DETECTION OF RESIDUAL FRAGMENTS DURING PERCUTANEOUS NEPHROLITHOTOMY: ROLE OF INTRA-OPERATIVE ULTRASOUND

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ABSTRACT: AIMS: To prospectively evaluate the efficacy of ultrasound and fluoroscopy for detection residual stones during percutaneous nephrolithotomy (PCNL). MATERIAL AND METHODS: We prospectively evaluated 49 patients (55 renal units) undergoing percutaneous nephrolithotomy for renal calculi greater than 2 cms, in 38 renal units or staghorn calculus in 17 renal units, from May 2011 to Sep 2011. In 35 renal units patients underwent standard fluoroscopic guided PCNL and in 20 renal units patients underwent standard fluoroscopic guided PCNL followed by ultrasound of kidney was done before concluding the procedure. The size and location of residual fragments determined fluoroscopically and identified by ultrasound were compared. RESULTS: Stone free status was achieved in 27 of the 35 renal units using fluoroscopy alone, of the 27 renal units significant residual fragment were detected postoperatively by CT kidney in 8 false negative rate of 29.6% renal units, 4(14.8%) of them required ESWL/ relook PCNL. Clinically insignificant residual fragments (≤4mm) not observed in 4 (14.8%) renal units by fluoroscopy were confirmed by post-operative CT scan. Stone free status was achieved in 14 of the 20 renal units and stone clearance was ensured by intra-operative ultrasound alone. Clinically significant residual stones were detected in 3 (21%) of 14 renal units by post-operative CT, managed conservatively. Clinically insignificant residual fragments (≤4mm) observed in 3 (21%) patients which were confirmed by post-operative CT scan. CONCLUSION: Routine intra-operative ultrasound after standard PCNL helps in detecting CIRF and significant residual calculi. There were significant false positive and false negative rate of detection of residual stones which can be overcome by further experience in use of intra-operative ultrasound. KEYWORDS: Renal calculi; percutaneous nephrolithotomy; clinically insignificant residual calculi (CIRF);

INTRODUCTION: Percutaneous nephrolithotomy (PCNL) effectively treats large volume renal calculi but relies on postoperative imaging to judge its success.[1,2] Residual stone fragments can occur in up to 8% of patients who are treated with percutaneous nephrolithotomy. Retained calculi generated by intracorporeal lithotripsy remain a concern because of their potential for growth and future symptoms. The ability to detect residual fragments is dependent on the imaging modality and this gives different outcomes when different modalities used to assess the stone free rate.[3,4,5] Residual stones worth to be more studied because it gives rise to two major problems namely regrowth and recurrent urinary tract infection (2) Although, Computerized Tomography (CT) is the ideal investigation to detect these residual fragments, but detection with this cannot be done intraoperatively, and patients detected to have residual fragments will require a second procedure. So accurate intra-operative detection of these residual fragments is very important to avoid a second procedure and give 100% clearance in a single surgery. Although in traditional PCNL fluoroscopy has been used to detect intraoperative residual fragments, but it has got its own limitations.
Besides increased radiation exposure, fluoroscopy may not detect small residual fragments (according to recent literature CIRF < 2 mm) and especially non-opaque stones.\(^6\)

Also contrast material is used during PCNL and it may mask many residual fragments.

So intraoperative USG (Ultrasoundography) may supplement fluoroscopy in accurate detection of residual fragments during PCNL.

**AIM:** To prospectively evaluate the efficacy of ultrasound and fluoroscopy for detecting residual stones during percutaneous nephrolithotomy (PCNL).

**Patients and Methods:** This is a prospective study conducted in Institute of Nephro-Urology Bangalore.

**Inclusion Criteria:** All patients who underwent PCNL for radio-opaque renal calculi (Greater than 2 cms. or staghorn (Total 55 renal units of 49 patients) from May 2011 to October 2011 were included in this study. Our institutional review board approved the study, and informed consent was obtained from all patients before surgery.

**Exclusion Criteria:** Patients were excluded if they had a history of open renal stone surgery or if they had impaired renal function, with an ectopic kidney and urosepsis from the study.

All patients were evaluated by thorough medical history, physical examination, urine analysis, urine culture, renal function test, a coagulation test and these patients underwent unenhanced CT or i.v. urography to clarify the size, location of the calculi and the grade of hydronephrosis, before undergoing surgery. During their hospital stay, all patients were prescribed parenteral antibiotics, according to their urine culture results.

Our surgical team and sonologist with more than ten years’ experience performed these procedures under general anesthesia. Standard PCNL with conventional fluoroscopy was performed in 35 renal units and standard PCNL by fluoroscopy, followed by an ultrasonography (USG) of same kidney was done intra-operatively to look for any residual calculus in 20 renal units. The size and location of residual fragments determined fluoroscopically and identified by ultrasound were compared.

Stone-free status was defined as the absence of visible fragments on CT. Clinically insignificant residual fragments (CIRFs) were defined as those that were ≤4 mm in diameter, non-obstructive, and asymptomatic. All patients were assessed for stone clearance between 3-4 weeks after surgery using CT before removal of double J stent.

**Characteristics Number (%)**

| Characteristics          | Mean age in years | 38.6 years (18-58 years) |
|--------------------------|-------------------|--------------------------|
| Gender                   |                   |                          |
| Male                     |                   | 29 (59.1)                |
| Female                   |                   | 20 (40.8)                |
| Laterality               |                   |                          |
| Left                     |                   | 30 (54.5)                |
| Right                    |                   | 25 (45.5)                |
| Bilateral                |                   | 06 (10.9)                |
RESULTS: Patients with 35 renal units underwent standard fluoroscopic guided PCNL and concluded the procedure by fluoroscopy only. Patients with underwent 20 renal units underwent standard fluoroscopic guided PCNL followed by ultrasound of kidney was done before concluding the procedure.

Stone-free status was achieved in 27 of the 35 renal units using fluoroscopy alone. Of the 27 renal units significant residual fragments were detected postoperatively by CT in 8 (false negative-29.6%) renal units, 4 of them required ESWL/re-look PCNL. Clinically insignificant residual fragments (≤4mm) not observed in 4 (14.8%) patients by fluoroscopy were detected by post-operative CT scan.

Stone free status was achieved in 14 of the 20 renal units and stone clearance was ensured by intra-operative ultrasound alone. Clinically significant residual stones were detected in 3 (21%) of 14 renal units by post-operative CT, managed conservatively. Clinically insignificant residual fragments (≤4mm) observed in 3 (21%) patients which were confirmed by post-operative CT scan.

Stone-free rates according to AGP, KUB film, and non-contrast CT were 73.6% (39/53), 62.3% (33/53), and 20.8% (11/53), respectively. However, if clinically insignificant residual fragments are included in the success rates, these rates increased to 84.9% (45/53), 83.0% (44/53), and 41.5% (22/53), respectively.

Pre-operative CT Scan showing Rt staghorn calculus
KUB Xray: Showing Stag horn calculus.

Intra-operative ultrasonogram of kidney for detection of stone fragments.

Post PCNL- USG and CT KUB: Showing residual calculi.
DISCUSSION: Percutaneous nephrolithotomy (PCNL) constitutes first line therapy for large and complex renal calculi. It has been proved to be a less morbid procedure compared to open stone surgery & better stone clearance than ESWL. Multiple investigators have showed that modification to standard technique may be accompanied by decreasing the length of hospital stay or promoting patient outcome.\(^{1,3,4}\) The sensitivity of intraoperative imaging with reference to the gold standard of postoperative CT was 40%, 38% and 100% at thresholds of 0, 2 and 4 mm, respectively. Specificity was 100%, 94% and 95%, respectively.\(^{7,8}\)

Flexible nephroscopy combined with high magnification rotational fluoroscopy allows sensitive and specific intraoperative detection of residual fragments, enabling immediate removal or planning for necessary second look nephroscopy.

Conventional CT, plain film radiography, nephrotomography and renal sonography were compared by Lehtoranta et al.\(^{9}\) in detecting residual stones after PCNL 12 to 36 months post-surgery. In a comparison for different modalities, residual fragments were detected by CT in 53%, by plain film in 44%, by nephrotomograms in 42% and by sonography in 28%.

Pires et al.\(^{10}\) compared the sensitivity of residual stones detection after PCNL between plain abdominal x-ray and computed tomography and found that sensitivity was 87% and 100% respectively especially in diagnosis of small residual fragments <5mm concluding that spiral CT is justified to confirm the absence of residual fragments in patients after percutaneous nephrolithotomy despite the higher cost and irradiation compared to plain abdominal x-ray.\(^{10}\)

In an attempt to increase the intraoperative detection of residual stones high magnification rotational fluoroscopy was used by Portis et al.\(^{11}\) in conjunction with flexible nephroscopy. Despite these measures only 60% of patients were stone-free on postoperative day 1 CT. However 40 % of patients who were endoscopically and fluoroscopically stone-free had residual stones 4 mm or smaller.

A KUB has a sensitivity and specificity of 45% and 77%, respectively, as reported in the literature. An excretory urogram has 94% to 100% sensitivity and 64% to 97% specificity.\(^{12,13}\) The sensitivity, specificity and accuracy of ultrasound for detecting calculi are 40%, 84% and 53%, respectively.

Intraoperative ultrasound of the kidney could able to detect 2 mm residual fragments & can be complementary to fluoroscopy during PCNL to obtain complete stone clearance.

In our experience differentiating residual fragments with artifacts produced by air, blood clots & Amplatz sheath inside the kidney was difficult, but may be overcome by experience. Finally, plain CT KUB is essential to define success or failure of the procedure.

| References             | Total no. of patients | No. risk for re surgery (%) | No. risk for stone growth (%) | No. risk for pain (%) | No. overall risk (%) |
|------------------------|-----------------------|-----------------------------|-----------------------------|----------------------|----------------------|
| Park et al51           | 160                   |                             |                             | 69(43)               |                      |
| Raman et al59          | 42                    | 11(26)                      | 6(14)                       | 12(28)               | 18(48)               |
| Altunrende et al8      | 38                    |                             | 8(21)                       | 10(26)               |                      |
| Our study, Fluoroscopy | 55                    | 04 (7.3)                    | 07 (12.7)                   | 07 (12.7)            | 11 (20)              |
| Ultrasound             | 35                    | 04 (11.4)                   | 04 (11.4)                   | 04 (11.4)            | 08 (22.8)            |
|                        | 20                    | 00                           | 03 (15)                     | 03 (15)              | 03 (15)              |

Table no. 2: Post PCNL: Summary of residual fragments
Our study

| Intra-operative fluoroscopy. | Stone clearance | % of stone clearance | False negative | % of false negative |
|-----------------------------|-----------------|----------------------|----------------|-------------------|
| 27/35                       | 77              | 8/27                 | 29             |
| Intra-operative ultrasonography | 14/20          | 70                   | 3/14           | 21                |

Lehtoranta et al

|                     | Stone clearance | % of stone clearance | False negative | % of false negative |
|---------------------|-----------------|----------------------|----------------|-------------------|
| Plain KUB           | NA              | 56                   | NA             | --                |
| Sonography          | NA              | 72                   | NA             | --                |
| CT- KUB             | --              | 42                   | --             | --                |

Table no. 3: Post PCNL: Comparison of stone clearance

**CONCLUSION:** Routine intra-operative ultrasound after standard PCNL helps in detecting CIRF and significant residual calculi.

There were significant false positive & false negatives rate of detection of residual stones which can be overcome by further experience in use of intra-operative ultrasound.

Improved intraoperative imaging also has the potential to further localize fragments and improve surgical outcome during the initial PCNL.

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