ORIGINAL ARTICLE

TOTAL ULTRASOUND GUIDED PERCUTANEOUS NEPHROLITHOTOMY: A NOVEL TECHNIQUE

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ABSTRACT

Introduction: Fluoroscopy is commonly used imaging technique during percutaneous nephrolithotomy but is associated with risks of radiation exposure. We evaluated the safety and efficacy of ultrasound guided Percutaneous Nephrolithotomy for treatment of renal stones.

Material & Methods: This was a cross-sectional study done at the Department of Urology and Renal Transplantation, Institute of Kidney Diseases, Hayatabad, Peshawar from July 2010 to June 2012. All procedures were performed in prone position. The location of the target calyx, puncture and dilation of the tract was performed under ultrasound guidance. Stones were broken with Swiss Pneumatic Lithoclast and residual fragments identified by ultrasonography.

Results: The lower pole calyx was most commonly punctured, 26 patients (41.9%) followed by middle calyx, 19 patients (30.6%) and upper pole calyx, 17 patients (27.4%). The average procedure time was 71 minutes ± 23.4 minutes (45–110 minutes). The mean hospital stay was 3± 0.9 (2-5) days and nephrostomy tube was kept for one day (Range 1-3). The mean size of stone was 3.0±1.3 (2.5-4.8) cm. Complete clearance was achieved in 54 patients (83%). With dual therapy (PCNL + ESWL/URS), stone clearance was achieved in 58 patients (93.5%). Only one patient required two pints of blood transfusion due to intraoperative bleeding (Hb dropped to 7.4 g/dl). Other minor complications were mild fever in seven patients, ureteric colic in four patients, and nephrostomy site leakage in six patients.

Conclusion: Totally ultrasonography guided PCNL is a good alternative to the fluoroscopic method and has satisfactory outcomes compared with the standard technique of PCNL.

KEY WORDS: Ultrasonography; Percutaneous Nephrolithotomy (PCNL); Renal Stone; Stag horn Stone; Flouroscopy.

This article may be cited as: Ullah A, Khan MK, Rahman AU, Naeem M, Khan S, Rehman RU. Total ultrasound guided percutaneous nephrolithotomy: a novel technique. Gomal J Med Sci 2013; 11: 149-54.

INTRODUCTION

Since its first introduction in 1976 by Fernstorm and his colleagues, there has been a lot of improvements in the technique and equipment of Percutaneous Nephrolithotomy in the next three decades which has made percutaneous nephrolithotomy (PCNL) an accepted management option for urolithiasis.[1,2] After an initial learning phase, a good success rate can be considered for PCNL (ultimately more than 90%). This high success rate is attributable to more experience, advances in endoscopic equipments, and also advanced devices for destruction of stones.[3]

Now, PCNL is the treatment of choice for patients with kidney stones that are larger than 2.5 cm in diameter.[4] Other indications include lower pole calculi, cystine stone disease, abnormal renal anatomy, and stones that are not amenable to ureteroscopy or extracorporeal shockwave lithotripsy (SWL).[5,6]

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The key requisite of any percutaneous nephrolithotomy (PCNL) technique is proper access to the collecting system. The ideal puncture would be to develop a percutaneous tract that leads straight from the skin through a papilla and the target calyx into the renal pelvis. This is a basis for any percutaneous renal procedure.[7]

Traditionally PCNL has been performed under fluoroscopy guidance which exposes patients, surgical staff and theatre staff to the hazards of ionizing x-ray radiations which are not radiation dose dependent.[8] Although surgical and theatre staff can wear protective apron, but they are bothersome and does not provide complete protection.[9] There has been a recent interest in many centers to use ultrasound as an alternative for fluoroscopy to puncture the pelvicaliceal system during PCNL and locate the residual

fragments during the procedure.

Ultrasound guided PCNL has definite advantages over fluoroscopy guided PCNL. There is no need of intravenous or retrograde administration of contrast dye, no radiation exposure of the surgical or theatre staff and it provides continuous real time control during puncture with accurate location of radiolucent stones.[10] It provides three dimensional picture during puncture while fluoroscopy provides only two dimensional picture and accurate imaging of all tissues/ viscera like intestines and lungs along an intended nephrostomy tract is possible only under ultrasound guidance.[11] Similarly imaging in numerous planes is possible simply by shifting, tilting and rotating the scanning head.[11]

Since kidney has a high degree of intrarenal vascular network, the use of real time B-scan sonography can be used as a tool for localization of intrarenal vessels and avoidance of puncture by needle thus reducing the risk of intraoperative and postoperative bleeding.[12] In this study we report our experience of ultrasound guided percutaneous nephrolithotomy with 62 patients.

MATERIAL AND METHODS

This was a cross-sectional study done at the Department of Urology and Renal Transplantation, Institute of Kidney Diseases, Hayatabad, Peshawar, Pakistan from July 2010 to June 2012**.** Total sixty-two cases of ultrasound guided Percutaneous Nephrolithotomy were included in the study. The inclusion criteria were pelvic or caliceal stones that were larger than 2.5 cm in diameter, while patients with gross kidney anomalies like horseshoe kidney or ectopic kidney, and those with uncontrolled coagulopathies were excluded from the study.

All procedures were carried out by a single surgical team, under general anesthesia and in prone position. Interventional radiologists were involved in the first 20 cases to help the surgical team in the puncture of desired calyx and localization of residual fragments.

After induction of general anesthesia, patients were put in lithotomy position and a 4-6 Fr open ended ureteric catheter was placed with the help of rigid cystoscope to allow injection of 50 to 100 ml of normal saline into the collecting system. A 10-16 Fr Foley's catheter was inserted into the bladder to provide drainage during the procedure. Patients were then shifted to prone position with one bolster below the lower chest and other below the lower abdomen. We found that in this position the kidneys are more fixed and least affected by the respiratory movements and the abdominal viscera were dropped down thus reducing their chances of injury during the procedure.

After standard preparation and draping, identification of the pelvicaliceal system and location of the stone was done with the help of ultrasound using 3.5 MHz probe in prone position (Fig. 1) and about 50 to 100 ml of saline was injected through ureteric catheter to induce hydronephrosis if needed for better visualization of the pelvicaliceal system. Percutaneous access into the desired calyx was made with the help of 18 G diamond tip needle (Cook Urological), guide wire was passed and the tract was dilated with metallic Alken dilators up to 30 Fr (Fig. 2). Finally a 28-30 Fr working sheath (Amplatz Sheath) was advanced into the collecting system over the Alken dilators.

Fig. 1: Position of the patient for Ultrasound guided Percutanous Nephrolithotomy

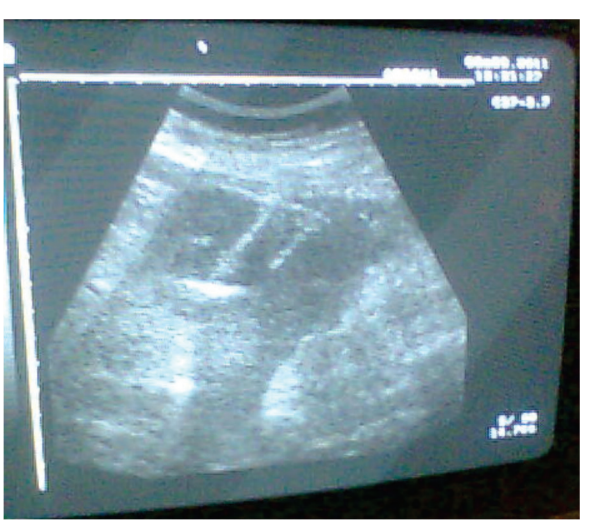

Fig. 2: Ultrasound guided puncture of the dilated Pelvicaliceal system

All the steps of puncture and dilation were monitored under ultrasound guidance. Rigid nephroscope (Storz) 26 Fr was used in all cases for visualization and extraction of stones and lithotripsy was performed by Swiss Pneumatic Lithoclast. Final nephroscopy was performed and ultrasonic images were taken to determine about the stone clearance and residual fragments. At the end of procedure, 12-16 Fr nephrostomy tube was placed which was removed after 24-72 hours.

Postoperatively, all patients received standard dose of narcotic analgesics and antibiotics for the first 24 hrs and then analgesia on demand basis. The day after surgery, full blood count was performed to determine any change in the hematocrit. X Ray KUB and ultrasound abdomen and pelvis (by an experienced radiologist) were performed on the 1st or 2nd postoperative day to confirm stone clearance or look for any residual fragments. If the residual fragments were larger than 5 mm, they were considered significant and were treated with ESWL usually one month after the procedure. In the absence of any complications patient were discharged on 2nd or 3rd postoperative day.

Follow-up stone-free rates were determined in an outpatient clinic setting at 1 to 3 months postoperatively. At each visit, patients were asked about the time required to return to normal activities. Urinalysis, urine culture (if required), serum creatinine, X-Ray KUB and abdominal ultrasound were performed. If stone recurrence was diagnosed, IVP was performed. Renal scans (DTPA) for selective determination of GFR was performed in selected patients with deranged renal function tests.

The demographic variables were gender and age in years and the research variables were stone side, size, type, access to PC system, location of puncture calyx, procedure duration, length of hospitalization, duration of nephrostomy tube, immediate complete stone clearance, stone clearance at 4 weeks without intervention, stone clearance at six weeks with intervention, clinically insignificant residual fragments (CIRF), presence of residual stones, intraoperative bleeding, post op fever, post op renal colic, post op urinary leakage.

Qualitative variables were analyzed as number (frequency) and percentages (relative frequencies) while quantitative variables were analyzed as mean, SD, minimum & maximum by SPSS version 10 (SPSS Inc., Chicago, IL) for Windows XP.

RESULTS

Out of 62 patients, 42 (67.74%) were male and 20 (32.26%) female. The mean age of the patients was 27.5 ± 2.6 (12-49) years. Stones were on the left side in 35 (56.45%) patients and on the right side in 27 (43.55%) patients. The mean size of the stone was 3.0 ± 0.4 (2.5-4.8) cm. The type of stone was solitary in 33 (53.2%) and staghorn or multiple stones in 29 (46.8%) patients.

Access to the PC system was successfull in all (100%) cases. The lower pole calyx was punctured in 26 (41.9%) patients, middle calyx in 19 (30.6%) patients and upper pole calyx in 17 (27.4%) patients. The average procedure time was 71 ± 7.4 (45–110) minutes. The mean hospital stay was 3 ± 0.2 (2-5) days and nephrostomy tube was kept for 1 day (1-3) days.

Immediate complete stone clearance was in 54 (87%) patients. Stone clearance at four weeks without intervention was in 58 (93%) patients. Stone clearance at six weeks with intervention was in 61 (98%) patients. Clinically insignificant residual fragments (CIRF) were in four (6.4%) patients. These were 2-5 mm in size, which passed within 2-4 weeks without any intervention. Two (3.22%) patients had residual fragments, 10-12 mm in size, which were treated with ESWL about one month after the operation. In one patient residual fragment of about 7 mm migrated into the upper ureter which was fragmented and cleared with uretero-renoscopic stone removal (URS). One patient was left with residual fragments of about 2.7 cm (had multiple calculi with mean diameter 4.9 cm and operation stopped due to intra-operative bleeding) and was treated with re-PCNL, six weeks after the initial procedure.

No serious complications were encountered during the study (grade 1-3 according to Clavien Dindo classification). Intra operative bleeding (grade 1) was in one (1.6%) patients. Hb dropped to 7.4g/dl, in which procedure was abandoned and was transfused two pints of blood. Post op fever (mild/grade 1, temperature ≤ 100 ^{0}F) was in nine (14.5%) patients, which settled down with antipyretics and routine antibiotics. Post op ureteric colic (grade 1) was in 4 (6.14%) patients, possibly due to the passage of small residual fragments which were treated with oral NSAIDs. Post op urinary leakage (grade 1) was in six (9.6%) patients for more than 24 hours after nephrostomy tube removal which settled down with conservative treatment. None of the patients suffered any visceral injury.

DISCUSSION

Today, open stone surgery is one of the least common management options for stone disease, and endourological procedures, such as extracorporeal shock wave lithotripsy (ESWL), uretero-renoscopic stone removal (URS), and PCNL, are more common modalities to deal with renal stones.[13] In the modern era of endourology, open stone surgery is only recommended in patients with severely distorted intrarenal anatomy.[14] Synder and his colleagues compared the

success rate, procedure duration, complications, and recovery time for percutaneous and anatrophic nephrolithotomy in patients with staghorn stones. They demonstrated a decreased cost, earlier return to activity, decreased requirement for either blood transfusion or narcotic drug, and shorter operative time in favor of patients undergoing PCNL.[15]

The most important consideration for achieving consistently successful outcomes in PCNL with minimal major complications is the correct selection of patients, a well-standardized technique, and good follow-up.[16] Similarly a proper access to the collecting system is the key requisite for any percutaneous renal procedure and the ideal tract would be that leads straight from the skin through a desired papilla and the target calyx into the renal pelvis.[7]

Both ultrasonography and fluoroscopy have been recommended for identification of the pelvicaliceal system, localization of the stone and puncture of the target calyx during percutaneous nephrolithotomy and the respective efficacies of both methods have been compared.[17] In some reports, CT scan has been recommended as a guidance method for access into the collecting system.[18] In addition, Krombach and coworkers[19] used ultrasound guided nephrostomy with the aid of a magnetic field-based navigation device in the porcine pelvicaliceal system. Montonari and associates recommended mixed ultrasonographic and fluoroscopic guidance for access to the collecting system.[20]

PCNL under fluoroscopic guidance generates significant radiation exposure to the surgeon and the radiation dose to the urologist averages milliroentgen (mR) per case.[21] The radiation exposure during PCNL arises because of scattered radiation produced from the primary radiation beam, the patient, and the operating table. The areas of concern for exposure include the bone marrow, gonads, thyroid gland, and eye lens.[21] The administration of contrast material to patients with renal failure may be harmful.[22] In addition, the contrast may overlie the opacity of the stone and may cause confusion when extravasations occur because of the inability to recognize the PCS.[23]

The use of ultrasonography as a guiding modality has a number of advantages such as lack of ionizing radiation, shorter operation time, fewer punctures, and no need for contrast agent administration.[22] In pregnancy, fluoroscopy is contraindicated because of teratagenic effect and ultrasound guided access to the kidney is feasible.[23] Other advantages of ultrasonography are detection of non-opaque stones, which are not visible with fluoroscopy, and also proper localization of the adjacent organs for prevention of injury. The main disadvantage of this modality is difficulty with the approach to a PCS with mild dilatation but this can easily be overcome by injecting 50-100 ml of saline through retrograde placement of ureteric catheter.[23]

Basiri and associates[17] reported a success rate of 94% for access to the pelvicaliceal system during percutaneous nephrolithotomy under ultrasonography guidance. In our study, the success rates of achieving access to the collecting system and to the targeted calyx was 100%. Hosseini et al reported ultrasound guided PCNL with a stone free rate of 83 % postoperatively and 92%, four weeks after the procedure without any ancillary procedure.[25] In our study the stone free rate in the immediate postoperative period and four weeks after PCNL without intervention was 87% and 93% respectively. With ancillary procedures (Two ESWL & One URS), we achieved stone free rate of 98% at six weeks after the initial procedure.

In our study, intra-operative stone clearance was confirmed by rigid nephroscopy and ultrasonography. We believe that rigid nephroscopy is not a reliable tool for intraoperative stone searching, but we did not have flexible nephroscope at our center. However searching for residual stone with ultrasound in experienced hands is specially valuable when dealing with radiolucent stones.[23]

Intraoperative and postoperative bleeding is considered one of the most common complication of percutaneous nephrolithotomy. Acute bleeding requiring blood transfusion after PCNL, varies from 1% to 10% depending on the experience of the operative surgeon.[2,26] In our study only one patient (1.6%) developed intraoperative bleeding, who was transfused with two pints of blood.

Most of the complications after ultrasound guided PCNL are not severe (grade 1-3 according to Clavien Dindo classification) and usually settle down with conservative treatment. Usman and colleagues[2] report their experience with ultrasound guided PCNL in 300 patients with a 45.7% primary stone-free rate and a 96.5% total stone-free rate. The overall complication rate was 50.8%, and fever was the most common complication (27.6%). In our study nine patients (14.5%) developed mild fever (grade 1) which settled down with antipyretics and routine antibiotics. Hosseini and colleagues[25] reported postoperative ureteric colic (grade 1) in 17% cases (8 out of 47) after ultrasound guided PCNL, while in our study the frequency of postoperative ureteric colic was 6.4% (four patients) which were treated with NSAIDs. No injury to the adjacent organs was observed during the study.

Although the study was performed during learning curve of the surgeon, and we involved interventional radiologist during the initial twenty procedures, the results are comparable to fluoroscopic guided PCNL and complications are minor and acceptable. We found a gradual increase in

experience to perform the procedure case by case. It is recommended that every endourologist involved in renal stone surgery should increase his or her skills in ultrasound guided PCNL.

CONCLUSION

Totally ultrasonography guided PCNL (both in caliceal puncture and tract dilation) is a good alternative to the fluoroscopic method and has satisfactory outcomes compared with the standard technique of PCNL without any major complications and with the advantages of preventing radiation hazards, preventing damage to adjacent organs, and checking for residual calculi. Being a novel technique, it has a good learning curve specially for those endourologist who are already performing fluoroscopic guided PCNL.

Note: These are the final results of a preliminary study which was presented in UROCON 2011 (April 1-3 Karachi) and in the first meeting of European Association of Urologist section of Urolithiasis (EULIS-2011), September 7-10, 2011, London United Kingdom.

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CONFLICT OF INTEREST
Authors declare no conflict of interest.
GRANT SUPPORT AND FINANCIAL DISCLOSURE
None declared.