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Original Article

Safety and Cost-effectiveness of Mini Percutaneous Nephrolithotomy as Day Care Surgery in Paediatric Patients

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ABSTRACT

Background: The increasing prevalence of urolithiasis in paediatric populations necessitates the exploration of efficient and safe treatment modalities. Mini percutaneous nephrolithotomy (PCNL), traditionally an inpatient procedure, has evolved with advancements in surgical techniques and pain management, prompting its consideration as a day care surgery.

Objective: This study aims to evaluate the safety, efficacy, and cost-effectiveness of day care mini PCNL in paediatric patients with kidney stones.

Methods: This prospective quasi-experimental study was conducted in a pediatric urology department. Patients aged 3 months to 14 years presenting with kidney stones were included. The procedure involved using a 16Fr mini PCNL nephroscope under general anesthesia and fluoroscopic guidance. Stone fragmentation was achieved using a pneumatic lithoclast, and fragmented stones were retrieved with wash and bifrong forceps. Inclusion criteria were stringent, considering factors like stone size, surgery duration, and patient recovery. Postoperative management included early mobilization, oral antibiotics, and analgesics. Follow-up was scheduled at 1 week and 1 month postoperatively. Data analysis employed SPSS version 20, focusing on variables like age, operative time, readmission rates, and cost comparisons.

Results: The study involved 92 patients, with a gender distribution of 71.7% male and 28.3% female. The average stone size was 2.2 ± 0.7 cm, and the mean operative time was 74 ± 16 minutes. The mean hospital stay was 11 hours, with readmission rates of 6.7%. The cost savings in day care mini PCNL were significant, with an average reduction of 8000 PKR per procedure compared to inpatient care. The success rate of day care surgery was 93.7%.

Conclusion: Day care mini PCNL is a viable, safe, and cost-effective treatment option for pediatric patients with kidney stones. It offers reduced hospital stay, lower costs, and high patient satisfaction without compromising on safety or treatment efficacy.

Keywords: Mini Percutaneous Nephrolithotomy, Pediatric Urolithiasis, Day Care Surgery, Kidney Stones, Cost-effectiveness, Surgical Outcomes.

INTRODUCTION

Urolithiasis, commonly known as kidney stones, is a prevalent condition affecting about 12% of the global population (1). This prevalence is on the rise in both developed and developing countries, a trend that can be attributed to factors such as sedentary lifestyles, dietary habits, and the effects of global warming (2). The Asian continent reports a variable prevalence rate of 1% to 19.1%, with a significant portion of these cases presenting in advanced stages, often accompanied by symptoms of chronic kidney disease. This contrasts with the situation in developed countries, where such advanced presentations are less common (3).

In the United States, urolithiasis has been identified in approximately 1 in every 11 individuals, posing a substantial economic burden on the healthcare system (4, 5). The annual cost implications of kidney stones in the U.S. have been estimated to exceed $5 billion. The management of urolithiasis is multifaceted, depending on various factors such as the size and location of the stone within the kidney, as well as the overall health and physical condition of the patient (6).

Traditionally, the only option for the treatment of kidney stones was open surgery. However, the last two decades have seen remarkable advancements in both the instrumentation and techniques used for treating this condition (7). Now, a range of treatment

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options exists, including medical management, extracorporeal shock wave lithotripsy (ESWL), and percutaneous nephrolithotomy (PCNL) (8). These minimally invasive procedures aim to achieve higher stone clearance rates, induce less postoperative pain, shorten hospital stays, facilitate a quicker return to normal activities, minimize kidney damage, and result in smaller surgical scars (9, 10).

The evolution of PCNL, in particular, has been noteworthy. Initially introduced by Fernstrom and Johansson in 1976 using a 28 Fr nephroscope, the procedure typically required an extended hospital stay and the placement of a nephrostomy tube. Since then, continuous refinements in PCNL instrumentation have led to significant improvements. Presently, the size of PCNL scopes has been reduced to less than 12 Fr, which has been associated with better patient outcomes, reduced renal trauma, and decreased overall morbidity.

Concurrent with these technological advancements, there has been a shift towards shorter hospital admissions for urolithiasis patients. This change is driven by several factors, including the aim to reduce hospital waiting lists, decrease healthcare costs, and increase the availability of hospital beds, without compromising patient safety and satisfaction. However, despite some studies suggesting that ambulatory PCNL is safe and cost-effective, larger randomized controlled trials (RCTs) have not conclusively reported on the safety and cost-effectiveness of mini PCNL as a day-case procedure. Wu et al., in a retrospective study of 86 patients, demonstrated that 82 patients were discharged within 12 hours post-procedure, including those with staghorn stones or stones treated using multiple tracks. In this study, only 4 patients required admission for more than 24 hours, and the readmission rate was noted to be 2.3%.

The present study aims to critically evaluate the safety and cost-effectiveness of day-case mini PCNL in a carefully selected pediatric population. However, due to the non-randomized nature of the study and the small sample size, there is a need for further research involving larger, randomized samples to validate these findings.

MATERIAL AND METHODS

This study was a prospective quasi-experimental investigation conducted in the pediatric urology department of a tertiary care hospital, specifically the Institute of Kidney Diseases. The research received approval from the institution's ethical committee (Approval No. 103/PEADS URO/IKD), and the study period spanned from 1st July 2018 to 31st March 2020. The cohort comprised pediatric patients who presented to the outpatient department with complaints of kidney stones. A comprehensive stone workup was undertaken for each patient, including a detailed history, general physical examination, relevant urological assessment, and baseline investigations. These investigations encompassed urine routine examination, complete blood count, renal function tests, and ultrasound imaging of the kidney, ureter, and bladder. Additionally, non-contrast CT of the kidneys, ureters, and bladder (CT KUB) was performed to obtain detailed anatomical information and to assess the stone's density (11).

All surgical procedures were carried out by a single experienced surgeon, utilizing a 16Fr mini PCNL nephroscope. The operations were performed under general anesthesia and with fluoroscopic guidance (12). The process of stone fragmentation was achieved using a pneumatic lithoclast, and the fragmented stones were retrieved using wash and bifrong forceps. At the conclusion of each surgery, double-J stents (DJS) were placed in an antegrade fashion in all patients (13).

Informed consent was obtained from all patients (or their guardians) scheduled for kidney stone surgery. They were thoroughly briefed about the details of the day-care procedure and the study's inclusion criteria. The inclusion criteria stipulated that patients should be older than one year, have a single subcostal puncture, stone size less than or equal to 2.5 cm, no excessive bleeding during the procedure, smooth induction and recovery from anesthesia, no injury to the kidney's mucosa, pelvis, or surrounding structures, the presence of a responsible caregiver at home, no social constraints, and a surgery duration of less than 60 minutes (14). The exclusion criteria included patients younger than one year, presence of stag horn stones, injury to the kidney parenchyma or pelvis, need for a nephrostomy tube, surgeries conducted late at night, supracostal puncture, requirement for double punctures for stone clearance, need for blood transfusion during surgery, surgeries lasting longer than 60 minutes, and difficulties in anesthesia management (15).

Postoperatively, patients selected for day-care surgery were retained in the day-care area for 4 to 6 hours. They were encouraged to mobilize early and commence fluid intake (16). Postoperative analgesia was initiated in the recovery room, as effective pain management is crucial for the success of day-care surgeries. Patients displaying normal vital signs, clear orientation, independent ambulation, and adequate food intake were discharged with oral antibiotics and analgesics (17). They were instructed to seek immediate medical attention in the event of symptoms such as gross hematuria, fever, urinary retention, or urine leakage from the puncture site. Contact information for the on-duty doctor and the operating surgeon was provided to all patients for use in case of emergencies. Follow-up visits were scheduled at 1 week for a general check-up and 1 month postoperatively for the removal of DJS (18).

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Data for the study were analyzed using the Statistical Package for Social Sciences (SPSS, Inc-, Chicago, Illinois, USA), version 20. Descriptive statistics were used to analyze numerical variables such as age, mean operative time, and readmission rate, with results presented as mean and standard deviation. Categorical variables like the reasons for inpatient readmission and perioperative complications, along with their management, were analyzed using chi-square tests and Fisher's exact tests. Additionally, the average cost of day-care mini PCNL was compared with that of inpatient mini PCNL to evaluate the cost-effectiveness of the day-care approach.

RESULTS

In this study, the demographic characteristics of the patient sample showed a diverse age range, extending from 3 months to 14 years. The gender distribution was predominantly male, accounting for 71.7% of the cohort (66 patients), while female patients constituted 28.3% (26 patients). Concerning the laterality of kidney stones, the right side was more commonly affected, with 60.8% (56 patients) having right-sided stones and 39.2% (36 patients) presenting with left-sided stones. The average size of the stones treated was approximately 2.2 ± 0.7 cm. The duration of the surgeries varied, with an average time of 74 ± 16 minutes.

Regarding the readmission rates for day care patients, the study observed both planned and unplanned readmissions. Planned readmissions, primarily due to patient preference, were noted in 2.7% of cases (2 patients). Unplanned readmissions included cases with puncture site discharge and hematuria, accounting for 2.7% (2 patients) and 1.3% (1 patient) of the cohort, respectively.

A significant aspect of the study was the cost comparison between inpatient and day care mini percutaneous nephrolithotomy (PCNL). For inpatient care, the cost for a 24-hour stay in a ward was 70,000 PKR, compared to 64,000 PKR for day care. Similarly, the cost for a 24-hour stay in a private room was 75,000 PKR for inpatient care, while day care maintained a steady rate of 64,000 PKR.

Table 1 Demographic Characteristics of the Study Sample

Variable	Value
Age	3 months to 14 years
Gender	No. (%)
Male	66 (71.7%)
Female	26 (28.3%)
Laterality	No. (%)
Right	56 (60.8%)
Left	36 (39.2%)
Size of Stone	2.2 ± 0.7 cm
Surgery Duration	74 ± 16 min

Table 2 Readmission Rates in Day Care Patients

Variable	No. of Patients (%)
Planned Readmission	
Patient Preference	2 (2.7%)
Unplanned Readmission	
Puncture Site Discharge	2 (2.7%)
Hematuria	1 (1.3%)

Table 3 Cost Comparison between Inpatient and Day Care Mini PCNL

Service Type	Inpatient Mini PCNL (PKR)	Day Care Mini PCNL (PKR)
Stay in Ward per 24 hr	70,000	64,000
Stay in Private Room per 24 hr	75,000	64,000

Table 4 Perioperative Complications and Management in Day Care Patients

Complaints	Management	No. of Patients (%)
Socially Not Willing for Day Care Surgery	Readmission	2 (2.7%)
Pain	Adjusted Pain Medications	1 (1.3%)
Puncture Site Discharge	Conservative	2 (2.7%)

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Complaints	Management	No. of Patients (%)
Fever	IV Antibiotics	1 (1.3%)
DJS Symptoms	Reassurance	3 (4.1%)
Bleeding	Conservative	1 (1.3%)

Perioperative complications and their management in day care patients were also documented. Notably, 2.7% of patients (2 individuals) were not willing to undergo day care surgery for social reasons and were readmitted. Pain management adjustments were required for 1.3% of patients (1 individual). Puncture site discharge and fever were each observed in 2.7% (2 patients) and 1.3% (1 patient) of the cases, respectively, and were managed conservatively or with IV antibiotics. Discomfort related to double-J stent (DJS) symptoms was reported in 4.1% of patients (3 individuals) and was addressed with reassurance. Finally, conservative management was also applied for a bleeding complication in 1.3% of patients (1 individual).

These findings illustrate a generally positive outcome for the day care mini PCNL procedure, with a low rate of complications and readmissions. The economic analysis further underscores the potential cost-effectiveness of the day care approach compared to traditional inpatient procedures.

DISCUSSION

The discussion of this study delves into the evolving landscape of pediatric urological surgeries, highlighting the shift towards day care procedures due to advancements in surgical instruments, heightened surgeon expertise, and improved postoperative pain management. Mini percutaneous nephrolithotomy (PCNL), once confined to inpatient settings, has increasingly been adopted as a day care surgery, reflecting this broader trend. The rationale behind this shift includes not only technological advancements but also the pressing need to mitigate healthcare facility burdens and financial constraints. The Vanwesemael et al. (2020) and other respective evidence reinforces this approach, advocating for increased use of day care surgeries to reduce hospital waiting lists and healthcare budgets without compromising patient safety and satisfaction (19-21).

In the context of mini PCNL, studies like those conducted by Wishahi et al. have shown that with stringent patient selection criteria, a substantial number of patients can be safely discharged within 12 hours post-surgery, thereby affirming the feasibility of day care PCNL (12). Such practices align with efforts to minimize patient morbidity, facilitate earlier returns to normal activities, and reduce hospital stays. In this study, the average operative time was 74±16 minutes, comparable to times reported in various other studies, although longer than some due to factors like patient age and complexity of cases, including partial staghorn stones requiring additional punctures (22).

The study's findings on hospital stay duration and readmission rates further underscore the efficacy of day care PCNL. With an average hospital stay of 11 hours and an earliest discharge at 7 hours, the study's parameters were more favorable compared to longer durations noted in another research (23). The readmission rate in this study was 6.7%, comparable to or better than rates observed in other studies. The reasons for readmission included puncture site discharge and hematuria, which were managed conservatively, aligning with findings from Kroczak et al. that post-PCNL bleeding is often venous and can be effectively managed without aggressive intervention (24).

Economic considerations also played a significant role in this study, with the cost difference between admitted and day care patients being about 8000 PKR per 24 hours. The success rate of 93.7% in patients selected for day care surgery highlights the procedure's efficacy. This finding is corroborated by other studies, including Zhao et al.'s retrospective analysis, which reported a similarly high discharge rate within 12 hours and a low readmission rate (25).

Systematic reviews and meta-analyses, such as the one conducted by Meng Gao et al., have further reinforced the parity between day care and inpatient mini PCNL in terms of stone clearance, complications, and readmission rates (26). These comprehensive studies provide robust evidence supporting the safety, cost-effectiveness, and feasibility of day care mini PCNL in a carefully chosen pediatric population.

In conclusion, this study validates the growing trend of performing mini PCNL as a day care procedure in pediatric patients with kidney stones. It demonstrates that with careful patient selection, day care mini PCNL is not only safe and cost-effective but also aligns with the broader objectives of modern healthcare: reducing hospital stays, minimizing patient morbidity, and ensuring high patient satisfaction and safety.

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CONCLUSION

In conclusion, this study presents compelling evidence supporting the use of mini percutaneous nephrolithotomy (PCNL) as a day care surgery for pediatric patients with kidney stones. The findings indicate that, with meticulous patient selection and adherence to defined criteria, mini PCNL can be safely and effectively performed in a day care setting. This approach significantly reduces the hospital stay duration and associated costs, without compromising patient safety or surgical outcomes. The study's implications are profound, suggesting a paradigm shift in pediatric urological surgeries towards more cost-effective and patient-centric care models. It underscores the potential of day care surgeries to alleviate the burden on healthcare facilities while maintaining high standards of patient care and satisfaction, thus paving the way for more efficient and sustainable healthcare practices.

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