

Research Article

One-Session Percutaneous Nephrolithotomy for Calculous Pyonephrosis: A Chinese Institute Experience

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Abstract

Objectives: To evaluate whether one-session PCNL be performed when patients with an easily treated kidney stones associated pyonephrosis and no evidence of acute infection.

Materials and Methods: 78 patients were carefully selected and treated in our department. A 24F percutaneous access was made; purulent urine in renal collecting system was aspirated as much as possible through the working channel assisted by the fifth generation of Swiss Litho Clast @ Master; and then the stones were fragmented and removed. The data of stone-free rate, bacterial culture for pyonephrosis and incidences of complications etc was all well-documented and analyzed.

Results: The stone-free rate was 84.6% (65/78). Only 15.4% had residual stones, but benefitted from decreased stone burden. All patients accepted antibiotics therapy based on experience or antibiotic susceptibility test for a median 5 days after PCNL. The days of hospitalization were 9 days. 14 (17.95%) were confirmed bacterial pyonephrosis, including 3 (3.85%) infection positive in blood sample. Escherichia coli was the most common cause of infection, among 14 infection confirmed patients, 6 (7.69%) pyonephrosis were infected by Escherichia coli, with 2 (2.56%) positive in blood sample as well. 57.8% (45/78) got early complications. The most common complication was fever (46.1%) during the first three days, among them. 12 (15.4%) patients got bleeding. And one (1.3%) suffered from sepsis. Most of complications were graded not more than grade 2, and no life-threatening complications happened.

Conclusion: One-session PCNL assisted by EMS lithoClast may be an effective and safe alternative choice for carefully selected patients with calculous pyonephrosis.

Introduction

Percutaneous Nephrolithotomy (PCNL) is a minimally invasive, efficient and recommended way to treat staghorn calculi [1,2]. Retrograde Ureteral Catheterization (RUC) or Percutaneous Nephrostomy (PCN) are usually performed to treat infected and obstructive urolithiasis for decompression of the collecting system, then a second session of PCNL or ureteroscopic lithotripsy would be carried out to remove the urinary stones [3-5]. Calculous pyonephrosis are a universal clinical feature, usually appearing in calculous obstructive kidney when performing PCNL, but usually without any obviously recognizable sign before surgery. Must it be always just performed nephrostomy rather than PCNL, when urologists met the patients with easily treated kidney stones together with associated pyonephrosis but no evidence of acute infection? The new-updated guidelines of kidney stones did not give an explicit state on this issue [2,6,7]. Recently, urologists from different institutions in China had reported several dozens of patients with calculous pyonephrosis were performed one-phase PCNL and most of them were successfully treated, without overt complications observed [8-14]. Their experiences confirmed the conclusions that one-phase PCNL under continuous negative pressure aspiration in renal collecting systems during whole surgical procedure might be

an alternative choice for carefully selected patients. However, they did not give data of routine purulent urine test and its bacterial culture, or did not analysis positive ratio bacterial culture between mid-stream urine and purulent urine obtained from renal collecting system, or did not well analyze the key points to ensure safety of one-session PCNL and to reduce related complications, etc [8-14]. Herein, we retrospectively analyzed 78 cases of calculous obstructive pyonephrosis being treated by one-session PCNL assisted by the fifth generation of EMS lithoClast, and shared our own experience on this technique, and the above unclear issues would be presented as well.

Methods and Patients

Patients

The ethics approval of this study was obtained from Institutional Review Board of the People's Hospital of Xiangtan Country, Xiangtan, China. From March 2013 to January 2015, a total number of 78 patients were treated in our department and retrospectively analyzed. Before admission, they had finished abdominal examinations of ultrasound, radiography of Kidney, Ureter and Bladder (KUB), and/or Intravenous Urography (IVU). Computed Tomography (CT) were routinely performed in all to assess the number, location and size of stones, to identify level of hydronephrosis and renal collecting system anatomy for providing anatomical proof to establish the location of

Table 1: Demographic information.

Classification	Value
Total patients (n)	78
Gender (n%)	
Male	46 (59.0%)
Female	32 (41.0%)
Age (median, range) (years)	45 (21-78)
Body Mass Index (kg/m ²)	24.6 (18.9-30.7)
Previous history of renal stones (n%)	
Yes	19 (24.4%)
No	59 (75.6%)
History of open stone surgery (n%)	
Yes	12 (16.7%)
No	66 (83.3%)
Body temperature (median, range) (°C)	36.8 (36.5-37.8)
Days of preoperative antibiotics (median, range) (days)	5 (3-14)
Stone location	
Kidney (n%)	49 (62.8%)
Left vs right (n%)	20 (25.6%) vs. 29 (37.2%)
Upper ureter (n%)	29 (37.2%)
Left vs right (n%)	12 (15.4%) vs. 17(21.8%)
Number of stones (n%)	
Single	47 (60.2%)
Multiple	19 (24.4%)
Staghorn calculi	12 (15.4%)
Size of stones (median, range) (mm ²)	23×37 (10×15-30×45)
Hydronephrosis (n%)	
Mild	9 (11.6%)
Moderate	38 (48.7%)
Severe	31 (39.7%)

percutaneous tract. All of them were confirmed having only one side of upper ureteral or renal calculi by CT, with a normal kidney on the other side. And they all were finally diagnosed as calculi associated obstructive pyonephrosis during PCNL and pyonephrosis tests. Their demographic information before PCNL was presented in (Table 1), including gender ratio, age, Body Mass Index (BMI), history of renal stones and open stone surgery, body temperature, days of preoperative antibiotics, as well as the location, number, size of stones, and level of hydronephrosis were all well-documented.

All the patients were given empirical antibacterial therapy for at least three days before operation. 3.8% (3/78) of them with slight fever (37.3-38.9°C) and kidney area kowtow painful, were considered as calculi combined with acute infections. Extra more days of antibacterial therapy were given to control inflammation completely. The median day of antibacterial therapy for all the patients were of 5 (range from 3 to 14 days). After admission, laboratory tests were examined, including blood routine tests, coagulation tests, urinalyses, serum biochemistry, and bacterial culture for urine and blood sample. The most recent results of their laboratory tests before the surgeries

Table 2: Preoperative laboratory results of the most recent tests.

Classification	Values	Normal reference values
Hb (g/L)	132.1 (102.0-173.5)	130-175
WBC (median, range) (×10 ⁹ /L)	5.8 (3.8-11.2)	3.50-9.50
Percentage of neutrophils (median, range) (%)	54.5 (48.2-75.3)	40.0-75.0
Platelet count (medium, range) (×10 ⁹ /L)	160.5 (90.2-310.5)	125-350
Routine mid-stream urine (medium, range) (n/HP)		
WBC	13 (5-38)	<5
pyocyte	3.4 (0-13)	0
Bacterial culture (n %)		-
urine sample	78 /78 (100%)	-
Positive	0 (0%)	-
blood sample	42/78 (53.8%)	-
Positive	0 (0%)	-
Serum creatinine (median, range) (umol/L)	73 (55-167)	40.0-133.0
Blood urea nitrogen (median, range) (mmol/L)	5.2 (3.2-7.2)	2.9-7.14

were listed in (Table 2). On the day of operation designed, all these patients had attained the following criteria and lasted at least three days, with no evidence of acute management should be carried out: (a) normal volume of urine (1000-1500 mL/24 hours); (b) no evidence of acute infections (no fever, except one patient had a body temperature of 37.8°C the day before operation but was 37.2°C on the morning of the operation day; no significant high or low of WBC count); (c) no moderate or more severe anemia (hemoglobin, Hb<90g/L); (d) no severe renal insufficiency, median serum creatinine concentration of them was 73 (range from 55 to 167) umol/L, less than 178 umol/L. In addition, they also had been confirmed without unstable level of blood pressure or blood glucose, with no history of cardiopulmonary dysfunction or coagulopathy; and they were not pregnant or severely obese (median BMI 24.6, range from 18.9 to 30.7). All of them accepted PCNL treatment and their written informed consents were obtained. General or continual epidural anesthesia could be performed; and lithotomy and lateral position could be placed for all of them.

Technique of PCNL

All the 78 patients were treated by a certain experienced urologist who had performed at least 1000 cases of PCNL. After anesthetized, all the patients were placed in lithotomy position firstly, and a retrograde F4 or F5 ureteral catheter was inserted into the lesion side of ureter until feeling of significant resistance or about 25cm long inside, then fixed. The isotonic perfusate, sometimes together with methylene-blue dye, was injected into the ureter slowly, freely and continuously through the outside of ureteral catheter, without any additional overwhelming force, in order to visualize the pelvi calyceal system and to occlude the ureter to avoid downward movement of small disintegrated stone fragments and formation of stone stairs [15].

Then they were placed in lateral position and sterilized. An 18-gauge coaxial needle (uroVision GmbH, Bad Aibling, Germany) was used and the kidney was punctured in the standard fashion *via* targeted calyx under ultrasound combined with fluoroscopic

Table 3: Intraoperative parameters.

Classification	Values
Operation time (median, range) (min)	70 (49-118)
Volume of perfusion fluid (median, range) (L)	18 (8-31)
Number of channels (n%)	
One channel	71 (91.0%)
Two channels	6 (7.7%)
Three channels	1 (1.3%)
Location of channels (n%)	
Subcostal	36 (46.2%)
Intercostal	42 (53.8%)
Ultrasonic lithotripsy	
Negative pressure values of Emphyema Sucking (median, range) ($\times 100\text{kPa}$)	0.2 (0.1-0.3)
Negative pressure values of lithotripsy (median, range) ($\times 100\text{kPa}$)	0.3 (0.2-0.4)
Ratio of energy and duty (median, range) (%)	70% (60-80%)
Pneumatic lithotripsy	
Energy (median, range) ($\text{mJ}\times 100\%$)	90 (85-100)
Frequency (median, range) (Hz)	8(5-10)
Time of Ultrasonic lithotripsy vs. Pneumatic lithotripsy (median, range) (min)	52 (36-71) vs. 25 (0-37)

guidance ("Echotec" Hitachi Ultrasound, Tokyo, Japan) as previously described [15]. The targeted calyx was designed based on the calculi location and status of hydronephrosis in each calyx. To confirm the the targeted calyx and avoid important renal blood vessels, the B-mode ultrasound guidance was used and then color Doppler ultrasound guidance in the same ultrasound system was carried out during the real time of puncture as described before [16].

After that, the working channel was dilated by a 2-step method for all patients [16]. Firstly, a serial facial dilator (uroVision, GmbH) from 8-16F, was performed subsequently to dilate the channel, with a 16F peel-away sheath placed as the access port. Then an 8/9.8F rigid ureteroscope (Richard Wolf, Knittlingen, Germany) was inserted into the collecting system to make sure if the puncture was made in the targeted calyx. Through the working channel of ureteroscope, about 5-10mL volume of fluid from the collecting system was gathered for further urinalysis and urine culture. Secondly, the tract dilation was implemented using a serial telescoped metal sheath (Karl Storz Endoscopes, Germany) from 18 to 24 F, then leaving the 24F metal sheath placed in. For patients with multiple stones or staghorn calculi, two or three working channels might be made (Table 3), complied with the above 2-step procedure.

Through the metal working channel, a F20.8 nephroscope (Richard Wolf) was directly placed into the kidney. The subsequent procedure was performed under the status of continuously negative pressure aspiration, *via* the fifth generation of Swiss LithoClas@ Master (EMS Electro Medical Systems, Nyon, Switzerland), which is combined with ultrasonic and pneumatic lithotripter. Before fragmenting the stones, the pyonephrosis was firstly withdrew as much as possible under the median negative pressure of about 0.2

Table 4: Postoperative parameters.

Classification	Values
Hb (median, range) (g/L)	12.61 (8.2-16.15)
Routine urine test for pyonephrosis	
WBC (median, range) (n/HP)	26 (22-50)
pyocyte (median, range) (n/HP)	6.5 (2-21)
Serum creatinine before checking out (median, range) ($\mu\text{mol/L}$)	65 (51-137)
Patients with stone-free (n%)	66 (84.6%)
Patients with residual stones (n%)	12 (15.4%)
Sizes of residual stones (median, range) (mm^2)	6 \times 11 (5-8 \times 9-13)
Days of postoperative antibiotics (median, range) (days)	5 (3-14)
Days of postoperative hospitalization (median, range) (days)	6 (4-10)
Days of hospitalization (median, range) (days)	9 (8-13)

Table 5: Postoperative bacterial culture in pyonephrosis and blood.

Classification	Pyonephrosis	Blood
Escherichia coli (n%)	6 (7.7%)	2 (2.6%)
Klebsiella (n%)	2 (2.6%)	1 (1.3%)
Proteus (n%)	2 (2.6%)	0
Pseudomonas aeruginosa (n%)	1 (1.3%)	0
Candida albican (n%)	3 (3.9%)	0
Sample contamination (n%)	2 (2.6%)	1 (1.3%)
Total number of infection (n%)	14 (17.9%)	3 (3.9%)

(range from 0.1 to 0.3) $\times 100\text{kPa}$, accompanying with the perfusion flow of 100-200mL/min (Table 3). Then the stones were fragmented and withdrew by ultrasonic lithotripsy with median negative pressure of 0.3(range from 0.2 to 0.4) $\times 100\text{kPa}$, with median ratio of energy and duty of 70% (range from 60 to 80%). If they were too hard to be fragmented by ultrasonic lithotripsy, they were crushed into small pieces by pneumatic lithotripsy (energy: median 90%, range 85-100%; frequency: median 8Hz, range 5-10Hz), and then ultrasonic lithotripsy was used subsequently to remove the smaller fragments. In order to minimize the stone load, ultrasonic lithotripsy and pneumatic lithotripsy could be performed in alternation. During this procedure of ultrasonic lithotripsy, the ultrasound device and suction device were performed simultaneously but sometimes separately. The median time of ultrasonic lithotripsy vs. pneumatic lithotripsy was about 52 (range 36-71) vs. 25 (range 0-37) min. The operation time was calculated from the beginning of percutaneous puncture to the end of nephrostomy tube placement.

Along the surgeries, 10mg dexamethasone was used to reduce inflammation and stress response. 20mg frusemide was applied to reduce excessive circulating volume due to absorption of perfusion fluid per hour of the surgery time when their blood pressure was stable, especially diastolic blood pressure was tendering to increase slowly. At the end of PCNL, an antegrade 6F double-j ureteral stent (D-J stent) (Cook, CA, USA) was indwelled *via* the percutaneous tract with assistance of guide wire for a median 21 (range 14-31) days. A 20F nephrostomy tube (Urovision, Germany) was left in the tract for a median 5 (range 3-9) days when a patient was confirmed

stone free after operation, or was kept for a second-stage PCNL or a flexible ureteroscopy would be performed within one month when insignificant residual stone fragments remained. 24-48 hours after these one-stage PCNL, KUB or ultrasound were performed to evaluate if the stones were cleared and to identify the position of D-J stent and nephrostomy tube. For the patients with residual stones were resubmitted about one month later and accepted a phase two PCNL, Extracorporeal Shock Wave Lithotripsy (ESWL), or Ureteroscopic Lithotripsy (URL).

Results

General postoperative information

Postoperative parameters were listed in the (Table 4). Their first tests of blood routine after surgery confirmed no severe intraoperative bleeding happened, with median Hb were 12.61 (range from 8.2 to 16.15). Routine urine test for pyonephrosis were examined, median number of WBC and pyocyte were 26 under power objective (/HP) and 6.5/HP, respectively. Renal function tests before they checking out suggested serum creatinine had significant reduced, with median 65 $\mu\text{mol/L}$ (range from 51 to 137 $\mu\text{mol/L}$). The complete stone-free rate was 84.6% (65/78). Only 15.4% had residual stones, but the sizes of residual stones had decreased, with median $6 \times 11 \text{mm}^2$. All of the patients accepted antibiotics therapy based on experience or antibiotic susceptibility test for a median 5 days (range from 3 to 14 days) after PCNL. The whole days of hospitalization was 9 days (range from 8 to 13 days), including a median 6 days of postoperative hospitalization.

Postoperative bacterial culture in pyonephrosis and blood

The details of postoperative bacterial culture were listed in (Table 5). Expect 2 (2.56%) sample contamination in pyonephrosis and 1 (1.28%) in blood sample, a total of 14 (17.95%) patients were confirmed bacterial pyonephrosis, including 3 (3.85%) of them with positive infection in blood sample. Rather, the rest of 64 patients (82.05%) were finally confirmed as aseptic pyonephrosis. *Escherichia coli* was the most common cause of bacterial pyonephrosis, among these 14 patients, 6 (7.69%) pyonephrosis were infected by *Escherichia coli*, with 2 (2.56%) of them positive in blood sample as well. In the rest of infective cases, *Candida albican* were positive in 3 (3.85%) cases of pyonephrosis, while *Klebsiella* and *Proteus* in 2 (2.56%) cases, respectively. In addition, 1 (1.28%) case of *Klebsiella* pyonephrosis was also confirmed *Klebsiella* positive in blood sample.

Stone composition analysis

Stone composition analysis was performed in all the 78 patients. Among them, 37 (47.4%) had magnesium ammonium phosphate; 19 (24.4%) had calcium phosphate; 11 (14.1%) had calcium oxalate; 9 (11.5%) had uric acid; 1 (1.3%) had cystine; and 1 (1.3%) matrix calculus.

Complications

Early complications happened in 57.8% (45/78) of the patients (Table 6). The most common complication was fever (46.1%) during the first three days after operation. Among them, only 3 (3.8%) got high fever with body temperature equal to or more than 39°C , 75 (96.2%) of them less than 39°C during the first three days. 12 (15.4%) patients got bleeding, however, without superselective angiographic embolization, most of bleedings stopped after conservative treatment,

Table 6: Complications and their incidences.

Complications	Incidences
Fever (n%)	36 (46.1%)
$\geq 39.0^\circ\text{C}$	3 (3.8%)
$38.1-38.9^\circ\text{C}$	9 (11.5%)
$37.4-38.0^\circ\text{C}$	24 (30.7%)
Bleeding (n%)	12 (15.4%)
Blood transfusion (n%)	3 (3.8%)
Urinary tract infection (n%)	14 (17.9%)
Bacteremia (n%)	3 (3.8%)
Colics (n%)	1 (1.3%)
organ injury (n%)	0 (0%)
Sepsis (n%)	1 (1.3%)
Perirenal empyema (n%)	0 (0%)

such as continuous traction and antibiotics therapy. Only 1 (1.3%) had severe bleeding and stopped by blood transfusion and conservative treatment; other 2 (2.6%) patients also accepted blood transfusion because of preoperative anemia and minor blood loss during perioperation. Urinary Tract Infection (UTI) was finally confirmed in 14 (17.9%) of them, based on the bacterial culture in pyonephrosis, without extra UTI happened after operation and one month follow-up. Among these 14 cases of UTI, 3 (3.8%) of them had bacteremia: 2 cases recovered after sensitive antibiotics; 1 (1.3%) case with more than ten-year history of diabetes got sepsis, after intensive antibiotics and auxiliary therapy for 7 days, the sepsis was completely resolved and the infection was cleared completely. 1 (1.3%) patients suffered colics at the surgical site but got relieved by hemostasis, alkalization of urine and pain treatment. No pneumothorax, or injuries to neighbouring organs and perirenal empyema happened.

Discussion

Pyonephrosis is usually defined based on the presence of pus in renal collecting system [17,18]. Percutaneous aspiration of purulent urine from the collecting system is the most accurate modality to confirm the diagnosis of pyonephrosis [18]. In our study, of 78 patients, some presented non-pyocyte in the routine mid-stream urine test, but were all finally diagnosed as calculous pyonephrosis, based on the presence of pus in all the cases and routine purulent urine test confirmed median pyocyte 6.5/HP (range from 2 to 21/HP) from their collecting systems. According to the new updated guidelines of kidney stones, nephrectomy should be considered firstly for the patients with the risk of persistent or recurrent infection, and then delaying definitive treatment of the stone was endorsed until the sepsis has resolved and the infection has cleared [2]. Thus, many of our colleagues and our department previously would just perform nephrectomy in this kind of patients with none evidence of acute infection before operation but presenting calculous pyonephrosis. However, in our own clinical experience and previous reports, pyonephrosis are not always combined with acute urinary tract infection, obstructive pyonephrosis can be aseptic purulent urine based on a larger percentage of negative repeatable bacterial culture, or chronic infections in an obstructed kidney [8,17-19]. Therefore, in recent years, Chinese urologists from different institutions

had tried several dozens of carefully selected cases with calculous pyonephrosis to perform one-session PCNL, and final results had met people's expectation, with high stone-free rates, effective stone-burden reducing and low severe complications [8-14]. In our data, 66 (84.6%) patients benefit from calculi completely removed and avoided additional nephrostomy; 12 (15.4%) with residual stones got stone-burden alleviated, with the stone sizes of 23×37 mm² reducing to 6×11mm²; the whole rate of early complications was 57.8%, but most of them were indifferent and easily dealt with, except only one patients with more than ten years diabetes and staghorn calculi suffered from sepsis, but recovered after intensive antibiotics and auxiliary therapy.

The percentage of positive bacterial culture in mid-stream urine is quite different from that in purulent urine obtained from obstructive renal collecting systems, usually the later one is a litter higher. In a previous study, 68.4% (13/19) was positive in bladder urine culture, compared with 76.2% (16/21) in renal urine culture [17]. In our study, we retrospectively analyzed 78 cases with negative bacterial culture in mid-stream urine, however, 14 (17.9%) of them presented positive results in renal purulent urine. Furthermore, 3 (3.9%) of them was also indentified positive in blood sample. We had noticed this kind of higher likelihood of infection in calculous pyonephrosis and given all of 78 patients a median 5 days of preoperative antibiotics, even though some of them presented no evidence of infection after elaborative examinations. According to the gridlines of kidney stones, when a emergence surgical treatment is designed for an obstructing stone, even a percutaneous drainage or ureteral stenting, the European Association of Urology recommends for urine culture, starting antibiotics, and then re-evaluating the antibiotic regimen based on culture results [2]. In our study, patients was carefully selected and acute infected ones was cured or excluded, thus, the incidence of complications were decreased at the very beginning; furthermore, after one-phase PCNL, potential or confirmed infection was adequately controlled as well. These two aspects may be the two key points to perform one-phase PCNL, without overt severe complications.

Another important key point, in our experience, may be the continuous negative pressure suction assisted by EMS lithoClast, firstly aspirating purulent urine from the renal collecting system as much as possible, then fragmenting the stones and removing them as quickly as possible. As we known, the fifth generation of EMS lithoClast meets the effective requirement of continuous negative pressure suction. Thus it is able to maintain renal collecting system at a condition of negative pressure and decrease absorption of bacterium and toxin, together with decreased perfusion fluid intaking [8,11,14,20].

The most common early complication was fever (46.1%), followed by UTI (17.9%) and bleeding (15.4%). The incidences of rest complications were lower, including blood transfusion (3.8%), bacteremia (3.8%), colics (1.3%) and sepsis (1.3%). No injuries to neighbouring organs or pneumothorax, or perirenal empyema happened. According to modified Clavien system of percutaneous nephrolithotomy [21], most of complications in our study were graded not more than grade 2, only 2 cases (colics and sepsis) suffered from complications in grade 3a and 4b, respectively. The incidences

of complications were a litter higher than previous reports [21,22], which was because of higher rates of infection (grade 2), together with secondary high rates of fever and bleeding in our study. Urinary tract infection as the grade 2 complication were not a life-threatening one, but prolonged hospitalization may be necessary; it was easily controlled after specific medication, including additional antibiotics (instead of prophylactics [21]. In a short, one-session PCNL assisted may provide an alternative choice to treat carefully selected patients with calculous pyonephrosis.

Conclusion

One-session PCNL assisted by the fifth generation of EMS lithoClast may be an effective and safe alternative choice for carefully selected patients with calculous pyonephrosis. Continuous negative pressure aspiration during the surgical procedure, and strictly controlling potential or confirmed infection, may result in low rate of complications.

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