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Study The Efficacy of Ultrasound-Guided Access during Percutaneous Nephrolithotomy

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ABSTRACT
Background: Percutaneous nephrolithotomy (PCNL) is a minimally invasive endourologic procedure for treatment of large renal stones. Our aim in this study is to assess role of using ultrasound guided renal access during PCNL in minimizing exposure of both patients and medical personnel to ionizing. **Methods:** This Prospective, non-randomized clinical trial was conducted on 40 patients with unilateral renal stones with stone burden 20 to 30 mm with moderate to marked backpressure and planned to undergo PCNL admitted to Urology Department Faculty of Medicine Tanta University. All patients were subjected to history talking, clinical examination, routine laboratory and radiological investigations including pelvic-abdominal ultrasound, KUB and non-contrast pelvi-abdominal CT. **Results:** The balloon dilation group was divided into two subgroups based on whether the dilation was successful on the first attempt. The success rate on the first attempt was 90%. Success rate was significantly higher with balloon than metal dilators and the latter was higher than Teflon dilators. Mean total operative time was statistically significant higher in failed than successful group. (P value=0.021). Fluoroscopic screening time was significantly higher in the failed group than successful group (P value=0.037). **Conclusions:** US PCNL can be used safely and effectively to treat patients with unilateral renal stones with stone burden 20 to 30 mm providing the advantages of less radiation exposure, no adjacent organ injury, and high success (90%) and low complication rates.

Keywords: Ultrasound-Guided, Percutaneous Nephrolithotomy, Renal stones

1. Introduction

Percutaneous nephrolithotomy (PCNL) is a minimally invasive endourologic procedure for treatment of large renal stones introduced by Fernström and Johansson in 1976 (Patel and Nakada 2015).

Currently, PCNL is the treatment of choice for kidney stones greater than 2 cm according to both EAU &AUA guidelines. However, PCNL has potentially higher rates of mild to moderate complications. The idea of using ultrasound-guided access in PCNL may allow better imaging of the kidney, stones and adjacent organs: pleura, spleen, liver, colon beside decrease radiation hazards (Grivas *et al.,* 2020).

PCNL stone free rate is 80-90% for renal calculi and 86% for proximal ureteric calculi. The success rate of PCNL is independent of stone burden, whereas the success rate of ESWL and ureteroscopy decline as stone burden increases. Obese patients have a lower stone free rate with PCNL (Wieder, 2014).

The percutaneous access is usually done under fluoroscopic guidance technique, since it was described by Wickham in 1981 (Iordache *et al.,* 2018). Although, fluoroscopy is very familial to urologists, it is associated with exposure to ionizing radiation, which has been calculated at 8.66 mSv per procedure, with the puncture representing the highest peak of radiation dose and is cumulative for both the patient and the personnel in the surgery room. Long-term cumulative effect includes the risk for cataract, hematopoietic, central nervous system and thyroid malignant tumors (Usawachintachit et

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al., 2016; Wenzl, 2005). By using ultrasound (US) for percutaneous renal access, these risks may decrease considerably (Linet *et al.,* 2005).

Other advantages are: (a) obtaining real time images of the kidney, stones and adjacent organs: pleura, spleen, liver, colon, (b) safer access in anatomical malformations like pelvic and horseshoe kidneys, (c) a clear delineation of anterior or posterior calyces (Ng *et al.,* 2017), (d) using the doppler, it is possible to avoid segmental arteries of the kidney and reduce possible bleeding (Chu *et al.,* 2016). (e) low-cost technique (f) detection of radiolucent stones.

This technique is often the preferred method for percutaneous nephrostomy tube placement among interventional radiologists and has been safely applied in pregnant and pediatric patients for whom radiation exposure is a significant concern (Lojanapiwat, 2013).

As such, we thought to run this study to find out the real impact of using ultrasound-guided access during PCNL on radiation exposure, feasibility of stone access. We will also compare our result to a historical group of patients who underwent standard PCNL using fluroscopy in full operation to document our end points results.

The aim of this study is to assess role of using ultrasound-guided renal access during PCNL in minimizing exposure of both patients and medical personnel to ionizing radiation (this is our primary end point). Our second end point will be the calculation of the operative time and stone access feasibility among patients who will be included.

2. Patients and Methods

In this study, 47 patients were assessed for eligibility, 7 patients were missed during follow up. The remaining 40 patients were classified into two groups: successful group (36 patients) and failed group (4 patients). All of them were followed up and statistically analyzed.

Study design

Prospective, non-randomized clinical trial.

Study location and patients' recruitments

After getting institutional review board approval (IRB number: 35041/11/21), the study had been conducted in a single tertiary centre at Urology department, Faculty of Medicine, Tanta University between October 2021 and October 2022. Eligible patients were asked to participate in this study. Patients had been diagnosed at the outpatient clinic and evaluated for their eligibility to the study inclusion criteria. Legible patients had been asked to participate in the study and to sign the informed consent form according to declaration of Helsinki (PP*,* 1964).

Sample technique

Patients with unilateral renal stone 20-30 mm in its maximum diameter with moderate hydronephrosis in the preoperative radiological examination or obvious during intraoperative retrograde study.

Inclusion criteria

1. Patient 18 years or older.
2. Normal serum creatinine (up to 1.4 mg/dl).
3. American Society of Anesthesiologists score 1- 2.
4. Unilateral renal stone 20-30 mm in its maximum diameter with moderate or marked hydronephrosis.

Exclusion criteria

1. Refusal of written consent.
2. Stag-horn stone.
3. Stone without significant hydronephrosis.
4. Untreated urinary tract infection (UTI).
5. Pregnancy.
6. Bleeding disorders.

7. Spine deformities.
8. Children under 18 years.
9. congenital anomalies including horse-shoe kidney, malrotated kidneys and pelvic kidneys.

Outcome measures:
The primary end point

The primary end point is to assess the rules of using ultrasound-guided renal access during PCNL in minimizing exposure of both patients and medical personnel to ionizing radiation.

The secondary end points

The secondary end points are to assess hemoglobin drop, length of hospital stay, operative time, stone access feasibility and evaluate one-session stone free rate (SFR) by NCCT within 48-72 hr after removal of nephrostomy tube to avoid any hidden significant fragments and assess early post-operative complications by Clavien-Dindo grades among patients who will be included (Crichton, 2001).

2.1. Methods
Clinical evaluation
History taking

Complete history taking was obtained from each patient and included:

- Personal data.
- History of any medical illness e.g.: Hypertension, diabetes mellitus, cardiac, renal or hepatic troubles.
- History of previous renal surgery or ESWL.
- History of any other previous surgeries.

Clinical examination
Laboratory

- CBC.
- Prothrombin time and activity.
- Kidney functions.
- Liver functions.
- Urine culture and sensitivity.

Radiology

All patients were preoperatively subjected to:

Pelvi-abdominal ultrasound

It was not routinely requested to our patients; however, some patients had it before attending our consultation.

Plain-film radiography

Plain-film imaging of the kidneys, ureters and bladder (KUB) was routinely requested as an initial evaluation and in follow-up to document the size and location of radiopaque urinary stones.

Non-contrast Pelvi-abdominal CT

Evaluation of the renal stone included the stone size, location, number, and stone density (HU). The stone size is the largest diameter for a single stone and the summation of the largest diameters for multiple stones. The stone volume was estimated using an ellipsoid formula, as recommended by EAU, (stone volume = $\pi*l*w*d$) where length (l), width (w) and depth (d) for stone diameter measurement in the three axes (Crichton *et al.,* 2021).

Outcome measures and data collection
Intra-operative evaluation

Method of stone disintegration, any intraoperative complication as significant blood loss, bleeding necessitating blood transfusion or aborting the procedure, perforation, anesthetic complications, operative time (from the retrograde ureteric catheterization to the nephrostomy tube placement).

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing paired Student's t- test. Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test. A two tailed P value < 0.05 was considered statistically significant.

3. Results

According to demographic data of the studied patients, the patients' age ranged from 31 – 71 years old with mean of 50.88 ± 11.78, there were 25 (62.5%) males and 15 (37.5%) females with a mean age of 50.88 ± 11.78 years and mean BMI 25.18 ± 4.25 kg/m^2 and American Society of Anesthesiologists (ASA) physical status classification ranged between class I to class II as shown in (Table 1).

Table 1: Demographic data of the studied patients

Age (years)	**Mean ± SD**	50.88 ± 11.78
	Range	31 – 71
Gender	**Male**	25 (62.5%)
	Female	15 (37.5%)
BMI (kg/m2)	**Mean ± SD**	25.18 ± 4.25
	Range	18 – 32
ASA	**ASA I**	27 (67.5%)
	ASA II	13 (32.5%)

BMI: body mass index, ASA: American Society of Anesthesiologists

Regarding to preoperative characters of the studied patients, stone size ranged from 20 – 30 mm with a mean value (± SD) of 25.1 (± 3.09) mm. Stone was located at right side in 29 (72.5%) patients and at left side in 11 (27.5%) patients. Stone density (HU) ranged from 400 – 1400 with a mean value (± SD) of 962.5 ± 251.96. According to degree of hydronephrosis, there were 29 (72.5%) patients with moderate hydronephrosis and 11 (27.5%) patients with severe hydronephrosis. The pre-operative serum creatinine ranged from 0.6 to 1.4 mg/dL with a mean value (± SD) of 1.11 (±0.34). Pre-operative GFR ranged from 60 – 180 ml/min/1.73m^2 with a mean value (± SD) of 120.1 ± 39.99 ml/min/1.73m^2. Pre-operative Hb ranged from11.5 - 14.8 mg/dL with a mean value (± SD) of 12.84 ± 0.99 mg/dL.

As regards to history of ipsilateral kidney surgery, there were 25 (62.5%) with no history of ipsilateral kidney surgery, 5 (12.5%) patients underwent ureteroscopy surgery, 7 (17.5%) patients underwent PCNL surgery, 2 (5%) patients underwent open pyelolithotomy surgery and 1(2.5%) patient underwent open nephrolithotomy surgery as shown in (Table 2)

Regarding number of punctures, there were 24 (60%) patients who underwent 1st trial, 8 (20%) patients underwent 2nd trial and 4 (10%) patients underwent 3rd trial while 4 (10%) patients had failed trial of puncture. The puncture time ranged from 90 to 159.2 Sec with a mean value (± SD) of 101.57 (± 13.73) Sec. Puncture location was upper calyx in 1(2.5%) patient, middle calyx in 9 (22.5%) patients and lower calyx in 30 (75%) patients. The tract number of the studied patients ranged from 1 to 2 with a mean value (± SD) of (1.17 ± 0.38). The dilation time ranged from 4 - 18.9 min with a mean value (± SD) of 11.1 ± 4.22 min. Dilation methods were balloon dilators in 33 (82.5%) patients, metal dilators in 5 (12.5%) patients and Teflon dilators in 2 (5%) patients. The fragmentation time ranged from 14.5 to 92.2 min with a mean value (± SD) of 41.69 (±23.43) min. Thirty-seven (92.5%) patients underwent pneumatic lithotripters and 3 (7.5%) patients underwent both (pneumatic and laser). Thirty-four (85%) patients underwent DJ plus nephrostomy while 6 (15%) underwent open tip plus nephrostomy as shown in (Table 3)

Table 2: Preoperative characters of the studied patients

Stone characters	**Stone size (mm)**	25.1 ± 3.09 20 – 30
	Stone side	**Right** 29 (72.5%) **Left** 11 (27.5%)
	Stone density (HU)	962.5 ± 251.96 400 – 1400
Degree of hydronephrosis	**Moderate** **Severe**	29 (72.5%) 11 (27.5%)
Serum creatinine (mg/dL)	**Mean ± SD** **Range**	1.11 ± 0.34 0.6 - 1.4
GFR (ml/min/1.73m2)	**Mean ± SD** **Range**	120.1 ± 39.99 60 – 180
Hb (mg/dL)	**Mean ± SD** **Range**	12.84 ± 0.99 11.5 - 14.8
History of ipsilateral kidney surgery	**No**	25 (62.5%)
	Ureteroscopy	5 (12.5%)
	PCNL	7 (17.5%)
	Open pyelolithotomy	2 (5%)
	Open nephrolithotomy	1 (2.5%)

HU: Hounsfield Units

Table 3: Intraoperative characters of the studied patients

Number of punctures	**From 1st trial**	24 (60%)
	From 2nd trial	8 (20%)
	From 3rd trial	4 (10%)
	Failed	4 (10%)
Puncture time (Sec)	**Mean ± SD**	101.57 ± 13.73
	Range	90 - 159.2
Puncture location	**Upper calyx**	1 (2.5%)
	Middle calyx	9 (22.5%)
	Lower calyx	30 (75%)
Tract number	**Mean ± SD**	1.17 ± 0.38
	Range	1 – 2
Dilation time (minutes)	**Mean ± SD**	11.1 ± 4.22
	Range	4 - 18.9
Dilation methods	**Balloon dilators**	33 (82.5%)
	Metal dilators	5 (12.5%)
	Teflon dilators	2(5%)
Fragmentation time (minutes)	**Mean ± SD**	41.69 ± 23.43
	Range	14.5 - 92.2
Lithotripters	**Pneumatic**	37 (92.5%)
	Laser	0 (0%)
	Both	3 (7.5%)
Stents	**DJ plus nephrostomy**	34 (85%)
	Open tip plus nephrostomy	6 (15%)

Regarding intraoperative measurements of the studied patients: The 40 patients were divided into two groups: successful group (36 patients) and failed group (4 patients) according to the success rate that was 90%.

Twenty- three patients (63. 89%) of these successful group and 4 (100%) patients of these failed group demonstrated moderate hydronephrosis on intraoperative imaging while all patients with severe hydronephrosis [13 (36.11%)] were successful. The failure rate was lower in severe degree of hydronephrosis in comparison with moderate hydronephrosis.

Puncture time varied from 101.7 to 105 seconds with a mean of 97.53 ± 4.71 seconds and varied from 122.7 - 159.2 with a mean of 137.93 ±15.32 seconds in successful and failed groups respectively. Puncture location was upper calyx in 1 (25%) patient in failed group, middle calyx in 7 (19.44%) patients in successful group and 2 (50%) patients in failed group and lower calyx in 29 (80.56%) patients in successful group and 1 (25%) patient in failed group. Lower calyx success rate was significantly higher in successful group than failed group (P value =0.003). The tract number ranged from 1 to 2 with a mean value (± SD) of 1.17 (±0.38) in the successful group while ranged from 3 to 4 with a mean value (± SD) of 3.25 ± 0.5 in failed group. Mean dilation time were 11.1 ± 4.22 and 15.73 ± 3.35 minutes in successful and failed groups, respectively with a significant difference between them (P value=0.041). The balloon dilation group was divided into two subgroups based on whether the dilation was successful on the first attempt. The success rate on the first attempt was 90%. Success rate was significantly higher with balloon than metal dilators and the latter was higher than Teflon dilators. Mean fragmentation time were 40.12 ± 23.4 and 55.83 ± 21.33 minutes in successful and failed groups, respectively. While the middle and lower calices were selected for puncture almost equal in in the failed group while lower in middle calyx in successful group. Mean total operative time of renal access obtained at the beginning of the procedure group was with a mean of 73.11 ± 23.83 and 102.5 ± 12.58 minutes in successful and failed groups respectively with statistically significantly higher in failed than successful group. (P value=0.021). The number of patients were 14 (2.7%) and 1(25%) in successful group and failed group respectively with no significant differences between both groups.

Mean total operative time of renal access obtained before the procedure group including cases with emphysematous pyelonephritis was with a mean of 51.69 ± 16.35 and 95 ± 8.12 minutes in successful and failed groups respectively with statistically significantly higher in failed than successful group. (P value < 0.001). The number of patients were 22(61.1%) and 3(75%) in successful group and failed group respectively with no significant differences between both groups

Fluoroscopic imaging was used for confirmation of nephrostomy tube positioning at the end of the procedure in all cases. For these procedures, mean fluoroscopic screening time was 20.84 ± 9.09 (range 5.2 to 32.7seconds) and 30.8 ± 2.11 seconds (range 28.3 to 33 seconds) in successful and failed groups respectively, fluoroscopic screening time was significantly longer in the failed group than successful group (P value=0.037). Mean radiation exposure dose was 0.26 ± 0.2 and 1.75 ± 0.5 mrem (range 0 to 0.5 and 1 to 2 mrem respectively), radiation exposure dose was significantly higher in the failed group than successful group (P value <0.001) as shown in (Table 4)

Regarding postoperative outcomes, postoperative Hb decreased as Hb dropped by 0.3 ± 0.12 gm/dL. However, about 2 (12.5%) needed blood transfusion. Hospital stay that ranged from 2 – 5 days with mean ± SD of 3.3 ± 1.16. Most of the patients [31 (77.5%)] were confirmed stone-free by ultrasound (immediate stone free rate) while 5(12.5%) patients were with insignificant residual stone ≤4mm and 4 (10%) patients were with significant residual stone >6mm of which two (5%) patients received one session of ESWL , one (2.5%) patient underwent 2nd look PCNL and the last one (2.5%) patient passed stone spontaneously 4 weeks postoperatively. therefore, final stone free rate was 92.5% as shown in (Table 5)

As regards to postoperative complications, there were nine (22.5%) patients showed postoperative fever, 6(15%) patients showed postoperative persistent loin pain, 2 (5%) needed blood transfusion due to Hb loss, 5 (12.5%) patients showed postoperative perforation of pelvicalyceal system and 1(2.5%) patient showed postoperative PUJ injury/ disruption as shown in (Table 6).

Table 4: Intraoperative measurements of the studied patients

			Successful (n=36)	Failed (n=4)	P value
Degree of hydronephrosis		**Moderate**	23 (63.89%)	4 (100%)	0.144
		Severe	13 (36.11%)	0 (0%)	
Puncture time (Sec)		**Mean ± SD**	97.53 ± 4.71	137.93 ±15.32	0.566
		Range	90 – 105	122.7 - 159.2	
Puncture location		**Upper calyx**	0 (0%)	1 (25%)	0.003*
		Middle calyx	7 (19.44%)	2 (50%)	
		Lower calyx	29 (80.56%)	1 (25%)	
Tract number		**Mean ± SD**	1.17 ± 0.38	3.25 ± 0.5	<0.001*
		Range	1 - 2	3 – 4	
Dilation time (minutes)		**Mean ± SD**	11.1 ± 4.22	15.73 ± 3.35	0.041*
		Range	4 - 18.9	13.1 - 20.2	
Dilation methods		**Balloon dilators**	31 (86.11%)	2 (50%)	0.096
		Metal dilators	4 (11.11%)	1 (25%)	
		Teflon dilators	1 (2.78%)	1 (25%)	
Fragmentation time (minutes)		**Mean ± SD**	40.12 ± 23.4	55.83 ± 21.33	0.208
		Range	14.5 - 92.2	36 - 85.8	
Operative time (min)	**Renal access obtained at the beginning of the procedure group**	**Mean ± SD**	73.11 ± 23.83	102.5 ± 12.58	0.021*
		Range	33 - 112	90 - 120	
		No (%)	14 (2.7%)	1(25%)	0.586
	Renal access obtained before the procedure group including cases of EPN	**Mean ± SD**	51.69 ± 16.35	95 ± 8.12	<0.001*
		Range	28 - 80	87 - 105	
		No (%)	22(61.1%)	3(75%)	0.586
Radiation dose (mrem)		**Mean ± SD**	0.26 ± 0.2	1.75 ± 0.5	<0.001*
		Range	0 - 0.5	1 – 2	
Radiation dose (mSv)		**Mean ± SD**	0.003 ± 0.002	0.017 ± 0.05	<0.001*
		Range	0 - 0.01	0.01 - 0.02	
Fluoroscopic screening time (Sec)		**Mean ± SD**	20.84 ± 9.09	30.8 ± 2.11	0.037*
		Range	5.2 - 32.7	28.3 - 33	

*: significant P value ≤0.05. Test: paired Student's t- test for quantitative results and Chi-square test for qualitative results. EPN: Emphysematous Pyelonephritis

Table 5: Postoperative outcomes of the studied patients

Postoperative Hb (mg/dL)	**Mean ± SD**	12.3 ± 1.1
	Range	10.8 - 14.1
Post operative Hb drop (mg/dL)	**Mean ± SD**	0.3 ± 0.12
	Range	0.1 - 0.5
Hospital stays (days)	**Mean ± SD**	3.3 ± 1.16
	Range	2 – 5
Stone-free status	**Stone free**	31 (77.5%)
	Insignificant residual stone ≤4mm	5 (12.5%)
	Significant residual stone >6mm	4 (10%)
Auxiliary procedures	**No**	37 (92.5%)
	2nd look PCNL	1 (2.5%)
	ESWL	2 (5%)

ESWL: Extracorporeal shock wave lithotripsy, PCNL: Percutaneous nephrolithotomy

Table 6: Postoperative complications of the studied patients

	N=40
Fever	9 (22.5%)
Persistent loin pain	6 (15%)
Blood transfusion	2 (5%)
Perforation of pelvicalyceal system	5 (12.5%)
PUJ injury/ disruption	1(2.5%)

4. Discussion

According to the demographic data of the studied patients, there were 25 (62.5%) males and 15 (37.5%) females with a mean age of 50.88 ± 11.78 years,mean BMI of 25.18 ± 4.25 kg/m^{2}and American Society of Anesthesiologists (ASA) physical status classification ranged between class I to class II.

The demographic data of our patients were similar to that of Wang *et al.* (2020). They investigated the feasibility and safety of tract dilation monitored by ultrasound in PCNL. The mean age of their patients was 51±10 years, mean BMI was 25.2±3.3 kg/m^2 and also the majority were males 248 (60.3%).

Also, in Usawachintachit *et al.* (2016), who evaluated the learning curve for the experienced surgeon in adopting ultrasound guidance for prone percutaneous nephrolithotomy, the demographic data were similar to our series. The mean age of patients was 52.3 ± 15.6 years, but female patients were slightly predominant. Half of the patients had an ASA physical status classification of 2 with an average BMI of 28.1 ± 7.3 kg/m^2.

Regarding preoperative characteristics of the studied patients, stone size ranged from 20 – 30 mm with a mean value (± SD) of 25.1 (± 3.09) mm. Stone was located at right side in 29 (72.5%) patients and at left side in 11 (27.5%) patients. Stone density (HU) ranged from 400 – 1400 with a mean value (± SD) of 962.5 ± 251.96.

Also, Fauzan *et al.,* (2023) in their series which compared between Ultrasound and Fluoroscopy-guided PCNL at Raden Mattaher Jambi Hospital, reported that the majority of the stone side was at left side .

Similar to our findings, Liu *et al.,* (2022) in their series which evaluated the safety and efficacy of combined ultrasound guidance, miniaturization and Galdakao-modified supine Valdivia (GMSV) position in PCNL. They reported that total stone size, cm (mean ± SD), was 3.19 ± 1.67, incomparable to our study, laterality was (left/right) 92/58 of 150 patients and stone density [Hounsfield unit (mean ± SD)] was 1199.1 ± 309.2.

Moreover, Wang *et al.,* (2020) who evaluated the feasibility and safety of tract dilation monitored by ultrasound in PCNL, stated that mean (±SD) of stone diameter (cm) was 3.6± 1.1.

In addition, Yan *et al.,* (2013) who evaluated the safety and efficacy of PCNL solely guided by ultrasonography , mean (SD) of stone burden was 453.86 mm^2 (131.63). Laterality was left in 365 (51.8%), right in 314 (44.5%) and bilateral in 26 (3.7%).

Regarding intraoperative parameters, the success rate in our study was 90%. This high success rate may be justified as ultrasound guidance can clearly show the path and depth of needles, as well as kidney anatomy (Chu et al., 2016).

In our series, there were 4 cases of failed tract dilation on the first attempt.

In the first failed case, the BMI of the patient was 32 kg/m^2. It has been reported that patients with a BMI greater than 30 kg/m^2 had more failed renal access attempts compared to those with lower BMI in ultrasound guided PCNL [(5)].Also, several studies have reported that obesity was significantly associated with increased risk of PCNL complications and steepened the learning curve in ultrasound-guided PCNL (Armas-Phan *et al.,* 2020; Bayne *et al.,* 2018. This can be explained by substantial signal attenuation and absorption of ultrasound energy that can occur in patients with obesity because of increased perirenal fat and prolonged percutaneous renal distance, which result in poor visualization of the kidney and needle tract (Modica *et al.,* 2011).

In the second failed case, the patient had a previous history of open surgery of the ipsilateral kidney in which ultrasound-guided puncture succeeded, but ultrasound-guided dilatation failed despite using Alkan telescopic metal dilators after failed balloon dilation. Another factor that was demonstrated to be a predictor of failed balloon dilation in our study was the history of ipsilateral kidney surgery. Similarly, Kurtulus et al. showed that the rate of successful balloon dilation in one step was lower in patients with previous ipsilateral open renal surgery (50% success rate) than in those without (83% success rate) (Kurtulus *et al.,* 2008).

Difficulty could be encountered either at the stage of needle insertion or tract dilatation due to perirenal fibrosis and anatomic changes in patients with prior open renal surgery. Bowel displacement may be present in such patients which assert a challenge in puncture. Careful intraoperative ultrasonography is useful to delineate the kidney from neighboring organs and determine the access site. Affected by scarring of the kidney and perirenal tissue, balloon inflation causes more axial force generation in comparison with radial force (Ziaee *et al.,* 2007), which may make the balloon tend to escape backward during inflation process. In some cases, the dense retroperitoneal fibrous tissue can make the working sheath advancement over the inflated balloon very difficult. We have overcome these problems in other cases with history of ipsilateral kidney surgery by using the fascial dilators to predilate the retroperitoneal fascia, monitoring the whole balloon inflation process under ultrasound and holding the balloon catheter firmly near the balloon to maintain it in place when advancing the working sheath.

Notably, the process of placing the working sheath over the balloon cannot be monitored by ultrasound. We generally rotated the sheath back and forth over the balloon until the proximal end of the sheath was at the same level with the end of the inflated balloon. At the same time, the urine would flow out between the sheath and the balloon. In this process, tactile feedback as we advancing the sheath was also of utmost importance.

Regarding the failed fourth case, there was an inadequate advancement of the working sheath, resulting in a "short tract". The trial of advancing the nephroscope along the guidewire to find the channel into target calyx under direct vision failed, so the case was completed as fluoroscopic-guided PCNL. The potential reasons for this include: (1) inability to identify the balloon clearly especially after gaining puncture with subsequent decline of hydronephrosis. One difficulty with accurate placement of the balloon with ultrasonography is that the deflated balloon tip is not easily visualized under ultrasound guidance (not echogenic). Once inflated, balloon can readily be seen, but its tip can be difficult to accurately identify in the deflated state. We overcame this problem by constantly moving the wire back and forth while passing the balloon over it and looking for a change in the wire contour to judge where the tip of the balloon was relative to the wire. Instead, real-time ultrasound monitoring of the catheter advancing process can generate a satisfactory image. When advancing the balloon catheter along the guidewire, a "V-shaped" impression of the renal cortex can be seen as the tip of the catheter passes through the renal capsule. The "V-shaped" impression will soon disappear as long as the catheter gets into the renal parenchyma. This can help to confirm the correct location of the catheter. In addition, balloon inflation can be easily detected under ultrasound as the "double-line sign"(Wezel *et al.,* 2009). If the tip of the "double line" was not in the collecting system, the balloon should be deflated to adjust its position. The shallow dilation was managed by advancing the nephroscope or semi-rigid ureteroscope along the guidewire to find the channel into target calyx under direct vision especially when the previous puncture had been confirmed by an outflow of urine. The working sheath can then be inserted into the collecting system over the nephoscope. If advancing into the calyx was impossible or the guidewire was lost, a new puncture and second dilation in the working channel should be made under ultrasound guidance. (2) automatic withdrawal of the balloon while inflating; and (3) an oblique angle between the sheath and the renal axis, resulting in a change of kidney location, especially in lower pole access. This was managed by advancing the nephroscope along the guidewire under direct vision into calyx and subsequently inserting the sheath into the collecting system over the nephroscope.

According to our outcomes, twenty- three patients (63. 89%) of the successful group and 4 (100%) patients of the failed group demonstrated moderate hydronephrosis on intraoperative imaging while all patients with severe hydronephrosis [13 (36.11%)] were successful. The failure rate was lower in severe degree of hydronephrosis in comparison with moderate hydronephrosis. The present technique achieved a higher success rate in certain patients. Hydronephrosis generates a sharp outline of the collecting system and identification of interventional instruments, facilitating puncture and dilation during PCNL. Furthermore, hydronephrosis enables the guidewire to pass through the gap between the stone and calyx. A non-hydronephrotic calyx that is fully occupied by a staghorn stone causes the guidewire to fold, losing dilation direction and causing formation of a false channel (Wang *et al.,* 2020).

Retrograde instillation of saline into the pelvicalyceal system (PCS) was used for enhancing the degree of hydronephrosis and better visualization of the PCS (Hosseini *et al.,* 2015).

As regards postoperative complications in our series, there were nine (22.5%) patients showed postoperative fever, 6(15%) patients showed postoperative persistent loin pain, 2 (5%) needed blood transfusion due to Hb loss, 5 (12.5%) patients showed postoperative perforation of pelvicalyceal system, 1(2.5%) patient showed postoperative PUJ injury/ disruption.

On the other hand, Fauzan et al. (2023) in their series of comparison between ultrasound and fluoroscopy-guided PCNL at Raden Mattaher Jambi hospital, documented that most of the patients had no complications, but post-operative fever was experienced by 11.24% patients in ultrasound-guided PCNL and 12.5% in fluoroscopy-guided PCNL.

Simayi *et al*. (2023) in their series which evaluated ultrasound-guided mini-percutaneous nephrolithotomy in the treatment of upper urinary tract stones in children, reported that 8 (11.4%) patients developed significant complications. The most common complication was postoperative fever, which was observed in four (5.7%) children. Among them, one required additional oral antibiotics (Clavien grade II), and the rest recovered spontaneously without any special management (Clavien grade I). One (1.4%) child had significant haematuria (Clavien grade I), which resolved spontaneously without additional intervention. Two (2.8%) children developed minor pelvic perforations (Clavien grade III), which were managed by applying a double-J stent for 4 weeks. One child (1.4%) presented with a perirenal hematoma (Clavien grade III) and was treated with a nephrostomy tube for 48 h. Blood transfusion wasn't required in any cases.

Moreover, Hosseini *et al.* (2015), who evaluated pure ultrasonograghy-guided radiation-free percutaneous nephrolithotomy, documented that 14 patients (3.9%) required blood transfusions and 26 (7.3%) experienced fever that was resolved with conservative therapy. Headache developed 4–5 days after the operation in 17 patients (4.8%) who had received epidural anesthesia for their surgery. All were managed conservatively with analgesics. Severe post-operative renal colic was observed in 8 (2.3%) patients which was managed conservatively in five patients and with ureteral stenting in three patients. There were no major intra-or postoperative complications.

Penbegül *et al.* (2012), who evaluated safety and efficacy of ultrasound-guided percutaneous nephrolithotomy for treatment of urinary stone disease in children, reported that fever, urine leakage, were observed in 3, and 1 patient, respectively.

Research conducted by Birowo *et al.* (2020), who evaluated x-ray-free ultrasound-guided percutaneous nephrolithotomy in supine position using Alken metal telescoping dilators in a large kidney stone ,reported that there were no major complications. The complication rate was 36% in this study, postoperative fever (10%) (Clavien grade I), which was treated with acetaminophen, and the need for a blood transfusion (26%)(Clavien grade II) because of active bleeding in the lacerated area of the infundibulum. Moreover, this was due to slightly lower mean pre-operative haemoglobin levels, which were 12.03±2.1, leading to post-operative transfusions, especially in the first ten cases. Also reported that as familiarity with ultrasound improved, the complication rate was lower. The median amount of transfusion was 234 mL (200–647 mL).

Collectively, the use of US guidance has other advantages in addition to being free of ionizing radiation; for example, it results in fewer punctures, has shorter operating times and avoids contrast-related complications (Basiri *et al.,* 2008). This form of guidance allows imaging of the intervening structures with the benefit of minimizing the risk of injury to nearby organs. Moreover, the use of US at the end of the procedure helps the urologist to look for non-opaque and semi-opaque residual stones that are not visualized by radiography. The European Association of Urology recommends initial puncture under US guidance because it reduces radiation hazards (Yan *et al.,* 2013).

5. Conclusion

Ultrasound-guided PCNL can be used safely and effectively to treat patients with unilateral renal stones with stone burden 20 to 30 mm providing the advantages of less radiation exposure, no adjacent organ injury, and high success (90%) and low complication rates. In contrast to the fluoroscopy-guided method, ultrasound-guided PCNL does not expose patients or operators to radiation. Failure rate is significantly associated with higher tract number, longer dilatation and operative time, higher radiation dose and longer fluoroscopic screening time.

References

Armas-Phan, M., D.T. Tzou, D.B. Bayne, S.V. Wiener, M.L. Stoller and T. Chi, 2020. Ultrasound guidance can be used safely for renal tract dilatation during percutaneous nephrolithotomy. BJU Int., 125(2):284-91.

Basiri, A., A.M. Ziaee, H.R. Kianian, S. Mehrabi, H. Karami and S.M. Moghaddam, 2008. Ultrasonographic versus fluoroscopic access for percutaneous nephrolithotomy: a randomized clinical trial. J Endourol., 22(2):281-4.

Bayne, D.B., M. Usawachintachit, D. Tzou, K. Taguchi, A. Shindel and T.L. Chi, 2018. Increasing body mass index steepens the learning curve for ultrasound-guided percutaneous nephrolithotomy. Urology, 120:68-73.

Chu, C., S. Masic, M. Usawachintachit, W. Hu, W. Yang, M. Stoller, et al., 2016. Ultrasound-Guided Renal Access for Percutaneous Nephrolithotomy: A Description of Three Novel Ultrasound-Guided Needle Techniques. J Endourol.,30(2):153-8.

Crichton L, Türk C and Skolarikos A. European Association of Urology Urolithiasis Guidelines: Where Are We Going? Eur Urol Focus. 2021;7(1):34-8.

Crichton, N., 2001. Visual analogue scale (VAS). J Clin Nurs., 10(5):706-6.

Fauzan, R., R. Manduaru, A.P. Sitompul, W. Rachman and H. Herman, 2023. Comparison between Ultrasound and Fluoroscopy-guided Percutaneous Nephrolithotomy (PCNL) at Raden Mattaher Jambi Hospital. Afr J Urol.,29(1):19-21.

Grivas, N., K. Thomas, T. Drake, J. Donaldson, A. Neisius, A. Petřík, et al., 2020. Imaging modalities and treatment of paediatric upper tract urolithiasis: a systematic review and update on behalf of the EAU urolithiasis guidelines panel. Journal of Pediatric Urology,16(5):612-24.

Hosseini, M.M., A. Yousefi and M. Rastegari, 2015. Pure ultrasonography-guided radiation-free percutaneous nephrolithotomy: report of 357 cases. Springer Plus., 4(1):313-5.

Iordache, A., C. Baston, S.S.Guler-Margaritis, E. Angelescu, V. Cerempei, T. Olivier, et al., 2018. Ultrasound for kidney access in percutaneous nephrolithotomy: a contemporary review. Med Ultrason, 20(4):508-14.

Kurtulus, F.O., A. Fazlioglu, Z. Tandogdu, M. Aydin, S. Karaca and M.Cek, 2008. Percutaneous nephrolithotomy: primary patients versus patients with history of open renal surgery. J Endourol., 22(12):2671-5.

Linet, M., D. Freedman, A. Mohan, M. Doody, E. Ron, K. Mabuchi, et al., 2005. Incidence of haematopoietic malignancies in US radiologic technologists. OEM., 62(12):861-7.

Liu, Y.Y., Y.T. Chen, H.L. Luo, Y.C. Shen, C.H. Chen, Y.C. Chuang, et al., 2022. Totally X-ray-free ultrasound-guided mini-percutaneous nephrolithotomy in galdakao-modified supine valdivia position: A novel combined surgery. J Clin Med.,11(22):120-3.

Lojanapiwat, B., 2013. The ideal puncture approach for PCNL: Fluoroscopy, ultrasound or endoscopy? Indian J Urol.,29(3):208-13.

Modica, M.J., K.M. Kanal and M.L. Gunn, 2011. The obese emergency patient: imaging challenges and solutions. Radiographics, 31(3):811-23.

Ng, F.C., W.L. Yam, T.Y.B. Lim, J.K. Teo, K.K. Ng and S.K. Lim, 2017. Ultrasound-guided percutaneous nephrolithotomy: Advantages and limitations. Investig Clin Urol.,58(5):346-52.

Patel, S.R. and S.Y. Nakada., 2015. The modern history and evolution of percutaneous nephrolithotomy. J Endourol., 29(2):153-7.

Penbegül, N., A. Tepeler, A.A. Sancaktutar, Y. Bozkurt, M. Atar, K. Yildirim, et al., 2012. Safety and efficacy of ultrasound-guided percutaneous nephrolithotomy for treatment of urinary stone disease in children. Urology., 79(5):1015-9.

PP, 1964. R. Human experimentation. Code of ethics of the world medical association. Declaration of Helsinki. British medical journal. 1964;2(5402):177-8.

Simayi, A., T. Tayier, A. Aimaier, P. Lei, X. Zhang and Y.Alimu, 2023. Ultrasound-guided mini-percutaneous nephrolithotomy in the treatment of upper urinary tract stones in children: A single-center evaluation. Asian J Surg., 46(1):1-5.

Usawachintachit, M., S. Masic, I.E. Allen, J. Li and T. Chi, 2016. Adopting ultrasound guidance for prone percutaneous nephrolithotomy: evaluating the learning curve for the experienced surgeon. J Endourol.,30(8):856-63.

Wang, S., Y. Zhang, X. Zhang, Y. Tang, B. Xiao, W. Hu, et al., 2020. Tract dilation monitored by ultrasound in percutaneous nephrolithotomy: feasible and safe. World J Urol.,38(6):1569-76.

Wenzl, T.B., 2005. Increased brain cancer risk in physicians with high radiation exposure. Radiology, 235(2):710-5.

Wezel, F., C. Mamoulakis, J. Rioja, M.S. Michel, J. de la Rosette and P. Alken, 2009. Two contemporary series of percutaneous tract dilation for percutaneous nephrolithotomy. J Endourol., 23(10):1655-61.

Wieder, J.A., 2014. Pocket Guide to Urology, 5th Edition: J. Wieder Medical.

Yan, S., F. Xiang and S. Yongsheng, 2013. Percutaneous nephrolithotomy guided solely by ultrasonography: a 5-year study of >700 cases. BJU Int.,112(7):965-71.

Ziaee, S.A., H. Karami, A. Aminsharifi, S. Mehrabi, S. Zand and A. Javaherforooshzadeh, 2007. One-stage tract dilation for percutaneous nephrolithotomy: is it justified? J Endourol., 21(12):1415-20.

Ziaee, S.A., H. Karami, A. Aminsharifi, S. Mehrabi, S. Zand and A. Javaherforooshzadeh, 2007. One-stage tract dilation for percutaneous nephrolithotomy: is it justified? J Endourol. 21(12):1415-20.