
		Super obese	58.4±11.2	10	9.0±8.2	1	90	116.0±49.8	5.3±3.1

Study Characteristics

Table 1 shows the characteristics of the included studies. All of the 7 eligible studies evaluated the outcomes of PCNL in renal stone treatment in obese, super-obese, and normal-weight individuals. We extracted the relevant data for our analyses. The included stud-

ies were conducted from 2004 to 2016 and involved a total of 2,720 normal-weight, 1,686 obese, and 286 super-obese individuals. We statistically analyzed the complication rate, stone-free rate, operative time, and length of hospital stay according to the specifications of each study.

Fig. 2. Forest plot showing the OR in complication rate. **a** Obese versus normal weight. **b** Super obese versus normal weight.

Safety Evaluation: Complication Rate

We identified 2,720 patients in the normal-weight group, 1,686 in the obese group, and 286 in the super-obese group. Safety was statistically evaluated based on the complication rate. No heterogeneity and no obvious difference were observed between the obese and normal-weight groups (OR 0.97, 95% CI 0.80–1.16, $p = 0.73$), and between the super-obese and normal-weight groups (OR 0.88, 95% CI 0.61–1.27, $p = 0.49$; Fig. 2).

Efficacy Evaluation: Stone-Free Rate

Efficacy was statistically evaluated based on the stone-free rate. No heterogeneity and no obvious difference were observed between the obese and normal-weight groups (OR 0.98, 95% CI 0.84–1.15, $p = 0.79$), and between the super-obese and normal-weight groups (OR 1.20, 95% CI 0.88–1.63, $p = 0.25$; Fig. 3).

Operative Time

The 3 groups were compared in terms of operative time. A heterogeneity test revealed that significant heterogeneity exists among the studies ($p = 0.07$, $I^2 = 52\%$; $p = 0.006$, $I^2 = 73\%$), so the random-effects model was used. A pooled analysis revealed that no significant difference exists between the obese and normal-weight groups (95% CI –3.36 to 1.17, $p = 0.34$). Moreover, the operation time was longer in super-obese individuals than in normal-weight individuals (95% CI –22.64 to –1.40, $p = 0.03$; Fig. 4).

Length of Stay

The 3 groups were compared in terms of the length of hospital stay. A pooled analysis revealed that no significant difference existed between the super-obese and normal-weight groups (95% CI –0.15 to 0.37, $p = 0.39$). Moreover, the length of hospital stay was shorter in obese individuals than that in normal-weight individuals (95% CI 0.04–0.34, $p = 0.01$; Fig. 5).

Fig. 3. Forest plot showing the OR in stone-free rate. **a** Obese versus normal weight. **b** Super obese versus normal weight.

Publication Bias

The funnel plot assessment showed no asymmetrical result (Fig. 6).

Discussion

WHO has estimated that over 50% of individuals in Europe, America, and in the Asia-Pacific region are overweight or obese [16]. Obesity is a risk factor for the formation of urinary calculi. Shavit et al. [17] reported that the incidence of kidney stones is higher in overweight and obese patients than in normal-weight individuals. The main causes of the high incidence of stone formation in obese patients include diabetes mellitus, hypertension, and metabolic syndrome [18]. Currently, many treatment methods to eliminate renal stones are available, including ESWL, RIRS, and PCNL. However, the application of ESWL in obese patients is limited because of the skin-to-kidney distance and the burden of the existence of large stones; similarly, the application of RIRS in obese patients

with stones >2 cm is limited [7]. PCNL is the gold standard first-line treatment in the management of renal stones larger than 2 cm [19]. Obesity is generally speculated to increase the morbidity of surgery, primarily because of wound, pulmonary, and cardiac complications [20].

To perform PCNL in obese individuals, careful attention must be paid to the moving and positioning of patients before surgery. Standard prone positioning presents challenges for ventilating heavy patients and impairs venous blood flow [25]. A majority of urologists advocate the potential advantages of the supine PCNL. However, there is no convincing evidence to support performing supine PCNL in obese patients. Mazzucchi et al. [26] compared the 2 techniques in obese patients and showed that PCNL performed in the prone or in the supine position in obese patients presented similar outcomes except that the supine position has the advantages of a significantly shorter operative time and hospital stay. Further randomized clinical trials of a large sample size in obese patients are required to recommend an extensive application of supine PCNL as an alternative to prone PCNL.

Fig. 4. Forest plot showing the standardized mean differences in operation time. **a** Obese versus normal weight. **b** Super obese versus normal weight.

The recognized challenges and effects in the application of PCNL in obese patients also include poor radiographic or ultrasonographic visualization, difficulties in identifying anatomic landmarks and in reaching the kidney because of excess fat tissue, stone location, and the safe positioning of patients [21]. The calyceal site was associated with decreased fitness for surgery and an increased risk of postoperative complications compared to the renal site [27]. The success rate in upper calyx stones is parallel to the other simple stones; the complication rate in some is higher [28].

However, studies show that the outcome of PCNL is independent of the patients' BMI. Koo et al. [22] reviewed the results of 223 PCNLs and their findings suggested that no significant differences existed among obese patients in terms of operative duration, hospital stay, stone-free rates, and complication rate. El-Assmy et al. [13] reviewed 1,121 cases involving treatment through PCNL and found that no significant differences in terms of hospital stay, stone-free rate, and complication rate were observed among the 4 study groups. Bagrodia et al. [14] reviewed

the charts of 200 consecutive patients who underwent PCNL and found no significant differences among groups in terms of stone-free and complication rates, operative time, and length of hospital stay; moreover, BMI exerted no impact on the efficacy or complication rates of PCNL. Alyami et al. [23] performed a retrospective chart review of 114 patients who underwent PCNL and found no significant difference among groups in terms of mean length of hospital stay (days), complication rates, and stone-free rates, demonstrating that PCNL is a safe and efficacious treatment method for eliminating kidney stones in patients of all sizes. Şimşek et al. [11] retrospectively reviewed a total of 2,360 patients treated with PCNL; no differences in terms of hospital stay, complication rate, or stone-free rate were observed among the 4 study groups, and the mean operation time was longer in the morbidly obese group, although the operation time was not significantly different from that in the other groups. BMI does not affect the success or complication rate of PNL. Fuller et al. [15] collected data from 5,803 patients treated with PCNL; data showed that the stone-free rate decreases

Fig. 5. Forest plot showing the standardized mean differences in the length of hospital stay. **a** Obese versus normal weight. **b** Super obese versus normal weight.

with obesity, and no differences in length of hospital stay and complication rate were observed among the 4 groups. Moreover, the operative time was significantly longer in the super-obese groups than in the other groups. PCNL may be performed safely in obese patients, although the operative time is extended and the stone-free rate is inferior. Torrecilla Ortiz et al. [12] performed 255 procedures, and no statistical differences in complication rate and stone-free rate were noted. However, the total operative time increases with BMI, and thus patients with larger BMI are at risk.

To our knowledge, this work is the first meta-analysis that compares the efficacy and safety of PCNL for renal stone treatment in patients with obese. A systemic review that included 12 studies and published in 2015 found that PCNL is a safe and effective treatment modality for renal stone(s) in obese and morbidly obese patients; moreover, the effect of BMI on PNL outcomes, including operation time, hospitalization time, complications, and stone-free rate remains debatable according to this work [24]. However, this study did not compare the PCNL outcomes and did not arrive at a definitive conclusion.

Fig. 6. Funnel plot for publication bias in the included studies.

To our knowledge, there has never been a comparable comprehensive and systematic review on treatment of renal stone with PCNL that has compared the operation time, hospitalization time, complications, and stone-free rates in obese and super-obese individuals. The outcomes

of PCNL in normal weight, obese, and super-obese individuals were similar, except that the operation time in super-obese patients is longer and the hospital stay of obese patients is shorter than in other groups. For hospital stay, we assessed all the studies separately, and most studies were not statistically significant between normal weight and obese individuals. In our meta-analysis, a short hospital stay was observed for obese individuals. Sergeyev et al. [29] had demonstrated that patients with normal weight had longer hospitalization times when compared with obese patients; they believed that longer hospitalization time was associated with operative or postoperative complications such as bleeding, fever, adjacent organ injuries instead of technical difficulties. Kuntz et al. [30] found hospital stay was significantly longer in normal-weight individuals despite lower ASA classification and equivalent stone burden on multivariable analysis. This could be related to postoperative bleeding, as they found a statistically significant increase in the transfusion rates in normal-weight patients. One potential cofounder for this finding could be stone characteristics, as there were significantly more staghorn calculi in normal-weight patients. Yang and Bellman [31] found no statistical difference in the transfusion rates between different groups, but all blood transfusions were

in patients with a BMI of $<30 \text{ kg/m}^2$. In summary, PCNL is a safe and efficacious treatment of renal stones in patients of all sizes.

Conclusion

No obvious differences in terms of complication rate and stone-free rate were observed among the 3 groups. Thus, PCNL is a safe and effective treatment modality for renal stones in obese and super-obese patients. However, the extended total operative time in super-obese patients possibly put these patients at risk, and thus, this parameter must be considered by urologists during treatment.

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Disclosure Statement

We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

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