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Ultrasonic guided versus fluoroscopic guided percutaneous nephrolithotomy for management of small renal stones; a comparative study.

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Abstract— Percutaneous nephrolithotomy (PCNL) is frequently performed by Urologist as a main way of management of renal stones of large size. Fluoroscopy is used commonly to guide Percutaneous nephrolithotomy (PCNL) with the hazards of radiation to the patients and the operating team, that is why Ultrasound represents a good lower cost alternative to guide this procedure as it gives a better needle access, ensures urinary tract dilatation and localization of small residual radiolucent stones.Also; it has lesser risk of adjacent organs' injuries.
Patients and methods: In this prospective interventional study, one hundred ninety-three patients, aged 12 years and morewith staghorn renal stones of 70 millimeters diameter and less involved for the period of January 2012 till March 2019. All patients underwent necessary basic blood,urine and imaging studies for preoperative assessment.
Patients divided into two groups based on the image guiding the operation, those who underwent Ultrasound guided Percutaneous nephrolithotomy (PCNL) were 115, and the rest 78 underwent Fluoroscopy guided Percutaneous nephrolithotomy (PCNL).

Then, under general anesthesia; stone extraction performed with intraoperative assessment of operative time, total time of access, exposure time to radiation. And post-operative follow up of patients for complications and outcomes including stone free rate, any residual stone, need for ESWL or for second PCNL, failure of needle access, hospital stay, bleeding or hematuria, need for blood transfusion or embolization, fluid extravasation, fever or sepsis, Colonic or inferior vena cava injury, Pneumothorax or hemothorax.

Results : The two groups were homogenous regarding gender and age, serum creatinine and hemoglobin concentration were not different between them pre-operatively. There was a higher stone free rate by using Ultrasonic guided percutaneous nephrolithotomy, and there was no statistical difference between the two procedures regarding the risk of injury to internal organs and bleeding, and both procedures did not cause colonic, hepatic or splenic injuries. Operative time, post-operative hospital stay and post-operative extravasation, fever, and sepsis were not significantly different between the two groups.
Conclusion: Apart from stone free rate and radiation exposure, both ultrasonic- guided, and Fluoroscopy guided Percutaneous nephrolithotomy have the same value as surgical procedures for treatment of renal stones, and there was no significant difference between them.

Introduction:

percutaneous nephrolithotomy is considered as the corner stone in management of large renal stone and widely used by the urologists [(1)], firstly described by Fernström and Johansson in 1976 [(2)].

Percutaneous access for kidneys is a common procedure in urologic surgeries to perform different procedures such as percutaneous nephrolithotomy (PCNL) and imaging is required usually to access the renal collecting system.[3]

The procedure depends mainly on establishing a proper access through the skin, to minimize the complications arises later. [4]

The fluoroscopy is a traditional way of PCNL and still used by Urologist around the world especially in the United States for the guidance of PCNL access. [4]

Urologists are more familiar with fluoroscopic imaging and they preferred its use in percutaneous renal access, due to its clear visibility, and its ability to visualize radiopaque calculi and anatomical details. [3]

Radiation safety is one of the major concerns during PCNL under fluoroscopic guidance. [5]

On the other hand, Ultrasound is radiation free, effective, and rapid, and is possible with a portable machine causing minimal complications in experienced hands. [3], it has been accepted to guide dilating and exploring renal collecting system, with a very high success rate [6] [7][8]

Ultrasound might be used to localize renal stone, especially for non-opaque stones, with satisfactory outcomes and minimum complication. [9]

It is considered as a good alternative in guiding the procedure of percutaneous nephrolithotomy[3,9], it gives better access for the selected calyx in addition to less probability of liver, splenic or visceral injury[10,11,12], it is a good tool to avoid the exposure to radiation for the patient and operative team, it provides an excellent pathway for needle access, tract dilatation, and localization of small residual radiolucent stone, it is also of lower cost than the fluoroscopy[13,14,15]

Aim of the study:
To compare the outcomes and complications between ultrasonic and fluoroscopic guided percutaneous nephrolithotomy.

Patient and method:

In the period from January 2012 to march 2019, one hundred andninety-three patients with renal stones were enrolled in this prospective study, exclusion criteria include age less than 12 years, staghorn stone more than 70 mm, and those patients needed more than one access for stone removal, each patient underwent complete blood picture, renal function test, bleeding profile, GUE, culture if there is pyuria, and native CT scan.

Ultrasonic guided PCNL (US PCNL) used in 115 patients and 78 patients used fluoroscopicguided PCNL (FG PCNL), the procedures done under general anesthesia except three patients done by spinal anesthesia due to medical comorbidities, we put the patient in lithotomy position, we placed ureteric catheter in FL PCNL and ureteric stent(DJ) in US PCNL.

In FL PCNL, we used C arm fluoroscopy, put the patient in prone position, injection of iohexol (omniopaque) through the ureteric catheter, we introduce a 18 gauge needle to the targeted calyx (usually the lower calyx), then J tip guide wire introduced through the needle, sequential tract dilatation by Amplatz dilators and sheath, all these steps done by using fluoroscopy, stone destruction done either by ultrasonic or pneumatic lithotripter, we used fluoroscopy to exclude any residual stone, a nephrostomy tube used routinely which is usually removed postoperatively after doing nephrostogram in suspected residual renal or ureteric stones.

In UG PCNL,if there is no hydronephrosis we inflate the bladder by normal saline to induce a hydronephrosis to facilitate the needle puncture to the target calyx (usually the lower calyx), then tract dilatation by Alkens dilators followed by Amplants sheath, all these steps done by real time ultrasoundguide using 3.5 MHz ultrasonic probe.

Stone destruction done by pneumatic lithotripsy, check ultrasound to exclude residual stone,nephrostomy tube used which is removed postoperatively after doing nephrostogram in suspected residual renal or ureteric stones.

Results:

One hundred and ninety-three patients with renal stones were enrolled in this prospective study, we divided them into two groups, the first group of 115 patients and managed by ultrasonic guided PCNL (US PCNL),and the second group by fluoroscopic guided PCNL (FL PCNL) composed of 78 patients.

In (US PCNL) group, there were 62(54%)male and 53(46%) female, in(FL PCNL) group there were 46(59%)male and 32(41%) female, their age range from 12-72 years with mean age (42.6) in (US PCNL) group and from 16-68 years with mean age (48.2) in (FL PCNL) group (table1). preoperative s. creatinine was 1.3 and 1.1 respectively, preoperative mean hemoglobin was 12.5 and 13.2 respectively, stone size was range from 12-68 mm with mean (35 mm) and 16-67mm with mean(48mm) respectively, there were 64 cases (55.7%) in the right side and 51 cases (44.3%) in the left side in (US PCNL) group, while 46cases (58.9%) in the right side and 32 cases (41.1%) in the left side in (FL PCNL) group, these parameters shown in (table1).

Table 1: Demographic, preoperative investigation, stone sizes and sides, previous procedures for patients.

Total 193	US PCNL (group 1) 115	FL PCNL (group 2) 78	P value
Sex	Male 62(54%) Female 53 (46%)	Male 46(59%) Female 32(41%)	X^2=1.72, P =0.184
Age	42.6±13.3	48.2±16.7	T=1.195, P=0.276
Serum Creatinine(preop.)	1.3±0.42	1.1±0.38	T=1.542, p=0.381
Hb%(preop.)	12.5±3.2	13.2±3.9	T=0.985, p=0.322
Stone size	12-68mm(35mm)	15-53(31)	
Previous Pcnl or pyelolithiotomy	12 (10.4%)	4 (5.1%)	X^2=3.291,p=0.022
Renal side	RT 64 (55.7%) LT 51(44.3%)	RT 46 (58.9%) LT 32 (41.1%)	X^2=3.578, p =0.048

Regarding outcomes and complications, in (US PCNL) group, stone free rate (SFR) was 88.7%, 13 cases get residual stone(11.3%), in (FL PCNL) group, SFR was 80.8%, 15 cases get residual stone (19.2%), there was 5 cases (4.3) needed for ESWL in (US PCNL) group, while in (FL PCNL) group, there was 6 cases (7.7%) needed for ESWL, there was one case (0.9%) needed for second PCNL (residual stone not responding to ESWL) in (US PCNL) group, while not needed in the second group.

There was failure of needle access in one case in (US PCNL) group which converted to FL PCNL.

Nephrostomy tube put in all cases except two cases in (US PCNL) group and one case in (FL PCNL) group.

The duration of needle puncture, tract dilatation and sheath access range from 12-35 minutes(min) with mean (21 min) and from 14-25 min with mean (18.5min) in (US PCNL) and (FL PCNL) groups respectively.

Time exposure to radiation was zero in (US PCNL) group, whereas range from 2-7 min with mean (3.3 min) in (FL PCNL) group.

Operative time was range from 55- 150 minutes with mean (95 minutes) in (US PCNL) group, while 65- 180 minutes with mean (110 minutes) in (FL PCNL) group, hospital stay was range from 24- 96 hour withmean (38) and from 24- 84 hour with mean (46) respectively.

Hematuria was seen in two cases in(US PCNL) group, whichrequired blood transfusion, while three case required blood transfusion in (FL PCNL) group which also required blood transfusion, there was no need for vascular embolization in both groups.

Fluid extravasation was seen in two cases in (US PCNL) group and in one case in (FL PCNL) group which were resolved conservatively.

Four cases (4.3%) get postoperative fever due to urinary tract infection (UTI) in (US PCNL) group, and two cases (2.5%) in (FL PCNL) group, these were treated by antibiotics only, urosepsis occurred in one case in both groups which were treated urgently without farther sequels.

There was no any case of colonic injury, inferior vena cava injury, pneumothorax, hydrothorax or arteriovenous fistula in both groups.

Table 2 outcomes and complications:

Outcomes and complications	US PCNL	FL PCNL	
Total	13 (11.3%)	15 (19.2%)	0.651
Stone free rate	7 (6%) <5 mm	9 (11.5%)	
(Residual stone)	6 (5.3) > 5mm	6 (7.7%)	
Need for ESWL	5 (4.3%)	6 (7.7%)	0.631
Need for second PCNL	1 (0.9%)	0 (0%)	0.001
Failure of needle access	1 (0.9%)	0 (0%)	0.001

Nephrostomy	113 (98.2%)	77 (98%)	NS
Total time of access (mean)	21 min	18.5 min	0.061
Time exposure to radiation (mean)	0 min	3.3 min	0.001
Operative time	55- 150 minute mean (95min)	65-180minute mean (110 min)	0.0541
Hospital stay (mean)	38 hour	46 hour	0.043
Bleeding(Brisk hematuria)	2 (1.7%)	3 (3.8%)	0.056
Need for blood transfusion	2 (1.7%)	3(3.8%)	0.056
Need for embolization	0 (0%)	0 (0%)	NS
Fluid extravasation	2 (1.7%)	1 (1.2%)	0.021
Fever (UTI)	4 (3.5%)	2 (2.5%)	0.022
Sepsis	1 (0.9%)	1 (1.2%)	NS
Colonic injury	0 (0%)	0 (0%)	NS
Pneumothorax (or) hemothorax	0 (0%)	0 (0%)	NS
Arteriovenous fistula	0 (0%)	0 (0%)	NS
Inferior vena cava injury	0 (0%)	0 (0%)	NS

Discussion:

Most urologist are using the fluoroscope for access in PCNL[16],but the using of real time and high resolution ultrasound is an emerging tool and alternative to fluoroscope for needle puncture, tract dilatation and sheath placement. [16,17,18]

In our study, we found higher stone free rate in US PCNL, but there was no statistical difference between both groups, this is comparable with a study by Karami H and et al who also showed no difference in stone free rate. [14]

In US PCNL there was difficult access only in one case, the kidney was left sided, high in position, therefore it was converted to FL PCNL, the ultrasound in PCNL is hand dependent, therefore, the urological residentsbetter to be familiar with its use from the first years of training, some residents did 32 PCNL with complete ultrasonic guide, 6 cases needed fluoroscopic adjustment which is expected as it needs long time training. [19]

In US PCNL, we used complete ultrasonic guidance and therefore there was no radiation exposure while in FL PCNL there was 3.3 min time exposure for radiation which is considered as a hazard for the exposed persons.

We can use color Doppler to decrease the risk of vascular injury, in our study there were 2 of 115 cases (1.7%) get bleeding in US PCNL while 3 of 78 cases (3.8%) in FL PCNL, despite there is no statistical difference, but US PCNL is still less risk of bleeding, there was no reported cases of inferior vena cava injury in both groups, some studies showed that the risk of bleeding in US PCNL is about 1.9% which is comparable to our study[20], while other study showed higher incidence of bleeding in FL PCNL (11.1%).[21]

In our study there was no colonic, splenic or hepatic injury (0%) in both groups, which is also comparable to other studies like Shiavash H, et alwhich reported no visceral injury and Carrissa chu, et al reported 0.1%.[22,23]

Regarding the fluid extravasation, fever, and sepsis, in our study there was no significant difference between two groups, all cases treated with antibiotics only and this is comparable with other studies. [14,20]

In our study there was no statistical difference in operative time or hospital stay, this is also comparable with other studies. [14,20]

Conclusion:

As procedures for management of renal stones; both ultrasonic- guided, and Fluoroscopy guided Percutaneous nephrolithotomy have the same value as surgical procedures for treatment of renal stones, and there were no significant differences between them regarding post-operative complications, or hospital stay, injury to internal organs. Ultrasonic- guided Percutaneous nephrolithotomy is a little superior regarding stone free rate, and it has no risk of radiation exposure.

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