Original Article

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Easing Discomfort in Percutaneous Nephrostomy: The Minor-Calyx Approach

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Objective: To evaluate the effectiveness of renal capsular block in enhancing pain management during the initial step of two-step percutaneous nephrolithotomy (PCNL) procedures.

Methods: Patient Profile: A retrospective study was conducted on 17 patients who underwent the initial step of two-step PCNL between November 2009 and October 2010. Patients received renal capsular block for analgesia without premedication. Procedures were performed by an interventional radiologist, and pain scores were recorded during various stages of the procedure.
Preparation and Pain Score Recording: Patients were briefed on the numerical rating scale (NRS) for pain before undergoing the procedure. Tract anesthesia was administered using ultrasound-guided injections of lidocaine solution. Pain scores were recorded during tract anesthesia, target puncture, guidewire manipulation, tube introduction, and at the end of the procedure.

Results: Data Presentation: The average stone size was 2.43 cm, with men comprising a predominant proportion of the sample. The average pain score during the nephrostomy procedure was 4.18, with some patients requiring rescue analgesics. Needle entry route significantly influenced pain scores, with entries through the minor calyx associated with lower scores than those through the major calyx. Data Analysis: Patients were categorized based on procedural pain scores, revealing significant differences between groups based on needle entry route. Procedures involving the minor calyx had significantly lower procedural pain scores (Median: 3.00, interquartile range [IQR] [1.00, 3.00]) compared to those (Median: 7.00, IQR [5.25, 7.75]; $p < 0.01$) involving the major calyx.

Conclusions: Renal capsular block demonstrated effectiveness in pain management during the initial phase of two-step PCNL procedures, particularly when the minor calyx was used as the needle entry route.

Key words: percutaneous nephrolithotomy, minor calyx approach, pain control

Introduction

In the management of urological stones, extracorporeal shock wave therapy is the standard noninvasive approach for treating

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relatively small renal stones. However, percutaneous nephrolithotomy (PCNL), a more invasive technique that includes one-step and two-step approaches, is generally necessary for managing relatively large renal stones. Although one-step PCNL has been traditionally favored, recent trends have indicated a growing acceptance of two-step PCNL among urologists.[1]

Our institution also conducts two-step PCNL. The two-step PCNL procedure is conducted collaboratively, with interventional radiologists performing the initial step and urologists performing the subsequent step. The standard procedure for the initial step involves a combination of analgesic premedication and local anesthesia for effective pain management.

Administering renal capsular block along with premedication has been recommended as a comprehensive strategy for pain control throughout one-step PCNL procedures. This approach has also been extended to the initial stages of specific two-step PCNL cases in our institution. We conducted a retrospective study to gain deeper insights into the effectiveness of renal capsular block in enhancing pain management during the first step of the two-step PCNL procedure.

Patients and Methods

Patient Profile

Between November 2009 and October 2010, 22 patients underwent the initial step of two-step PCNL at our interventional radiology suite. These patients received renal capsular block for analgesia without premedication. All procedures were independently performed by an interventional radiologist with 5 years of experience. Several cases were excluded from our analysis because of a failure of the procedure (n = 1), lack of pain score records (n = 1), and lack of attached lead rulers required for measurement (n = 3). Thus, a total of 17 patients were included in the study, all of whom had complete pain score records related to tract anesthesia and the nephrostomy procedure, including target puncture, guidewire manipulation, and tube introduction.

Preparation and Pain Score Recording

Each of the patients was initially placed in a prone position on the examination table, with a lead ruler securely attached to their backs. Concurrently, the patient was thoroughly briefed on the 0 – 10 numerical rating scale (NRS) for pain.

Tract Anesthesia

The optimal entry route was primarily determined through renal ultrasound imaging. Subsequently, a 22-gauge spinal needle (TOP SPINAL NEEDLE, MEDITOP Corporation (M) Sdn. Bhd) was directed under ultrasound guidance through sterilized skin toward the target calyx (minor or major), as depicted in Figure 1. The needle tip was positioned close to the renal capsule, after which a lidocaine solution (Xylocaine Injection 2%) was administered to ensure a uniform distribution as the needle was gradually withdrawn. Typically, 10 – 12 mL of lidocaine solution was dispensed into the tract.

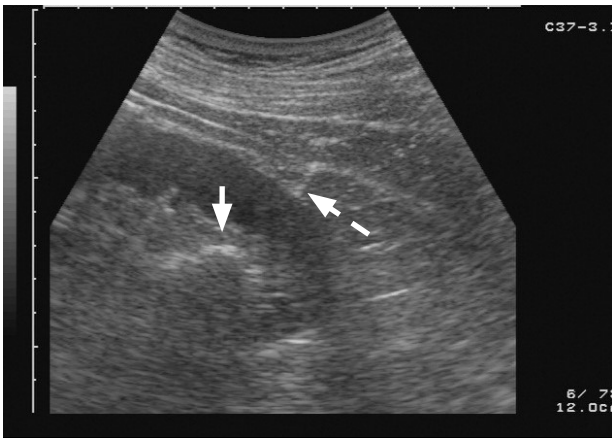

Fig. 1 A coaxial needle is advanced toward the hyperechoic surface of the target stone (arrow) under ultrasonic guidance and reaches the renal surface finally (dotted arrows).

Target Puncture

After a waiting period of 5 – 10 minutes, an 18-gauge coaxial needle (Angiotech Chiba Style, MEDICAL DEVICE TECHNOLOGIES, INC.) was used to puncture the targeted calyx through the anesthetized tract under both ultrasound and fluoroscopy guidance. Subsequently, an iodinated contrast agent (OMNIPAQUE) was injected to visualize the pelvicalyceal lumen and accurately localize the needle tip.

Guidewire Manipulation and Tube Introduction

Once the needle tip was appropriately adjusted, a long guidewire (RADIFOCUS GUIDE WIRE M, 0.035 in./120 cm, TERUMO CORPORATION) was threaded through the coaxial needle; the objective was to navigate the wire through the pelvicalyx to the urinary bladder. The coaxial needle was then replaced with a 6-French vascular sheath (RADIFOCUS INTRODUCER II, TERUMO CORPORATION), which facilitated the introduction of a shorter guidewire (RADIFOCUS GUIDE WIRE M, 0.035 in./80 cm, TERUMO CORPORATION). Subsequently, an 8-French Pigtail nephrostomy tube (SKATER Drainage Catheter Non-locking Pigtail, PBN MEDICALS) was inserted over the shorter wire, which remained in that location for the second phase of the procedure.

Stone Measurement and Pain Score Recording

The size of renal stones was measured using the attached lead ruler, with emphasis placed on the longest axis. Pain scores were measured during the administration of tract anesthesia, during the procedure itself, and at the end of the procedure and were all documented in the interventional radiology suite. Statistical analysis was conducted using the Wilcoxon rank-sum test and Fisher's exact test, and the significance level (α) was set to 0.05.

Results

Data Presentation

Table 1 presents the patients' demographics and statistical data, including sex, age, body mass index (BMI), stone size, and pain scores. The patients' age ranged from 32 to 70 years, and men constituted a predominant proportion of the sample. The average stone size, measured along the longest axis, was 2.43 cm. The average pain score during the nephrostomy procedure was 4.18, which was noted to closely align with the average pain score derived during tract anesthesia (3.53). Although most of the patients successfully underwent the procedure without the need for additional analgesics, three patients reported high pain scores (7, 7, and 8) and required rescue analgesics. Conversely, patients who did not require rescue analgesics exhibited lower average pain scores during (3.41) and at the end of the procedure (1.59).

Data Analysis

Patients were categorized into two groups on the basis of their procedure-related pain scores; the cutoff score for this categorization was 3. Nine patients had a score of ≤ 3, and eight had a score of > 3. Table 2 presents a comparison of these groups and indicates no significant between-group differences in sex,

Table 1. Baseline characteristics of the study population (N = 17).

Demographic characteristics	mean ± SD
Gender	13 males, 4 females
Age	52.35 ± 10.14
BMI (kg/m^2)	25.96 ± 4.08
Stone sizes in long axis (cm)	2.43 ± 1.06
Pain scores related to tract anesthesia	3.53 ± 2.21
Pain scores related to the procedure	4.18 ± 2.58
Pain score at the end of the procedure	1.59 ± 2.03

SD: Standard deviation.

age, BMI, stone size, or median pain scores from tract anesthesia. Notably, the choice of needle entry significantly influenced pain scores; entries through the minor calyx were associated with lower pain scores (≤ 3) and those through the major calyx were associated with higher pain scores (> 3). The groups were further divided into subgroups on the basis of needle entry route (Table 3): minor-calyx and major-calyx groups. No significant differences in demographics or median pain scores from tract anesthesia were noted between the minor- and major-calyx groups. However, the minor-calyx group exhibited significantly lower median procedure-related pain scores (3.00, interquartile range [IQR] [1.00, 3.00)]) than did the major-calyx group (7.00, IQR [5.25, 7.75]; $p < 0.01$). Similarly, postprocedure median pain scores were significantly lower in the minor-calyx group (0.00, IQR [0.00,0.50]) than in the major-calyx group (3.00, IQR [0.75, 4.75]; $p < 0.01$).

Discussion

PCNL is a key approach in the management of large renal stones and comprises two essential phases: the establishment of a

Table 2. Comparison of patients categorized by procedural pain score with a cutoff value of 3.

	Cases with procedural pain score ≤ 3 (n = 9)	Cases with procedural pain score > 3 (n = 8)	*p*-value
Gender			0.58[#]
Male	6	7	
Female	3	1	
Age, Median (IQR)	56.00 (40.00, 70.00)	49.00 (40.75, 60.00)	0.36[*]
BMI (kg/m^2), Median (IQR)	27.30 (24.00, 28.96)	24.09 (21.21, 27.16)	0.12[*]
Stone size (cm), Median (IQR)	2.45 (1.60, 3.71)	2.19 (1.53, 2.89)	0.50[*]
Needle entry route			< 0.01[#]
through minor calyx	8	1	
through major calyx	1	7	
Pain score related to tract anesthesia, Median (IQR)	3.00 (2.00, 8.00)	3.50 (1.25, 5.50)	0.29[*]

[*] Wilcoxon rank-sum test.
[#] Fisher's exact test.
IQR: interquartile range.

Table 3. Comparison between minor calyx approaches and major calyx approaches.

	Patients with minor calyx approach (n = 9)	Patients with major calyx approach (n = 8)	*p*-value
Gender			0.53
Male	6	7	
Female	3	1	
Age, Median (IQR)	56.00 (32.00, 70.00)	49.00 (40.00, 69.00)	0.44
BMI (kg/m^2), Median (IQR)	25.42 (23.23, 28.06)	25.09 (21.49, 29.11)	0.77
Stone size (cm), Median (IQR)	2.45 (1.30, 3.71)	2.19 (1.68, 2.89)	0.85
Pain score related to tract anesthesia , Median (IQR)	3.00 (2.50, 3.00)	3.50 (1.25, 5.50)	0.76
Pain score related to the procedure, Median (IQR)	3.00 (1.00, 3.00)	7.00 (5.25, 7.75)	< 0.01
Pain score at the end of the procedure, Median (IQR)	0.00 (0.00, 0.50)	3.00 (0.75, 4.75)	< 0.01

p-value: Wilcoxon rank-sum test; IQR: interquartile range.

suitable percutaneous nephrostomy tract and subsequent nephrolithotomy. These phases can either be conducted in a single session (also referred to as the one-step method) or spread across separate days (also referred to as the two-step method).[2] Despite historical preferences for the one-step method, the two-step approach offers various benefits, including enhanced operative time efficiency and reduced anesthesia requirements.

In the conventional one-step PCNL procedure, general anesthesia is typically administered to patients. However, Dalela et al. proposed an innovative pain management approach that entails the incorporation of renal capsular block combined with specific premedications.[3] Specifically, this approach involves numbing the PCNL tract from the skin to the superficial renal parenchyma by using lidocaine injections, along with administering intravenous tramadol and promethazine at the beginning of the procedure. Their findings indicated that 9 out of 11 participants reported NRS scores of < 3, whereas the remaining 2 reported NRS scores of 6 and 7 separately.[4,5] Similarly, in our radiological department, a comparable renal capsular block technique is employed during the initial phase of two-step PCNL procedures; however, the anesthesia depth and alterations or exclusions in the premedication regimen vary. The present study evaluated the effectiveness of the modified renal capsular block method during the initial step and focused on only patients who did not receive the standard premedication.

Our findings reveal an average procedural pain score of 4.18 among the 17 patients assessed in this study. Subsequent data analysis indicated that nine patients reported procedural pain scores of ≤ 3, whereas the remaining patients reported higher scores. Notably, a significant difference in median procedural pain scores was observed between the patients with procedural pain scores of ≤ 3 and those with scores of > 3 (3.00 vs. 7.00). Additional evaluations considering factors such as BMI, stone size, and needle entry routes revealed a significant distinction in terms of only needle entry route. Specifically, the minor-calyx group had lower procedural pain scores than did the major-calyx group, which may be attributed to a denser concentration of pain fibers in the major calyces. During the initial phase of two-step PCNL, patients may experience pain at various stages, including during tract anesthesia, target puncture, guidewire adjustment, and tube placement. Pain during tract anesthesia can be managed by slowing the injection rate; considering the sparse distribution of pain fibers, discomfort from needle or tube penetration into the renal parenchyma tends to be minimal. Conversely, penetration of the renal capsule, pelvicalyx, and renal hilum may lead to substantial discomfort owing to the abundant pain fiber supply in these structures. Moreover, probing the lumen of the urinary collecting system can cause mild discomfort, with the severity being dependent on the delicacy of the probing technique.

The use of the minor calyx as the needle entry route in our study significantly reduced the median procedural pain score to 3.00, IQR (1.00, 3.00), equal to the median pain score for tract anesthesia. After the procedure, the minor-calyx group reported a remarkable median pain score of 0.00, IQR (0.00, 0.50). By contrast, procedures requiring penetration through the major calyces and surrounding hilar tissues were associated with an increase in median pain scores to 7.00, IQR (5.25, 7.75), despite the use of renal capsular block.

To minimize procedural pain, the entry route involving the minor calyx is recommended when feasible (Fig. 2). However, certain situations may necessitate the use of the major calyx as the needle entry route. For example, minor calyces might not be sufficiently distended or may lack visible stones, and this renders the hyperechoic surface of stones in the major calyces a critical reference

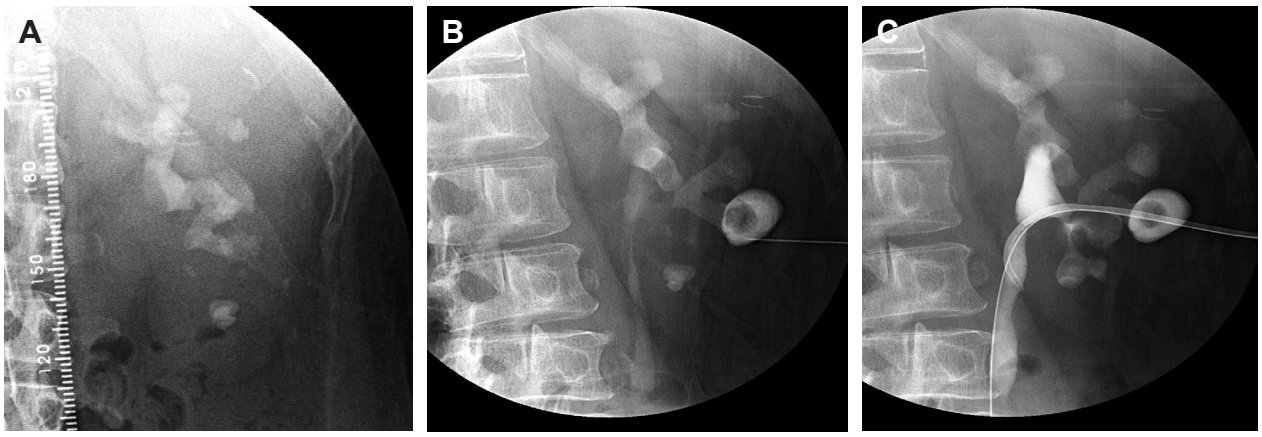

Fig. 2 (A) Right renal staghorn stone was revealed on scout film. (B) Minor calyx approach through puncturing the distended minor calyx was shown. The injected contrast flowed to the ureter smoothly with mild pelvicaliectasis. (C) Finally a Pigtail tube and a long guidewire were transmitted through the minor calyx to the upper ureter and the urinary bladder respectively.

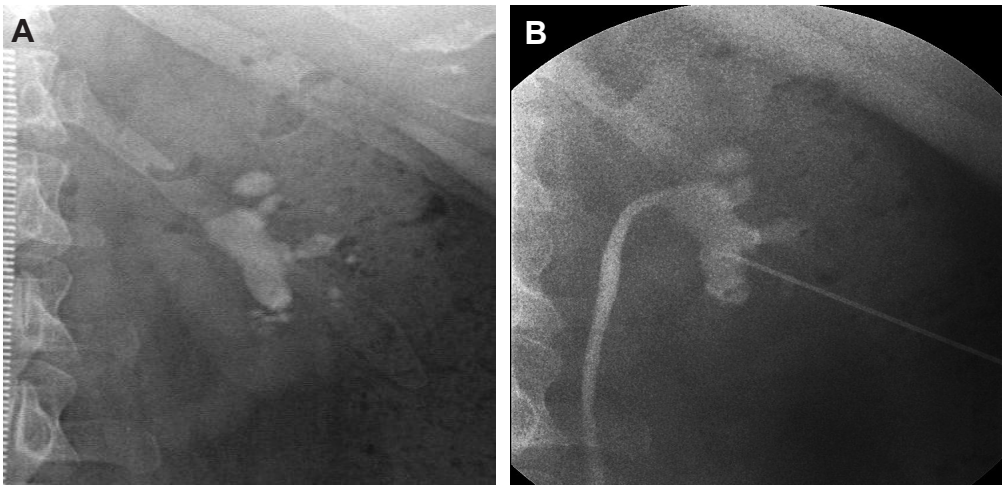

Fig. 3 (A) The scout film revealed right renal staghorn stone. (B) Major calyx approach through puncturing the stone in the inferior major calyx was shown. Administration of testing contrast revealed smooth contrast passage to the ureter without apparent pelvicalyceal distention.

point for the procedure. Additionally, access to the minor calyx may be impeded by obstructing pelvicalyceal stones, preventing guidewire advancement to the ureter. In such cases, a strategic shift to the major-calyx route may be required to navigate around minor calyx obstructions and ensure guidewire progression to the ureter (Fig. 3).

To enhance procedural outcomes, several strategies can be implemented. First, when the minor calyx is used as the entry route, a contrast agent should be injected through the needle until ureteral flow or retrograde filling of the renal parenchyma becomes evident, facilitating guidewire navigation. Second, the introduction of a vascular sheath can provide enhanced support, aiding in guidewire insertion; however, meticulous care must be taken to prevent inadvertent pelvicalyx perforation. Emphasizing careful guidewire manipulation and recommending a rigid iron-stylet over a soft plastic one can substantially facilitate the passage of the drainage tube, even in the presence of a stone-blocked renal pelvis.

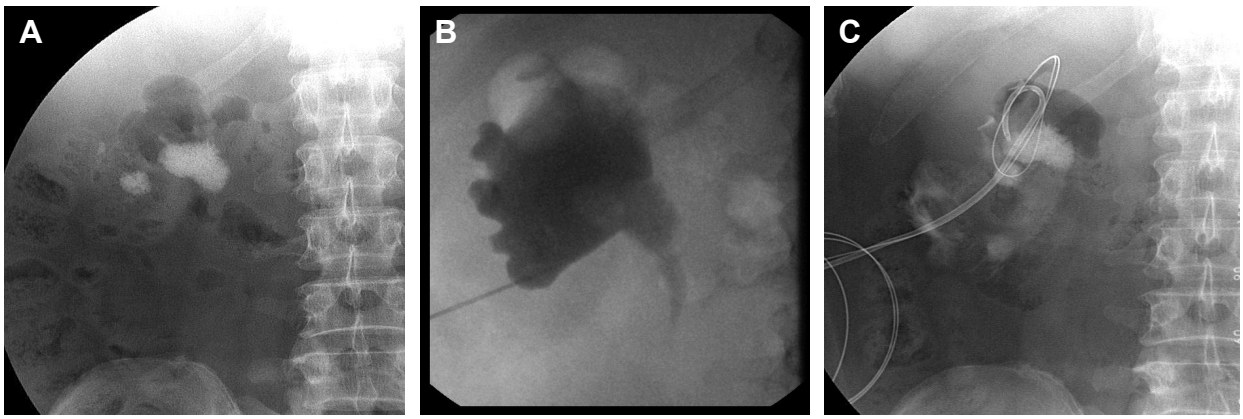

Fig. 4 (A) Scout film revealed left renal staghorn stone. (B) Puncture of the lower calyx was noted. Although the pelvicalyx had been quite distended by injecting much testing contrast, only little contrast could flow through the stone to the ureter. (C) Even with much effort, the procedure still failed due to severe ureteropelvic junction obstruction. Finally the Pigtail tube and long guidewire could just be left in the pelvicalyx.

Nevertheless, success in this approach is not guaranteed, particularly in cases with complete renal pelvis obstruction (Fig. 4).

In summary, the use of renal capsular block as a standalone technique demonstrates moderate effectiveness in pain management during the initial phases of two-step PCNL, particularly when the minor calyx is employed as the needle entry route. Therefore, it serves as a viable pain management strategy for percutaneous nephrostomy, particularly in scenarios of obstructive uropathy where the minor calyces are distended and more accessible. This approach allows for the preservation of major calyces and the renal hilum.

In scenarios where densely packed stones within the pelvicalyx necessitate the use of the major calyx as the needle entry route, relying solely on renal capsular block for pain management is often inadequate; hence, for additional sedative and analgesic premedication would be necessary.

This study has some limitations that should be considered when interpreting the results. These limitations include a small patient cohort, potential variability in local anesthetic distribution during renal capsular block, and the potential inaccuracies in stone size measurement by using plain film radiography with a lead rule. These factors underscore the importance of a careful and cautious interpretation of our findings.

Conclusions

Renal capsular block, when applied as the sole anesthetic technique, was demonstrated to be effective in pain management during the initial phase of two-step PCNL procedures, particularly when the minor calyx is used as the needle entry route. However, its effectiveness diminishes when the major calyx is used as the needle entry route. However, additional larger-scale studies are warranted to validate these observations and refine pain management protocols for urological stone treatments.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Chung-Hsien Chen, Chia-Lung Tsai and Yu-Chi Chen. The first draft of the manuscript was written by I-Chang Lin, Hung-Yu Lin and Ching-Yu Huang. All authors commented on previous versions of the manuscript. All

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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