Effective evaluation of using ultrasound-guided renal access for percutaneous nephrolithotomy

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ABSTRACT

Purposes: To evaluate the effectiveness of using ultrasound-guided renal access for percutaneous nephrolithotomy (PCNL). Methods: Between January 2016 and April 2017, at Saint Paul hospital, 130 patients were treated, 88 men and 42 women, with a mean age of 52.4 ± 11.5 years and a mean stone size of 30.82 ± 11.47 mm. All stones were located in the renal pelvis with mild to moderate hydronephrosis seen on ultrasound or uroscanner. A ureteral catheter was inserted cystoscopically, and saline was injected for more...
localization of the pelvicalyceal system (PCS) if needed. Puncture of the PCS was performed with an 18-gauge nephrostomy needle through the calyx, and all the stages, including dilatation, were performed under ultrasonography guidance. Results: Pyelocaliceal access: 95% of the lower caliceal group, 5% of the middle caliceal group, no case in the upper caliceal group. The intervention time was 12.4 ± 3.7 minutes. The average number of punctures was 1.25 ± 32. There was a correlation between the number of punctures and the patient’s BMI with p = 0.016. Complications: 13 cases (10%) significant bleeding have to blood transfusions, 10 cases (7.7%) postoperative fever, one case (0.8%) pseudo-aneurysm after seven days, and one case (0.8%) perirenal fluid collection. Conclusion: ultrasound guidance for renal access and tract dilation in PCNL is a useful technique and fewer complications; however, more experience is needed.

Keywords: percutaneous nephrolithotomy (PCNL), renal stones, sonography guidance.

1. INTRODUCTION

Percutaneous nephrolithotomy (PCNL) was first described in 1977 by Frenström and Johansson (Fernstrom and Johansson, 1976) and has now become the first-line method of treating large nephrolithiasis with minimal invasive features and high rate of removal nephrolithiasis. Inserting and dilating a tunnel through the skin into the renal pelvis to bring the endoscope into the lithotripsy is a critical step that determines the success of the technique. This process is carried out under the guidance of images, most commonly fluoroscopy or ultrasound. At present, in many countries, fluoroscopy is still widely used. However, there is a disadvantage of causing X-ray exposure to health workers and patients (Kumari et al., 2006). It is very rare for operating rooms to be equipped fluoroscopy due to the high cost. Therefore, the use of guided ultrasound to access the renal pelvis is increasingly popular in our country. This study aims to evaluate the results of the success and safety of this technique and discuss the factors related to possible complications.

2. MATERIALS AND METHODS

From January 2016 to April 2017, at Saint Paul Hospital, we used guided ultrasound to puncture of the PCS for nephrolithotomy of 130 patients. The subjects selected were patients diagnosed with kidney stone burden in pelvis ≥ 20 mm or inferior major calyces > 15 mm, coral-like stones, and ineffective extracorporeal lithotripsy (Turk et al., 2016). Patients excluded from the study included: inadequate physical condition for general anesthesia, untreated urinary tract infections, coagulopathy, pregnant women, ectopic or abnormal rotating kidneys.

The technique of ultrasound-guided renal access for PCNL is done by two radiologists who have experience in ultrasound interventions. Technical process: after general anesthesia and ureter catheterization, the patient is placed on his prone with pillows under his abdomen, his arms stretched out. Using a 3.5 MHz convex probe (Medison X6 sonoache), the placement of the transducer: the angular formed by lateral lumbar muscle and 12th rib; Slight oblique transducer to find the suitable calyx to puncture, usually the direction creates an angle of 45 forward and upward in a horizontal plane. The chosen calyceal group depends on the position of the stones and the kidney’s relative proximity to the surrounding organs, usually choosing the lower or middle calyceal groups. The needle will go to the top of the calyx because when done, the needle will go into the avascular region of the kidney, and the path of the needle will pass through the thinnest renal parenchyma (David R Webb, 2016). Using the 18 G needle, puncture to the defined calyceal group, observe the direction, and the tip of the needle on ultrasound is a bright line from the parenchyma to the renal pelvis (Figure 1A). In the case of no or mild hydronephrosis, observing the needle tip in the parenchyma is quite easy. Still, when the needle enters the renal pelvis, the needle tip will be more difficult because of interfered fatty and stones, so we made dilate the renal pelvis by pumping water through the ureter sonde into the renal pelvis, creating a good window for ultrasound, quickly identifying and controlling the needle tip. Signs confirming needle entry into the renal pelvis: 1) ultrasound showing a needle tip in the renal pelvis; 2) yellowish urinary discharge fluid from the needle; 3) feeling scratchy needle puncture into stones (Chi et al., 2016). After confirming that the needle has introduced the renal pelvis, insert a wire through the needle to the upper of the ureter; observe the path of the wire continuously on ultrasound. When the wire reaches the upper ureter firmly, removing the needle and introducing the first dilator into the renal pelvis under ultrasound (Figure 1B). When ultrasound observed, this dilator reached the renal pelvis; we determined once again to see urine flow out of the catheter (which can pump water through the catheter sonde into the renal pelvis). Alternately replace this dilator with the larger ones up to 16 Fr. Amplatz attaching to the 18Fr dilator is the final step in the process of being inserted similarly to previous dilators. Once the dilator is secured in the renal pelvis, the dilator is removed, leaving Amplatz, which is the tunnel created to enter the scope into the pyelocalyceal spaces for nephrolithotomy.
Figure 1 (A) Guided ultrasound, the needle inserted into the renal pelvis and (B) the dilator in the renal pelvis

We assessed patients on: age, gender; type, location, and size of stones; patient BMI, needle placement, number of puncture, and complications with particular emphasis on bleeding complications in which severe bleeding is defined as bleeding that requires stopping nephrolithotomy and bleeding requiring blood transfusions. Hematocrit and serum creatinine were quantified before and after surgery to assess changes in kidney function as well as bilirubin status. The time of puncture and dilatation of the tunnel (from the time the starting of puncture until the needle is accessible to stone), the entire time of the surgery is statistical to evaluate and compare the results of lithotripsy. After three days of lithotripsy, the patient was urinary X-ray. The results were assessed at three levels: no remaining of stones, insignificant remaining of stones (there were stones on the X-ray with size <5mm), significant remaining of stones.

3. RESULTS

Among 130 patients with 88 males and 42 females, the average age was 52.4 ± 11.5 (24 - 83); The average BMI was 21.65 ± 2.78 (14.13 - 28.3) of which the rates of underweight, average and overweight were 31.5%, 55.4%, and 13.1%, respectively. There are 31/130 cases with a history of kidney stone treatment, including 21 old surgery cases, 9 cases of extracorporeal lithotripsy, and one surgery to remove the kidney due to stones. The average stones size is 30.82 ± 11.47mm (14 - 82mm). Only 23.1% of patients had a single stone; the remaining 76.9% were coral or complex stones (many stones in the pyelocaliceal groups and renal pelvis). There is 26/130 cases of moderate to severe hydronephrosis (grade III-IV). 23% of patients had thin parenchyma (less than 10mm). One patient has a single kidney. 2 patients could not place sonde ureter on the renal pelvis, of which one patient did not have hydronephrosis. Most of the cases punctured on the lower calyceal group, accounting for (123/130), only 5.4% (7/130) punctured into the middle calyceal group, and no patients punctured into the superior calyceal group. The time of puncture and the widening tunnel is an average of 12.4 ± 3.7 (minutes). The average operative time is 135±25 (minutes). The average number of punctures was 1.25 ±32, including 29 cases had two puncture times and 2 cases 3 times. There was a correlation between the number of punctures and the BMI of patients with p = 0.016 (Figure 2), 2 cases having to puncture three times were in the overweight group.

Figure 2 Correlation between BMI and puncture times
In terms of complications, we noted that there were 26 patients (20%) who had complications of which the most common was surgery bleeding with 13 cases (10%), 1 case of late bleeding after seven days who was performed renal angiography and was detected pseudo-aneurysm, then was successfully embolized. Fever after surgery has 10 cases (7.7%). There was 1 case (0.8%) of peri-renal fluid, but not signification and dissolute after drainage (Figure 3).

![Figure 3 Complications due to creation of the tunnel]

The mean hematocrit before and after PCNL, respectively, was 41.3 ± 4.3 and 38.9 ± 4.6, indicating with significant difference (p = 0.001). The mean creatinine before and after PCNL, respectively, was 95.8 ± 36.8 and 94.8 ± 32.9, indicating without significant difference. After the PCNL, 70 patients (53.8%) completely cured stones, 44 patients (33.8%) insignificantly remained stones (size <5mm on the urinary X-ray after three days of PCNL), and 16 patients (12.4%) significantly remained stones.

4. DISCUSSION

PCNL is a preferred treatment for patients with large stones that are unsuitable for extracorporeal lithotripsy or other treatment. Puncture and tunnel creation is a first step, simple but important, and determining the success of the technique. Ultrasound provides information on nearby organs to avoid damage to organs and pleura during puncture. Doppler ultrasound helps to confirm the avascular area of the renal parenchyma, thereby guiding the needle. Some cases of renal pelvis dilate slightly, difficult to identify the needle into the renal pelvis, need to retrograde pump water through the catheter ureter (Chi et al., 2016). However, not every case can do this, we have two such cases, of which one patient does not have renal pelvic dilatation; this is a relatively difficult case. Still, the procedure is successful and without complications. In the study of Vu Nguyen Khai Ca, he used fluoroscopy to guide puncture and dilatation, but two patients did not have a renal ureter catheter, he performed a puncture and dilatation under the guidance of ultrasound and proceeded smoothly in both cases without complications (Vu Nguyen Khai Ca, 2009).

Our study patient group had an average BMI of 21.65, which was significantly lower than that of Thomas Chi (26.1). Compared to some of the studies on tunnel puncture and dilatation under ultrasound guidance, our study group had a significantly lower BMI (Chi et al., 2016). This is an advantage when under the guidance of ultrasound since BMI is positively correlated with the thickness of the subcutaneous fat layer, the thicker the fat layer is, the harder it is to puncture and adjust the needle due to increased mobility of the kidney.

Our study shows a positive correlation between BMI and the puncture times and time to tunnel achievement. This helps explain that the tunneling time in the study is 12.4 ± 3.7 minutes, shorter than that of Thomas Chi (an average of 14 minutes) (Chi et al., 2016). Technically, we choose mainly to puncture into the lower calyceal group; this is the path that allows access to all stones in the renal pelvis, the middle, and upper calyceal groups. Moreover, when selecting the lower calyceal group, the ultrasound field for puncture is relatively wide, less affected by the ribs, avoiding pleural injury. There is no way into the upper calyceal group; this is
different from the other studies as in the study of Thomas Chi, he chose to puncture the upper calyx up to 42% of the cases (Chi et al., 2016). The reason for this difference is that the access tunnel to the upper calyx is usually applied to the stones in the upper 1/3 portion of the ureter, but in our study, we did not select this group of patients. On the other hand, the ultrasound field to contact with the upper calycal group is relatively narrow due to rib problems and high risk of complication. Eric Taylor et al. performed a multicenter study with 5803 patients who had PCNL and recorded a rate of complication 21.5% (Taylor et al., 2012). Song Yan et al., in a five-year study with over 700 cases of PCNL under ultrasound guidance, had a complication rate of 16% (Yan et al., 2013). The complication rate in our study is 20%, similar to the results of the above studies.

The most common complication in PCNL is bleeding. This rate is 5.1%, according to Vu Nguyen Khai Ca (Vu Nguyen Khai Ca, 2009); We recorded 13 cases (10%) with significant bleeding complications requiring blood transfusions. This rate is higher than that of Vu Nguyen Khai Ca (Vu Nguyen Khai Ca, 2009); however, most of these cases were mildly bleeding and recovered without any intervention. Of these 13 cases, one has been severe bleeding from the calyx, not decreasing after the lavage of the renal pelvis. The surgeon could not observe the surgical field and therefore had to stop the PCNL process. This patient was then given a second PCNL one week later and was successful. There was one patient who was bleeding late after five days postoperation; renal angiography showed an image of pseudo-aneurysm; the patient was successfully carried out the embolization. Bleeding complications are more common in patients with thick renal parenchyma, the large size of stones, slightly pyelonephritic dilatation, and multiple punctures. The second most common complication in PCNL is fever. We encountered 10 cases (7.7%) with fever lasting 2-4 days and disappeared after antibiotics. We did not experience complications of neighboring organs; the studies also showed that the complications were uncommon, ranging from 0 to 4.4% (Taylor et al., 2012; Yan et al., 2013).

5. CONCLUSION

PCNL using ultrasound to guide and puncture the tunnel is a safe technique, high success rate, especially suitable for Vietnamese people with small body condition, not too much subcutaneous fat giving thick, clear ultrasonic images. Bleeding complications are common (10%), to reduce the risk of this complication, it is necessary to identify the location of puncture through renal parenchyma, avoid repeatedly puncture or puncture large blood vessels.

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Conflicts of Interest: The authors declare no conflict of interest.

Informed consent

Informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

Ethical approval for study protocol

The study was approved by the Medical Ethics Committee of Saint Paul Hospital (ethical approval code: 0031-SPH).

REFERENCE