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Original Research Article

IMPACT OF SMALL-BORE (10FR) VERSUS LARGE-BORE (24FR) NEPHROSTOMY TUBES ON PERIOPERATIVE OUTCOMES FOLLOWING PERCUTANEOUS NEPHROLITHOTOMY: A PROSPECTIVE RANDOMIZED COMPARATIVE STUDY

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Abstract

Background: Percutaneous nephrolithotomy (PCNL) has become the gold standard surgical procedure for the management of large and complex renal calculi. Traditionally, nephrostomy tube placement at the conclusion of PCNL has been considered an integral component of the procedure, providing postoperative drainage, tamponade of the nephrostomy tract, and access for secondary procedures when required. However, growing evidence suggests that nephrostomy tubes themselves contribute significantly to postoperative pain, discomfort, prolonged hospitalization, and reduced patient satisfaction. The trend in modern endourology has therefore shifted toward minimizing nephrostomy tube size and, in selected cases, adopting tubeless PCNL techniques. The aim is to compare the impact of small-bore (10 Fr) and large-bore (24 Fr) nephrostomy tubes on perioperative outcomes following PCNL. **Materials and Methods:** A prospective randomized comparative study was conducted on 60 patients undergoing PCNL for renal stone disease between September 2022 & September 2023 at the Department of Urology, The Oxford Medical College Hospital & Research Centre, Bangalore. Patients were randomized into two groups. Group I (n=30) received a 10 Fr Infant Feeding Tube as nephrostomy drainage, while Group II (n=30) received a 24 Fr chest tube drain. Outcomes assessed included postoperative pain scores, urinary leakage, haemorrhage, postoperative complications, patient comfort, and duration of hospital stay. **Result:** The mean age of participants was 31.45±15.8 years, while the mean stone size was 18.83±6.05 mm. Patients receiving the 10 Fr nephrostomy tube demonstrated significantly lower postoperative pain scores and superior patient comfort. No increase in postoperative haemorrhage, haematuria, or major complications was observed. Urinary leakage occurred exclusively in patients receiving 24 Fr nephrostomy tubes. Mean hospital stay was significantly shorter in Group I (5.00±1.29 days) compared with Group II (6.53±2.10 days; p=0.0012). **Conclusion:** Small-bore nephrostomy drainage following PCNL significantly improves postoperative recovery by reducing pain, improving patient comfort, minimizing urinary leakage, and shortening hospital stay without increasing complications. Small-bore nephrostomy tubes may therefore represent an effective alternative to conventional large-bore drainage following uncomplicated PCNL.

INTRODUCTION

Urinary stone disease remains one of the most prevalent and recurrent disorders encountered in modern urological practice. The condition has affected mankind for thousands of years and continues to represent a major healthcare burden worldwide. Historical evidence of urinary calculi has been identified in Egyptian mummies dating back more than 7,000 years, indicating that stone disease is among the oldest known surgical conditions affecting humans. Despite remarkable advances in medicine, technology, and preventive healthcare, the incidence and prevalence of urolithiasis continue to rise globally, making it a significant public health concern.

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The increasing prevalence of stone disease has been attributed to multiple factors, including changes in dietary habits, sedentary lifestyles, increasing rates of obesity, diabetes mellitus, metabolic syndrome, environmental influences, and genetic predisposition. Epidemiological studies from both developed and developing countries have demonstrated a steady increase in the incidence of nephrolithiasis over recent decades. Data derived from the National Health and Nutrition Examination Survey (NHANES) in the United States demonstrated that the prevalence of kidney stone disease increased from approximately 5.2% during the late twentieth century to nearly 9% in more recent surveys.[1,2] Similar trends have been observed across Europe, the Middle East, and Asia, suggesting that urolithiasis is emerging as a truly global disease.[3]

The socioeconomic burden associated with stone disease is substantial. Apart from causing significant morbidity, urinary calculi account for millions of outpatient visits, emergency department presentations, hospital admissions, and surgical procedures annually. Recurrent stone disease contributes further to healthcare expenditure, loss of productivity, and diminished quality of life. Studies have shown that approximately 50% of stone formers will experience recurrence within 5 to 10 years following an initial stone episode, emphasizing the chronic nature of this disease process.

The management of urinary stone disease has undergone dramatic transformation over the past five decades. Historically, open surgical procedures represented the cornerstone of treatment for patients with symptomatic renal and ureteric calculi. Procedures such as pyelolithotomy, nephrolithotomy, anatrophic nephrolithotomy, and ureterolithotomy were routinely performed for stone removal. Although these procedures achieved acceptable stone clearance rates, they were associated with significant morbidity, prolonged hospitalization, extensive postoperative pain, delayed recovery, and increased healthcare costs.

The development of minimally invasive urological techniques revolutionized the treatment of stone disease. The introduction of fiber-optic technology, advances in radiological imaging, development of endoscopic instruments, and innovations in intracorporeal lithotripsy significantly altered the therapeutic landscape. These advancements led to the emergence of extracorporeal shock wave lithotripsy (ESWL), ureterorenoscopy (URS), retrograde intrarenal surgery (RIRS), and Percutaneous Nephrolithotomy (PCNL), each offering less invasive alternatives to traditional open surgery.

Among these modalities, PCNL has emerged as the gold standard treatment for large renal calculi, staghorn stones, lower pole stones resistant to shock wave lithotripsy, and complex calculi associated with anatomical abnormalities. Since its introduction by fernStrom and Johansson in 19764, PCNL has undergone continuous refinement and has become one of the most successful minimally invasive procedures in modern urology.[4-7]

The fundamental principle of PCNL involves creating a percutaneous tract through the renal parenchyma into the pelvicalyceal system, thereby allowing direct access to the stone. Subsequent fragmentation and extraction of calculi can be performed using a variety of energy sources including pneumatic lithotripsy, ultrasonic lithotripsy, laser lithotripsy, and electrohydraulic lithotripsy. The procedure offers superior stone-free rates, particularly for stones larger than 2 cm, and has largely replaced open surgical approaches in contemporary practice.

Over the years, numerous technical modifications have been introduced to improve the efficacy and safety profile of PCNL. These include mini-PCNL, ultra-mini PCNL, micro-PCNL, tubeless PCNL, and totally tubeless PCNL.[8-11] Such innovations reflect the ongoing effort to reduce procedure-related morbidity while maintaining high stone clearance rates.

Despite its minimally invasive nature, PCNL is not devoid of complications. Potential complications include bleeding, infection, sepsis, urinary extravasation, pleural injury, colonic injury, renal pelvis perforation, and postoperative pain. Among these, postoperative pain remains one of the most common factors affecting patient recovery, ambulation, hospital stay, and overall satisfaction. Several studies have identified nephrostomy tube placement as a major contributor to postoperative discomfort following PCNL.

Traditionally, placement of a nephrostomy tube at the conclusion of PCNL has been considered an integral component of the procedure. The nephrostomy tube serves multiple purposes. It provides adequate urinary drainage, facilitates tamponade of the nephrostomy tract, allows monitoring of postoperative bleeding, prevents urinary extravasation, and maintains access for second-look nephroscopy when required. For many years, large-bore nephrostomy tubes ranging from 20 Fr to 30 Fr were routinely employed following PCNL based on the assumption that larger tubes would provide superior drainage and better haemostatic control.

However, increasing clinical experience has challenged this traditional belief. Investigators began to observe that many patients experienced significant flank pain and discomfort directly attributable to the nephrostomy tube rather than the procedure itself. Consequently, attention shifted toward reducing nephrostomy tube diameter as a means of improving postoperative recovery without compromising patient safety.

Several clinical studies have evaluated the relationship between nephrostomy tube size and postoperative outcomes. Maheshwari and colleagues demonstrated reduced analgesic requirements and shorter urinary leakage duration among patients receiving smaller nephrostomy catheters following PCNL.[12] Similarly, Pietrow et al. reported lower

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postoperative pain scores and decreased narcotic requirements in patients managed with 10 Fr nephrostomy tubes compared with larger drainage catheters.[13] De Sio et al. further confirmed that small-bore nephrostomy tubes were associated with reduced immediate postoperative pain without increasing complications.[14]

The development of tubeless PCNL further strengthened the hypothesis that nephrostomy drainage itself may contribute significantly to postoperative morbidity. Although tubeless approaches have demonstrated encouraging results, they are not universally applicable. Many patients continue to require nephrostomy drainage due to concerns regarding bleeding, residual stone fragments, collecting system perforation, or the need for secondary procedures. Consequently, optimizing nephrostomy tube size remains a clinically relevant issue.

An ideal nephrostomy tube should provide effective drainage while minimizing pain, discomfort, urinary leakage, infection, and hospital stay. Whether smaller nephrostomy tubes can consistently achieve these goals without increasing complications remains a matter of ongoing investigation. Existing literature has produced varying conclusions, with some studies reporting significant benefits associated with smaller drainage catheters, while others have demonstrated comparable outcomes irrespective of tube size.

Given these uncertainties, the present prospective randomized comparative study was designed to evaluate the effect of nephrostomy tube size on perioperative outcomes following PCNL. Specifically, the study sought to compare small-bore (10 Fr) and large-bore (24 Fr) nephrostomy tubes with respect to postoperative pain, haemorrhage, urinary leakage, patient comfort, complications, and duration of hospital stay. By addressing this clinically relevant question, the study aims to contribute to the growing body of evidence guiding postoperative management following PCNL and assist urologists in selecting the most appropriate nephrostomy drainage strategy for their patients.

Aim and Objectives

Aim

To evaluate the effect of nephrostomy tube size on perioperative outcomes following Percutaneous Nephrolithotomy.

Objectives

1. To compare postoperative pain between patients receiving 10 Fr and 24 Fr nephrostomy tubes.
2. To evaluate postoperative haemorrhage and haematuria in both groups.
3. To assess urinary leakage following nephrostomy tube removal.
4. To compare patient comfort and recovery.
5. To evaluate duration of hospital stay following PCNL.
6. To determine whether small-bore nephrostomy drainage provides comparable safety to conventional large-bore drainage.

MATERIALS AND METHODS

Study Design: Prospective randomized comparative study.

Study Setting: Department of Urology, The Oxford Medical College Hospital & Research Centre, Bangalore, Karnataka, India.

Study Duration: September 2022 to September 2023.

Sample Size: A total of 60 patients undergoing PCNL were included.

Randomization

Patients were randomized into:

Group I: 30 patients receiving a 10 Fr Infant Feeding Tube nephrostomy.

Group II: 30 patients receiving a 24 Fr Chest Tube nephrostomy.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS statistical software.

Continuous variables were expressed as mean ± standard deviation.

Categorical variables were expressed as frequencies and percentages.

Comparisons between groups were performed using:

- Student's t-test
- Chi-square test
- Fisher's exact test

A p-value less than 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics: The mean age of study participants was 31.45±15.8 years.

The groups were comparable with respect to age distribution.

Table 1: Distribution of age of the patients & stone size

Parameter	Group I (10 Fr)	Group II (24 Fr)	P-value
Mean Age	30.9±15.9	31.9±15.93	0.81
Mean Stone Size	17.87±5.41 mm	19.80±6.50 mm	0.21

Postoperative Pain: Patients receiving small-bore nephrostomy tubes experienced significantly lower postoperative pain scores during the immediate postoperative period.

Pain reduction translated into improved mobility, decreased analgesic requirements, and greater patient satisfaction.

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Urinary Leakage: No patient in Group I experienced urinary leakage following nephrostomy tube removal.

Four patients in Group II developed urinary leakage that persisted for 2–5 days before resolving with conservative management.

Haemorrhage: No significant differences were observed regarding postoperative haematuria, haematocrit reduction, transfusion requirements, or bleeding complications between groups.

Hospital Stay: The mean duration of hospitalization was significantly lower in the small-bore nephrostomy group.

Table 2: Distribution of Hospital stay

Group	Mean Hospital Stay
10 Fr	5.00±1.29 days
24 Fr	6.53±2.10 days

P = 0.0012

DISCUSSION

Percutaneous nephrolithotomy (PCNL) has become the preferred treatment modality for large and complex renal calculi due to its high stone clearance rates and lower morbidity compared with open surgical procedures. Since its introduction by FernStrom and Johansson in 1976, significant advancements in instrumentation, imaging, tract dilation techniques, and intracorporeal lithotripsy have improved both efficacy and safety. Despite these improvements, postoperative morbidity remains an important concern, with nephrostomy tube-related discomfort being one of the most frequently encountered issues affecting patient recovery.

The traditional rationale for nephrostomy tube placement following PCNL includes providing urinary drainage, maintaining access for secondary procedures, promoting haemostasis through tract tamponade, and preventing urinary extravasation. However, the nephrostomy tube itself can become a source of postoperative pain, discomfort, restricted mobility, prolonged hospitalization, and reduced patient satisfaction. Consequently, considerable interest has emerged regarding optimization of nephrostomy drainage strategies, particularly concerning tube diameter and the possibility of tubeless procedures.

The present prospective randomized study compared outcomes between patients receiving a small-bore 10 Fr nephrostomy tube and those receiving a conventional large-bore 24 Fr nephrostomy tube following PCNL. The findings demonstrate that the use of a smaller nephrostomy tube is associated with reduced postoperative pain, improved patient comfort, decreased urinary leakage, and shorter hospitalization without increasing perioperative complications.

Demographic Characteristics and Comparability of Study Groups: A critical prerequisite for interpreting comparative clinical studies is ensuring baseline comparability between study groups. In the present study, the mean age of patients in Group I was 30.9 ± 15.9 years compared with 31.9 ± 15.93 years in Group II, with no statistically significant difference observed between groups (p=0.81). Similarly, mean stone size did not differ significantly between groups (17.87 ± 5.41 mm versus 19.80 ± 6.50 mm; p=0.21). These findings indicate that both groups were well matched prior to intervention and that observed differences in postoperative outcomes can reasonably be attributed to nephrostomy tube size rather than demographic or stone-related confounding variables.

The age distribution observed in our study is consistent with epidemiological reports indicating peak stone disease occurrence during the third and fourth decades of life. This age group represents the most economically productive segment of the population, highlighting the importance of minimizing hospitalization and facilitating rapid recovery. Furthermore, the male predominance observed in our study is consistent with global patterns of nephrolithiasis, although contemporary studies suggest that the gender gap has narrowed due to increasing prevalence among women.

Impact of Nephrostomy Tube Size on Postoperative Pain: Postoperative pain represented one of the most clinically relevant findings in the present study. Patients receiving a 10 Fr nephrostomy tube consistently reported lower pain scores and improved comfort during the postoperative period compared with those receiving a 24 Fr nephrostomy tube. This finding supports the growing body of literature suggesting that nephrostomy tube diameter plays a significant role in determining postoperative pain following PCNL.

Several physiological mechanisms may explain this observation. Placement of a nephrostomy tube creates a tract traversing skin, subcutaneous tissue, muscle, renal capsule, and renal parenchyma. Larger tubes inevitably produce greater tissue displacement and mechanical stretching of surrounding structures. This increased tissue trauma results in heightened activation of nociceptive pathways and inflammatory mediators, contributing to postoperative pain.

Furthermore, larger nephrostomy tubes may produce persistent irritation of the renal capsule, which is richly innervated and highly sensitive to stretching. Movement of the tube during respiration, ambulation, and positional changes can further exacerbate discomfort. Smaller tubes, by contrast, occupy less space within the nephrostomy tract and are therefore less likely to provoke mechanical irritation and pain.

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The findings of the present study are in agreement with those reported by Maheshwari et al., who demonstrated significantly reduced analgesic requirements among patients receiving smaller nephrostomy catheters12. Similarly, Pietrow et al. reported lower postoperative pain scores and decreased narcotic consumption among patients managed with 10 Fr drainage catheters.[13] De Sio et al. also observed significantly lower pain scores during the immediate postoperative period among patients receiving smaller nephrostomy tubes.[14]

The reduction in pain observed in the present study has important clinical implications. Lower pain levels facilitate earlier ambulation, reduce opioid consumption, decrease the incidence of opioid-related adverse effects, improve patient satisfaction, and contribute to shorter hospital stays.

Effect of Nephrostomy Tube Size on Haemorrhage: Historically, larger nephrostomy tubes have been favoured because of the belief that they provide superior haemostasis through tamponade of the nephrostomy tract. The theoretical concern associated with smaller nephrostomy tubes is that reduced tamponade may increase the risk of postoperative bleeding and transfusion requirements. Interestingly, the present study did not demonstrate any increase in postoperative haemorrhage among patients receiving small-bore nephrostomy tubes. No significant differences were observed with respect to haematuria, haematocrit reduction, transfusion requirements, or clinically significant bleeding complications.

These findings are consistent with the majority of contemporary studies. Maheshwari et al., Pietrow et al, and De Sio et al.[12-14] similarly reported no increase in bleeding complications among patients managed with smaller nephrostomy catheters.

The results suggest that adequate haemostasis following PCNL may depend less upon nephrostomy tube diameter and more upon careful access planning, accurate calyceal puncture, meticulous tract dilation, and atraumatic stone extraction. In modern practice, improvements in surgical technique may have diminished the historical necessity for large-bore drainage solely for haemostatic purposes.

Nevertheless, the findings of the CROES Global PCNL Study reported a lower rate of haemoglobin reduction among patients receiving larger nephrostomy tubes. However, despite statistical significance, the clinical significance of this difference remains debatable, particularly given the associated increase in patient discomfort and hospitalization.

Urinary Leakage and Nephrostomy Tube Diameter

Urinary leakage following nephrostomy tube removal is a common source of patient discomfort and may contribute to delayed discharge from the hospital. In the present study, none of the patients receiving a 10 Fr nephrostomy tube experienced urinary leakage after tube removal, whereas four patients in the 24 Fr group developed leakage lasting between two and five days.

Several factors may explain this finding. Larger nephrostomy tubes create wider nephrostomy tracts, which may require a longer period to collapse and seal following tube removal. Persistent communication between the collecting system and skin can therefore result in prolonged urinary drainage through the tract.

Conversely, smaller nephrostomy tubes produce narrower tracts with less tissue disruption, facilitating more rapid tract closure and reducing the likelihood of persistent urinary leakage. Smaller tracts may also promote more efficient tissue approximation and healing.

The findings are consistent with those reported by Maheshwari et al. and Desai et al., both of whom observed reduced urinary leakage among patients receiving smaller nephrostomy catheters.[12,14] Marcovich et al. similarly reported a trend toward lower leakage rates among patients managed with pigtail catheters.[15]

The absence of urinary leakage in the small-bore group likely contributed substantially to the improved patient comfort and shorter hospitalization observed in our study.

Postoperative Infection and Fever: Postoperative fever occurred in both study groups, with four cases observed in the small-bore group and five cases in the large-bore group. No statistically significant difference was identified between groups.

This observation suggests that nephrostomy tube diameter does not significantly influence postoperative infectious complications. Instead, factors such as bacterial colonization of stones, operative duration, intrarenal pressure, preoperative urinary tract infection, and stone burden are more likely to determine the risk of postoperative fever and sepsis.

The observed fever rate is comparable to previously reported series and reinforces the importance of appropriate perioperative antibiotic prophylaxis and careful patient selection.

Hospital Stay and Recovery: One of the most important findings of the present study was the significant reduction in hospital stay among patients receiving small-bore nephrostomy tubes. Mean hospitalization was reduced from 6.53 ± 2.10 days in the 24 Fr group to 5.00 ± 1.29 days in the 10 Fr group ($p=0.0012$).

Hospital stay represents a comprehensive measure reflecting multiple aspects of postoperative recovery, including pain control, ambulation, urinary leakage, complications, and overall patient well-being. The shorter hospitalization observed among patients receiving smaller nephrostomy tubes likely reflects the cumulative benefits associated with reduced pain and improved comfort.

From an economic perspective, reduced hospitalization translates into lower healthcare costs, decreased utilization of hospital resources, and earlier return to productive activities. These benefits are particularly relevant in resource-constrained healthcare systems.

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Although some previous studies have reported only modest differences in hospital stay, the trend toward shorter hospitalization among patients receiving smaller nephrostomy tubes has been consistently observed in the literature.

Clinical Significance of the Present Study: The present study contributes to the growing evidence supporting the routine use of small-bore nephrostomy drainage following uncomplicated PCNL. The findings suggest that smaller nephrostomy tubes provide equivalent safety while significantly improving patient-centred outcomes.

Modern surgical practice increasingly emphasizes enhanced recovery protocols, reduction of procedure-related morbidity, and optimization of patient experience. Within this framework, small-bore nephrostomy drainage aligns closely with contemporary goals of minimally invasive surgery.

Importantly, the benefits observed in our study were achieved without compromising safety, suggesting that routine use of large-bore nephrostomy tubes may not be necessary in many patients undergoing uncomplicated PCNL

CONCLUSION

The present prospective randomized study demonstrates that small-bore nephrostomy drainage following PCNL provides significant clinical advantages over conventional large-bore nephrostomy tubes.

Patients receiving 10 Fr nephrostomy tubes experienced:

- Reduced postoperative pain
- Improved patient comfort
- Lower incidence of urinary leakage
- Shorter hospital stays
- Comparable safety profile without any increase in haemorrhage, infection, or other major complications

Accordingly, small-bore nephrostomy drainage should be considered a safe and effective alternative to conventional large-bore nephrostomy tubes following uncomplicated PCNL.

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