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Safety and Efficacy of Simultaneous Bilateral Percutaneous Nephrolithotomy

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Abstract: A retrospective review was conducted to evaluate intraoperative and patient outcomes following simultaneous bilateral percutaneous nephrolithotomy (SB-PCNL). Target stone characteristics, operative time, hospitalization length, post-operative complications, blood loss, opioid use, pain, and stone-free rates were evaluated. In total, 42 patients with large renal stones (>20 mm^2) were identified for this study, and 38% of them achieved stone-free status with no residual fragments apparent on post-operative day one CT imaging. The maximum mean residual fragment size was 3.67 mm^2 and average number of residual fragments following the procedures was 1.63. The rates of blood loss, post-operative complications, opioid use, and pain from the study cohort were similar to the reported outcomes of studies conducted by others. The potential benefits of a single procedure and anesthesia to treat bilateral stone burdens, lower total pain medication prescribed, and lower hospital costs render SB-PCNL as an attractive option in the treatment of bilateral kidney stones.

Keywords: bilateral calculi; PCNL; percutaneous nephrolithotomy; renal stones; urolithiasis

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1. Introduction

Urolithiasis poses a significant healthcare burden amongst the working-age population, with prevalence and incidence rates increasing globally. In the United States alone, the prevalence has increased from approximately 3% in the 1980s to 10% in the 2010s [1]. Approximately 7% of women and 13% of men will develop a kidney stone during their lifetime [2]. Although not all kidney stone episodes require treatment, surgical intervention is warranted if stones are symptomatic, associated with obstruction or infection, or pose a threat to renal function [3]. When the total stone burden for a urolithiasis patient exceeds 20 mm^2 on cross sectional imaging, percutaneous nephrolithotomy (PCNL) is the gold-standard surgical intervention recommended by the American Urological Association [4]. This procedure has demonstrated the highest stone-free rate for larger stones when compared to other endourological modalities [3]. Despite this, PCNL accounts for only 5% of all stone-related procedures. This is in large part due its invasive nature, higher complication rates, and more technical demands compared to ureteroscopy or extracorporeal shockwave lithotripsy [5,6]. For patients requiring bilateral PCNL procedures, complications are an even greater concern [7].

Traditionally, large bilateral renal stones were treated with unilateral PCNL (U-PCNL) procedures performed in a staged fashion (one kidney per surgery visit). This was thought to reduce morbidity, renal injury, infection, and a prolonged anesthetic time associated with simultaneous bilateral PCNL (SB-PCNL), where both kidneys are operated on in the same surgery under the same general anesthetic [8]. However, with advances in anesthesia, antibiotic therapies, and surgical techniques, SB-PCNL may now be a safe and feasible option in treating patients with a large, bilateral stone burden. Furthermore, SB-PCNL has

the potential to reduce overall hospitalization, limit exposure to repeat anesthetic, obviate the need for re-operation, and shorten a patient's return-to-work interval. [9–11]. Despite these potential benefits of SB-PCNL, there have been concerns amongst urologists about the potential for acute renal failure, increased blood loss, prolonged operative times, and postoperative respiratory distress. As a result, SB-PCNL has not been widely adopted [11].

At our high-volume tertiary hospital, most patients requiring bilateral PCNL undergo SB-PCNL in one surgical session rather than coming back for two surgeries (one for each kidney). In this retrospective cohort study, we aimed to investigate the safety and efficacy of SB-PCNL.

2. Materials and Methods

This study was approved by the University of British Columbia Clinical Research Ethics Board (UBC CREB) (Approval Number: H14-00475). Electronic Medical Records at Vancouver General Hospital were queried for patients who underwent PCNL procedures between 2010 and2015. Demographic, stone characteristics, intraoperative and post-operative data were recorded. CT scans were analyzed using Philips IntelliSpace PACS 4.4.541 (Koninklijke Philips, Amsterdam, The Netherlands) to confirm stone location and to determine stone characteristics.

All procedures were performed by two fellowship-trained endourologists with a surgical load of >100 PCNL procedures per year. All patients underwent general anesthesia and were placed in the prone position and fluoroscopy-guided renal access was achieved bilaterally using 30F access sheaths prior to stone manipulation. Standard PCNL was performed synchronically. Stone fragmentation was then undertaken for one kidney, and upon completion, the other kidney was then addressed. Renal stone fragmentation and evacuation were achieved using the Shockpulse-SE dual action lithotripter (Olympus Medical Systems, Center Valley, PA, USA) and holmium:YAG laser lithotripsy (Odyssey laser, Cook, Spencer, IN, USA). Five French Nephrostomy tubes were placed at the end of each procedure. Stone clearance was confirmed using flexible nephroscopy and fluoroscopy. A low-dose, non-contrast CT-KUB was performed on post-operative day one to assess for the presence of residual fragments or adjacent organ injury. This is routinely performed at our institution after PCNL. The stone-free rate was defined as the absence of stone. The stone-free rate and residual fragment size were assessed for both kidneys. Statistical data analysis was conducted using RStudio Software Version 1.2.5001.

3. Results

3.1. Patient and Stone Characteristics

A total of 42 SB-PCNL patients who presented with large renal stones (>20 mm^2) treated with PCNL were identified for this study. Patient demographics and pre-operative stone characteristics are summarized in Table 1. The mean age and BMI of patients included in this study were 57.7 years of age and 30.2, respectively. The stone surface areas of each individual kidney (right and left) of SB-PCNL subjects were 767 mm^2 for the right kidney and 501 mm^2 left kidney (Table 1). The total stone surface area treated with SB-PCNL was 1280 ± 1120 mm^2. Within our cohort, the largest stone of the patient was most commonly found in the renal pelvis.

3.2. Operative Time and Hospitalization

The operative time in this study was defined by the time from the initiation to the cessation of anesthesia. The mean operative time was found to be 250 ± 47.0 min. Establishing the day of the PCNL operation as day one of hospitalization, patients who underwent SB-PCNL were hospitalized for a mean duration of 3.60 ± 2.11 days (Table 2).

Table 1. Patient demographic and target stone size.

	Simultaneous Bilateral PCNL
Patients, n	42
Sex, M/F	25/17
Age, Mean (SD)	57.7 (12.7)
Mean BMI (SD), n	30.2 (7.55)
Number of Stones, Mean (SD)	3.10 (3.81)
Stone Surface Area per Kidney (mm^2), Mean (SD)	Right Kidney = 767 (991) Left Kidney = 501 (516)
Total Stone Surface Area Treated with PCNL (mm^2), Mean (SD)	1280 (1120)

Table 2. Intraoperative data.

	Simultaneous Bilateral PCNL
Mean operative time, minutes (SD)	250 (47.0)
Mean length of hospitalization, days (SD)	3.60 (2.11)
Patients Re-admitted, n (%)	4 (9.52)
Patients admitted into ICU, n (%)	3 (7.14)
Patients requiring a blood transfusion, n (%)	5 (11.9)
Mean hemoglobin changes following PCNL, g/L	22.69 (16.9)
Patients with post-operative complications, n (%)	10 (23.8)
Patients with Clavien–Dindo Grade 1, n	5 (11.9)
Patients with Clavien–Dindo Grade 2, n	5 (11.9)

3.3. Complications Post-PCNL

Post-operative complications were classified according to the Modified Clavien Classification System [12]. Overall, no Modified Clavien Classification grade 4–5 complications were observed within the study cohort. A total of three patients were admitted into the ICU, and four were re-admitted into the hospital post-procedure. Intraoperative blood loss as calculated by the post-operative change in hemoglobin levels was 22.69 g/L (Table 2). A total of five patients required a blood transfusion related to their SB-PCNL procedure.

3.4. Residual Fragments and Stone-Free Rates

Stone-free status was defined as the absence of any residual fragments visualized on computerized tomography (CT) imaging post-operative day one. The stone-free rate was 38% (Table 3). The maximum residual fragment size was 3.67 ± 1.95 mm^2. The average number of residual fragments following the procedures was 1.63 ± 0.49 stones.

Table 3. Residual fragments post-PCNL.

	Simultaneous Bilateral PCNL
Patients with residual fragments following PCNL, n (% SFR [1])	26 (38% SFR [1])
Mean number of residual fragments following PCNL, n (SD)	1.63 (0.49)
Mean maximal Size of residual fragments, n (SD)	3.67 (1.95)

[1] Stone-free Rate (SFR).

3.5. Opioid Use

Inpatient narcotic use was recorded from the post-anesthesia care unit records and in-hospital medication administration records (Table 4). Intraoperative, in-ward, and total narcotic use was measured in total morphine equivalent dose (MED). The total mean MED

dose for the duration of hospitalization for patients included in this study was 80.9, with 23.8 per day. Post-operative pain was assessed with a standard numerical analogue scale ranging from 0 to 10. The maximum reported mean pain score was 5.33 ± 2.73.

Table 4. Opioid-use and pain data.

	Simultaneous Bilateral PCNL
Mean anesthesia morphine equivalent dose, MED [1] (SD)	18.5 (22.0)
Mean in-ward morphine equivalent dose, MED [1] (SD)	63.0 (79.0)
Total morphine equivalent dose for duration of hospitalization, MED [1] (SD)	80.9 (89.3)
MED [1] per day of stay, MED [1] (SD)	23.8 (24.3)
Mean highest pain score at rest, pain score (SD)	5.33 (2.73)

[1] Morphine Equivalent Dose (MED).

4. Discussion

Bilateral PCNL is typically performed in a staged manner, dictated by the preference of the performing urologist along with patient and stone characteristics. Previous studies have indicated that SB-PCNL is a safe and effective method for the treatment of bilateral kidney stones in a variety of patients without increased morbidity [8,10,11,13]. With improvements in anesthetic methods and techniques, longer procedures are safer and more feasible than in the past. This potentially circumvents the need to undergo staged procedures, allowing for a decreased overall hospital length of stay, rapid resumption of daily activities for a patient's post-procedure, and an increased total number of patients receiving treatment since two procedures would not be required [14].

In this study, patients who underwent SB-PCNL had shorter operative times (in total) and length of hospitalization when compared to patients who underwent staged bilateral PCNL procedures from studies conducted by others [11]. Other centers have compared staged U-PCNLs (two separate U-PCNLs to treat bilateral stone burden) to SB-PCNL and results suggest that SB-PCNL results in shorter total operative times and hospital stay [11]. While not seen directly in this study, we would expect these results to be similar in our institution. Consequently, total hospital costs (e.g., surgeon, anesthesia, nursing time) may also be a significant factor in the justification for SB-PCNL.

Stone-free rate in our study was defined as the absence of any residual fragments visualized on post-operative CT imaging. With the stone-free rate of 38% for SB-PCNL, our rates are comparable to those achieved by other studies comparing SB-PCNL to U-PCNL or staged bilateral PCNL. Other urologists who performed SB-PCNL were able to achieve similar stone-free rates compared to staged bilateral PCNL [8–11]. Additionally, 78.6% of SB-PCNL residual fragments were 4 mm or smaller in size in our study. In regard to admissions post-procedure, there were no significant difference in readmission rates or complications compared to rates from other studies [8–11]. Taken together, our data suggest that SB-PCNL patients are not adversely affected by the lower stone free-rates; however, we did not look at long term re-operation rates. The Canadian Urological Association guidelines for the management of ureteral calculi suggest that 95% of ureteral stones 2 to 4 mm in size will pass spontaneously [15]. Moreover, in a study on residual fragments post-PCNL by Emmott et al., only 16.5% of patients with residual fragments >4 mm required re-intervention [16]. Thus, we contend that SB-PCNL for bilateral stone patients can be warranted due to its potential benefits compared to staged U-PCNL despite the lower stone-free rates in our study.

One of the main concerns regarding the indication for SB-PCNL is the potential risk of increased complications. Kadlec and colleagues found that SB-PCNL resulted in a higher overall complication rate than unilateral PCNL using the Modified Clavien System for classification [17]. However, in our study, the total number of complications as well as

the stratification of complications into the Modified Clavien Classification System did not show a high rate of complications with only a total of 10 patients (23.8%) having complications (five in Grade 1 and five in Grade 2 of the Clavien–Dindo Classification). Furthermore, blood loss during SB-PCNL and the percentage of patients requiring blood transfusions during the procedure were quite low, at 11.9% (Table 2). It should be noted that hemoglobin changes may result from blood loss and may also be dilutional [18]. Nephrostomy tubes were placed at the end of SB-PCNL procedures without obvious adverse effects on patient outcomes.

Beyond complications, opioid use in the post-operative setting is a major concern. The prescription of opioids during hospitalization has been routine within the hospital setting for post-operative pain management. Clinical opioid-use data from the United States have suggested that there has been an increase in opioid prescriptions for minor invasive surgeries in recent years [19]. The prescription of opioids in these circumstances increases the risk of patients using opioids chronically as well as the development of opioid-use disorders [20,21]. As such, due to the necessity for only one procedure, opioid use may potentially decrease overall in patients who undergo SB-PCNL. It can be deduced that when U-PCNL is conducted in a staged manner for the treatment of bilateral stones, the total MED prescribed to patients for pain management would increase.

Our study has several limitations. First, due to a lack of staged U-PCNL procedures at our hospital, we could not compare SB-PCNL to staged unilateral PCNL. Ideally, SB-PCNL would be compared directly to staged U-PCNL. Second, we did not assess the long-term re-operation rates of the SB-PCNL patients to see the impact of an increase in residual fragments. Lastly, this study is retrospective in nature and, as such, the results may be influenced by unintentional biases.

5. Conclusions

Despite these limitations, our study suggests that simultaneous bilateral PCNL (SB-PCNL) is safe and efficacious for patients requiring surgical management of large bilateral stones. Opioid use, pain, blood loss, overall complications, and re-admission rates were comparable to unilateral PCNL (U-PCNL) or staged bilateral PCNL reported by other studies. However, SB-PCNL may lead to more residual fragments. Further prospective studies comparing staged U-PCNL versus SB-PCNL are required to determine the optimal treatment timing for patients with substantial bilateral stone burden. From the results obtained in this study, future work from our center will compare these two modes of treatment in a prospective fashion to determine the optimal treatment timing for patients with substantial bilateral stone burden to improve patient outcomes.

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