Original Article
Improved nephrostomy tube can reduce percutaneous nephrolithotomy postoperative bleeding

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Abstract: Renal hemorrhage is one of the most common and worrisome complications of post-percutaneous nephrolithotomy (PCNL). This study aimed at evaluating the safety, effectiveness of utilization of the absorbable hemostatic gauze cover renal tract for hemorrhage of post-PCNL. The prospective study including 188 patients with upper urinary tract calculi was carried out in the department of Urology at Linyi People's Hospital from November 2011 to September 2013. All patients underwent PCNL procedures and they were divided into two groups randomly before the procedure. Group A (n=91) was indwelled a 16F catheter as nephrostomy tube at the end of the surgery, Group B (n=97) was indwelled a 14F catheter covered with absorbable hemostatic gauze for hemostasis. Blood loss was estimated based on the mass of hemoglobin in the draining liquid and urine during postoperative duration by HiCN method. The average blood loss was 25.76±23.99 g for Group A, and 14.25±6.87 g for Group B, respectively, with statistical difference by comparison (P<0.05). The delta hemoglobin was 16.24±10.98 mmol/L for Group A, and 10.71±5.57 mmol/L for Group B, respectively, also with statistical difference by comparison (P<0.05). Nephrostomy channel applications of absorbable hemostatic gauze after PCNL can significantly reduce postoperative bleeding. Utilizing the absorbable hemostatic gauze for post-PCNL hemorrhage is safe, effective and feasible.

Keywords: Percutaneous nephrolithotomy (PCNL), hemorrhage, absorbable hemostatic gauze, upper urinary tract calculi

Introduction

Nephrolithiasis can be treated by extracorporeal shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), or open surgery. ESWL often leads to persistent residual stone fragments, which limits its application. PCNL is a surgical procedure to remove stones from the kidney by a small puncture wound through the skin. PCNL has been used in the treatment of nephrolithiasis which could not be treated successfully by ESWL and/or is >2 cm in diameter [1, 2]. PCNL achieves a higher stone-free rate and has low morbidity and is minimally invasive when compared to open surgery. Nowadays, PCNL represents a safe and efficient procedure and becomes the standard surgery in the treatment of nephrolithiasis. Since the kidney is an extremely vascular organ, certain degree of bleeding always occurs during the PCNL [3].

Even for the most experienced urologists, major complications, including hemorrhage, extravasations, and fever, can still occur in 1.1% to 7% of patients undergoing PCNL, and minor complications may occur in 11% to 25% of the patients [4, 5]. Intraoperative and postoperative hemorrhage is one of the most frequent complications associated with PCNL.

The causes of PCNL hemorrhage can be divided into the following: puncturing injury during percutaneous tract establishment, intraoperative bleeding during lithotripsy, and delayed postoperative hemorrhage. When creating a percutaneous tract, intercostal vessels, intrarenal vessels or renal hilum could be injured. In the process of lithotripsy, looking for stones forcefully through the calyceal neck could cause tear and bleeding. Delayed postoperative hemorrhage is possible due to false aneurysm or arteriove-

nous fistula formation resulting from repeat puncturing during percutaneous tract establishment, but also could be caused by postoperative excessive activity leading to soft crust of blood shedding. Severe bleeding not only increases the economic burden on patients, and even endangers the lives of patients. How to deal with severe bleeding after PCNL remains a challenge.

To reduce bleeding after PCNL, tubeless PCNL, puncture channel coagulation, fibrin puncture channel closure and other treatment methods have been reported. However, no matter what approach you take, it is still difficult to completely avoid postoperative bleeding. In most cases bleeding can be treated conservatively, including occlusion of the percutaneous tract, which stop renal hemorrhage by increasing pressure of the renal collecting system; avoiding premature ambulation; and intravenous application of hemostatic agents. However, super selective renal artery embolization (SRAE) is needed in patients with arterial bleeding, pseudoaneurysm, and arteriovenous fistula. SRAE is a minimally invasive, simple, safe, and highly effective modality for the management of post procedural renal bleeding associated with PCNL, and to maximize the retention and protection of renal function, is considered the "gold standard" treatment of postoperative bleeding after PCNL [6, 7]. But no matter what measure to use embolization inevitably result in varying degrees of renal tissue damage, especially in patients with solitary kidney or bilateral renal embolization performed simultaneously. There were also risks of incorrect and excessive embolization. Moreover, contrast-induced nephropathy could occur, and the cost of SRAE is high.

The purpose of our current study is to compare outcomes of placing nephrostomy tube only with placing nephrostomy tube covered with absorbable hemostatic gauze after PCNL, on postoperative bleeding, sought to find a better approach for bleeding control after PCNL.

Materials and methods

Patients

This was a prospective study which was approved by the Ethics Review Board of Linyi People's Hospital, Shandong, China. All patients fully understood the treatment and aim of this study. Informed consent was obtained from each patient and/or the guardians. Between November 2011 and September 2013, PCNL was performed in 188 patients totally. The indication for PCNL was nephrolithiasis >2 cm in diameter and ESWL could not be performed or was unsuccessful. All patients were diagnosed with nephrolithiasis by kidneys, ureters and bladder X-ray (KUB) or ultrasonography before admission. All the patients were evaluated with intravenous pyelography (IVP) and non-contrast computed tomography (CT) urogram before operation. Patient exclusion criteria: 1) PCNL clearing stone failure, bleeding caused by conversion to open surgery; 2) calyceal neck tear; 3) pyonephrosis; 4) unilateral renal multichannel PCNL; 5) over the same period of bilateral kidney stones PCNL; 6) renal insufficiency; 7) has a history of ipsilateral kidney stone surgery. Age, gender, stone burden in the kidney, body mass index (BMI), urine analysis, urine culture, serum creatinine, hemoglobin, operative time, complications, and hospital stay were recorded as intraoperative data. Residual stone burden and change in hemoglobin level (delta hemoglobin=hemoglobin level before operation-hemoglobin level after operation) were recorded as post-operative data. Broad spectrum prophylactic antibiotics were administered one hour preoperatively to patients with sterile urine. Patients with culture proven bacteriuria were first treated with antibiotics according to the susceptibility results. The patients were divided into two groups randomly. In Group A, there were 91 patients who were placed a 16F nephrostomy tube after surgery; in Group B, there were 97 patients who were indwelled a 14F nephrostomy catheter covered with absorbable hemostatic gauze after surgery.

Surgical procedure

In this series, all PCNL operations were performed under epidural anesthesia. At the first step, in lithotomic position, a 6F ureter catheter was inserted to the side with kidney stone. In the mean time, a Foley catheter was inserted. The patient was then changed to a prone position. Access into kidney at middle calyx was achieved by initially puncturing the kidney using an 18G percutaneous needle under the guidance of ultrasonography (Toshiba Med. System,

Figure 1. Absorbable hemostatic gauze (ETHICON, USA) and 14F nephrostomy tube.

Figure 2. A 14F nephrostomy tube covered with absorbable hemostatic gauze was indwelled.

guide wire passed through it and D-J stent was indwelled in the ureter. For patients in Group A, a 16F nephrostomy tube was placed in the kidney. For patients in Group B, a 14F nephrostomy tube covered with absorbable hemostatic gauze (5×3 cm, ETHICON, USA) was indwelled (**Figures 1** and **2**).

Postoperative care

Close observation was executed for all of the patients after the procedure. Serum level of hemoglobin was measured pre-operatively and every 6 hours on postoperative day one (POD-1). If there was not a significant drop in hemoglobin level during POD-1, the measurement for the hemoglobin was changed to one time daily until the patients' discharge. Patients' vital signs were monitored closely. The draining liquid and urine were collected every 24 hours and were mixed completely during the postoperative course. The nephrostomy tube was removed 3 to 5 days after the procedure once the urine was clear. The Foley were then removed 6 to 12 hours after leakage from the nephrostomy tract stopped. After discharge, the patients were followed up closely for 3 months to rule out recurrence of bleeding.

Measurement of blood loss

The mass of hemoglobin in the draining fluid from nephrostomy tube and urine during postoperative course was measured by the hemoglobin cyanide (HiCN) method. Urine and draining liquid were collected and mixed every 24 hours during the postoperative course. At first, 20 μl of the mixed urine and draining fluid was

Japan). After seeing urine coming out of the needle, a sensor guide wire was then placed. A 30F amplatz sheath was placed into the access pole, after serially dilating the tract with rigid renal dilators. A 26F nephroscope (KARL STORZ GmbH & Co. KG. Tuttlingen, Germany) was then inserted.

The stones were then disintegrated with ultrasonic or pneumatic lithotripter and the gravels were removed from the kidney with suctioning irrigation device and/or grasping forceps. Ureteral catheter was taken out and the sensor

Table 1. Comparison of demographic data of patients

Parameter	Group 1 (n=91)	Group 2 (n=97)	P
Age (year, SD)	51.79±12.99	51.26±12.94	0.8605
Gender (male)	63	68	0.8965
BMI (kg/m^2, SD)	23.97±3.02	24.46±2.96	0.4866
kidney	49	54	0.8316
Stone position ureter	20	18	0.6769
kidney & ureter	22	25	0.8004
Stone burden (cm, SD)	4.25±1.26	3.98±1.40	0.2821
Diabetes mellitus	5	7	0.6293
hypertension	10	11	0.9391
Pre-operative serum creatinine level (mmol/L, SD)	76.42±16.72	80.67±14.74	0.2479
Post-operative serum creatinine level (mmol/L, SD)	84.64±17.17	81.53±14.61	0.4001
Operation time (minute, SD)	42.16±15.58	48.82±15.92	0.0734
Pre-operative hemoglobin (g/L, SD)	130.05±18.93	135.15±12.92	0.178
Post-operative hemoglobin (g/L, SD)	113.84±19.94	124.45±13.58	0.0101*
Delta hemoglobin (g/L, SD)	16.24±10.98	10.71±5.57	0.009*
Post-operative blood loss (g, SD)	25.76±23.99	14.25±6.87	0.0072*
Stone-free	75	74	0.3003
Post-operative hospital stay (day, SD)	5.24±2.31	5.13±1.17	0.8031
Super-selective renal arterial embolization	4	1	0.1519
Blood transfusion	5	1	0.0819

SD: Standard deviation; BMI: Body mass index; delta hemoglobin=Pre-operative hemoglobin-post-operative hemoglobin; *Statistical significant P value.

added into 5 ml HiCN reagent; second, the mixed urine and drainage fluid was mixed with the HiCN reagent completely and the mixture was rested standing for 5 minutes. Using a spectrophotometer that has been zeroed with HiCN reagent at a wavelength of 540 nanometers and a light path of 1.0 centimeter, the absorbency was determined [8]. Postoperative blood loss was calculated using the following formula: postoperative blood loss (g)=A×370×V (A=absorbency: V=collected volume of urine and draining fluid from nephrostomy tube every 24 hours during the postoperative course).

Statistical analysis

The age, stone burden, hospitalization, operative time, pre-operative serum creatinine level, pre-operative hemoglobin, post-operative hemoglobin, post-operative blood loss, delta hemoglobin were compared using Student's t test. The rate of stone-free, gender, blood transfusion, super-selective renal arterial embolization and stone position were compared using the chi-square test. Statistical significance was defined as *P*<0.05.

Results

In this study, the mean age of the patients was 51.53±12.88 years and there were totally 57 females and 131 males. There were 91 patients (28 females and 63 males) in Group A, and 97 patients (29 females and 68 males) in Group B. Mean follow-up duration was 10.71±1.2 months. There was no statistically significant difference between two groups in age, gender, BMI, stone burden, pre-operative hemoglobin, operation time, and serum creatinine levels. There was no significant statistical difference between the groups for stone-free rate (*P*>0.05) (**Table 1**). There was no statistical difference between the groups for Super-selective renal arterial embolization and Blood transfusion (*P*>0.05) (**Table 1**). The bleeding was significantly less in Group B than Group A (*P*<0.05). The delta hemoglobin was significantly less in Group B than Group A (*P*<0.05) (**Table 1**).

Discussion

PCNL is recommended as the first-line surgical option in the treatment of nephrolithiasis which can not be managed with ESWL [9]. Although

PCNL is a minimal invasive procedure, the potential for significant complications still exists and hemorrhage is the most significant complication of PCNL [10]. Longer operation time, staghorn stones, large-sized stones, multiple percutaneous tracts used, solitary kidney, and the presence of diabetes mellitus were associated with increased renal hemorrhage during PCNL on multivariate analysis of previous studies [10, 11]. Puncturing to the kidneys with abnormal anatomy, increased intraoperative puncture time and renal pelvic perforation are also associated with an increased risk of bleeding [11-13]. In addition, the patients without hydronephrosis before operation and patients on anticoagulant or antiplatelet medications were more likely to suffer severe renal bleeding [11, 13].

Bleeding associated with PCNL poses a challenge for the physician regarding the safety and efficacy of this procedure. Parenchymal bleeding is often seen at the site of the nephrostomy tract dilation. Advancement of the distal segment of the working sheath into the collecting system provides effective parenchymal tamponade, allowing the procedure to continue [14]. Several studies have demonstrated that dilation of the tract using balloon dilating catheters as opposed to Alken metal telescopic dilators or the Teflon-coated Amplatz dilators results in less blood loss [15]. Arterial bleeding is relatively rare during percutaneous renal surgery, but may be encountered intra-operatively or in the early or late postoperative period. If it occurs during dilation of the tract, the vessel is usually a tiny arteriole and tamponade may be successful [16]. The reported incidence of serious arterial injuries ranges from 0.9% to 3% after percutaneous procedures [16]. Martin and coworkers reported a 1% incidence of severe bleeding after PCNL requiring super-selective embolization [12].

Delayed bleeding after percutaneous procedures is almost always secondary to pseudoaneurysms or arteriovenous fistulas. It is reported that calculus morphology, its location, composition, or size did not affect total blood loss, nor did the number of fragments or stone-containing calices. Furthermore, factors such as age, hypertension, urinary infection, degree of hydronephrosis, renal insufficiency, puncture site, type of fascial dilation, previous open renal surgery, previous ESWL, or function of the ipsi-

lateral renal unit did not affect total estimated blood loss, either [17]. Other studies showed that the risk of transfusion is associated with increased patient age, working sheath, operative duration [18, 19].

Current managements for renal bleeding after PCNL include placement of a nephrostomy tube, Tubeless PCNL with nephrostomy tract fibrin sealant, a Kaye nephrostomy tamponade, balloon catheter, and endovascular embolization. If the above-mentioned measures fail to control the hemorrhage, partial nephrectomy may be required [20, 21]. The rate of transfusion after percutaneous procedures differs. In the majority of the subjects, the amount of blood loss during PCNL is not significant enough to require transfusion. Segura and colleagues reported need for transfusion in only 3% of their patients [22], whereas Stroller and associates had a 23% transfusion rate [23]. To reduce renal bleeding, we covered the nephrostomy tube with absorbable hemostatic gauze in group B. In our study the rate of transfusion was 5.5% in the group A and 1.1% in the group B, but there was no statistical difference. The rate of Super-selective renal arterial embolization was 4.4% in the group A and 1.1% in the group B, but there was no statistical difference also. Maybe we need more samples to get significant statistical difference. But in our study the blood loss after operation was significantly less in Group B than in Group A. The delta hemoglobin was significantly less in Group B than Group A also. The finding indicated that our improved nephrostomy tube can significantly reduce postoperative bleeding.

For patients at risk of severe bleeding, PCNL should be performed by an experienced endourologist [23]. In our study, all the procedures were performed by a single physician. Kukreja and colleagues [16]. described strategies that may reduce blood loss and transfusion rate, including ultrasound-guided access, using Amplatz or balloon dilatation systems, reducing the operation time, and staging the procedure in cases with a large stone burden or intraoperative complications. Our study showed that nephrostomy tube covered with absorbable hemostatic gauze reduced postoperative blood loss significantly. Postoperative delayed bleeding was significantly decreased. The main reason by speculation is that the postoperative bleeding after PCNL is mainly caused by percu-

taneous tract bleeding after puncturing and dilating.

Absorbable hemostatic gauze is usually absorbed within 7-14 days. Compared to tubeless PCNL with nephrostomy tract fibrin sealant, placing nephrostomy tract covered with absorbable hemostatic gauze may reduce the pressure of the renal pelvis, thus the risk of blood infection is decreased. Compared to traditional way by using balloon catheter, placing nephrostomy tract covered with absorbable hemostatic gauze may cause less pain postoperatively and less damage to the kidney.

This study, to the best of our knowledge, is the first study to compare outcomes of standard nephrostomy tube versus nephrostomy tube covered with absorbable hemostatic gauze in postoperative bleeding control. The drawback of this study is that the absorbable hemostatic gauze tends to drop when we are trying to put it into the sheath. So we need to invent a new kind of nephrostomy tube with integrating absorbable hemostatic gauze outside and design clinical trials to test this device.

Disclosure of conflict of interest

None.

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