Brief Report

Preliminary experience with lost mini percutaneous nephrostomy channel retrieval by methylene blue injection

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Abstract: Percutaneous nephrolithotomy (PCNL) is the primary choice for managing large renal stones and the establishment of mini-/micro-channels has been increasingly gaining practice. The smaller the channel, the easier it is to be lost, which may require a new puncture site and increase the risk of bleeding complications. In this study, we retrospectively reviewed 1,056 PCNL procedures in our single institute, The University of Hong Kong – Shenzhen Hospital, between March 2014 and August 2023. Twenty-three cases of nephrostomy channel loss during mini PCNL were identified, resulting in an incidence rate of 2.2%. Methylene blue was immediately injected into the ureteral catheter to facilitate location and retrieval of the channel. Once extravasation of the dye was identified under rigid ureteroscope, a first guidewire was introduced into the channel for maintenance, followed by another guidewire inserted in parallel to facilitate dilatation. The major reasons for PCNL channel loss were mild hydronephrosis and complete obstruction of the target calyx due to renal stones. Technical success, defined as the ability to retrieve the lost channel within 5 minutes, was 78.3% (n=18/23). Three channels were completely lost and 2 patients showed channel bleeding despite successful identification, all of which required establishment of a new PCNL channel. No major intraoperative nor postoperative complication was observed.

Keywords: Nephrolithiasis; percutaneous nephrolithotomy (PCNL); surgical technique

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Introduction

The American Urological Association guidelines recommend percutaneous nephrolithotomy (PCNL) as the primary choice for managing large (>2 cm) or proximal renal stones (1). Successful establishment of a nephrostomy tract is crucial for the operation to proceed. This is done by making a direct puncture to the target calyx under ultrasound guidance and introducing a guidewire into the renal pelvis or ureter before tract dilatation. Failure to provide access into the target calyx can potentially lead to secondary complications and prolong operation duration, which may overall affect postoperative outcomes.

Despite sufficient surgeon experience, several factors such as a mobile kidney, a thin renal parenchyma, and imprecision of the surgical team, can still eventually lead to the accidental loss of the nephrostomy channel. Access to the target calyx is complicated. Current methods to locate a lost nephrostomy channel include ultrasound guidance or endoscopic assistance (2,3). There is no standard or best method. Regardless, failure to achieve access from the original channel would require reestablishment of a new PCNL channel.

This study aimed to describe a novel technique applied to identify a lost nephrostomy channel during PCNL and evaluate the initial outcomes by retrospectively reviewing the 23 patients included. We present this article in

accordance with the STROBE reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-23-608/rc).

Methods

Study design

In a prospectively collected database, the medical and surgical records of all patients who underwent PCNL at our single institute (The University of Hong Kong – Shenzhen Hospital) between March 2014 and August 2023 were reviewed. Of the 1,056 patients, we identified 23 patients whose PCNL procedures were complicated with nephrostomy channel loss.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the institutional ethics committee of The University of Hong Kong – Shenzhen Hospital (No. hkuszh2019239-01) and individual consent for this retrospective analysis was waived.

Preoperative preparation

Routine laboratory tests were performed on all the patients preoperatively. The sterility of the preoperative urine culture was ensured in all patients, and a computed tomographic urography was undertaken. Prophylactic antibiotics were administered.

Surgical technique

Under general anesthesia, the patient was placed in either lithotomy (March 2014 – April 2020) or split-leg prone (May 2020 – August 2023) positions. A 0.035-inch guidewire was introduced into the target ureter under ureteroscopic guidance. The tip of a 6 Fr ureteral catheter was trimmed prior insertion to the renal pelvis or proximal ureter along the guidewire and fixated to a Foley catheter. Patients in lithotomy position were carefully adjusted to prone position. Percutaneous puncture to the target middle calyx from the posterior aspect was conducted under ultrasonographic (USG) guidance at the level beneath the 11th or 12th intercostal space. Access was made by puncturing against the lateral aspect of the USG with an 18 G needle. This technique differs from conventional methods as previously described (4). Continuous flushing with normal saline was performed to ensure a clear pathway, as well as facilitate dilatation. Gradual dilatation of the nephrostomy tract was performed with sequential dilators up to 8–18 Fr from a nephrostomy kit (CLINY, Create Medic, Japan). A compatible peel-away sheath was introduced. A rigid ureteroscope (Richard Wolf GmbH, Knittlingen, Germany) was inserted via the guidewire to directly visualize and confirm the position of the working channel.

During the circumstance in which the nephrostomy channel was lost or that the guidewire was displaced from the collecting the system, the rigid ureteroscope would be adjusted and maintained in the same direction as the puncture site. Methylene blue diluted with 0.9% saline at 1/25 was immediately injected into the preplaced ureteral catheter. Once extravasation from the puncture site was detected, a 0.035-inch Zebra or Loach guidewire was inserted to introduce the rigid ureteroscope followed by the parallel insertion of another guidewire to dilate the retrieved tract. Once successful, standard PCNL procedure was again proceeded.

If bleeding occurred from the original tract, the flow rate and pressure of the saline flush would be increased to 0.8–1.0 L/min and 250–400 mmHg, respectively. If the original nephrostomy channel could not be identified within 5 min, another puncture site would be established. If the target calyx stone obstructed the parallel insertion of the second guidewire, stone fragmentation by holmium laser lithotripsy (VersaPulse® PowerSuite™ 100W, LUMENIS, CA, USA) at 1.0 W, 15 Hz setting or pneumatic lithotripsy (Swiss LithoClast® Select, Boston Scientific, NJ, USA) would be performed based on the surgeon's discretion.

Results

The mean age of patients was 49.6±13.8 years. Four patients (17.4%) had prior renal procedures performed on the same side. The mean maximum diameter of the renal stone was 4.0±1.4 cm and the mean maximum computed tomography value was 1,272.2±349.2 Hounsfield units.

Operative details are summarized in *Table 1*. Ultrasound-guided puncture to establish nephrostomy tract access was mainly performed at the intercostal space beneath the 11th rib to reach the middle calyx (65.2%, 15/23). The identified causes of nephrostomy channel loss were mild hydronephrosis (82.6%, 19/23) and complete obstruction of the target renal calyx due to heavy stone burden (69.6%, 16/23).

Table 1 Summary of patient characteristics and surgical details

Parameters	Values
No. of patients	23
Age, mean ± SD, years	49.6±3.8
Renal stone characteristics	
Maximum diameter, mean ± SD, cm	4.0±1.4
Maximum CT value, mean ± SD, HU	1,272.2±349.2
STONE score, mean ± SD	147.6±25.0
Puncture site, n (%)	
Intercostal space	
Beneath 11th rib	15 (65.2)
Beneath 12th rib	8 (34.8)
Calyx	
Superior	5 (21.7)
Middle	15 (65.2)
Lower	3 (13.0)
Reason for channel loss, n (%)	
Fully obstructed target calyx	16 (69.6)
Mild hydronephrosis	19 (82.6)
Prior renal procedure	4 (17.4)
Successful retrieval of lost NC, n (%)	18 (78.2)
Reason of failure to retrieve lost NC, n (%)	
No MB extravasation	3 (13.0)
NC bleeding	2 (8.7)
Secondary PCNL, n (%)	8 (34.8)

SD, standard deviation; CT, computed tomography; HU, Hounsfield units; NC, nephrostomy channel; PCNL, percutaneous nephrolithotomy; MB, methylene blue.

Technical success, defined as successful identification and retrieval of the original nephrostomy tract within 5 minutes that did not require establishment of a new PCNL tract, of methylene blue injection method was 78.3% (18/23). Among the 5 unsuccessful cases, 2 were due to bleeding of the original tract that, despite successful identification and retrieval, was deemed unsuitable for further dilation.

The mean total operative duration was 147.6±25.0 min. No major intraoperative or postoperative complication was observed. Eight patients (34.8%) required secondary PCNL during follow up due to significant residual stones.

Discussion

To the best of our knowledge, this is the first study to describe the novel technique of methylene blue injection into the ureteral catheter to enable identification a lost nephrostomy channel by dye extravasation under rigid ureteroscope observation. The technique has been safely utilized in 23 patients and deemed relatively effective to retrieve a lost nephrostomy channel based on the preliminary experiences.

According to the European Association of Urology guidelines, the contraindications of PCNL include ongoing anticoagulant therapy, untreated urinary tract infection, pregnancy, tumor in the presumptive access tract area, and potential malignant renal tumor (5). PCNL can be widely performed in patients with upper urinary tract stones, including patients diagnosed with horseshoe kidney or polycystic kidney disease (6,7). PCNL has a higher stone-free rate than flexible ureteroscopic lithotripsy regardless of stone size and composition (8). Mini-PCNL demonstrated more advantages for certain cases of proximally impacted ureteral stones (9).

Given the advances of PCNL and its steep learning curve, the authors would like the reiterate the importance of establishing a safe and clear PCNL access and that PCNL channel loss may still occur despite increased surgical experience and technological developments (10). This minor inconvenience may increase the risk of secondary complications. Inability to achieve access was reported by 2% of the urologists (5). Reasons include insufficient dilatation, complete obstruction of the target calyx due to renal stones, displacement of the dilator as a result of not carried along the guidewire, or scarring of the calyx due to prior renal surgery that creates difficulty in the advancement of the Amplatz sheath (11).

In order to increase the overall success rate of establishing a PCNL tract, other steps were undertaken. First, our department preferred making the puncture at the intercostal space beneath the 11th or 12th rib, which targets the posterior middle calyx. A study has found that intercostal access could increase the rate of achieving a stone-free status, lower the postoperative complication rate, and significantly reduce operation duration (12). Secondly, we mentioned trimming the tip of the preplaced ureteral catheter before insertion, this is done to increase the efficiency of continuous retrograde infusion of normal saline. Thirdly, a calyx fully obstructed with renal

stones creates an obstacle for the smooth introduction of a guidewire due to its soft tip. Javali *et al.* suggested the application of a rigid ureteroscope introduced percutaneously through the PCNL puncture site as a safe and effective technique that facilitates guidewire maneuver along the ureter (2). This method was applied in our procedure. However, fragmentation of the stones may be necessitated to prevent damage of the guidewire and minimize operation time.

Nephrostomy channel loss often occurred during the tract dilation process. Currently, there are 4 different dilation methods, including the Amplatz dilation, metal telescopic dilation, balloon dilation, and one-shot dilation method (13). Comparative studies showed preference towards the Amplatz dilation method than balloon dilation, which is regarded as the gold standard, as balloon dilation is more costly and has a higher failure rate in cases with calyceal/staghorn stones, mild hydronephrosis, and a history of prior renal operation (14). Based on our experience, we identified several other reasons that may lead to channel loss, including (I) insufficient coiling of the guidewire despite successful puncture; (II) difference in distance between the tip of the 16/18 Fr dilator and the stripping sheath, which was approximately a 22-mm difference and could inadvertently lead to guidewire displacement during removal of the inner core; (III) failure to introduce the outer sheath into the renal collecting system.

Since the nephrostomy channel remained patent in most cases (87.0%, 20/23), extravasation of the methylene blue dye can be observed through the rigid ureteroscope and effectively identify the lost channel. However, despite the successful retrieval of lost nephrostomy tract in 2 patients, further dilation would increase the risk of bleeding and therefore the surgeon decided it safer to establish a new tract.

The main limitations of this study are its retrospective design, the heterogeneity of stones in all PCNL cases, and the inability to conduct a comparative study due to the lack of a prospective database despite the many PCNL operations in a single academic institute. The incidence of PCNL channel loss is low and may decrease in the future as surgical precisions improve. Nonetheless, this was a feasibility study. The technique is safe, simple, and readily available without the need of extra applications, thereby leading to a steep learning curve. The authors believe that this technique is useful when accidental PCNL channel loss occurs.

Conclusions

The incidence of PCNL channel loss is low but may occur. Immediate injection of methylene blue and extravasation of the dye found directly under rigid ureteroscope is a safe and effective method to retrieve a lost PCNL channel.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tau.amegroups.com/article/view/10.21037/tau-23-608/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tau.amegroups.com/article/view/10.21037/tau-23-608/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional ethics committee of The University of Hong Kong – Shenzhen Hospital (No. hkuszh2019239-01) and individual consent for this retrospective analysis was waived.

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