Role of Ultrasonography in Percutaneous Renal Access in Patients With Renal Anatomic Abnormalities

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OBJECTIVE To present our experience regarding the feasibility, safety, and efficacy of ultrasound (US)-guided percutaneous nephrolithotomy in anatomically abnormal kidneys.

MATERIALS AND METHODS We performed US-guided percutaneous nephrolithotomy in 15 patients with anatomically abnormal kidneys and renal calculi. Of the 15 patients, 5 had horseshoe kidneys, 5 had rotation anomalies, 2 had kyphoscoliosis, and 3 had scoliosis. The stone size, number of access tracts, operative time, hospitalization duration, rate of stone clearance, and complication rate were recorded. Percutaneous access was achieved with US guidance in the operating room by the urologist.

RESULTS Successful renal access was obtained by the surgeon using US guidance in all patients, and a single access was obtained in all cases. Of the 15 patients, 8 were females, and 7 were males; 8 patients had solitary stones, and 7 had multiple calculi. The renal calculi were on the right in 7 patients and on the left in 8. Three patients had previously undergone unsuccessful shock wave lithotripsy. Complete stone clearance was achieved in 13 patients. The mean operative time was 54.2 minutes. No patient required a blood transfusion because of bleeding. Urinary tract infections occurred in 2 patients, who were treated with antibiotics. A double-J catheter was not inserted in any patient; however, a ureteral catheter was used in 3 patients for 1 day. None of the patients had any major complications during the postoperative period. The stone-free rate was 87%, and 2 patients had clinically insignificant residual fragments.

CONCLUSION Our results have demonstrated that US-guided percutaneous nephrolithotomy can be performed feasibly, safely, and effectively in anatomically abnormal kidneys. UROLOGY 81: 938−942, 2013.

It has generally been accepted that percutaneous nephrolithotomy (PNL) is the reference standard modality for the management of large renal calculi. PNL has been shown to be an effective and safe procedure, with high success and low major complication rates.[1] In PNL, most surgeons have used fluoroscopy to obtain access to the renal collecting system. Recently, numerous publications have demonstrated that PNL is a reliable procedure for patients with anatomic problems (eg, horseshoe kidneys, rotation anomalies, ectopic kidneys, fusion anomalies, and musculoskeletal abnormalities).[2] Percutaneous renal access in these patients is more complicated because of their anatomic differences. However, no consensus has been reached regarding the guidance method used before puncture to apply PNL in these patients with problematic anatomic features.

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Fluoroscopy, ultrasonography (US), computed tomography (CT), and laparoscopy have been used solely orcombined as a guidance method to obtain percutaneous renal access for PNL in abnormal situations.[3-6] Desai and Jasani[3] and others[4-7] have described a US-guided PNL technique for pelvic ectopic kidneys. Srivastava et al[4] used US to perform percutaneous nephrostomy in a radiology suite by a radiologist and urologist during the preoperative period. Subsequently, they performed PNL through the same tract in another session. With the exception of these cases, no data have been reported on US-guided PNL in anatomically abnormal kidneys.

We present our experience regarding the feasibility, safety, and efficacy of US-guided single-session PNL in anomalous kidneys, including horseshoe kidneys, rotation anomalies, and musculoskeletal abnormalities, such as kyphoscoliosis and scoliosis.

MATERIAL AND METHODS

We retrospectively reviewed and analyzed the medical records and files of 15 patients (15 renal units) with anatomically abnormal kidneys and renal calculi who had undergone

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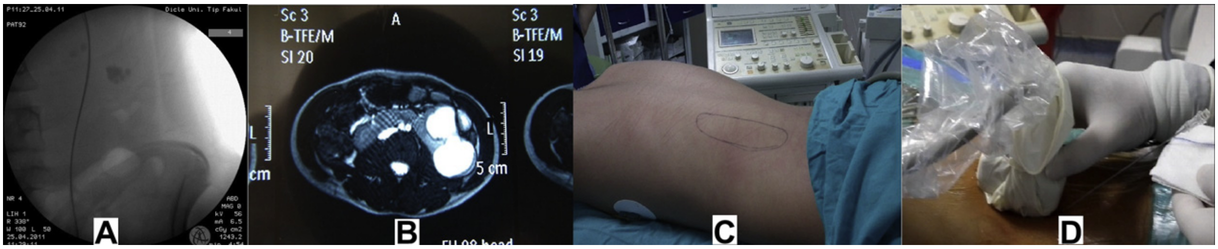

Figure 1. Patient with horseshoe kidney. **(A)** Ureteral catheter first inserted, and renal calculus observed on fluoroscopic screen. **(B)** Magnetic resonance imaging scan showing horseshoe kidney, isthmus, and left hydronephrosis. **(C)** Renal position identified by ultrasonography. **(D)** Renal access gained with ultrasound guidance. (Color version available online.)

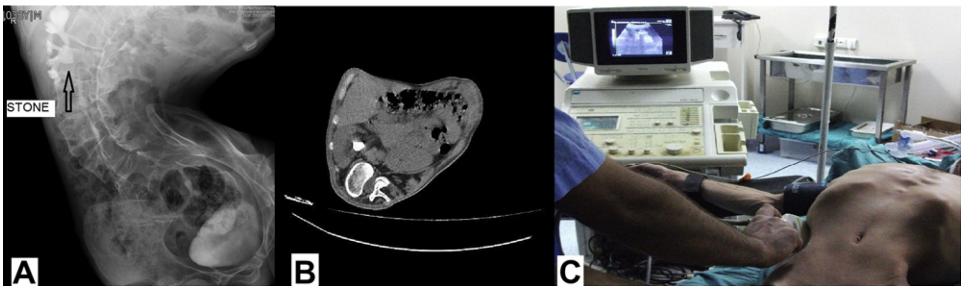

Figure 2. Patient with kyphoscoliosis. **(A)** Intravenous urogram showing renal pelvic calculi. **(B)** Computed tomography scan showing right renal position, pelvic calculi, and adjacent organs. **(C)** Determination of renal position, localization, and anatomy with ultrasonography. (Color version available online.)

US-guided PNL from July 2009 to May 2012. Of the 15 patients, 5 had horseshoe kidneys, 5 had rotation anomalies, 2 had kyphoscoliosis, and 3 had scoliosis; 8 patients had solitary calculi, and 7 had multiple calculi. The stone size was determined according to the longest axis measured on radiologic evaluation in patients with solitary calculi. If the patients had multiple calculi, the stone size was measured as the sum of the longest axis of each stone.

Preoperative urinalysis, blood count, renal biochemistry, US, and noncontrast-enhanced abdominal CT scans were performed for all patients. If required, intravenous urography and urine culture were also performed. The stone burden (ie, size and location), number of access tracts, operative time, hospitalization duration, stone clearance rate, and number of complications were recorded.

Technique

All PNLs were performed as single-stage procedures. In every case, percutaneous access was achieved in the operating room by the urologist. With the patient under general anesthesia and in a supine position, retrograde catheterization was performed by cystoscopic placement and secured to a urethral Foley catheter. The operation was continued with the patient in the prone position, except for 3 patients (Fig. 1). In 1 patient with kyphoscoliosis, the supine position was used,[8] and in 2 patients, 1 with scoliosis and 1 with kyphoscoliosis, the supine-oblique position was used because the musculoskeletal abnormalities blocked the prone position (Figs. 2 and 3). After achieving the operating position, all pressure points were padded. US with a 3.75-3.5 MHz probe was used to identify the renal and pelvicaliceal system anatomy and localization, adjacent organs and relationships, calculi, and the calix that would provide access to the calculus. Punctures of the tip of the desired calix were safely performed with an 18-gauge access needle with US guidance. The renal pelvis was rotated anteriorly, and the parenchyma of the kidney was rotated medially in anomalous kidneys, such as horseshoe kidneys and those with rotation anomalies. Thus, the access was more medial than with anatomically normal kidneys. We also found this to be true in the present series (Fig. 1). In patients with kyphoscoliosis/scoliosis, the location of the kidney is changed owing to the severity of the musculoskeletal deformity of the patients. In these patients, the kidney location was determined with CT guidance before surgery. During surgery, the location of the kidney was visualized using US, and access was achieved in the proper position (Figs. 2 and 3). After observing the flow of urine from the needle, the position of the needle was checked under fluoroscopic screening. The next steps of the operation were continued with fluoroscopic control. Tract dilation was performed with Amplatz dilators or a balloon dilator followed by placement of a 30F Amplatz sheath. A rigid 26F nephroscope and pneumatic lithotripsy were used in all patients. After stone clearance was assessed with fluoroscopy, a Foley or Nelaton catheter was placed as the nephrostomy tube in all patients.

All patients were evaluated with a plain abdominal film, US, and laboratory tests on the first postoperative day to assess the stone-free rate and hematocrit changes. After the nephrostomy catheter was removed, the patients were discharged with oral antibiotics and analgesic regimens in the absence of fever, urine leakage from the tract, or any complaints.

RESULTS

The present study included 8 female patients and 7 male patients, with an age range of 5-49 years (mean 41.1). Of the 15 patients, 8 had a solitary stone, all of which were in the renal pelvis, and 7 had multiple calculi. In the latter patients, the stone location was the renal pelvis and lower pole in 5 patients and the renal pelvis, lower pole,

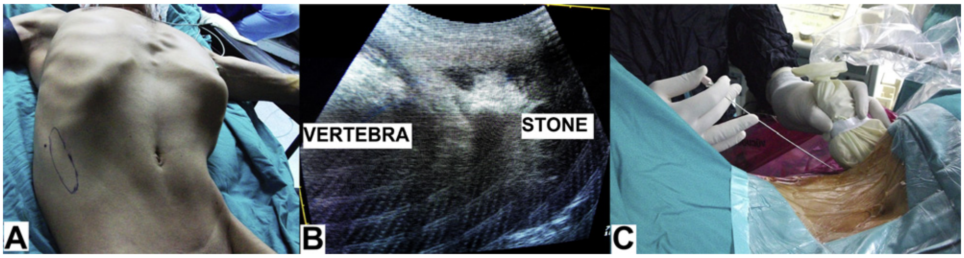

Figure 3. Patient with kyphoscoliosis. **(A)** Patient position and renal position. **(B)** Ultrasound view of relationship between kidney and vertebrae. **(C)** Renal access gained with ultrasound guidance. (Color version available online.)

and upper pole in 1 patient; 1 patient had staghorn calculi. The mean stone size was 26.8 mm (range 16-34). In 7 patients, the right renal collecting system was affected, and in 8, the left was affected. Three patients had previously undergone unsuccessful shock wave lithotripsy, but the others were considered inappropriate for shock wave lithotripsy.

Successful percutaneous renal access was achieved by the surgeon in all cases with US guidance, and a single tract was sufficient in all cases. In 1 patient, access was achieved by way of the middle calices because of a retrorenal colon, and the others were performed by way of the lower calices. The mean operative time was 54.2 minutes (range 40-72), and the average total fluoroscopy time was 3.3 minutes (range 1-6). The postoperative mean hemoglobin decrease was 0.65 mg/dL.

The mean duration of hospitalization was 2.6 days (range 2-4). Intraoperative complications did not occur nor was conversion to open surgery required. No patient required blood transfusion for significant bleeding. Urinary tract infections occurred in 2 patients (Clavien grade II complication[9]), who were treated with antibiotics. A double-J catheter was not inserted in any patient, but a ureteral catheter was used in 3 patients for 1 day. None of the patients had any major complications during the postoperative period. The stone-free rate was 87%, and 2 patients had residual fragments.

COMMENT

PNL was first described in 1976 by Fernstrom and Johansson[10] and has since become the first-line treatment for kidney stones >2 cm in diameter, especially in anatomically normal cases.[11] However, recently, several studies have involved relatively small numbers of patients in which PNL was used in anatomically anomalous kidneys.[2] Of course, an abnormal renal position combined with an abnormal renal caliceal and vascular situation, and abnormal relationships with other organs will complicate the surgery. However, with increasing experience and technological support (flexible nephroscopes and nitinol stone baskets), these problems can be addressed, and have resulted in 93.9%-100% stone-free rates in anatomically anomalous kidneys.[2]

Creating acceptable, successful access to the renal collecting system is the first and most important process in PNL, and this procedure has mostly been performed under fluoroscopic guidance. Other guidance techniques for obtaining access include laparoscopy, CT, US, and combinations of these imaging modalities.[3-6,12] All these techniques can be used for anomalous kidneys. Laparoscopy-assisted guidance and CT guidance are infrequently required to facilitate safe and efficacious PNL.[13] Additionally, fluoroscopic access carries a radiation exposure risk for the surgical team and the patient and can prevent the evaluation of adjacent organs, such as the colon.[14,15]

Recently, the number of studies demonstrating the success of US-guided PNL has increased. Even after successful US-guided access, Gamal et al[16] reported the use of US during all stages of PNL without fluoroscopy. Generally, with the US-guided PNL technique, after puncture under US guidance, the operation continues with fluoroscopic screening. However, in recent years, especially in children, the use of fluoroscopy has decreased, and the use of US has increased.[17] The advantages of US guidance include the absence of radiation exposure, imaging of the intervening structures between the skin and kidney (retrorenal colon), evaluation of the collecting system in a 3-dimensional orientation, the ability to distinguish between anterior and posterior calices, the opportunity to achieve the shortest access to the collecting system with minimal morbidity, the ability to perform the procedure with the patient in different positions, the accurate assessment of the depth and plane of the puncture, the ability to evaluate residual nonopaque and semiopaque stones not visualized by fluoroscopy, the potential for use in unsuccessful ureteral catheterization, and the avoidance of ureteral catheter insertion in selected cases.[14-18]

In the published data, only 2 studies have mentioned US-guided access for PNL in anomalous kidneys. However, in 1 of these 2 studies, the percutaneous nephrostomy tube was preoperatively placed using US or CT guidance at the radiology department by a radiologist and urologist. PNL was performed through the same tract in another session.[4] Intraoperatively, a second US-guided puncture was required in these 2 patients. In our study, we performed the PNL in a single session, and pelvicaliceal access was achieved by a urologist with US guidance in the operating room without a radiologist. The surgeon was especially experienced in US-guided nephrostomy catheter placement and PNL in adults and children. Because of the performance of single-session PNL in our patients, the duration of hospitalization (2.6 days) was shorter than that in the study by Srivastava et al[4] (4.5 days). Additionally, access obtained by radiologists might not be adequate for PNL,[19] and urologists must obtain access using a technique such as we have described. Other than these situations, the other operation parameters were similar.

In a second study, Desai and Jasani[3] reported their experience with pelvic ectopic kidneys treated with PNL using US-guided access with the patient in the supine position. After they punctured the collecting system, they continued the operation under fluoroscopic control, similar to our procedure. In their study, they completed the procedure in 2 stages in the initial 3 patients. In the first stage, they introduced the nephrostomy catheter, and PNL was performed in the subsequent stage. They treated all subsequent patients in a single stage. Their results were positive, and complete stone clearance was reported in all cases. Bowel injury occurred in 1 patient and was managed conservatively. No vascular injury was reported, and blood transfusion was not required for any of the patients. In our study, we performed PNL in a single stage beginning with the first patient. Additionally, their study included only patients with ectopic kidneys. In contrast, in our study, we performed PNL in several types of anomalous kidneys, including horseshoe kidneys and kidneys with rotation anomalies, kyphoscoliosis, and scoliosis. Our success rate was similar to that reported in the study by Desai and Jasani.[3]

No studies have been published on US-guided PNL access for several types of anomalous kidney stones, such as those presented in the present study. Our surgical technique was as successful as other techniques (ie, fluoroscopy guidance, laparoscopy-assisted guidance, and CT guidance) presented in published reports. Although the complete stone clearance rate was 81%-100% at the end of the primary surgery, by the end of the subsequent operations or after shockwave lithotripsy, this rate had increased to 92.3%-100%.[4,20-22] In our study, the stone-free rate was 86.7% at the end of the first and last operation. Two patients had clinically insignificant residual calculi, and we did not perform any intervention. Although the mean operative time range has been reported as 69-144 minutes in different studies,[20-22] in our series, the operations were completed within an average of 54.2 minutes. The patients were hospitalized for an average of 2.6 days in our clinic, similar to the duration of hospitalization reported in other studies (1.92-4.5 days).[4,20-22] The complications of PNL performed in anomalous kidneys have included colonic injury, sepsis, pneumothorax, urinary tract infection, transfusion, urine leak from the percutaneous tract, obstruction, postoperative fever, and ileus.[2] None of our patients required a blood transfusion, and no patient had any major complications. Urinary tract infections developed in only 2 patients and were treated with antibiotics.

The small number of cases, retrospective nature, and the lack of patients with anatomic abnormalities treated with PNL with the guidance of other imaging modalities were major limitations of our study. The lack of information about the access time and radiation doses was an additional limitation of the present study. US is an operator-dependent x-ray-free imaging modality. Therefore, the duration of access was not routinely measured during US-guided PNL. Our primary goal was to present the safety and feasibility of US-guided PNL for patients with anatomic abnormalities. In our routine practice, we do not use a dosimeter to measure the amount of radiation for patients. However, the duration of fluoroscopic screening, which has been accepted as a major predictor of radiation exposure, was reported in the present study.[23]

CONCLUSION

PNL in anomalous kidneys is difficult because of the anatomic diversity and abnormal renal position. Therefore, alternative surgical techniques are necessary to achieve a successful surgery. Our results have demonstrated that despite the presence of anatomic abnormalities, in experienced hands, US-guided PNL can be performed feasibly, safely, and effectively in anomalous kidneys.

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