Chinese One-shot Dilation versus Sequential Fascial Dilation for Percutaneous Nephrolithotomy: A Feasibility Study and Comparison

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Purpose: Nephrostomy tract creation is a key step to perform a successful percutaneous nephrolithotomy (PCNL). In an attempt to improve the conventional technique of the tract dilation, a Chinese one-shot dilation was developed and compared with the sequential fascial dilation using a retrospective study.

Materials and Methods: We retrospectively reviewed medical records of 116 patients who had undergone 116 PCNL in our department from January 2012 to December 2012. The nephrostomy tracts had been created by using Chinese one-shot (one-shot group, 59 cases) or sequential fascial dilation technique (sequential group, 57 cases). Tract creation time, hemorrhage loss, overall renal function, tract dilation failure and major complications were compared between the two groups.

Results: The one-shot group had a significantly shorter mean (SD) tract creation time (1.9 ± 0.5 vs 4.5 ± 0.8 min, $P < 0.001$) and lower mean (SD) decrease in hemoglobin concentration (0.60 ± 0.34 vs 0.69 ± 0.36 g/dL, $P = 0.0008$) compared to the sequential group, respectively. There were no significant differences in mean (SD) value changes of preoperative and postoperative serum creatinine concentrations (4.7 ± 11.5 vs 4.8 ± 14.8 μmol/L, $P = 0.2611$) and stone-free rate (86.4% vs 85.9%, $P = 0.6145$) between the one-shot and sequential group. No tract dilation failure or major complications occurred in both of the groups.

Conclusion: This retrospective study demonstrated that the Chinese one-shot dilation technique is as safe and feasible as the conventional sequential fascial dilation. Furthermore, a greater reduction in tract creation time and blood loss was achieved using this technique.

Key words: Nephrolithotomy, Percutaneous; Dilation; Kidney Calculi; Complications

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is an effective treatment method for large and complex kidney stones [1,2] and increasingly applied to moderate stone burdens, particularly for stones in the lower pole calyces[3]. The key step of PCNL is nephrostomy tract creation and the most common complications of PCNL, such as renal hemorrhage, tract dilation failure, and collecting system perforation, are all associated with this step[4]. Currently, nephrostomy tract creation is performed with three classical dilation techniques: Alken metal telescopic dilation[5], Amplatz serial fascial dilation[6,7], and high-pressure balloon dilation[8]. Alken metal telescopic dilation and Amplatz serial fascial dilation are sequential dilation methods composed of repeated insertion and withdrawal of incremental dilators, and associated with prolonged tract dilation time, excessive radiation exposure and increased possibility of tract loss and collecting system perforation[9]. High-pressure balloon dilation technique, though decreases the number of exchanges, still requires multiple exchanges and time consuming[10], and may cause disruption of dilated structures. Moreover, the expensiveness of high-pressure balloon precludes it to be commonly used[9,11], and the effect of this technique on blood loss is still in controversy[2,12-14].

A safe, efficient and easy-to-perform technique for nephrostomy tract creation of PCNL are always highly desired by endourologists. Over a decade before, a "one-step" or "one-shot" dilation technique was developed by using a single 25-30 F Amplatz dilator over Alken guidance, which was safe and effective, as well as less time consuming, less blood loss, and less X-ray exposure as reported[15,16]. However, this technique still required to exchange the dilator once. Recently, we described a novel one-shot nephrostomy tract dilation technique (Chinese one-shot) using a single fascial dilator, and the clinical outcome demonstrated that it was safe and highly efficient[17]. In this retrospective study, we present our experiences by comparing the outcomes of Chinese one-shot dilation group to those of a conventional sequential fascial dilation group. The parameters included tract creation time, hemorrhage loss, overall renal function, tract dilation failure and major compli-

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Table 1. Patient demographics and stone features

	One-shot group n: 59	Sequential group n:57	*P* value
Age (y)			
Mean ± SD	46.7±12.3	47.4 ± 10.6	0.6076
Range	20-77	24-69	
Gender, n (%)			
Male	36 (61.0)	37 (64.9)	0.6641
Female	23 (39.0)	20 (35.1)	
Stone side, n (%)			
Left kidney	32 (54.2)	35 (61.4)	0.4347
Right kidney	27 (45.8)	22 (38.6)	
Stone location, n (%)			0.2312
Pelvis	23 (39.0)	17 (29.8)	
Upper segment of ureter	5 (8.5)	2 (3.5)	
Middle calyceal group	1 (1.7)	4 (7.0)	
Lower calyceal group	6 (10.2)	3 (5.3)	
Pelvis and calyx	24 (40.7)	31 (54.4)	
Stone burden (cm)			0.5169
Mean ± SD	4.9 ± 3.2	4.8 ± 3.9	
Range	1.9-10.5	1.6-11.4	

cations. We aim to further evaluate the safety and efficacy of our Chinese one-shot technique and discuss the possibility of popularizing it.

PATIENTS AND METHODS

A retrospective review of 116 PCNL cases performed by a single surgeon from January 2012 to December 2012 in our department were performed. Demographic and stone information was presented in **Table 1**. Stone burden was assessed by preoperative CT, where for each stone the cross-sectional area was calculated by multiplying length by width. The cross-sectional area of all stones was summed and reported as the total burden in case of multiple stones.

Fifty-seven consecutive patients who had undergone the sequential fascial dilation technique (the sequential group) were compared to fifty-nine patients who had undergone with the Chinese one-shot technique (the one-shot group). All patients were in accordance with the routine indications of PCNL, and exclusion criteria were patients who required bilateral PCNL or second stage PCNL. Nephrostomy tract creation time, puncture position, renal hemorrhage, blood transfusion rates, overall renal function (preoperative and postoperative serum creatinine concentrations), tract dilation failure, the incidence of complications and stone-free rate were compared between the two groups.

The outcomes included tract creation time, hemorrhage, overall renal function, tract dilation failure, stone-free rate and major complications. The tract creation time was defined as the time from the Chiba needle puncture to the direct observation of the collecting system under nephroscope. The hemorrhage loss was evaluated by comparing the last preoperative hemoglobin level with 24-hour postoperative counterpart. Blood transfusion was conducted provided that the cardiopulmonary compensation mechanisms were insufficient due to anemia or the postoperative hemoglobin value was less than 80 g/dL. The number and volume of blood transfusion were recorded. The overall renal function assessed by comparing the last preoperative and the 24-hour postoperative serum creatinine concentration level. Residual fragments <4 mm was considered to be stone-free. The incidence of complications such as tract dilation failure and collecting system perforation was noted.

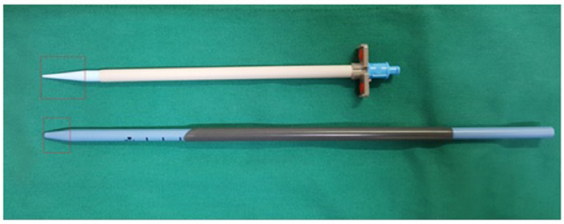

Figure 1. The detail of the special design of Creator dilator. As pointed out by the red square, Creator dilator (the upper) has a sharper tip and longer tapered end compared to Amplatz dilator (the lower) (2.5 cm vs. 1.5 cm).

Chinese one-shot dilation

After adequate epidural anesthesia was induced, each patient received a single dose of antibiotic intravenously and positioned in the lithotomy position. A 6 F ureteral catheter was introduced to the ipsilateral renal pelvis using cystoscopy. After indwelling a Foley catheter, the patient was then repositioned in a prone position. The puncture pathway of the 18 G Chiba needle was strictly through the central point of the target fornix and along the axis of the infundibulum with the guidance of a grayscale ultrasound (US, B-K Medical, Herlev, Denmark) (Supplementary **Figure. 1**). The aspiration of urine on removal of the stylet of the needle confirmed the entrance into the collecting system, a super-rigid guidewire (Urovision GmbH, Bad Aibling, Germany) was then introduced under US guidance (Supplementary **Figure. 2**). Before the needle was removed, the skin and fascia were incised over the puncture site, and then a 22 F pencil-shaped fascial dilator (Create, Yokohama, Japan, **Figure. 1**) with matched sheath was advanced into collecting system over super-rigid guidewire directly. Rotating the dilator with angular shearing force may facilitated the passage through the renal capsule into the renal collecting system. The appearance of break-through feeling or aspiration of urine from the dilator indicated the matched sheath was advanced smoothly into the collecting system, and then the dilator was removed while holding the sheath in position for the next operation (**Figure. 2**). All steps including needle puncture, tract dilation and sheath placement were performed without fluoroscopic control in all patients.

Table 2. Comparison of two groups: the outcomes during and after surgery of 116 cases

	One-shot group n: 59	Sequential group n:57	*P* value
Tract creation time (min)			
Mean ± SD	1.9 ± 0.5	4.5 ± 0.8	< 0.0001
Range	1.5-3	3.5-6	
Successful access, n (%)	59 (100%)	57 (100%)	
Hemoglobin value (g/dL), mean ± SD			
Preoperative	133.7 ± 16.3	131.6 ± 16.5	0.6405
Postoperative	127.5 ± 15.7	123.5 ± 15.8	0.5917
Decrease after operation	0.60 ± 0.34	0.69 ± 0.36	0.0008
Serum creatine concentration (μmol/L), mean ± SD			
Preoperative	85.4 ± 42.7	78.4 ± 21.6	0.6164
Postoperative	80.6 ± 39.4	73.2 ± 18.4	0.4759
Increase after operation	4.7 ± 11.5	4.8 ± 14.8	0.2611
Stone-free rate	51 (86.4%)	49 (85.9%)	0.6145
Adjacent organ injury	0	0	
Major vascular injury	0	0	
Collecting system perforation during tract dilation procedure	0	0	
Dilation failure	0	0	
Transfusion requirement	0	0	
Angiography requirement	0	0	

Stone treatment and removal were performed in a conventional manner. A 20.8 F nephroscope (Wolf, Mainburg, Germany) was introduced through the 22 F sheath and stones were disintegrated using ultrasonic/pneumatic lithotripters (Swiss Lithoclast, Nyon, Switzerland). At the end of the procedure, residual stones were detected by abdominal radiography (Siemens, Muenchen, Germany) or ultrasound in case of radiolucent stones. After complete clearance was confirmed, a 6 F double-J stent was introduced antegradely, followed by a 20 F nephrostomy tube placement. After the clearance of hematuria (usually within 12 to 48 h), the urethral catheter was removed and the nephrostomy tube was clamped. If neither fever nor urine leakage occurred, the nephrostomy tube was removed 12-24 hours later after the clamping.

Conventional sequential fascial dilation

Using the conventional technique, the access tract was dilated with a series of pencil-shaped fascial dilators (Create, Yokohama, Japan) from 8 F to 22 F in a multi-increment manner, overlapping at 2 F intervals, over the super-rigid guidewire. After the correct position of 22 F dilator (with matched sheath) was verified, the matched sheath was introduced and retained in the collecting system.

Statistical

Data were analyzed using SAS 9.13 for Windows (SAS Institute Inc, Cary, NC), whereby statistical significance was determined at the level of $\alpha = 0.05$. Univariate descriptive statistics included mean and standard deviation (mean ± SD) for quantitative variables and frequency and percentage for qualitative variables. Student's t test or Mann-Whitney *U* test was applied to compare one-shot dilation with sequential fascial dilation for quantitative variables, and Chi-square test or Fisher's exact test for qualitative variables.

RESULTS

As shown in **Table** 1, there were no significant differences between the one-shot and sequential group in demographic data such as age, gender, or clinical data such as stone location and burden. Nine patients in the one-shot group and seven in the sequential group had a history of ipsilateral open nephrolithotomy.

The intraoperative and postoperative variables of clinical data in both groups were summarized in **Table 2**. Successful access was established in all patients of both groups. The one-shot technique resulted in a significant reduction in mean tract creation time (1.9 ± 0.5 min vs 4.5 ± 0.8 min, $P < 0.0001$) compared to the conventional technique. Of note, a statistically significant drop in mean postoperative hemoglobin value was observed in the sequential group (0.60 ± 0.34 g/dL vs 0.69 ± 0.36 g/dL, $P = 0.0008$). However, none of these patient was administered blood transfusion intraoperatively or postoperatively. There were no significant difference in serum creatine concentration between the two groups (4.7 ± 11.5μmol/L vs 4.8 ± 14.8 μmol/L, $P = 0.2611$) and stone-free rate (86.4% vs 85.9%, $P = 0.6145$).

No tract dilation failure occurred in both of the groups. Notably, there were three cases (two cases in one-shot group and one in the sequential group) whose kidney rotated even when the 18 G needle touched the renal capsule surface. For those patients, target calices were punctured successfully with prompt action, and then the nephrostomy tracts of all the 3 cases were dilated successfully. Furthermore, there are no major complications such as adjacent organ injury, major vascular injury or hydrothorax occurred in all cases during or after the surgery.

DISCUSSION

The success and safety of PCNL are directly influenced by the quality of the access[18]. Great efforts have been made to improve the methods for establishing renal access over decades. In 1991, Travis et al[10] first described a single-increment dilation method in a canine model, and the result demonstrated that this technique was as safe as conventional dilation techniques with minimal hemorrhage or parenchymal damage either immediately or at 6 weeks. Fattini et al[15] later reported a novel "one-shot" method to dilate the nephrostomy access for percutaneous lithotripsy. They first introduced Alken guide or 8 F Amplatz dilator over the guidewire, and then a single 25 F or 30 F Amplatz dilator was advanced, followed by a 34 F sheath. Their results showed that this "one-shot" technique was feasible and effective and also significantly reduced X-ray exposure during

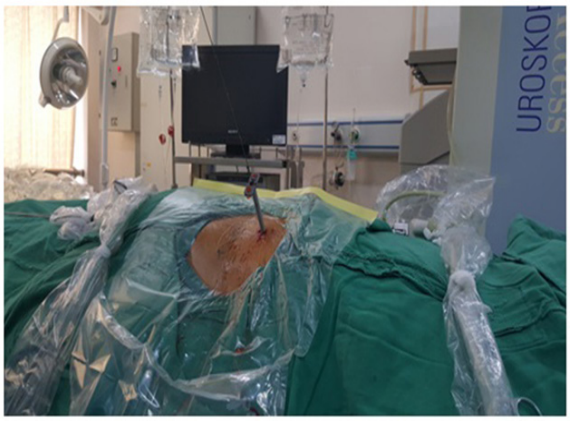

Figure 2. The dilator is removed and the sheath kept in place for the next nephroscopic operation when the sheath is advanced smoothly into the collecting system.

the dilation of the tract. The safety and efficacy of this method were subsequently verified by other urological centers in adult patients[9,11,16,19-23]. As distinct from the one-shot dilation technique described by Fattini[15] and Falahatkar[16], we established the renal access with a single 22 F fascial dilator passing over the J-tip super-rigid guidewire into the collecting system directly[17]. In this study, the retrospective data strongly demonstrated that our Chinese one-shot dilation technique was as safe and feasible as the conventional sequential fascial dilation, and greater reductions in tract creation time and blood loss were achieved using this technique as well. On the basis of these results, we later innovated our Chinese one-shot dilation technique by applying stimulated diuresis instead of retrograde ureteral catheter placement, which is more time-saving[17].

Dilation failure is one of the most frequent complications of PCNL, especially when more exchanges or passes were needed during dilation with sequential dilators[3]. The cause could be ascribed to the presence of excessive fibrotic scarring from previous open surgery or displacement of guidewire. It was documented that the tract dilation failure rates were 6% (4/67) in Amplatz group and 1.7% (2/121) in Alken group, respectively[4]. Ozok et al[4] reported that excessive scarring, renal hypermobility and insufficient insertion of the J-tip rigid guidewire into the collecting system resulted in dilation failure when using Amplatz serial dilation. The scarring and renal hypermobility also attributed to dilation failure of one-shot dilation technique and used to be regarded as real contraindications to one-shot dilation[15]. However, Falahatkar et al[16] reported that the successful access rate of one-shot dilation technique was 87.0% (20/23) in patients who had past history of ipsilateral open stone surgery. Amjadi[19] and Sofikerim [24] also confirmed that one-step dilation was feasible in patients with previous open nephrolithotomy as well as Amplatz serial fascial dilation.

In our study, we chose a special designed dilator with sharper tip and longer tapered end compared to Amplatz dilator (**Figure.1**), and applied it in both of the groups. The successful access rate was 100% in either group, including sixteen patients who had previous history of ipsilateral open nephrolithotomy (nine in one-shot group and seven in the sequential group). Moreover, the data analysis revealed a significant reduction in mean tract creation time in one-shot group (1.9±0.5 min vs 4.5 ± 0.8 min, $P < 0.0001$) compared to the conventional technique, since the operating procedure was remarkably simplified in one-shot technique. The renal hypermobility often causes guidewire displacement. We encountered three cases (two in one-shot group and one in sequential group) whose kidney rotated along the long axis even when the 18 G Chiba needle touched the renal capsule surface, and we managed to create the nephrostomy tract successfully in all of the cases. There are two key points that should be noticed under certain situations mentioned above. First, the super-rigid guidewire should be inserted as deep as possible, which ensures the super-rigid part of the guidewire is actually located in the collecting system. Second, do remind that the super-rigid guidewire should be pushed gently by the assistant all the time, which allows the movement of the guidewire is synchronous with that of the kidney during the dilation procedure.

Renal hemorrhage is the most common complication of PCNL and related to sheath size, aggressive manipulation, stone burden and operating time[2,25,26]. It was reported that nephrostomy tract dilation procedure accounted for half of the total blood loss in PCNL[27]. The correct needle puncture route and proper dilation technique are critical factors that may affect, even decide, the bleeding and transfusion rates. Practice indicates that renal hemorrhage can be best avoided when the puncture and dilation route strictly goes through the center point of the fornix of the target calyx and along the axis of the infundibulum[17,28]. During the process of stone disintegration, a cautious and minimal angulation of the working sheath and nephroscope may minimize the risk of calyceal neck laceration and consequent renal bleeding. In the present study, the mean hemoglobin decline 24 h after surgery in one-shot and sequential group was 0.60 ± 0.34 g/dL and 0.69 ± 0.36 g/dL, respectively, which clearly indicated that the one-shot technique was associated with less blood loss ($P = 0.0008$). The fascial sequential dilators system comprised 8 semi-rigid dilators which increased at a 2 F interval from 8 F to 22 F. During the tract dilation, every exchange of serial dilators would cause hemorrhage due to disappearance of tamponade effect on the small vessels. On the contrary, there is no dilator exchange or increment happened during the tract creation process with one-shot dilation technique. Employment of a single 22F fascial dilator tamponades the access tract, imposes consecutive pressure on the potential impaired small vessels throughout the entire dilation procedure, and therefore reduces blood loss. Ozok et al[4] reported that mean hemoglobin decrease was 1.5 ± 1.2 g/dL in Amplatz group with mean stone surface area 673.4 ± 466.9 mm^2. The Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Study Group concluded that working sheath was associated with increased transfusion rates, with rates of 1.1% for the smallest sheath and 12.0% for the largest sheath[2]. One of the reasons account for the different hemoglobin decrease values between our study and Ozok's might be the different size of working sheath used in the two studies (22 F vs 30 F).

CONCLUSIONS

We developed a novel, safer and more efficient Chinese one-shot tract dilation technique for PCNL. In contrast to the conventional sequential dilation technique, the major advantages of this solution are simpler without any dilator exchanges, less time-consuming and less renal hemorrhage.

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