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Original article

The value of three-dimensional helical computed tomography for the retrograde flexible ureteronephroscopy in the treatment of lower pole calyx stones

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Abstract

Objective: The aim of our study was to determine if there is any advantage of three-dimensional helical computed tomography (3D-HCT) over intravenous urogram (IVU) for the retrograde flexible ureteronephroscopy in the treatment of lower pole calyx stones.
Methods: From June 2012 to January 2014, a total of 52 cases of lower pole renal stones underwent retrograde intrarenal surgery (RIRS) in our center. All patients underwent a preoperative IVU and three-dimensional helical computed tomography urography (3D-CTU) program to define the collecting system anatomy, manly concerning the following lower pole features; infundibulopelvic angle (IPA), infundibular length (IL), and infundibular width (IW). The examinations were performed in the same center of reference with a standardized method and with 3D-HCT Siemens Somaton Plus equipment. The measurements were performed by the same researcher, using a ruler and a square.
Results: Based on clinical threshold difference of the anatomic factors on an IVU image to compare the difference between an IVU image and a 3D-CT image of 52 patients, the IPA was <30° when measured on intravenous pyelography (IVP) for 21 patients. We found that with the IPA of <30° measured with IVP only 19% (4/21) were correctly classified in the same size category using 3D-HCT, whereas 81% (17/21) were upgraded to 40—50° on 3D-CT. This difference was significant between IVP and 3D-HCT.
Conclusions: 3D-HCT has advantages over IVU when analyzing the morphometric and the morphological features of kidney lower pole spatial anatomy for the retrograde flexible ureteronephroscopy in the treatment of lower pole calyx stones.

Keywords: Intravenous urogram; Computed tomography urography; Flexible ureterorenoscopy; Lower pole; Renal stones

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Introduction

The life-long incidence of stones in the population is 5–15%, and it has often been questioned whether gravity was the only factor responsible for lower pole lithiasis. The frequency of stones in the lower renal calyces had increased from 2% in mid eighties to 48% in the early nineties, which is roughly the same time as the widespread use of extracorporeal shock wave treatment (ESWL).[1] Over the past 20 years, based on the anatomical structure of the lower pole renal stones, a lower pole infundibu-lopelvic angle (IPA) of <45°, infundibular length >30 mm, and an infundibular width <5 mm are considered unfavorable for drainage of stone fragments.[1–4] These ideas are based on the SWL, and the anatomical topography of the inferior caliceal system plays an important role in the outcome of extracorporeal treatment, but along with better instrumentation and technology, these anatomic parameter are considered unfavorable for flexible ureterorenoscopy treatment.

The anatomy of the lower pole is classically studied in an intravenous urogram (IVU). However, IVU is being phased out of clinical practice as the imaging technique of choice, since CT is more frequently used in the diagnosis of urolithiasis. Along with the development of three-dimensional imaging in CT, three-dimensional helical computed tomography (3D-HCT) is a commonly used examination in the investigation of much renal pathology such as lithiasis, tumors, vascular anomalies and also in the study of the vascular anatomy in renal donors.

Although an European Association of Urology (EAU) guideline has already recommended that CT is preferable because it enables 3D reconstruction of the collecting system, as well as measurement of stone density and skin-to-stone distance. there are few prospective studies comparing the anatomical measurements of the lower pole collecting system obtained using IVU with those obtained using three-dimensional helical computed tomography (3D-HCT). A study reported[5] that there was no significant difference in the measurements of the lower IPA obtained with 3D-HCT when compared with values obtained with IVU. However, we found there are some differences between 3D-HCT and IVU in clinical practice.

Therefore, the objective of our study was to compare the morphometric evaluation of some features of the lower pole collecting system spatial anatomy that would be involved in fragment elimination after retrograde flexible ureteronephroscopy, using IVU and 3D-HCT.

Methods

From June 2013 to September 2014, a total of 52 cases of lower pole renal stones underwent retrograde intrarenal surgery (RIRS) in our center. All patients underwent a preoperative intravenous urogram (IVU) and three-dimensional helical computed tomography urography (3D-CTU) program to define the collecting system anatomy.

Patients were preoperatively evaluated with a history, physical examination, and image system (including a plain roentgenogram and ultrasound). Preoperative laboratory evaluation included urinalysis, urine culture, coagulation profile, serum creatinine level and complete blood count. The Institutional Ethics Committee on Human Research approved the study and all patients signed an informed consent.

This study compared the findings obtained using IVU and 3D-HCT, concerning the following lower pole features: IPA, infundibular width (IW), and infundibular length (IL). The examinations were performed with the same center of reference with a standardized methodology and with the 3D-HCT Siemens Somaton Plus equipment. The measurements were performed by the same researcher, using a ruler and a square. The patients who were allergic to the iodinated contrast medium as well as those who presented with a doubtful radiological analysis were excluded. All patients were informed that they would undergo two examinations.

The IPA was determined by the intersection of the infundibular axis (which is a line connecting the center of the pelvis with the bottom of the stone bearing calyx) and the ureteropelvic axis (which is a line connecting the center of the pelvis with a point in the upper ureter opposite the lower pole of the kidney). The IW was measured as the narrowest point in the axis of the lower infundibulum. The IL was measured as the distance between the most distal point of the calyx containing the calculus and the midpoint of the lower lip of the renal pelvis (Figs. 1–3).

All procedures were carried out with a URF-V digital flexible ureteroscope (Olympus, Tokyo, Japan) through a ureteral access sheath (Flexor ureteral access sheath with AQ Fus-120 04512/14F; Cook Medical, Bloomington, IN).

Statistical analysis was conducted comparing the IPA, IL, and IW obtained using 3D-HCT versus IVU. For the statistical analysis and comparison of the values obtained using the two examination methods, data were processed using SPSS-15 for Windows. The

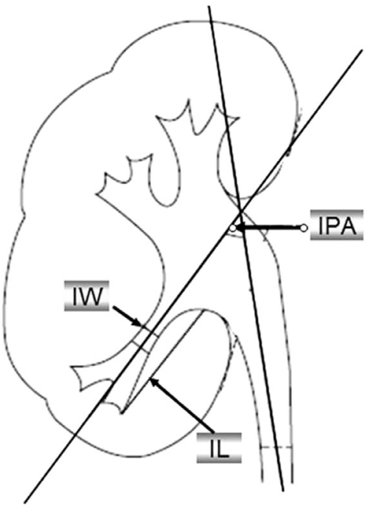

Fig. 1. Measurement of lower pole infundibular length, width and infundibu-lopelvic angle. IPA: infundibu-lopelvic angle; IW: infundibular width; IL: infundibular length.

results are presented as mean ± standard deviation. All of the parameters were analyzed statistically using the unpaired Student's t test and χ^2 test. A P value <0.05 was considered statistically significant.

Results

The mean age of patients was 36.6 ± 14.3 years (range, 21–55). There was a predominance of males, 41 male (78.8%) and 11 female (21.2%) patients in the analysis. For the lower IPA, a mean and standard deviation (SD) value of 68.65 ± 16.28 was obtained with 3D-HCT and 58.26 ± 17.73 with IVU. The median was 66.32 with 3D-HCT and 64.51 with IVU (a P-value of 0.03). For IL the mean was 33.15 ± 8.7 mm with 3D-HCT and 32.78 ± 9.1 mm with IVU. The median was 33 mm with 3D-HCT and 32 mm with IVU (a P-value of 0.26). For IW we obtained the following values; 4.68 ± 8.3 mm with 3D-HCT and 4.45 ± 6.8 with IVU. The median was 4 mm with 3D-HCT and 4 mm with IVU (a P-value of 0.26). The detailed results are shown in Table 1.

Based on clinical threshold difference of the anatomic factors on IVU images to compare the difference between IVU images and 3D-CT images of 52 patients, the IPA reported to be <30° was measured on IVP for 21 patients. We found that of the IPA of <30° measured on IVP, only 19% (4/21) were correctly classified in the same size category by 3D-HCT,

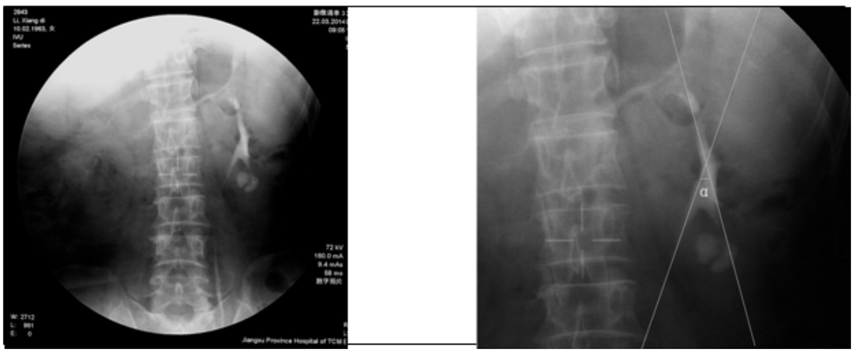

Fig. 2. Pelvicaliceal and ureteral excretory phase demonstrating the infundibulum-pelvic angle (IPA) measurement. In the same renal unit. Image obtained with intravenous urogram (IVU).

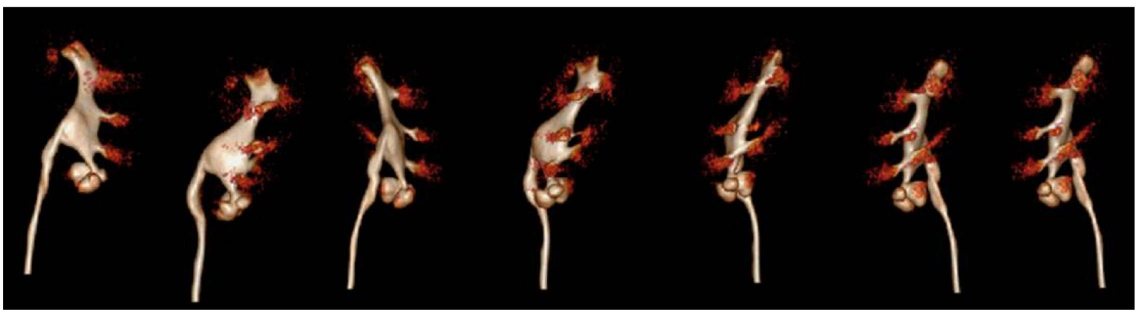

Fig. 3. Pelvicaliceal and ureteral excretory phase demonstrating the infundibulum-pelvic angle (IPA) measurement in the same renal unit. Image obtained with three-dimensional helical computed tomography.

Table 1
Lower pole measurements with IVU and 3D-CT.

Variable	IVU			3D-CT		
	Mean ± SD	Median	Range	Mean ± SD	Median	Range
IL (mm)	32.78 ± 9.1	32	9–40	33.15 ± 8.7	33	6–42
IW (mm)	4.68 ± 2.3	4	2–12	4.45 ± 2.8	4	3–10
IPA	68.65 ± 16.28	64.51	10–115	58.26 ± 17.73	66.32	10–110

IVU: intravenous urogram; IL: intravenous urogram; IW: infundibular width; IPA: infundibu-lopelvic angle.

whereas 81% (17/21) were upgraded to 40–50° on 3D-CT. This difference was significant between the results of IVP and 3D-HCT (Table 2). However there was no significant difference between the sizes measured for IL and IW using IVP and 3D-HCT.

The overall stone-free rate at the 1-month follow-up visit after initial treatment was 95.2% flexible ureterorenoscopy treatment.

Discussion

Current treatments for lower pole lithiasis include SWL, percutaneous nephrolithotripsy (PCNL), and retrograde ureterorenoscopy. The anatomical variations of caliceal infundibula and lower pole angles, as well as the complexity of the lower pole drainage system affect the success rates for each treatment chosen.[6,7]

Although SWL has advantages of noninvasiveness, minimal anesthesia, and better subjective acceptance, it is associated with lower stone-free rate (SFR) and higher retreatment rate for lower pole (LP) calculi. More findings led to the detailed study of calyceal anatomy, especially for the lower pole moiety. The first anatomic parameter evaluated was the infundibu-lopelvic angle (IPA), the second parameter evaluated was the infundibular length (IL), the third anatomic parameters were the infundibular width (IW). Over the past 20 years, based on the anatomical structure of the lower pole renal stones, people think a lower pole infundibu-lopelvic angle (IPA) of <45°, an infundibular length >30 mm, and an infundibular width <5 mm are considered unfavorable for drainage of stone fragments.[2–4,8,9]

These ideas are based on the SWL, the anatomical topography of the inferior caliceal system plays an important role in the outcome of extracorporeal treatment, but along with better instrumentation and technology, retrograde intrarenal surgery (RIRS) is increasingly used as a primary modality to treat lower pole calculi.[7,10,11] The retrograde endoscopic approach to lower calyceal calculi represents the latest result of technological advancement in the field of endourology.[5,7,11] Small caliber, flexible instruments with the use of holmium:YAG laser fibers and nitinol end baskets, as well as advanced access sheaths have improved access to the pelvicalyceal system and stone management. However, the lower pole calyceal (LPC) stone continues to be a challenge to the urological community. The complex anatomy of the lower pole collecting system, along with other factors like acute pelvi calyceal angle and narrow and long infundibulum, are some of the complicating factors affecting stone clearance[5,12–15]; these anatomic parameter are considered unfavorable for flexible ureterorenoscopy treatment. On the other hand, the anatomy of the lower pole is classically studied in an intravenous urogram (IVU).[2–4,6,8,9] However, IVU is being phased out of the clinical practice as the imaging technique of choice, since CT is more frequently used in the diagnosis of urolithiasis, along with the development of three-dimensional imaging in CT. Comparing 3D-CT versus IVP in the measurement of the anatomical predictors we need to ask which is more of an advantage.

There have been many studies assessing the impact of the collecting system anatomy and most think that the complex anatomy of the lower pole moiety factors, such as IPA, IL and IW, does impact the overall stone-free rate of flexible ureterorenoscopy treatment.[12–14] A study reported[15] that there was no statistically significant difference in the measurements of lower IPA, obtained with 3D-HCT when compared with those values obtained with IVU. In clinical practice we found there are some differences between 3D-HCT and IVU

Table 2
Difference between IVU image and 3D-CT image.

Variable	*n*	IVU	3D-CT	*P*
Infundibular length (mm) on IVU				
≤35	36	29.78 ± 7.6	30.53 ± 5.4	0.351
>35	16	40.73 ± 10.5	42.67 ± 11.5	0.247
Infundibular width (mm) on IVU				
≤5	38	4.37 ± 2.7	5.12 ± 1.5	0.560
>5	14	5.22 ± 3.2	5.32 ± 2.8	0.500
IPA on IVU				
≤30	21	26.37 ± 13.51	41.64 ± 15.32	0.002
>30	31	69.75 ± 18.68	67.55 ± 16.56	0.09

IVU: intravenous urogram.

when the flexible ureteroscopy was used to observe, such as some IPA of <30° measured on preoperative IVP, but the angle is often greater than 30° observed by the operating flexible ureteroscopy, and with the flexible ureteroscopy it is not very difficult to go to the lower pole. We find that for an IPA reported to be <30° measured on IVP, only 19% (4/21) were correctly classified in the same size category using 3D-HCT, whereas 81% (17/21) were upgraded to 40–50° on 3D-HCT. However this difference was not significant between the sizes measured for IPA >30°, IL and IW comparing IVP and 3D-HCT.

How to explain why the actual size of the IPA on IVP is lower than the size of the IPA from images of 3D-CT scan? The kidneys lie high up on the posterior abdominal wall behind the peritoneum, largely under the cover of the costal margin, and each kidney lies obliquely with its long axis parallel with the lateral border of the psoas major. As a result of this slight 'rotation' of the kidney, an anteroposterior radiograph gives a somewhat foreshortened picture of the width of the kidney. The same reasoning can explains why the IPA in IUP is smaller than the actual kidney.

Many techniques have been proposed for describing the pelvic anatomic parameter of the lower pole infundibular. The pioneering study of Sampaio and Aragao[3–4] investigated the anatomy of the lower pole calyces by reproducing the collecting system in 3D with the use of polyester resin casts. The anatomy of the lower pole has been classically studied with an intravenous urogram (IVU) in clinical practice.[5,12,13] However, IVU is being phased out of clinical practice as the imaging technique of choice, since CT is more frequently used in the diagnosis of urolithiasis; along with the development of three-dimensional imaging in CT.[11,14–16] Rachid Filho and colleagues[14] compared the 3D-HCT with IVU in defining the anatomy of the pelvicalyceal system, noting that although 3D-HCT is more precise for studying the calculus location, tumors, and vessels, IVU has also been demonstrated to be as precise as 3D-HCT for studying the lower pole spatial anatomy. However, they did not observe any statistically significant difference in the measurements of the infundibu-lopelvic angle (IPA) or the infundibular length and width obtained using 3D-HCT when compared with those obtained using IVU.

In view of its high accuracy and short acquisition time, non-contrast CT scans have now become the gold standard for the evaluation of patients presenting with urolisiasis.[14,17,18] It not only provides information regarding the presence and localization of stones but also other details that can help in the management plan, such as an anatomic parameter evaluation.[18] High quality multiplaner reformations with excellent temporal and spatial resolution can be generated from 3D-CT because of its ability to perform thin slice volumetric studies. It can display the inferior caliceal system along its longitudinal axis, thus improving the orientation of IPA without increasing the evaluation time.[18–20] Coronal images reformations from 3D-CT can provide important complimentary information for axial images, and also shown to improve the estimate of the IPA, IL and IW diameter, especially for the acute pelvi calyceal angle and narrow and long infundibulum that are oriented in the vertical plane. Another advantage of a coronal image is that it enables visualization of the kidney, ureter, and bladder simultaneously in a plane that is almost parallel to the orientation of these organs.[15]

Conclusions

3D-HCT present advantages over IVU when analyzing the morphometrics and the morphological features of the kidney lower pole spatial anatomy for the retrograde flexible ureteronephroscopy in the treatment of lower pole calyx stones.

Conflicts of interest

There is no conflict of interest.

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