Ultrasonographic Guidance versus Fluoroscopic Guidance for Renal Access in Percutaneous Nephrolithotomy (PCNL): A Comparative Study

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ABSTRACT:

BACKGROUND:

Guiding access of percutaneous nephrolithotomy is essential in acquiring better surgical outcomes and preventing serious postoperative complications.

OBJECTIVE:

To assess the safety and efficacy of ultrasonographic guidance vs. fluoroscopic guidance for renal access in percutaneous nephrolithotomy (PCNL) focusing on the success rate of renal access, stone-free rate, operating time, duration of hospitalization, and major complications after the procedure.

PATIENTS AND METHODS:

A Prospective comparative study conducted in Shahid-Ghazi Hariri Surgical Specialties Hospital and Nursing Home Hospital in Baghdad Medical city. The duration of study was through the period from 1st of October, 201٦ to 1st of October, 2018 on convenient sample of 70 patients with renal stones underwent percutaneous nephrolithotomy. The selected patients were categorized into two groups were undergoing percutaneous nephrolithotomy ;(35 patients guided with ultrasound) and (35 patients guided with fluoroscopy), they compared mainly by stone free rate, and secondarily by access time, operative time and post operative complication. S. T. O. N. E. score use to determine the charecter of the stone.

RESULTS:

For patients with low S.T.O.N.E score no difference was found regarding stone free rate between ultrasonographic guidance and fluoroscopic guidance percutaneous nephrolithotomy (p value 0.1). For patients with high S.T.O.N.E score fluoroscopic guidance percutaneous nephrolithotomy achieve higher stone free rate (p value 0.04) . No significant difference was found between the two groups regarding hemoglobin decline, blood transfusion, operative time and hospitalization.

CONCLUSION:

Percutaneous nephrolithotomy under ultrasound guide is safe and effective as fluoroscopic guidance for patients with low S. T. O. N. E. score. Fluoroscopic guidance is more effective for patients with high S. T. O. N. E score.

KEYWORDS: Percutaneous nephrolithotomy, Ultrasonography guidance, Fluoroscopy guidance

INTRODUCTION:

Percutaneous nephrolithotomy (PCNL), an important treatment technique for the management of large, complex renal stone, it is widely accepted as a safe and cost-effective intervention because of its high success rate and low morbidity. A PCNL can be performed using several positions including the prone, flank, semi flank, supine, and its modified position [(1)]. The usual indications for PCNL are stones larger than 20 mm, staghorn, partial staghorn calculi.

The contraindications for PCNL include bleeding disorders, uncontrolled urinary tract infections [(2)].

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The choice of puncture guidance either fluoroscopic or ultrasound guided is dictated by the calyceal anatomy and the surgeon expertise in a particular technique. [(3)].Advantages of ultrasound guidance over fluoroscopy guidance include reduction of radiation exposure, financial cost, safety in pregnancy and can be used in patient with pelvic kidney ,decrease incidence of visceral (colon, liver ,spleen) injury, real-time imaging of the collecting system and renal parenchyma, detection of radiolucent stones, improved visualization of adjacent organ, clearer delineation of the anterior and posterior calices, and the potential to avoid vascular injury with Doppler flow imaging [(4).]

The high quality of current C-arm fluoroscopic devices and the familiarity among urologists of fluoroscopic imaging has led to its preferred use in percutaneous renal access. Surgeons prefer fluoroscopy for guidance due to clear visualization of the needle and guide wire. For percutaneous renal surgery such as PCNL or endopyelotomy, fluoroscopic monitoring is very important for the entire procedure during renal access, guide wire manipulation, tract dilatation, residual stone evaluation [5].

AIM OF STUDY:

To assess the safety and efficacy of ultrasonographic guidance vs. fluoroscopic guidance for renal access in percutaneous nephrolithotomy (PCNL) focusing on the success rate of renal access, stone-free rate, operating time, duration of hospitalization, and major complications after the procedure.

PATIENTS AND METHODS:

Design, settings & sampling

A prospective comparative study conducted at Al- Shahid-Ghazi Hariri Surgical Specialties Hospital and Nursing Home Hospital at Baghdad Medical city.

The duration of study was through the period from 1st October, 2016 to 1st of october, 2018. Inclusion criteria were adults (age >18 years) with normal renal function, absence of congenital renal anomaly, and renal stones of more than 2 cm in size. The exclusion criteria were congenital anomalies of renal system, patients who underwent diversion and transplant, patient with active urinary tract infection. Thirty five patients were selected for PCNL under ultrasonographic guidance and thirty five patients were selected for PCNL under fluoroscopic guidance. The two group were compared mainly by the stone free rate (SFR) and blood loss. The other comparative points includes access time, operative time and post-operative complication .S.T.O.N.E score (S{size}, T{tract length}, O{obstruction}, N{number of calyx with the stone}, E{essence}[6] were used to determine the stone character.

Table 1: S.T.O.N.E score[6]

Variable	1	2	3	4
Stone size (mm^2)	0-399	400-799	800-1599	≥1600
Tract length (mm) (mm)obstruction	≤100(mm)	>100(mm)	-	-
Obstruction(hydronephrosis)	Non/mild	Moderate/severe	-	-
Number of involved calices	1-2	3	Stghorn	-
Essence (HU)	≤950(HU)	>950(HU)	-	-

The questionnaire included the following:-

Demographic characteristics of patients: Age, gender, BMI .Laterality of stones: Right or Left. Characteristics of stones: stone Type, stone burden and S.T.O.N.E score. Preoperative characteristics of patients: Creatinene level, hemoglobin level, previous open surgery and grade of hydronephrosis. Intraoperative characteristics: Access time, operative time, punctures site and tract number.

Postoperative characteristics of patients: Creatinene level, hemoglobin level, hospital stay, stone free rate, nephrostomy time, fever, blood transfusion, hydrothorax and colon perforation.

The information was taken mostly from the patients, Agreement was taken from Shahid-Ghazi Hariri Surgical Specialties Hospital administration. A written informed consent was taken from the patient.

Preoperative preparation:

A detailed preoperative workup, including a complete medical history and examination, CBC, serum creatinine, urine culture, coagulation profile, CT scan, U/S was carried out at Al Shahid-Ghazi Hariri Surgical Specialties Hospital. The pre-operative stone assessment was performed by using the S.T.O.N.E. score.(see table)· The score categorized into 3 grades (5-6,7-8,9-13). The selected patients were categorized into two groups undergoing PCNL (35 under ultrasound guide and (35 patients under fluroscopy guide.).

PCNL under fluoroscopic guidance:

under GA in lithotomy position, cystoscope was used to insert 5Fr uretric stent into the kidney under FSG, the stent was connect to a syringe and fixed to the drape with hemostat. The patient was turned to the prone position; retrograde pyelogram was done by injecting contrast media (iohexol) via the ureteric stent.. Once the appropriate calyx for access selected the puncture was done using (eye of the needle technique) bulls eye technique using 18-gauge needle (Balton), the inner stylet was removed and successful penetration into the collecting system was indicated by the return of urine, next J tip 0.035 inch. hydrophilic tipped guide wire introduced through the needle, once the wire is in the collecting system blade number (11) used to make 1.5cm incision in the skin, next the needle was removed and Alken cannula was inserted over a guide wire, followed by the guide rode all under FSG, then Amplatz dilator used followed by the Amplatz sheath, 26 Fr nephroscope was introduce and stone broken by pneumatic lithotripsy and the fragments were removed by stone forceps. At the end of the procedure fluoroscope was used to look for any residual stone and 5Fr jj stent was inserted over a guide wire under FSG. Then 14 Fr Foleys catheter was used as nephrostomy tube.

PCNL under ultrasonographic guidance:

Under GA, at first in a lithotomy position, cystoscope was used to insert 5Fr JJ stent, then Foley catheter was used for continuous normal saline infusion into the bladder for dilatation of the collecting system, and then in prone position ultrasound used to check the renal vascularity by Doppler, visualize the stone, and to determine the desired calyx for entry. Then 18-gauge needle was inserted under US guidance into the desired calyx, successful placement was confirmed by the flow of urine through the needle after removing the stylet. A 0.035 Inch. Hydrophilic flexible tip guide wire is inserted through the needle into the collecting system ,Then guide rode was inserted and dilatation was done by sequential metal dilator (Alken dilators) up to 26Fr, then the Amplatz sheath was used followed by the nephroscope and stone was destructed by pneumatic lithotripsy and fragments were removed by stone forceps. At the end a14 Fr Foleys catheter was inserted as nephrostomy tube.

Post operative evaluation and Follow up

The patients were followed postoperatively by KUB and US to check the presence or the absence of residual stone and the site of jj stent, CBC, RFT, also done, the nephrestomy tube was removed when the urine became clear. The patients were discharged home with oral antibiotics and analgesia .Follow up U/S and KUB were also done in (1-3) month, JJ stent was removed in outpatient setting by flexible cystoscope.

Statistical analysis

The data of patients were analyzed by application of Microsoft excel program and Statistical Package for Social Sciences (SPSS) version 23. Outcomes of analysis were arranged in scales variables (means & standard deviation) and in categorical variables. Chi square test was used for comparison between categorical data (Fishers exact test applied when expected variable was less than 20% of total). The level of significance (p value) was set as ≤ 0.05.

RESULTS:

A total of 70 patients surgically operated with PCNL were included in this study; thirty five patients were guided with U/S and thirty five patients were guided with FS. No significant difference was observed between patients guided with U/S and those guided with FS regarding their age categories (p=0.2). No significant difference was observed between patients guided with U/S and those guided with FS regarding gender (p=0.03). All these findings were shown in table (2)

Table 2: Distribution of patients' demographic characteristics according to PCNL guidance

Variable	U/S		FS		P
	No.	%	No.	%	
Age					
<30 years	2	5.7	7	20.0	0.2* NS
30-39 years	5	14.3	6	17.1	
40-49 years	6	17.1	7	20.0	
50-59 years	13	37.1	11	31.4	
≥60 years	9	25.7	4	11.4	
Gender					
Male	18	51	20	57.1	**0.6**** NS
Female	17	49	15	42.9	

*Fishers exact test, ** Chi-square test, NS=Not significant,

Intraoperatively, no significant difference was observed between patients guided with U/S and those guided with FS regarding access time (p=0.4) and operative time (p=0.4). There was a highly significant association between upper pole puncture site and patients guided with FS (p=0.01). Tract number was significantly higher for patients guided with FS (p=0.02). All these findings were shown in (table 3)

Table 3: Distribution of patients' intraoperative characteristics according to PCNL guidance.

Variable	U/S		FS		P
	No.	%	No.	%	
Access time					
<15 minutes	16	45.7	19	54.3	0.4* NS
≥15 minutes	19	54.3	16	45.7	
Operative time					
≤1 hour	26	74.3	22	62.8	0.4* NS
>1 hour	9	25.7	13	37.2	
Puncture site					
Lower pole	35	100	29	82.9	**0.01**** S
Upper pole	0	-	6	17.1	
Tract number					
1	35	100	30	85.7	**0.02**** S
2	0	-	5	14.3	

*Chi square test, Fishers exact test, S= Significant, NS=Not significant.

Postoperatively, no significant difference was observed between patients guided with U/S and those guided with FS regarding postoperative Hb (p=0.5), postoperative creatinine (p=0.9), hospital stay (p=0.07), stone free rate (p=0.1) and nephrostomy time (p=0.6). All these findings were shown in (table 4A)

Table 4A: Distribution of patients' postoperative characteristics according to PCNL guidance.

Variable	U/S		FS		P
	No.	%	No.	%	
Postoperative Hb					0.5* NS
Mean ±SD	10.9±1.1		10.7±1.4		
Postoperative creatinine					0.9* NS
Mean ±SD	1.18±0.5		1.17±0.3		
Hospital stay					
≤1 day	3	8.6	0	-	0.07** NS
>1 day	32	91.4	35	100.0	
Stone free rate					
Yes	22	62.9	28	80.0	0.1* NS
No	13	37.1	7	20.0	
Nephrostomy time					
≤1 day	13	37.1	10	28.6	0.6* NS
>1 day	22	62.9	25	71.4	

* Chi square test, **Fishers exact test, S=Significant, NS=Not significant.

No significant difference was observed between patients guided with U/S and those guided with FS regarding postoperative fever (p=0.3) and postoperative blood transfusion (p=0.3).. All these findings were shown in (table 4B)

Table 4B: Distribution of patients' postoperative characteristics according to PCNL guidance.

Variable	U/S		FS		P
	No.	%	No.	%	
Postoperative fever					
Yes	13	37.1	9	25.7	0.3* NS
No	22	62.9	26	74.3	
Postoperative blood transfusion					
Yes	0	-	1	2.9	0.3** NS
No	35	100	34	97.1	

* Chi square test, **Fishers exact test, S=Significant, NS=Not significant.

All the patients with S.T.O.N.E score of 5-6 had SFR in both group. For patients with stone score 7-8, there was no significant difference between patients guided with U/S and patients guided with FS regarding stone free rate (p=0.1).

For patients with stone score 9-13, FS guide PCNL achieve higher SFR than US guide PCNL (p=0.04). All these findings were shown in and(figure5)

Table 5: Distribution of patients' postoperative SFR for each stone score according to PCNL guidance.

Variable	U/S		FS		P
	No.	%	No.	%	
Stone free rate for score 5-6					
Yes	5	100	2	100.0	-
No	0	-	0	-	
Stone free for score 7-8					
Yes	16	69.6	18	90.0	0.1* NS
No	7	30.4	2	10.0	
Stone free for score 9-13					
Yes	1	14.3	8	61.5	**0.04*** S
No	6	85.7	5	38.5	

*Fishers exact test, S=Significant, NS=Not significant.

DISCUSSION:

The present study revealed that postoperative SFR for the patients with S.T.O.N.E scores 9-13 was significantly higher among patients guided by fluoroscopy as compared to patients guided by ultrasonography (p=0.04). This finding is similar to results of Zhu et al [7] study in China which reported that fluoroscopic guidance is more effective than ultrasonography guidance in stone scores of > 7. Although the US is regarded as useful alternative for PCNL guidance by many authors [8, 9]. The ability in visualization of needle, the guide-wires, fascial dilators, in addition to the collecting system and stones under real-time images make the FS the preferred image modality for PCNL [10]. The main limitations reported for fluoroscopy are radiation exposure and limitation related to examining the surrounding soft tissues [11].Inconsistent with our findings, Qiu et al [12] study in China found that US guidance of PCNL is more effective and safer than fluoroscopy with additional advantages of no radiation exposure, shorter surgical time and higher stone free rates. In present study, there was a significant difference in BMI between patients guided with U/S and those guided with FS (p=0.003), 45.7% of patients guided with U/S were obese. This finding coincides with results of Usawachintachit et al [13] on 135 patients with PCNL (93 patients with US guidance and 42 patients with fluoroscopy guidance) which found that ultrasonographic guidance for PCNL in obese patients is more difficult because of challenge in obtaining successful renal access due to poor visualization of renal and perirenal anatomy as a result of absorption of US energy by the thick subcutaneous ,paranephric and perinephric adipose tissue, but with its use the obese patients experience greater reduction in radiation exposure. Fulelr et al [14] study in Canada found that PCNL may be done safely in obese patients, although with a longer operative time, lower stone-free rate and a higher re-intervention rate. Current study showed no difference between US guided patients and fluoroscopy guided patients regarding the degree of hydronephrosis. Kalogeropoulou et al. [15] and Gamal et al. [16] reported some difficulty in ultrasound-guided PCNL with a non distended collecting system. For the patient with mild hydronephrosis we used continuous normal saline bladder infusion to assessed in collecting system dilatation retrogradely through the JJ stent, Li et al. [17] presented a series of successful ultrasound puncture in 132 cases after artificial retrograde dilatation of the collecting system. Intraoperatively, this study showed no significant differences between PCNL guided with US and PCNL guided with Fluoroscopy regarding access time and operative time.

Zeng et al [18] study in China showed that operative time was not significantly different between US and fluoroscopy guidance of PCNL but it showed that fluoroscopy access time was significantly longer. The puncture site for upper pole in the present study was significantly used in fluoroscopic guidance PCNL (p=0.01). This finding is in agreement with results of Basiri et al [19] study which stated that for upper pole puncture, U/S guidance during PCNL is less successful. But Foo Cheong et al [20] study in Singapore found that when upper pole access was needed, U/S guide were favored. They stated that despite more upper pole punctures performed using US, there was no lung or pleural injury reported compared to one in FS PCNL. This may be due to the improved visibility of renal calyces and surrounding anatomy by ultrasound. Postoperatively, no significant difference was observed between patients guided with US and those guided with fluoroscopy regarding postoperative Hb level, postoperative creatinine level, and hospital stay. These findings are consistent with results of Iordachi et al. [21] study in France which revealed no statistical significant difference between US and fluoroscopy guidance of PCNL in postoperative hospital stay, creatinine level, and Hb level. No significant difference was observed between patients guided with US and those guided with fluoroscopy regarding postoperative fever and blood transfusion. These findings are in agreement with results of Sarica study[22] in Turkey which reported no significant differences in postoperative complications of PCNL guided with US and PCNL guided with fluoroscopy. But Wang K et al. [23] study in china in their meta analysis stated that ultrasonographic guidance had many advantages, such as a shorter access time, reduced intraoperative blood loss, a lower rate of operative complications, a lower rate of blood transfusion, and a higher stone-free rate. In current study and for both study groups, there was a decrease in mean Hb level after PCNL. Said et al [24] study in Egypt stated that bleeding and Hb decline after PCNL surgery is common.

CONCLUSION:

Although there was no significant difference in the ultrasonic guide PCNL and fluoroscopy guide PCNL regarding blood loss,hospital stay and post-operative complications .ultrasound guide PCNL is safe and effective as fluoroscopy guide PCNL in achieving stone free rate in low stone score.

RECOMMENDATIONS:

Encouraging the surgeons to adopt U/S guidance for PCNL as alternative to FS guidance especially for pregnant women, children and in well selected patient with simple stone character to prevent radiation risks and post op complication.

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