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How accurate is unenhanced multidetector-row CT (MDCT) for localization of renal calculi?

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ABSTRACT

Purpose: To investigate the correlation between unenhanced MDCT and intraoperative findings with regard to the exact anatomical location of renal calculi.
Design, setting, and participants: Fifty-nine patients who underwent unenhanced MDCT for suspected urinary stone disease, and who underwent subsequent flexible ureterorenoscopy (URS) as treatment of nephrolithiasis were included in this retrospective study. All MDCT data sets were independently reviewed by three observers with different degrees of experience in reading CT. Each observer was asked to indicate presence and exact anatomical location of any calcification within pyelocaliceal system, renal papilla or renal cortex. Results were compared to intraoperative findings which have been defined as standard of reference. Calculi not described at surgery, but present on MDCT data were counted as renal cortex calcifications.
Results: Overall 166 calculi in 59 kidneys have been detected on MDCT, 100 (60.2%) were located in the pyelocaliceal system and 66 (39.8%) in the renal parenchyma. Of the 100 pyelocaliceal calculi, 84 (84%) were correctly located on CT data sets by observer 1, 62 (62%) by observer 2, and 71 (71%) by observer 3. Sensitivity/specificity was 90–94% and 50–100% if only pyelocaliceal calculi measuring >4 mm in size were considered. For pyelocaliceal calculi ≤4 mm in size diagnostic performance of MDCT was inferior.
Conclusion: Compared to flexible URS, unenhanced MDCT is accurate for distinction between pyelocaliceal calculi and renal parenchyma calcifications if renal calculi are >4 mm in size. For smaller renal calculi, unenhanced MDCT is less accurate and distinction between a pyelocaliceal calculus and renal parenchyma calcification is difficult.

1. Introduction

Nephrolithiasis is a common disease with increasing prevalence. Data from United States have shown that by 70 years of age, 11% of men and 5.6% of women will have a history of a symptomatic kidney stone [1]. Unenhanced (non-contrast) spiral CT has become the modality of choice for assessing urinary tract calculi [2] since CT offers highly specific information such as stone location, size, number, density, and renal anatomy.

Treatment of renal calculi has changed over the last years, and urologists increasingly employ minimally invasive techniques to treat patients with renal calculi. The indication for minimally invasive surgical technique as well as the choice of the adequate method requires adequate information prior to surgery. Among other clinical factors, the number, size and location of renal calculi are of interest. Of particular interest is the question if the calcification is located either in the pyelocaliceal collecting system (pyelocaliceal calculus) or within the renal parenchyma which includes the renal cortex and the renal papilla (renal parenchyma calcification). In clinical practice the preoperative correct prediction of calculi either located in the pyelocalyceal collecting system or in the renal parenchyma on unenhanced CT may be challenging in particular for small size renal stones.

Despite extensive research in the field of urolithiasis and CT, to the best of our knowledge, there is very limited data on how accurate unenhanced CT is for the exact anatomical location of renal calculi (i.e. pelvicaliceal calculus versus renal parenchyma calcification).

The purpose of this study was to investigate the correlation between unenhanced MDCT and intraoperative findings during

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flexible URS with regard to the exact anatomical location of the renal calculus.

2. Patients and methods

2.1. Patients

This retrospective study was performed in accordance with the principles of the Declaration of Helsinki in particular with regard to confidentiality and protection of personal rights of our patients as well as data security [3]. Our institutional review board approved this retrospective study and waived the informed consent requirement.

The medical records of patients who underwent flexible ureterorenoscopy (URS) at our institution as treatment of nephrolithiasis between October 2007 and May 2010 were reviewed. Inclusion criteria were preoperative unenhanced MDCT examination and flexible URS performed within three months after imaging. Overall, we identified 59 patients (39 males, 20 females; mean age 52 years; age range 22–89 years ± 14 SD) who underwent unenhanced MDCT for suspected urinary stone disease, and who underwent subsequent URS as treatment of nephrolithiasis. These 59 patients represented the study group. Between acquisition of MDCT and URS there was a mean delay of 46 days (range 0–91 days). Aside of the clinical and individual situation of the patient, in our institution indication for URS is given if CT demonstrates nephrolithiasis with pelvicaliceal calculi measuring equal or fewer than 10 mm in size and if stone density does not indicate suspicion for uric acid stones (Hounsfield Units, HU ≤ 300). Among the 59 patients URS was performed in 30 left-sided and in 29 right-sided kidneys. None of the patients underwent bilateral URS.

2.2. Imaging technique

All CT examinations were performed on a 16-row MDCT scanner (Brilliance16; Philips Medical Systems, Eindhoven/NL). Unenhanced scans were obtained with the following parameters: section thickness, 2 mm (for a detector configuration of 16 × 1.5 mm); rotation time, .5 s; pitch, 1.0; table speed, 45 mm/s; tube voltage, 120 kvp; and effective tube current product, 100 mAs. The scan length was adapted of each patient's abdomen and pelvis. For image reconstruction, a moderately smoothing convolution kernel (B30) and a 512 × 512 pixel matrix was used.

We reconstructed transaxial images with a section width of 2 mm with an increment of 1.0 mm. Coronal reformations were reconstructed using a standard CT workstation with the section width of 2 mm.

2.3. Image evaluation

All MDCT data sets were independently reviewed by three observers (two radiologists with 9 respectively 4 years of experience, and one urologist with 4 years of experience in interpretation of abdominal CT examinations). All observers were blinded to patient history, laboratory results, findings of other imaging modalities, and surgical findings.

Each observer was asked to indicate presence and exact anatomical location of any pyelocaliceal calculus as well as calcification within renal parenchyma. Calculi were defined as focal calcified structures located within the pyelocaliceal collecting system. The readers were asked to assign the location of the pyelocaliceal calculus to the pyelon, the superior, middle or inferior calyx. The observers had to differentiate pyelocaliceal calculi from calcifications within the renal papilla or renal cortex. For the purpose of this study, any calcification located either in the renal papilla or the renal cortex was called parenchymal calcification. We did not use the term "nephrocalcinosis" since this term has been used not uniformly in literature with various meanings from microscopic calcification at time of necropsy to gross calcification evident only radiographically [4].

Calcifications located in the pyelocaliceal system were called pelvicaliceal calculi. Calculi located either at the ureteropelvic junction or in the ureter itself were not considered for further analysis in this study. In addition the observers measured the size of all calcifications in mm as well as the density in Hounsfield units (HU). All images were reviewed by using a local picture archiving and communication system (PACS) monitor (Impax 6.4; AGFA Healthcare, Mortsel, Belgium) with the possibility to perform multiplanar reconstructions. Measurements were performed with the metric software devices provided with the PACS workstation. Results were recorded in an electronic form with a reference sheet containing a renal schematic diagram (Filemaker 6.0, FileMaker Inc., Santa Clara/CA, USA).

2.4. Standard of reference

Results from URS were used as standard of reference. During URS our urologists always inspected the entire pyelocaliceal collecting system. For the purpose of the study only those calculi were analyzed which were described during surgery. If a calculus was not described at surgery, but present on MDCT data this was counted as a renal cortex calcification.

2.5. Statistics

Statistical analysis was performed by using statistical software (SPSS, version17.0.1, SPSS, Chicago, Ill). Descriptive statistics was used. Agreement between the three readers was determined by calculating kappa values. A kappa value of 0 indicated poor agreement; .01–.20 slight agreement; .21–.40, fair agreement; .41–.60, moderate agreement; .61–.80, good agreement; and .81–1.00, excellent agreement [5]. McNemar test was used to calculate differences with regard to interobserver agreement among the different observers. For calculation of size and density of the calculi mean values of all three readers are reported. Differences in measurement between the different readers were assessed with the McNemar test.

3. Results

According to the standard of reference of the 166 calculi 100 (60.2%) in 59 kidneys were located in the pyelocaliceal system, and 66 (39.8%) were located in the renal parenchyma (Table 1). Of the 66 renal parenchymal calcifications 19 calcifications (29%) were located in the papilla, whereas 47 were located in the renal cortex (71%). The distribution of calculi with regard to the pyelocaliceal system and the renal papilla is shown in Table 1.

The mean size of the calculi located in the pyelocalyceal system as measured on CT images was 4.3 mm (range 1–10 mm) with a mean density of 437 HU (range 43–1456 HU). Mean size of calcifications located in the parenchyma was 3.8 mm (range 1–14 mm) and the mean density was 273 HU (range 31–1157). Mean size of renal papilla calcifications was 2.3 mm (range 1–6 mm) with a mean density of 124 HU (range 30–244). There was no statistical difference among the three observers for measurement of either the size or the density of all calcifications ($p > .005$).

Of the 100 pyelocaliceal calculi 84 (84%) were correctly located on CT data sets by observer 1, 62 (62%) by observer 2, and 71 (71%) by observer 3 (Figs. 1 and 2).

In all three observers the differences mainly related to pyelocaliceal calculi of ≤4 mm in size (Fig. 3). Observer 1 classified 11 pyelocaliceal calculi as papillar calcifications, and none as renal calcification. Observer 2 classified 15 pyelocaliceal calculi as papillar