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Comparison of imaging modalities for detection of residual fragments and prediction of stone related events following percutaneous nephrolitotomy

Mehmet Ilker Gokce[1], Eriz Ozden[1], Evren Suer[1], Basak Gulpinar[1], Omer Gulpınar[1], Semih Tangal[2]

[1]Department of Urology, Ankara University School of Medicine, Ankara, Turkey; [2]Department of Urology, Ufuk University School of Medicine, Ankara,Turkey

ABSTRACT

Introduction: Achieving stone free status (SFS) is the goal of stone surgery. In this study it is aimed to compare effectiveness of unenhanced helical computerized tomography (UHCT), KUB and ultrasonography (US) for detection of residual RFs and predicition of stone releated events following percutaneous nephrolitotomy (PNL).

Materials and Methods: Patients underwent PNL for radiopaque stones between November 2007 and February 2010 were followed. Patients were examined within 24-48 hours after the procedure by KUB, US and UHCT. For stone size 4 mm was accepted as cut off level of significance.Sensitivity and specificity of KUB and US for detection of RFs and value of them for prediction of stone related events were calculated.

Results: SFS was achieved in 95 patients (54.9%) and when cut off value of 4 mm for RFs was employed, SFS was achieved in 131 patients (75.7%). Sensitivity was 70.5% for KUB, and 52.5% for US. UHCT was shown to be significantly more efficient for detection of RFs compared to both KUB (p=0.01) and US (p=0.001). When cut off level of 4 mm employed, sensitivity of KUB and US increased to 85.7% and 57.1%. Statistical significant superiority of UHCT still remained (p value vs. KUB: 0.03 and p value vs. US: 0.008).

Conclusion: UHCT is the most sensitive diagnostic tool for detecting RFs after PNL. It has higher sensitivity regardless of stone size compared to KUB and US. Additionally UHCT has higher capability of predicting occurrence of stone related events.

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INTRODUCTION

The achievement of stone free status (SFS) is the primary goal of any treatment modality for stone disease. Residual fragments (RFs) are associated with such potential short and long-term sequelae, as renal colic, urinary tract infection (UTI),stone regrowth, need for hospitalization and additional intervention (1).

Percutaneous nephrolitotomy (PNL) is currently one of the most commonly employed surgical procedures for the treatment of renal stones and especially indicated in large or complex stone cases. Following PNL, diagnosis of RFs is crucial in the early postoperative period while percutaneous access is still in place. Depending on the SFS, further interventions can be employed (2).

The use of diagnostic tools for determination of RFs during the early postoperative period is controversial. The use of any imaging modality has its advantages and disadvantages. Plain kidney-ureter-bladder radiography (KUB), ultrasonography (US), unenhanced helical computerized tomography (UHCT), antegrade pyelography and

flexible nephroscopy through renal access site are the choices (2). The superimposition of bowel gas, feces and soft-tissue calcifications as well as the presence of obesity, faint radiopaque stones, and nephrostomy tubes decrease the accuracy of these diagnostic modalities (3, 4). UHCT, in conjunction with image reconstruction, was prospectively compared to other imaging modalities, KUB and US for the detection of RFs and found to have significant superiority (3, 5, 6).

The sensitivity of the UHCT reached 100% and this method has been accepted as the gold standard for detection of residual stones. However clinical significance of RFs detected through UHCT is unclear and besides, performing UHCT is costly and causes radiation exposure. Therefore its role in the prediction of occurrence of stone related events and deciding for any additional interventions should be clarified. Although diameter of 4-5 mm is generally accepted as the cut off, size of the residual stone does not always correlate with clinical significance (7, 8). Apart from size follow-up of patients for occurrence of stone related events and application of additional interventions should be performed to determine the fate of RFs.

In this study, it is aimed to compare effectiveness of UHCT, KUB and ultrasonography for detection of RFs and predicition of stone releated events following PNL.

PATIENTS AND METHODS

Patients underwent PNL for radiopaque renal stones between November 2007 and February 2010, in Ankara University Hospital Department of Urology and were followed prospectively. All patients were evaluated with intravenous urography preoperatively.

All patients were examined within 24-48 hours after the procedure by KUB, US and UHCT. US was performed by a single radiologist especially experienced in ultrasonographic examination of urinary system (EO). KUB and UHCT images were investigated by a single clinician (MIG) and presence of any RFs along with size and location were recorded. For stone size, 4 mm was accepted as cut off level of significance.

Unenhanced helical scanning was performed using a 4 row multislice LightSpeed Plus CT scanner (GE Medical Systems, Milwaukee, Wisconsin). Images were obtained from the upper border of 10th rib to the lower border of the symphysis pubis using 4 mm slice thickness.

Patients were followed prospectively and stone related events were recorded. Stone related events were defined as renal colic, stone regrowth, need for hospitalization and additional intervention. Outcome measures were sensitivity and specificity of KUB and US for detection of RFs and value of the imaging modalities for prediction of stone related events.

UHCT was accepted as the gold standard for detection of RFs, and sensitivity of KUB and US were calculated. Sensitivity was defined as the number of positive test results divided by the overall number of positive cases using the gold standard. Statistical significance was determined by use of Pearson chi-square test and P value of <0.05 was accepted for statistical significance.

RESULTS

Totally 173 PNL cases were performed and one stage procedure was performed in all of the cases. Access through 1 caliceal puncture was performed in 148 patients (85.5%), and multiple access was performed in 25 cases (14.5%). Mean age of the patients was 48.4 ± 7, 1 and 113 of the patients (65.3%) were males. Median follow-up of patients was 9 months (3-36 months).

SFS with RFs of any size was achieved in 95 patients (54.9%) using UHCT as the gold standard test to diagnose RFs. When cut off value of 4 mm for RFs was employed, SFS was achieved in 131 patients (75.7%). Sensitivity was 70.5% (55 of 78 cases) for KUB, and 52.5% (41 of 78 cases) for US when RFs of any size was considered. UHCT was shown to be significantly more efficient for detection of RFs compared to both KUB ($p=0.01$) and US ($p=0.001$). When cut off level of 4 mm was employed, sensitivity of KUB increased to 85.7% (36 of 42 cases) and US increased to 57.1% (24 of 42 cases). Statistical significant superiority of UHCT still remained (p value vs. KUB: 0.03 and p value vs. US: 0.008). Sensitivity values of the ima-

ging modalities are summarized in Table-1. Considering specificity, neither KUB nor US resulted in any false positive results. Therefore specificity of both modalities were calculated as 100%.

Considering stone related events, among the 78 patients with RFs of any size in UHCT, 36 patients (46.1%) experienced an event. Distribution of stone related events is summarized in Table-2. Regarding ancillary procedures, shock wave lithotripsy was employed in 12 patients and additional surgery was needed for 8 patients (PNL: 4 patients with renal stones ≥2 cm and ureterorenoscopy: 4 patients with ureteral or renal stones<2 cm). Of these 36 patients with a stone related event, 25 of them were shown to have RF in KUB and 18 of them were shown to have RF in US. Seven and six patients that underwent surgery were found to have RFs in KUB and US respectively. For prediction of stone related events, UHCT was found to be superior to KUB (p=0.01) and US (0.001).

Table 1 - Sensitivity values of imaging modalities for detection of RF's following PNL.

	Sensitivity			
	All stones	P value vs. UHCT	Stones > 4 mm	P value vs. UHCT
UHCT (%)	100		100	
KUB (%)	70.5	0.01	85.7	0.03
US (%)	52.5	0.001	57.1	0.008

Table 2 - Stone related events within the 78 patients with residual fragments following PNL.

	Number of patients (%)
Renal colic episode	23 (29.4)
Stone regrowth	10 (12.8)
Shock wave lithotripsy	12 (15.3)
Additional surgery	8 (10.2)

DISCUSSION

Aim of surgical treatment for urinary calculi is achieving SFS. However the cut off level for SFS and selection of the appropriate imaging modality is controversial. It is clear that complete stone removal after PNL is crucial for preventing recurrence and regrowth of stones and further need for additional procedures (3, 5). This makes postoperative imaging for RFs necessary.

KUB is one of the most commonly used imaging modality for detection of RFs following PNL. Main advantages of KUB are its cost and lower radiation exposure.

Majority of urinary calculi are radiopaque, however RFs are sometimes difficult to be seen on plain abdominal radiographs because of their size, location, and also to the presence of stents and tubes and bowel loops (3, 9). US is noninvasive and does not cause radiation exposure, and can directly visualize residual fragments in the upper collecting system as small as 2 mm diameter. It also gives information on dilation of the collecting system (10). However, routine follow-up with only US for the detection of RFs after PNL is not advised, because its sensitivity is directly affected from the presence of a nephrostomy tube, and postoperative debris in the collecting system (3).

UHCT is currently the imaging modality of choice for evaluation of SFS, detection and localization of RFs after PCNL (3, 5, 8, 11,12). Sensitivity and specificity of UHCT was shown to exceed 90%, for all types of stones, with the exception of indinavir stones (13). High sensitivity results and widespread availability of UHCT restricts the utilization of flexible nephroscopy for the detection of RFs after PNL.

The superiority of UHCT over KUB for detection of RFs was shown in the study of Park et al. (5). In their study stone free rates of 62.3% and

20.8% were detected when KUB and UHCT were used respectively. In another study, sensitivity of KUB and US was investigated, regarding UHCT as the gold standard imaging modality.

Sensitivity of KUB and US to detect RFs of radiopaque stones was 62.9% and 48.6% for KUB and US respectively (3). Similarly, in our study only radiopaque stones were considered and sensitivity of KUB and US were found to be 70.5% and 52.5% for KUB and US , respectively. However in their study Osman et al. detected no significant difference for detection of RFs of radiopaque stones of >5 mm. Based on this result they concluded that utilization of UHCT for radiopaque stones should not be routine (3). In our study, 4 mm was accepted as the cut off value and for detection of RFs above this cut off level, sensitivity of KUB increased to 85.7%. But despite this increase, sensitivity of UHCT was still significantly greater than KUB.

Based on the results of previous studies, use of KUB, US or UHCT for detection of RFs following PCNL is still controversial. The data indicates that UHCT is the best method for detection of RFs, but the superiority is especially prominent for smaller stone fragments (<4-5 mm). However, size of the RF does not always correlate with the presence of stone related events. Sometimes even small fragments of 2 mm can cause significant obstruction or act as a nidus for further stone regrowth especially in infection stones. For this reason we evaluated the stone related events during the follow-up and found out that, over 30% of the cases with a stone related event were reported to have no RFs in KUB, although they have RFs in UHCT images. Additionally these results are maintained from a population with radiopaque stones and this gap between the two imaging modalities would increase if radiolucent stones are also included. When US is considered, RFs were detected only in half of the patients with a stone related event and RFs in UHCT images. On the other hand, in our study more than half of the patients with a RF in UHCT images did not experience a stone related event. Therefore the question of unnecessary utilization of UHCT should also be kept in mind as UHCT is expensive and causes significant radiation exposure.

Optimal timing for utilization of imaging modalities for detection of RFs is also a subject of debate. In many centers, as in our center, an imaging is performed routinely at postoperative day 1, but this is probably associated with increased false--positive results from stone dust postoperatively, and also RFs that would pass spontaneously during the early postoperative period without causing any stone related events are also detected. Therefore imaging at the end of the first month after surgery is considered optimal (5, 14, 15). Results of our study demonstrates the results of these 3 imaging modalities in the early postoperative period.

CONCLUSION

UHCT is found to be the most sensitive diagnostic tool for detecting RFs after PNL in the early postoperative period. It has higher sensitivity regardless of stone size compared to KUB and US. Additionally UHCT has higher capability of predicting occurrence of stone related events.

ABBREVIATIONS

SFS = stone free status
RFs = Residual fragments
UTI = urinary tract infection
PNL = Percutaneous nephrolitotomy
KUB = kidney-ureter-bladder radiography
US = ultrasonography
UHCT = unenhanced helical computerized tomography

CONFLICT OF INTEREST

None declared.

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Correspondence address:
Mehmet Ilker Gokce, MD
Adnan Saygun Caddesi,Altındağ, Ankara, Turkey
Fax: + 9 031 2311-2167
E-mail: migokce@yahoo.com