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Ultrasound versus Fluoroscopic Complete Supine Percutaneous Nephrolithotomy: A Randomized Clinical Trial

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ABSTRACT

Introduction: To compare complications and outcomes of totally ultrasonic versus fluoroscopically guided complete supine percutaneous nephrolithotomy (csPCNL).

Materials and Methods: In this randomized clinical trial study from January 2009 to September 2010, 26 of 51 patients with renal stones underwent csPCNL with ultrasonographic guidance (group A), and the other 25 patients underwent fluoroscopically guided csPCNL (group B). Statistical analysis was performed with SPSS 16 software.

Results: The mean BMI was 28.14 in group A and 26.31 in group B (ρ = 0.30). The mean stone burden was 26.48 and 30.44 in groups A and B, respectively (ρ = 0.20). The stone-free rate was 88.5% and 75.5% in groups A and B, respectively (ρ = 0.16). Overall, 2 patients (7.7%) in group A and 6 patients (24%) in group B had complications (ρ = 0.11). The mean operative time in groups A and B were 88.46 and 79.58 minutes, respectively (ρ = 0.39). The mean hospital stay was 69.70 and 61.79 hours in groups A and B, respectively (ρ = 0.22).

Conclusion: Totally ultrasonic had similar outcomes to fluoroscopic csPCNL in selected cases. Ultrasonography can be an alternative to fluoroscopy in csPCNL.

INTRODUCTION

A common method for kidney stone treatment is percutaneous nephrolithotomy (PCNL) [1,2]. Proper image guidance should be applied during each step in PCNL, because the dangers that may occur in vital structures during imageless PCNL should never be applied [3].

The popular imaging of PCNL is fluoroscopy, so the patient and surgical team would be exposed to some level of radiation by fluoroscopy during PCNL. The side effects of extensive radiation are well known. Thus, ultrasound-guided PCNL can be an alternative method for decreasing the hazardous radiation exposure to the surgeon [4,5].

The purpose of the present study is to compare the complications and outcomes in patients who underwent complete supine percutaneous nephrolithotomy (csPCNL) with these 2 methods, and to share the authors' experience of complete ultrasound-guided csPCNL procedure with the urological community.

MATERIALS AND METHODS

From January 2009 to September 2010, 51 patients with renal stones were selected for csPCNL. All the participants were informed about the surgical method and consented to be in the experiment. This was a random block study. We used total ultrasonographic guidance in all steps of the procedure during csPCNL in 26 of our patients (group A), whereas the other 25 patients underwent standard fluoroscopically guided csPCNL (group B). In both groups, PCNL was performed in the complete supine position without any towel under the patient's flank and with no change in the leg position [12,13]. For all patients,

KEYWORDS: Percutaneous nephrolithotomy, supine, ultrasound, fluoroscopy, complete supine, csPCNL

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routine blood and urine tests, coagulation profiles, and imaging series, including intravenous urogram and ultrasonography, were carried out, and medical conditions were studied.
Inclusion criteria included patients with a single pelvic stone larger than 2 cm, lower caliceal stones, stones in the pelvis and lower calyx, middle caliceal stones alone or with pelvic stones, and non-opaque stones.

Exclusion criteria in this study included multiple stones in multiple calyxes, staghorn stones (except non-opaque stones), urinary tract abnormalities, patients with a single kidney, and patients with a BMI ≥ 30. All of the patients underwent general anesthesia, and a 5 Fr ureteral catheter was placed transurethrally for an injection of saline or contrast media. An injection of saline created mild dilatation of the collecting system and this was useful for the total ultrasound-guided PCNL group.

In group A, for assessing the location of the kidney, needle entrance point, urinary tract dilatation, and checking the residual stone at the end of the procedure, ultrasonography was performed. Because the rough guide wire is more rigid, helping to reach the access point, we used this type of guide wire. Although the guide wire was clearly visible, the Amplatz dilatators and the Amplatz sheath were not exactly visible by ultrasonography [16].

In group B, we performed all the above steps of csPCNL with the guidance of fluoroscopy. Our technique was a 1-shot dilatation in both groups. In this study, the items, including the side of the renal unit, the stone burden, the stone-free rate, complications (extravasation, colon injury, fever, etc.), and the history of previous open renal surgery or previous ESWL, meant hospital stay, mean operative time, body mass index (BMI), serum creatinine before the operation, and hemoglobin before and after the csPCNL were studied.

In group A, after removal of the stone(s), ultrasonography was used to detect any residual stones, hematoma, or extravasation of urine outside of the kidney. In the fluoroscopic group, residual stones and extravasation were checked by fluoroscopy. We performed tubeless PCNL except in patients with severe extravasation, ureteral obstruction, severe hemorrhage, or large residual stones, or if the surgeon obsessed about the patient. Statistical analysis was performed with SPSS 16 software. A *P* value of less than 0.05 was considered statistically significant.

We performed csPCNL on our patients. The number of patients in this study was 26 patients in group A and 25 patients in group B. The mean age was 48.41 and 51.17 years in group A and B, respectively. The mean BMI was 28.14 in group A and 26.31 in group B. The mean stone burden was 26.48 and 30.44 mm in groups A and B, respectively, with no significant difference.

RESULTS

The total number of patients in the 2 groups was 51 (26 patients in group A and 25 patients in group B). Demographic data and stone characteristics of both groups are shown in Table 1. In group A, the mean age was 48.41 years and in group B it was 51.17 years (ρ = 0.46). The mean BMI was 28.14 in group A and 26.31 in group B (ρ = 0.30). The mean hemoglobin before operation was 12.81 and 13.38 in groups A and B, respectively (ρ = 0.23). The mean stone burden was 26.48 and 30.44 in groups A and B, respectively (ρ = 0.20). The stone burden was detected on the basis of the maximum diameter of stones on the KUB or ultrasonography. Four patients (15.4%) in group A and 7 patients (28%) in group B had coexisting disease (ρ = 0.44). All of the patients underwent general anesthesia, and access was subcostal in all patients. Intra- and postoperative parameters of the 2 groups are shown in Table 2. The stone-free rate was 88.5% in group A and 75.5% in group B, and it was not significant (ρ = 0.16). Overall, 2 patients (7.7%) in group A and 6 patients (24%) in group B had complications (ρ = 0.11). In group A, 1 patient (3.8%) had fever, and in group B, 4 patients (16%) needed transfusion and 2 patients (8%) had fever (grade I and II of the Clavien Classification of Surgical Complications). Mean operative time (including access time) in group A was 88.46 minutes, and in group B, it was 79.58 minutes (ρ = 0.39). The mean hospital stay was 69.70 and 61.79 hours in group A and B, respectively (ρ = 0.22). There were no complications compatible with grade III to V of the Clavien Classification of Surgical Complications in the 2 groups.

DISCUSSION

Despite the shortage of endourology, its scope has been widened. Accessing the collecting system by fluoroscopy, ultrasonography, or computed tomography (CT) guidance is the first step of PCNL [6-8]. In order to decrease the hazardous radiation exposure, the use of ultrasonography for PCNL is a good alternative imaging method, and it is the first and standard technique for imaging [9,10]. PCNL under ultrasonography guidance and with the patient in the flank or prone position confirmed that there would be a high success rate with limited complications, and it can be a safe and effective alternative to fluoroscopy in experienced hands. The detrimental effects of radiation exposure to the patient, surgeon, and operating staff would be decreased [10-12,19,27,28].

Some advantages and some disadvantages have been found in ultrasound-guided PCNL without fluoroscopy. The advantages in US-guided PCNL are X-ray exposure avoidance, no necessity to wear a lead shield, visibility of all organs upon access, and the possibility to look for residual stones at the end of the procedure, especially for non-opaque stones.

Disadvantages of US-guided PCNL are unfamiliarity of

Table 1. The demographic data of the 2 groups according to method.

	Ultrasonographic Group	Fluoroscopic Group	*P* Value
Total N	26	25	-
Sex Male (%) Female (%)	 17 (65.4) 9 (34.6)	 15 (60) 10 (40)	0.69
Age (year) Mean (SD)	48.41 (13.22)	51.17 (11.82)	0.46
BMI (kg/m^2) Mean (SD)	28.17 (4.17)	26.31 (5.88)	0.30
Serum creatinine before operating, mean (SD)	1.45 (1.60)	1.16 (0.28)	0.38
Hb before operating, mean (SD)	12.81 (1.78)	13.38 (1.56)	0.23
Stone Size (mm), Mean (SD)	26.48 (10.90)	30.44 (11)	0.20
Number of Stones, Mean (SD)	1.42 (0.50)	1.58 (0.50)	0.26
Side, N (%) Right Left	 **16 (61.5)** **10 (38.5)**	 **17 (68)** **8 (32)**	0.51
Coexisting disease, N (%) Yes No	 **4 (15.4)** **22 (84.6)**	 **7 (28)** **18 (72)**	0.44
Previous open or percutaneous surgery, N (%) Yes No	 **6 (23.1)** **20 (76.9)**	 **7 (28)** **18 (72)**	0.68
Previous ESWL, N (%) Yes No	 **11 (42.3)** **15 (57.7)**	 **13 (52)** **12 (48)**	0.48

endourologists with ultrasonography and poor echo of the Amplatz dilatator and Amplatz sheath [10,11,13,16]. Nowadays, PCNL is considered a generally safe management option with a low incidence of complications, and it is used as the method of choice for the treatment of renal stones [10,14,15].

PCNL was done in the prone, flank, semisupine, and csPCNL positions. Better control of the airway, a higher tolerance for patients (especially with cardiopulmonary diseases), easier ureteroscopy or TUL performance, better drainage and evacuation of stones by the Amplatz sheath, a possibility of changing regional anesthesia to general anesthesia, and less risk of colon injury are some advantages of csPCNL. So, we believe that due to these mentioned advantages, the preferred method is csPCNL [12].

A successfully reaching the kidney in PCNL is important and usually is performed via fluoroscopy, ultrasonography, or computed tomography guidance. It was reported 86.7 to 100% [8,10,16-18,20]. The success rate in achieving access in our study was 100% in both groups. Gaining access to the collecting system under ultrasonographic guidance was similar to fluoroscopically guided access.

Some studies showed that the stone-free rate was 66.6 to 94.7% [5,6,11,16,19,21]. The other studies showed that the primary stone-free rate and total stone-free rate were 45.7 and 69.6%, and 82.6 and 96.5%, respectively [14,20]. In our study, similar to the other studies, the stone-free rate was 88.46% in group A and 72% in group B, without any significant statistical difference (P = 0.16).

The mean operative time was reportedly 120 ± 68 min (range: 45 to 350 min), the exact time that ultrasound can be applied for guiding the percutaneous puncture [20]. In one study, the mean (range) operative time was 111 (70 to 180) min. PCNL by ultrasonographic guidance is feasible, but fluoroscopy must be in an operating room [21]. In another study, the mean

Table 2. The comparison of results after the procedure between the 2 groups.

	Ultrasonographic Group	Fluoroscopic Group	*P* Value
Total N	26	25	-
Stone-free rate (%)			
Stone free	20 (77)	18 (72)	
Residual stone < 5 mm	3 (11.5)	1 (4)	0.16
Residual stone > 5 mm	3 (11.5)	6 (24)	
Complications			
Yes	2 (7.7)	6 (24)	0.1
No	24 (92.3)	19 (76)	
Nephrostomy tube			
Yes	**2 (7.7)**	**1 (4)**	0.55
No	**24 (92.3)**	**24 (96)**	
Duration of access to target calyx (sec) Mean (SD)	14.36 (14.84)	14.78 (25.54)	0.08
Duration of entrance to target calyx (sec) Mean (SD)	84.87 (112.83)	41.22 (48.51)	0.07
Duration of 9 Fr dilator dilatation (sec) Mean (SD)	22.48 (26.7)	23.39 (37.7)	0.78
Duration of Amplatz dilator dilatation (sec) Mean (SD)	32.72 (82.45)	15.57 (15.94)	0.77
Duration of Amplatz sheath insertion (sec) Mean (SD)	17.46 (26.72)	12.41 (15.67)	0.28
Hb drop after the operation Mean (SD)	1.11 (1.35)	1.14 (1.52)	0.93
Operating time, min Mean (SD)	88.46 (39.49)	79.58 (32.6)	0.39
Hospital stay, hour Mean (SD)	69.70 (18.87)	61.79 (25.22)	0.22
Extravasation (%)	0	0	-
Pseudo aneurism (%)	0	0	-
Fever, N (%)	1(3.8)	2(8)	-
Colon injury (%)	0	0	-

operative time was reportedly 88.92 and 79.28 in sonographic and fluoroscopic groups, respectively [16]. Similar to other studies, in the current study, the mean operative time was 88.46 minutes in group A and 79.58 minutes in group B, without any significant statistical difference (*P* value = 0.39).

Hospital stay was 3.6 days (range: 2 to 8 days) in one study and the other reported it as 2.7 to 4.1 days [5,11,16,17,21]. In our study, hospital stay was 69.70 ± 18.87 and 61.79 ± 25.22 hours in groups A and B, respectively. There was no significant difference in mean hospital stay between group A and group B (P = 0.22).

In this study, no extravasation was found in either group. These results were common with other research [14,16]. In 4 to 9% of studies, postoperative fever was seen and reported [11,19]. Other studies stated that in 26.3 to 27.6% of cases suffering postoperative fever, antibiotic therapy was effective [14,21]. In this study, fever occurred in 3.8% of group A (1 patient) and 8% of group B (2 patients). All patients were cured with appropriate antipyretics and antibiotics. Septic shock was not a major complication in our patients.

In the other studies, the same as ours, no severe complications

such as colon damage, pneumothorax or hydrothorax, or any adjacent injuries occurred [17,20].
We had 6 patients (23.1%) in group A and 7 patients (28%) in group B with a history of renal surgery.

We showed that total ultrasound-guided PCNL is feasible and safe in patients with a history of renal surgery, similar to other published data [26]. In the current study, the mean BMI in group A was 28.17 ± 4.17 kg/m^2 and in group B it was 26.31 ± 5.88 kg/m^2, respectively. There was no significant statistical difference between the 2 groups (P value = 0.3); therefore, the BMI had no effect on the results of our study. We achieved access in all patients, and we believe that ultrasound-guided csPCNL in obese patients is more difficult but it is safe and feasible.

In the supine position, PCNL is feasible and safe. In the csPCNL method, handling of the patient is less than the standard prone method, and if general anesthesia is needed, the change is easier in this position, access to the urethra and the airway is easier, it is a more tolerable position for cardiopulmonary and corpulent patients, and allows for prolonged anesthesia. An easier access to the upper calyces, facilitation of stone fragment evacuation, distance of the fluoroscopy tube from the surgical field, and the surgeon's sitting position are the other benefits of csPCNL. And against the semi-supine position, in csPCNL, stone density overlap on the vertebrae density rarely occurs [12,22-25].

CONCLUSION

Nowadays, endourologists must be experts in the ultrasonographic-guided PCNL. This randomized study showed that totally ultrasonic csPCNL had outcomes similar to fluoroscopic csPCNL. In selected cases endourologists can use sonography rather than fluoroscopy to avoid radiation exposure. Till now the preferable imaging method for PCNL was fluoroscopy, but we have shown that the surgeon can use ultrasonography as an imaging method for PCNL rather than fluoroscopy, especially when fluoroscopy is not available or does not work during the procedure, or when fluoroscopy is dangerous (for example, in pregnant women).

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