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Treatment of renal calculi without hydronephrosis using a standard channel assisted by a visual puncture system

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Abstract

Objective: To study the safety and efficacy of standard channel establishment using a visual puncture system in the treatment of renal calculi without hydronephrosis.

Methods: We retrospectively analyzed data from 46 patients undergoing percutaneous nephrolithotomy via a standard channel assisted by a visual puncture system, including number of punctures, duration of procedure, hemoglobin level after surgery, calculi clearance rate, and postoperative complications.

Results: Sixty-nine channels were established, including a single channel in 26 cases, double channel in 17 cases, and three channels in 3 cases. The mean number of punctures was 1.50, mean time to establish the standard channel was 2.6 minutes, and duration of surgery was 31.3 minutes. No significant change in hemoglobin was observed after surgery. Forty-three patients had no residual calculi and three had small residual calculi on the day after surgery, representing a first-phase clearance rate of 93.48% (43/46). No significant complications were observed.

Conclusions: Hemorrhage during operation can be significantly reduced by establishing a standard channel using a visual puncture system. Moreover, the number of standard channels can be reduced and the incidence of complications lowered using this approach, which should be adopted widely for the treatment of renal calculi without hydronephrosis.

Keywords

Visual puncture system, percutaneous nephrolithotomy, renal calculi without hydronephrosis, hemorrhage, standard channel, duration of surgery

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Introduction

Percutaneous nephrolithotomy has been widely applied as a minimally invasive technology in the treatment of urinary calculi.[1] However, this procedure is limited by the degree of proficiency required for the ultrasonic technique and puncturing, time taken to establish the channel, and inaccuracies in puncturing. Particularly, it is more difficult to treat renal calculi without hydronephrosis via puncturing.[2]

Renal calculi without hydronephrosis is a common clinical condition. Because kidney obstruction without hydronephrosis is not significant and the pelvis is minimally or not dilated, the puncture target and subsequent puncture area is small. However, few percutaneous nephrolithotomy operators are sufficiently proficient to establish the channel via puncturing guided by B-ultrasound and achieve satisfactory results, and even then cannot avoid the limitations described above.[3] To evaluate the safety and clinical efficacy of standard channel establishment assisted by a visual puncture system in the treatment of renal calculi without hydronephrosis, data from 46 patients with renal calculi without hydronephrosis treated at our hospital from February 2017 to April 2018 were analyzed. None of the patients had significant hydronephrosis and were subsequently treated using a standard channel assisted by a visual puncture system and lithotripsy.

Data and methods

Ethical approval

The study was approved by the Institutional Ethics Committee of Affiliated Hospital of Hebei University, and written informed consent was obtained from all participants.

Clinical data

We retrospectively analyzed data from 46 patients with a mean age of 41.5 years (range: 29–64 years), including 29 male patients and 17 female patients. Renal calculi without hydronephrosis was present on the left side in 32 patients and on the right side in 14 patients. Mean BMI was 21.5 (range: 19.1–24.9). The primary symptom upon physical examination was intermittent waist and abdomen discomfort (28 patients) and nausea (18 patients). Calculus size measured via kidney-ureter-bladder (KUB) gave a vertical diameter of 2–5.5 cm, with an average of 4.6 cm; and transverse diameter of 1.5 to 4.5 cm, with an average of 3.7 cm. Patients with a urinary system infection underwent urine culture and susceptibility testing prior to surgery and were treated with appropriate antibiotics until routine urinalysis was normal and neutrophil esterase and nitrite were negative. All patients had normal hepatorenal function and clotting mechanism and had no contraindications to surgery.

Surgical method

Patients received general anesthesia and were placed in a lithotomy position. After disinfection of the surgical site, an F5 ureteral catheter was placed in the pelvis assisted by ureteroscope, the ureter was indwelled, and the F5 ureteral catheter and ureter were fixed. The external terminal of the F5 ureteral catheter was connected to 0.9% stroke-physiological saline solution to establish artificial hydronephrosis. Patients were placed in a prone position with the waist raised, and received puncturing at an appropriate puncture point after surgical site disinfection and surgical drape laying. A visual puncture system was connected and the target kidney calices were punctured using a visual puncture needle assisted by B-ultrasound. The inserting needle path was adjusted with the aid of the ultrasonic tool until the calculi or collective system became visible under the scope (verifying the success of puncturing) and urine

flowed out as the stylet was pulled out (further verification of the success of puncturing). A Zebra Urological Guidewire was placed after the stylet was removed, the skin adjacent to the needle was incised by 1.0 cm, the visual puncture needle was removed, and the Zebra Urological Guidewire was indwelled in the renal collective system. An F8 fascial dilator was imported via the Zebra Urological Guidewire for predilation. The F8 fascial dilator was removed after predilation and an N30 balloon ductal dilating catheter (BD, New Jersey, NJ, USA) was inserted via the Zebra Urological Guidewire and linked to a pressure pump filled with stroke-physiological saline solution. The pump was pressured up to 25 Kpa to fully dilate the balloon ductal, an F24 theco was placed, and the N30 balloon ductal dilating catheter was withdrawn with the guidewire remaining in the renal collective system. After connecting a 22F nephroscope, a Swiss EMS ultrasonic lithotripsy and stone removal system was used for lithotripsy and aspiration of small calculi. For calculi outside the area visible via the nephroscope, a channel was established with the aid of a visual puncture needle, a 200-μm holmium laser fiber with parameters of 0.8 J and 25 Hz was directly placed for lithotripsy, and small calculi were aspirated via the first channel. After lithotripsy, ureteral stents was placed and the fistula was indwelled via the first channel. Following surgery, the visual puncture system channel was covered with sterilized dressing instead of being sutured. The nephrostomy tube was removed 2 to 4 days after surgery as appropriate, and the ureteral stents were removed at 4 to 6 weeks.

For lithotripsy therapeutic evaluation, KUB or CT results at 4 to 6 weeks after surgery showed no residual calculi or only small calculi with a diameter >4 mm. Lithotripsy was thus considered successful.

Results

In the 46 patients with renal calculi without hydronephrosis included in our analysis, a single standard channel was successfully established using a visual puncture system. The number of punctures was 1 to 3 (mean 1.50; 69 channels in total). A second channel was established in 17 cases, a third channel in 3 cases, and an F4.8 ultramicro channel using a holmium laser fiber in 20 cases. The time taken to establish the standard channel was 2 to 4 minutes (mean 2.6 minutes); and surgical duration was 20 to 55 minutes (mean 31.3 minutes). There was no significant change in hemoglobin during routine blood examination on the day immediately after surgery (hemoglobin decreased <1 g/L), and 43 patients had no residual calculi while 3 patients had small residual calculi as evaluated by KUB or CT on the day immediately after surgery, representing a calculi clearance rate of 93.48% (43/46) for the first phase. The three patients with small residual calculi received extracorporeal shock wave therapy, postural lithotripsy, and drug lithotripsy, and were found to have no residual calculi via KUB or CT at 4 to 6 weeks after surgery, representing a total clearance rate of calculi of 100% (46/46). After surgery, four patients developed fever and received appropriate anti-pyretic therapy as well as anti-infective therapy based on their preoperative urine culture and drug sensitive test results. All four patients had normal body temperature within 1 to 2 days of treatment. No significant complications such as pneumothorax, peripheral organ injury, infectious shock, or massive hemorrhage were observed in any of the patients.

Discussion

Renal calculi without hydronephrosis refers to calculi in the pelvis or in one or more

kidney calices or stag horn calculi without significant obstruction of the renal collective system.[4] Currently, the main treatment methods for renal calculi without hydronephrosis include flexible ureteroscope and percutaneous nephrolithotomy. Considering the limitations of flexible ureteroscope, including large calculi, prolonged duration, and difficulty in accessing calyceal calculi with an infundibulopelvic angle $<30^{\circ}$, the treatment of renal calculi without hydronephrosis is typically performed using percutaneous nephrolithotomy, which has become the first-line therapeutic method for upper urinary tract calculi.[5] The key stage of nephroscopy is to establish a percutaneous renal channel. Research by Sun Yinghao et al.[6] show that the renal collective system is clearly visible under ultrasonic puncture in the case of renal calculi with percutaneous hydronephrosis, in which the entire puncture process can be monitored in real-time under B-ultrasound guidance. This results in an improvement in the puncture accuracy and avoidance of complications such as peripheral organ injury or kidney penetrating injury. In kidneys without hydronephrosis, the collective system is not dilated by hydronephrosis, the renal parenchyma is thick, and the space in kidney is small, meaning that it is difficult to puncture and that complications such as channel loss or extensive bleeding may occur.[7] Karatag et al.[8] reported that the time taken for puncturing and the success rate of the puncture is not affected by hydronephrosis if percutaneous nephrolithotomy assisted by visual puncture system is employed, indicating that a visual puncture system is superior to a general puncture needle in establishing a percutaneous renal channel in patients with renal calculi without hydronephrosis. Furthermore, most PCNL-related complications are closely related to the size of the renal channel and include hemorrhage, kidney calices and funnel-shaped dilacerations, persistent urinary fistulae, and nephron loss.[9,10] In the present study, for the 17 cases for whom the second channel was established and the 3 cases for whom the third channel was established, the combination of an F4.8 ultramicro channel with 200-μm holmium laser lithotrity was applied. None of the 20 patients had residual calculi after the procedure. All patients in this study had a channel established with the aid of a visual puncture system, and complications including puncturing aorta, kidney calices, and funnel-shaped dilacerations were not reported. The F4.8 visual puncture system is beneficial in determining the optimal channel prior to percutaneous nephroscope dilation to improve the safety of the procedure.[11] The entire puncture process is conducted visually, so that significant complications such as injury to large blood vessels or peripheral organs can be avoided. Karatag et al.[12,13] reported that only a slight decrease in hemoglobin occurred after percutaneous nephrolithotomy with a visual nephroscope, and that no patient required blood transfusion. Ölçücüoğlu et al.[14] found that the curative effect of an F4.8 visual puncture system in combination with holmium laser lithotrity was effective for the treatment of calculi <2 cm, and that the wound size was reduced and the success rate of channel establishment improved. Silay et al.[15] reported that the curative effect of the combination of a F4.8 visual puncture system with a 200-μm holmium laser lithotrity in the treatment of pediatric renal calculi was effective. Xie Guohai et al.[16] also reported satisfactory results when establishing an F12 channel with a visual puncture system in the treatment of calculi <2 cm. Percutaneous nephrolithotomy (F4.8 ultramicro channel) with visual puncture nephroscopy is clearly superior to the use of a flexible ureteroscope or extracorporeal shock wave in the treatment of 1 to 2 cm renal calculi, and a satisfactory curative effect has been achieved with an F4.8 visual ultramicro channel nephrolithotomy in most instances.[12,17,18] In the

treatment of large renal calculi, however, this approach is limited by incomplete lithotripsy, long duration, and increased infection risk. In the case of percutaneous nephrolithotomy with visual nephroscopy (F4.8 ultramicro channel), intrapelvic pressure is significantly higher than that in the case of a standard channel, which can increase the risk of infection. Research by Karatag et al.[19] has demonstrated the relative safety of this approach if the intrapelvic pressure is lower than 30 mmHg. Therefore, it is desirable to reduce intrapelvic pressure, shorten the duration of surgery, and reduce the risk of infection by establishing a standard channel in the case of large renal calculi. In the present study, most cases were patients with large renal calculi. An N30 balloon ductal dilating catheter was therefore used to dilate the standard channel, which enabled whole-process visual puncture with the visual puncture system to ensure high lithotripsy efficiency and a reduced risk of infection.

For all 46 patients with renal calculi without hydronephrosis, a single standard channel was established successfully using a visual puncture system. For 20 patients, an F4.8 ultramicro channel was established using a holmium laser fiber. A satisfactory outcome was achieved in all 20 cases. Three patients had residual calculi detected via KUB or CT on the day after surgery, and subsequently received extracorporeal shock wave therapy, postural lithotripsy, and drug lithotripsy. No residual calculi were detected via KUB or CT in these patients at 4 to 6 weeks after surgery. Four patients developed fever after surgery, but the fever resolved 1 to 2 days after treatment.

Our findings show that the therapeutic method of establishing a standard channel assisted by a visual puncture system for the treatment of renal calculi without hydronephrosis has a number of advantages. First, the visual puncture system allows the skin, subcutaneous tissue, and renal parenchyma to be observed throughout the procedure and the target kidney calices to be punctured safely, so that the accuracy rate of puncture is improved and the time taken to establish the channel is reduced. In the present study, the mean number of punctures was 1.50 and the mean time taken to establish a standard channel was 2.6 minutes. Additionally, damage to blood vessels and bleeding after dilation can be avoided when using a visual puncture system, which is also small in size and easy to operate. Akman et al.[20] showed that duration of surgery and hemorrhage risk are increased with a multichannel approach, while Kukreja et al.[21] reported that channel diameter was related to the incidence of hemorrhage. In the present study, a single standard channel and an F4.8 ultramicro channel were adopted and no significant change in hemoglobin level was observed, indicating that the risk of bleeding was reduced by comparison with the decrease in hemoglobin of 11.0 g/L previously reported after mini-percutaneous nephrolithotomy (MPCNL) surgery.[22] For renal calculi of large size and quantity, ultramicro channels were established in the present study to avoid renal dilaceration or bleeding due to violent oscillation of the nephroscope. Finally, the clearance rate of calculi is improved using the approach adopted in the present study. For calculi that cannot be cleared via the standard channel, ultramicro channels established using a visual puncture system can improve the clearance rate. The clearance rate of calculi for the 46 patients with renal calculi without hydronephrosis in our study was up to 93.48% (43/46). Only three patients had small residual calculi, which were subsequently removed successfully.

In summary, the establishment of a standard channel with the aid of a visual puncture system for the treatment of renal calculi without hydronephrosis has the following advantages of a shorter time, reduction in bleeding, and improved calculi clearance

rate. The F4.8 visual puncture system is thus safer and more efficient for establishing the channel and increasing the success rate, and should be widely adopted. However, the retrospective design and small sample size of our study mean that our findings should be verified in long-term randomized controlled studies.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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