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Multitract percutaneous nephrolithotomy in the management of staghorn stones

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Abstract

Background: Staghorn stones are difficult to manage with a risk of significant renal impairment and urosepsis. Percutaneous nephrolithotomy is the first-line treatment for staghorn stones. Often, multiple access tracts are needed to render the patient stone-free. PCNL has been combined with SWL, flexible URS (ECIRS), and mini-PCNL to access residual fragments without the need of additional tracts. However, in a country with limited access to technology and a restraint on resources, multitract PCNL still is the preferred option. The aim of this study was to assess the safety and efficacy of multitract PCNL in such an environment.

Methods: We analyzed data on sixty-five patients with staghorn calculus who underwent multitract PCNL for a staghorn calculus. Data included demographics, stone parameters, intraoperative parameters, complications and clinical outcomes. Hb-drop and creatinine changes were assessed pre- and post-OP. Complications were graded according to the modified Clavien-Dindo classification.

Results: In a total of 65 patients [47 males (72%)], 154 percutaneous access tracts were used in 66 renal units. The number of tracts varied between 2 and 4 in a single renal unit. The stone-free rate was 85%. 20% of patients developed grade I, 14% grade II, and 3% grade III b complications. There were no grade IV and V complications.

Conclusion: Multitract PCNL is safe and efficient, with a good stone-free rate and an acceptable complication rate. When auxiliary combination treatments are not available, multitract standard PCNL remains an option.

Keywords: Percutaneous nephrolithotomy, Staghorn stones, Multiple tracts, Complications

1 Background

The treatment of staghorn stones is challenging. Due to their high recurrence rates, particularly in infectious stones, complete removal of stone material is mandatory [1].

The estimated five-year recurrence rate is up to 50% [2]. Staghorn stones, by definition, are branched into two or more calyces. Particularly when the stone burden reaches $>2000\ mm^2$, surgical treatment remains technically difficult regardless of the treatment modality used [3].

Different treatment modalities include open surgery, laparoscopy, percutaneous nephrolithotomy (PCNL), multi-staged ureterorenoscopy (URS) in selected cases, and endoscopic combined intrarenal surgery (ECIRS). Some studies suggested that open or laparoscopic surgery is an efficient method for the management of large and complex renal stones associated with a high single-session stone-free rate [4, 5]. Notwithstanding the fact that both are more invasive, PCNL can easily be repeated if needed, whereas laparoscopic or open surgery become more complicated after an initial procedure due to anatomical changes and scarring [6].

PCNL is regarded as the treatment of choice for staghorn calculi [7]. Although it has stood the test of time as a minimally invasive, safe, and efficient procedure in

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its various forms, it is associated with an overall complication rate of 25%, usually assessed with the modified Clavien-Dindo classification [8]. The most frequent complications are fever (0–32%) and bleeding requiring blood transfusion (0–20%) [9]. Radiation exposure during PCNL is another concern still discussed [10]. Over time, the safety and efficacy of PCNL have improved through various changes and modifications [11]. The introduction of flexible URS and its combination with PCNL (ECIRS) has aided in the most complex cases and, in many instances, abolished the need for multiple punctures [12]. Flexible ureterorenoscopy is however not widely available in the developing world. These scopes are expensive, fragile, of limited lifetime, and require a specific back-up infrastructure (light and camera system, sterilization, disposables, etc.).

Many complex staghorn stones, therefore, do require multiple accesses into various calyces in order to access and remove all parts of the stone [13]. The debate continues whether to do a single tract procedure with a 2nd look PCNL, or sandwich therapy in which initial PCNL is combined with extracorporeal shock wave lithotripsy (SWL) and followed by another 2nd look PCNL, or rather a multitract PCNL in an attempt to render the patient stone-free in one single session. The latter may achieve a stone-free rate of 84–95% [14]. Moreover, multitract single-session PCNL would bring down costs significantly by avoiding multiple procedures of any kind [15–17]. Multitract PCNL has a similar complication rate compared to combined treatments [18], although some studies suggest multiple tracts as a cause for peri-operative bleeding [19, 20].

Most data on multitract PCNL come from well-established stone centers in the developed world [1, 2, 7, 9–12, 14, 16, 17]. As a developing country, we do not have easy access to multi-modality treatments because they are not available or affordable to the patients, and hence we have to use resources sparingly. Therefore, multitract PCNL remains our treatment of choice in patients with large complex stone burdens. In this study, we assessed whether multitract PCNL is efficient and safe in our hands in terms of stone-free rate and complication-rate. We believe that these data are important for stake-holders in similar economic environments.

2 Methods

Ethical approval was obtained from the National Board for Medical Specializations (Urology).

Sixty-five patients who underwent elective PCNL for large and complex staghorn stones between August 2016 and April 2019 were included and prospectively analyzed.

The preoperative workup included complete medical history, physical examination, and laboratory investigations (urinalysis, complete blood count, blood biochemistry, coagulation profile, renal function test, viral markers, and blood group with cross-match). Preoperative imaging included ultrasound-KUB and an unenhanced CT scan in all patients.

Patients with uncontrolled coagulopathy, severe musculoskeletal deformities, pregnancy, and active infections were excluded.

Preoperative data recorded were age, gender, BMI, comorbidities, previous surgeries, site and size of the stone, and the presence of hydronephrosis.

Intraoperative data included the type of anesthesia, number of tracts, tract diameters, point of entry to the collecting system, intraoperative bleeding, extravasation, pelvic and PUJ injury, and operative time.

Postoperatively, blood transfusion, fever, sepsis, thoracic complications, transient hematuria, transient renal function disorder, and stone-free rate were recorded.

All patients were operated by the same highly experienced surgeon in a high-volume stone center with a standard prone PCNL in either spinal or general anesthesia, under prophylactic IV-administration of a third-generation cephalosporin at induction. Access was obtained with fluoroscopy guidance and serial plastic dilators. A F18 standard rigid nephroscope (Karl Storz, Tuttlingen, Germany) and pneumatic lithotripsy were used (NidhiLith, Nidhi Medical systems, Delhi, India). When it was not possible to reach all stones, additional PCNL tracts were laid. The procedure was continued until stone-freeness was confirmed radiologically and optically, or safe continuation had become compromised by impaired vision, mostly through bleeding. All patients had an anterograde JJ stent, a percutaneous nephrostomy (PCN), and a bladder catheter. The latter was removed after 6 h, the PCN after 24 h unless there was persistent bleeding.

Hb was measured after 24 h again, postoperatively. Under the assumption that one transfused unit of blood increases the Hb by 1 gr/dL, Hb-drop was calculated as:

$$\begin{aligned}\text{Hb - drop} &= (\text{Preoperative Hb} - \text{postoperative Hb}) \\ &\quad + \big(\text{number of units transfused} \\ &\quad \times 1\ \text{g/dL Hb per unit transfused}\big)\ [21]\end{aligned}$$

Complications were graded according to the modified Clavien-Dindo system.

Patients were assessed for residual fragments by Xray and US KUB 2 weeks postoperatively. Patients were

Table 1 Patients (*n* = 65) and stones

Characteristics	Value	Percentage
Age, year	43.24 ± 13.775 SD (20–70)	
Gender		
Male	47	72%
Female	18	28%
Chronic disease		
Hypertension	15	23%
Diabetes	12	18%
Both	5	8%
BMI	26.445 ± 4.577 SD	
Laterality of stones (*n* = 66)		
Left	31	47%
Right	33	50%
Bilateral	1	1.5%
Staghorn		
Complete	41	62%
Partial	25	38%
Stone size, mm	60.06 ± 18.101	(36–120 mm)
Grade of hydronephrosis		
No	9	14%
Mild	30	45%
Moderate	17	26%
Severe	10	15%
History of previous stone intervention		
SWL	10	15%
URS	9	13%
PCNL	13	19%
Open	25	37%

kept on ongoing regular follow-ups and late complications were recorded.

Data were analyzed using the Statistical Package for Social Sciences (SPSS version 25). A paired *T* test was used for comparative analyses. A p value < 0.05 was considered statistically significant.

3 Results

Data on 65 patients were analyzed in this study, thereof 47 (72%) males. Mean age was 43.2 ± 13.7 years (20–70 years). Mean BMI was 26.4 ± 4.5. As the most prevalent comorbidities, diabetes mellitus was present in 12 (18%), high blood pressure in 15 (23%), and a combination of both in 5 (8%).

The mean stone burden was 60 ± 18 mm (36–120 mm). Mild/moderate/severe hydronephrosis was present in 45/26/15% of cases, respectively. Half of the stones were in the right kidney. Fifty-seven (88%) of patients had had previous stone interventions (Table 1).

Mean OP time was 79 ± 25 min (55–160 min). The vast majority of patients were operated upon under spinal anesthesia.

The number of tracts needed to achieve stone clearance varied from 2 to 4 in a single renal unit. A total of 154 percutaneous access tracts were established in 66 renal units, thereof 33 (50%) on the right side. Two tracts were used in 48 (72%), three in 14 (22%), and four in 4 (6%), respectively. Tracts were positioned in 66 (43%) in the lower pole, in 52 (34%) in the middle pole, and in 36 (23%) in the upper pole of the kidneys.

Table 2 Operation and immediate postoperative outcomes

	Value (*n*), percentage (%), (range)		*p* value
Number of accesses (*n* = 66)			
2	48	72%	
3	14	22%	
4	4	6%	
Point of entry (*n* = 154)			
Lower calyces	66	43%	
Mid calyces	52	34%	
Upper calyces	36	23%	
Anesthesia			
Spinal	58	88%	
General	8	12%	
Mean operating time, min	79.54 ± 24.839 SD		
Mean preoperative HB g/dL	13.8 ± 1.36 SD (9.1–16.3)		< 0.001
Mean postoperative HB g/dL	11.1 ± 1.19 SD (7.8–14.2)		
Mean preoperative creatinine mg/dL	1.25 ± 0.76 SD (0.65–4.3)		0.56
Mean postoperative creatinine mg/dL	1.23 ± 0.56 SD (0.67–3.5)		
Mean hospital stays (days)	1.5 (1–5)		

Table 3 Complications according to the Calvien grading system

Grade	Percentage
Grade 1	13 patients (20%)
Fever	7 patients (11%)
Transient renal function derangement	2 patients (3%)
Postoperative nausea and vomiting	4 patients (6%)
Grade 2	9 patients (13.8%)
Blood transfusion	6 patients (9%)
Infection require additional antibiotic	2 patients (3%)
Nephrostomy site leakage	1 patient (1.5%)
Grade 3(b)	2 patients (3%)
Bleeding require termination of the procedure	1 patient (1.5%)
Ureteric stone after JJ removal	1 patient (1.5%)
Grade 4	None
Grade 5	None

Table 4 Follow-up and adjuvant treatments

Stone-free after 2 weeks	56 (84.8%)
2nd look PCNL	2 (3%)
URS	1 (1.5%)
Conservative management	5 (7%)
Refused further treatment	2 (3%)

As to laboratory parameters, the mean creatinine did not significantly change from preoperative levels at 24 h post-PCNL. In contrast, the Hb level did drop from 13.8 ± 1.3 gr/dL (9.1–16.3) to 11.1 ± 1.1 gr/dL (7.8–14.2). This was statistically significant with a mean Hb-drop of 2.7 gr/dL. Six (9%) patients required blood transfusion. The mean hospital stay was 1.5 days (Table 2).

Clavien grade I complications occurred in 13 (20%) cases: fever in 7 (11%), transient impairment of renal function in 2 (3%), nausea/vomiting in 4 (6%).

Clavien grade II complications occurred in 9 (14%) cases: blood transfusion in 6 (9%), infection requiring additional antibiotics in 2 (3%), transient urinary leakage in 1 (1.5%).

Calvien grade IIIb complications occurred in 2 (3%) cases: bleeding and abortion of PCNL in 1 (1.5%), postoperative renal colic after JJ removal and URS in 1 (1.5%). There were no Clavien IV and V complications (Table 3). We observed no late complications after more than 2 weeks post-PCNL.

84.8% of patients were completely stone-free after one session of multitract PCNL. Of the 10 patients with residual fragments, 2 (3%) underwent a 2nd look PCNL, 1 (1.5%) URS, 5 (7%) opted for conservative management, and 2 (3%) refused further treatment (Table 4).

4 Discussion

The target of surgical intervention in staghorn stones is to achieve complete stone clearance to prevent recurrences and associated complications [22].

To increase the stone-free rate, many investigators evaluated multitract PCNL, either with standard PCNL or mini-PCNL, or a combination of both. The term "mini-PCNL" has been described by Manohar et al. [19]. With reduced-size instruments, they obtained complete stone clearance in 86% of cases, albeit with more than 60% of cases needing multiple tracts.

Cho et al. [23] found that in appropriately chosen patients, a multitract PCNL is safe and efficient. Fei et al. [24] achieved a 78% stone-free rate in 55 patients with complete staghorn stones who underwent multitract PCNL. They found multitract PCNL crucial to increase total stone clearance and to reduce reliance on supplemental extracorporeal lithotripsy and/or 2nd look PCNL. However, they used a flexible nephroscope to retrieve small peripheral fragments and to confirm stone clearance on the one hand, and to establish the need and location for another puncture on the other hand.

In our study, we achieved an 85% stone-free rate, which is comparable with other studies (84–89%) [24–26].

It is noteworthy that the hospital stay was only 1.5 days on average. This is because most of our patients (72%) needed only two tracts, which were removed usually after 24 h. Patients then were observed for a few hours and discharged on antibiotics.

One shortcoming of our study is that we relied on US and Xray alone to establish stone-free status, which may overestimate stone-free status by 17–35% [27]. Admittedly, using a CT scan post-procedure to detect residual fragments would be the more accurate method. But again, this is a report from a developing country with limited and restrained resources, and we make use of what we have easily and cost-effectively available.

The rate of blood transfusion in our study was 9.2%, which compares favorably with the literature (7.7–45%) [21, 22, 28, 29].

The overall complication rate using the modified Clavien–Dindo classification of surgical complications was 36.8%, which corresponds again with other authors' findings (30–41%) [25, 26]. Most complications were grade I and II. None of our cases developed bleeding that required super-selective angioembolization. Despite controversies in the literature concerning the impact of BMI on the outcome of PCNL, Chen et al. [30] found that BMI has neither affected the stone-free rate nor the postoperative complication rate in patients undergoing PCNL. The same findings were observed in our patients.

Limitations to our study are the relatively small number of cases and—as mentioned above—the use of Xray and US KUB, which have the potential to overestimate the stone-free rate. Also, procedures were performed by a highly experienced high-volume stone surgeon. Rates achieved might therefore not be fully representative for general urologists.

5 Conclusion

Multitract PCNL is feasible, safe, and efficient in managing staghorn calculi, with acceptable morbidity and complications. When auxiliary combination treatments are not available, multitract standard PCNL remains a good option.

Abbreviations

BMI: Body mass index; CT: Computertomography; dL: Deciliter; ECIRS: Endoscopic combined intrarenal surgery; F: French; gr: Gram; Hb: Hemoglobin; JJ: Double-J; KUB: Kidney, ureter, bladder; mm: Millimeter; OP: Operative; PCN: Percutaneous nephrostomy; PCNL: Percutaneous nephrolitholapaxy; SWL: Extracorporeal shock wave lithotripsy; URS: Ureterorenoscopy; US: Ultrasound; y: Year.

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Authors' contributions

SNM recorded, collected and assisted analyzing the data. AKA recorded, collected and assisted analyzing the data. OAR recorded, collected and assisted analyzing the data and was instrumental in developing the concept of the study. RB developed the concept, initialized the study, and wrote the first draft paper. NB reviewed, edited and submitted the final version. All authors read and approved the final manuscript.

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Ethics approval and consent to participate

Ethical approval was obtained from the Iraqi Board for Medical Specialization and consent to participate (Urology) approval number 4691. All participants gave written consent prior to their operation to be included in the study.

Consent to publish

Not applicable.

Competing interests

None declared by any of the authors.

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