Ultrasonography Combined with Fluoroscopy for Percutaneous Nephrolithotomy: An Analysis Based on Seven Years Single Center Experiences

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Purpose: To assess the efficacy and safety of percutaneous nephrolithotomy (PCNL) under the guidance of ultrasonography and fluoroscopy.

Materials and Methods: We retrospectively analyzed 562 renal calculi patients (313 men and 249 women; mean age 46 years, ranged from 13 to 70 years) who underwent 582 PCNL from March 2004 to October 2011 in our department.

Results: Of participants, 89.6% experienced less than 3 puncture times; 2 patients (0.4%) experienced puncture failures; percentage of single or multiple tracts was 89.7% and 10.3%, respectively, 55 patients (9.5%) needed auxiliary measures after one PCNL (24 second PCNL and 31 extracorporeal shock wave lithotripsy). The mean operative time was 82.3 min (range, 45-190 min). The stone free rate was 90.5%. Thirty five patients (6.0%) had postoperative fever and responded to antibiotics. Three patients (0.5%) developed pleural effusion and recovered after closed drainage of thoracic cavity. Thirteen patients (2.2%) needed blood transfusion. Twelve patients (2.1%) developed septic shock and were given anti-shock therapy. Two patients (0.3%) needed angiographic renal embolization or nephrectomy.

Conclusion: With its high success rate for achieving access to the targeted calyx and high stone clearance rate, the guidance of ultrasonography and fluoroscopy should be the first option in PCNL.

Keywords: nephrostomy; percutaneous; methods; retrospective studies; humans; fluoroscopy.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) has become the preferred method of treating patients with large or complex stone burdens since the first successful removal of a renal calculus via a nephrostomy tract in 1976.[1] PCNL is usually performed in the prone position with fluoroscopy guidance.[2] However, long-term X-ray exposure may cause deleterious effects for both patient and physician. Ultrasonography (US) guided PCNL has become more and more popular recently.[3] US-guided access does well to avoiding adjacent and visceral injury. But the learning curve of US is longer than that of X-ray. With the growing of the number of these papers,[4-6] a debate has ensued in the urological literature regarding the optimal guiding approach.

In our center, we adopted the method that combines US with fluoroscopy for PCNL in the prone position. The aim of our study was to evaluate the efficacy and safety of PCNL under the guidance of combined US and fluoroscopy.

MATERIALS AND METHODS

Study Participants

A total of 562 renal calculi patients (313 men and 249 women, mean age 46 years, ranged from 13 to 70 years) who underwent 582 PCNL from March 2004 to October 2011 were retrospectively reviewed. All the patients were diagnosed definitely before operations with a plain film X-rays, intravenous pyelography, or computed tomography (CT) scan. The inclusion criteria were patients who had kidney stones of diameter > 2.0 cm. Patients were excluded from the study if they had serious cardiovascular and cerebrovascular diseases. All surgeries were performed by the same doctor. Informed consent was obtained from patients before operation. The study protocol was approved by Institutional Review Board of the First Hospital of Jilin University.

Equipment and Instruments

A 18-gauge coaxial needle (Cook Medical Inc., Bloomington, IN, USA), fascial dilators (Cook Medical Inc., Bloomington, IN, USA), Zebra guide wire ((Zebra® Wire, Boston Scientific, Natick, MA, USA), X-Force N30 Nephrostomy Balloon Dilation Catheter (BCR Inc. NY, USA), F9 Olympus ureteroscope (Kuehnstmsse St. 22045 Hamburg, Germany), F20 Storz nephroscope (Karl Storz, Tuttlingen, Germany), Lumenis 60W holmium lithotripter (Santa Clara, CA 95051, USA), Cybersonics Double-catheter system (Cybersonics, Erie, PA, USA), and Aloka 5 multicolor ultrasound instrument with transducer frequency 3.5 MHz fluoroscopic table (Siemens, Erlangen, Germany).

Technique of PCNL

The entire procedure was performed in the urology department with the patient under general anesthesia. After the patient was placed in lithotomy position, retrograde ureter catheterization with a 5-French (F) open-ended ureteral catheter was performed. All the other procedures were completed in the prone position.

Under the guidance of ultrasound and X-ray, the coaxial needle was placed in the desired calyx. In the meantime, an assistant injected 0.9% sodium chloride into the ureter catheter. Successful placement was confirmed if water flowed from the needle sheath. A 0.032-inch floppy-tipped guide wire was then passed through the needle into the collecting system. The working channel was then dilated by using the plastic dilator system under X-ray control to either 18F or 26F. And then, the 9F ureteroscope or the 20F nephroscope was placed directly into the kidney through the established tract. The Lumenis 60W lithotripter or Cybersonics double-catheter system was used to fragment the renal stone.

An X-ray check for residual stone fragments was performed at the end of the procedure and the condition of residual fragments was assessed. We routinely antegradely put a double J ureteral catheter into the ureter in prone position which is to be removed about 1 month later after the operation in the out-patient clinic. A clamped 14F or 20F Foley catheter was placed as a nephrostomy tube which was opened within 24 hours. The tube was removed if there was no extravasation within approximately 4 days after the operation.

Patients were considered stone-free when no stone > 4 mm was visualized. Residual fragments > 5 mm in diameter were treated with extracorporeal shock wave lithotripsy (SWL) or the second phase PCNL. Hospitalization time referred to the time from admission to discharge. However, because of the reason of health insurance, almost all preoperative examination of patients was performed after patients admitted to hospital. It took 2-3 days to arrange the operation after the relevant lab results came out. Meanwhile, some patients

Table 1. Demographic and clinical characteristics of study patients.

	No.	%	Mean	Range
Age (year)	----	----	46.2	13-70
Male/Female	313/249	----	----	----
Stone side (left/right)	272/310	----	----	----
Average stone diameter (cm)	----	----	3.2	2.1-7.6
BMI (kg/m^2)	----	----	23.9	20-28
Hydronephrosis	515	91.6	----	----
Positive preoperative urine culture	101	18.0	----	----
Renal intervention history	15	2.7	----	----
One phase nephrostomy	23	4.1	----	----
Solitary kidney	18	3.2	----	----
Horseshoe kidney	8	1.5	----	----

needed antibiotics before operation since they often merged with infection, which further makes the average hospitalization time increase in all patients. Stone diameter referred to the longest diameter of stones.

RESULTS

The average stone diameter was 3.2 cm (range, 2.1-7.6 cm). Of study subjects 101 patients (18.0%) had positive preoperative urine culture, and 15 patients (2.7%) had a stone intervention in the same kidney (previous PCNL, 6 patients; previous pyelolithotomy or nephrolithotomy, 9 patients). The number of solitary kidney and horseshoe kidney patients was 18 (3.2%) and 8 (1.5%), respectively (Table 1).

The total access success rate was 99.5%. Access to calices through a subcostal route was established in 503 renal units (89.9%) and the other was supracostal 12th rib approach. The lower posterior calices were the most common sites of entry (72.5%). Of these, 501 (89.6%) got less than 3 punctures, while 58 (10.4%) got more than 3 punctures. The success rate in achieving access to the targeted calyx was 99.6%. There were 2 (0.4%) puncture failures. Of patients 522 (89.7%) needed a single tract, while 60 (10.3%) needed multiple tracts. Of study subjects 495 (89.7%) were treated by Lumenis 60W lithotripter and the remainders (10.3%) were treated by Cybersonics double-catheter system. Fifty five patients (9.5%) needed auxiliary measures after one PCNL (24 second PCNL and 31 SWL). The mean operative time was 82.3 min (range, 45-190 min). The stone free rate was 90.5%. Mean (±SD) hemoglobin before PCNL was 14.2±2.3 and after procedure it was 12.2 ±1.5 ($P < .05$). Mean hospital stay was 10.2 days (range, 6-16 days) (Table 2).

Thirty five patients (6.0%) had postoperative fever and responded to antibiotics. Three patients (0.5%) had pleural effusion and recovered after drainage of thoracic cavity was closed. Thirteen patients (2.2%) needed blood transfusion, 12 patients (2.1%) developed septic shock and were given antishock therapy and 2 patients (0.3%) needed angiographic renal embolization or nephrectomy.

DISCUSSION

Access to the collecting system is the first and most important step in PCNL. Access is usually achieved by using fluoroscopy, ultrasonography, or CT guidance. Some scholars found that the puncture success rate of PCNL under US and fluoroscopy was 98%.[4,7] In our study, the success rate in achieving access to the targeted calyx was 99.6%.

Many centers perform PCNL under fluoroscopy only,[8,9] which results in patients' longer radiation exposure during operation. Bush and colleagues[10] reported that mean fluoroscopy time were 8 min under the exclusive use of fluoros-

Table 2. Intraoperative and postoperative data.

Puncture position	**No**	**%**
Subcostal	503	89.9
Intercostal	56	10.1
Calyx puncture		
Lower	405	72.5
Middle	142	25.4
Upper	12	2.1
Puncture times		
> 3	501	89.6
> 3	58	10.4
Puncture failure	2	0.4
No. of tracts		
Single	522	89.7
Multiple	60	10.3
Fragment instrument		
Lumenis 60W lithotripter	495	85.1
Cybersonics double-catheter system	87	14.9
Seconder procedure requirement	55	9.5
Duration of radiation exposure, sec (range)	18.3 (5-42)	
Mean blood loss(ΔHb), g/dL	1.8 ± 1.2	
Mean hospital stay, day (range)	10.2 (6-16)	
Complications		
Postoperative fever	35	6.0
Pleural effusion	3	0.5
Required blood transfusion	13	2.2
Septic shock	12	2.1
Requiring angiographic renal embolization or nephrectomy	2	0.3

copy in PCNL. Longer radiation exposure could cause skin changes such as erythema, ulcers, telangiectasia, and dermal atrophy are deterministic side effects and radiation-induced cancers. Wahib and colleagues[11] evaluate the intraoperative outcomes of PCNL using fluoroscopic-guided access (FGA) or endoscopic-guided access (EGA). They found that patients undergoing EGA had shorter fluoroscopy time (3.2 vs. 16.8 minutes, $P < .001$). Agarwal and colleagues[12] recently compared the safety and efficacy of US or fluoroscopy in PCNL. They described that the duration of radiation exposure in the group of fluoroscopy was 28.6 sec and in the group of US was 14.4 sec. In this study, mean fluoroscopy time was only 18.3 sec.

Ultrasonography guidance was a burgeoning method in PCNL.[3] The US approach allowed imaging of intervening structures between the skin and kidney. The ideal puncture tract should lead straight from the papilla of target calyx into the renal pelvis, which could minimize the likelihood of bleeding. The US approach could evaluate the pelvicalyceal system of kidney in three dimensional (3D) orientation and help to distinguish between anterior and posterior calyces with great accuracy. It also showed the exact relationship between stone and pelvicalyceal system. US-guided access do well to avoiding adjacent and visceral injury. In our study, none of the patients experienced injuries to the adjacent organs.

A few published studies have discussed US-guide puncture in PCNL. Karami and colleagues[4] compared ultrasonography-guided access for PCNL with the patient in the flank position with conventional fluoroscopy-guided access. They concluded that US has a high ability to access calculi more easily through the pelvicalyceal system with the patient in the flank position. Falahatkar and colleagues[5] compared totally ultrasound versus fluoroscopically guided complete supine PCNL. They showed that totally ultrasound-guided complete supine PCNL was safe and feasible even in reoperative patients. Given the electronic dotted line helped in assessing the depth and plane of the puncture needle, Desai and colleagues[13] believed that US-guided access was optimal.

The high stone clearance rate of PCNL was an important successful landmark.[14] In our study, the stone free rate was 90.5%. The use of US at the end of the PCNL helps the urologist to look for residual stones. This advantage was more obvious when there were nonopaque and semiopaque stones that were not visualized by radiography. Still, the effect of X-ray was also very important when fluid leaked around the kidney resulting in that ultrasound could not accurately determine the residual stones during a longer operative time. Karami and colleagues[15] compared PCNL safety and efficacy in prone, supine and flank positions. The success rates were comparable among them. Our result was a little lower than them in prone position. The reason may be that the stone burden of them was small in their literature. The overall complication rate during or after PCNL may up to 83%,[16,17] including transfusion (11.2%-17.5%) and fever (21.0%-32.1%); whereas major complications, such as septicemia (0.3%-4.7%) and colonic perforation (0.2%-0.8%), were rare. In our study, only 2.2% of patients needed blood transfusion and 6.0% had postoperative fever. The incidence of septic shock and severe renal bleeding that needed angiographic renal embolization or nephrectomy was 2.1% and 0.3%, respectively. Compared with them, the complications in our study were relatively fewer.

This study had some limitations. For example, it was not a randomized and prospective study; the number of patients was not enough for full assessment.

CONCLUSION

With its high success rate for achieving access to the targeted calyx and high stone clearance rate, the combined guidance of US and fluoroscopy was an efficient and safe method in PCNL and it should be the first option in PCNL.

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Qinglong Chi and Yan Wang contributed equally to this work.

CONFLICT OF INTEREST

None declared.

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