ORIGINAL RESEARCH

Assessment of ureteric diameter using contrast-enhanced helical abdominal computed tomography

Ukamaka Dorothy Itanyi[1*] , Joshua Oluwafemi Aiyekomogbon[1], Felix Uduma Uduma[2]
and Matthew Abodunde Evinemi[3]

Abstract

Background: Assessment of ureteric size is imperative for diagnosis of urinary tract abnormalities especially with regard to obstructive pathologies. The ureteric opacification and distension obtained from contrast-enhanced computed tomography allows for differentiation from surrounding soft tissue and better assessment of ureteric diameter. Abdominal computed tomographic scans are commonly requested for the evaluation of the urinary tract, and we therefore aim to establish a normal reference value of the ureteral diameter using contrast-enhanced computed tomographic scans of the abdomen.

Method: With the purpose of establishing our local normogram of ureteric diameter, we did a retrospective study of archived images of 170 patients referred to the radiology department of a tertiary hospital for contrast-enhanced abdominal CT from January 2016 to June 2018. The largest transverse dimension along the course of the ureter beginning 1–2 cm below the ureteropelvic junction was measured at the delayed phase and obtained data subjected to analysis using SAS software version 9.3 with statistical level of significance set at 0.05.

Result: A total number of 340 ureters in 170 patients were analyzed with the mean age of 47.9 years (range 1.0–94.0 years) and male-to-female ratio of 1.2:1. The mean left ureteric diameter of all patients was 4.3 mm (range 1.7–8.0 mm) while the mean right ureteric diameter of all patients was 4.4 mm (range 1.5–8.0 mm). Ninety-five percent of ureters in our study measured 6.9 mm and less with no significant difference in ureteric sizes across gender and ages.

Conclusion: The mean CT normogram for ureteric caliber is 4.3–4.4 mm with no significant age and gender difference and 7 mm proposed as upper limit of normal.

Keywords: Ureter, Diameter, Contrast, Computed tomography

1 Background

The ureter has a narrow lumen, and measurement of its diameter can reveal information regarding its condition especially with regard to obstructive pathologies resulting from congenital aetiologies, ureterolithiasis, compressive abdominal mass or any other distal obstruction. Prolonged obstruction could lead to hydronephrosis and subsequent renal damage. Inflammatory processes of the urinary tract and adjacent to the ureter, such as appendicitis or diverticulitis, may also impair ureteral peristalsis and result in non-obstructive ureteral dilatation [1, 2]. Correct diagnosis of ureteral dilatation is imperative for patient management especially in subtle or borderline cases of ureteral calculi, small non-obstructive stones, low-density stones, periureteral calcifications and adjacent inflammations.

Unenhanced computed tomography, CT, is the imaging method of choice for evaluating patients with acute flank pain and suspected ureteral obstruction and offers

*Correspondence: amakaitanyi1995@gmail.com
[1] Department of Radiology, Faculty of Clinical Sciences, University of Abuja, Gwagwalada, Nigeria
Full list of author information is available at the end of the article

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unique advantages over older imaging methods such as excretory urography and sonography [3]. CT has the advantage of speed of acquisition of images and ability to precisely identify the cause and level of obstruction and at the same time allows assessment of the surrounding viscera as a cause of secondary obstruction, thereby obviating the need for cumbersome bowel preparation. Evaluation of the ureters on CT can, however, be difficult if the walls are not well visualized. This can be due to inadequate ureteral distension and opacification and paucity of retroperitoneal fat. These conditions are mostly noted with the use of non-contrast CT. There could also be confusion in differentiating the ureter from the surrounding vessels which are closely related to it. Contrast-enhanced CT on the contrary allows for distension and opacification of the ureteric lumen, thereby enabling better assessment of the diameter and differentiation from surrounding soft tissue. The above advantages of enhanced CT in elucidation of ureters explain our choice of this modality in this study. Published studies examining the size of the ureter as visualized on enhanced CT are, however, scarce. Having a normal reference range for ureteral diameter in our local environ is imperative in correctly diagnosing pathologies of the urinary tract especially in cases where direct obstruction is not elucidated. Our purpose is to establish ureteric normogram using enhanced helical CT of the abdomen.

2 Methods

The study is approved by the hospital ethical committee. Delayed images of triphasic scan of 170 consecutive patients who underwent contrast-enhanced abdominal CT scans in the radiology department of a tertiary hospital for abdominal CT from January 2016 to June 2018 were studied retrospectively. All CT examinations were performed using a HI Speed Advantage 16 slice CT scanner (TOSHIBA Medical). Images were acquired from the tops of the lower diaphragm through the bladder base using 5-mm-thick sections and a pitch of 1. The images were examined using soft tissue window settings on the scanner console at a level of 40 H and a width of 400 H. Visual inspection was used to determine the slice for the measurement. Included in the study were patients with adequate distension and opacification of both ureters established on 3D reconstructed images (delayed phase). For each patient and on each side, ureteral diameter was determined as the largest transverse dimension along the course of the ureter beginning 1–2 cm below the ureteropelvic junction (Fig. 1). Single measurements were taken by a general radiologist (with more than 10-years experience) of the widest contrast column along the course of each ureter with the use of electronic calipers. Statistical analysis was done using SAS software (SAS Institute,
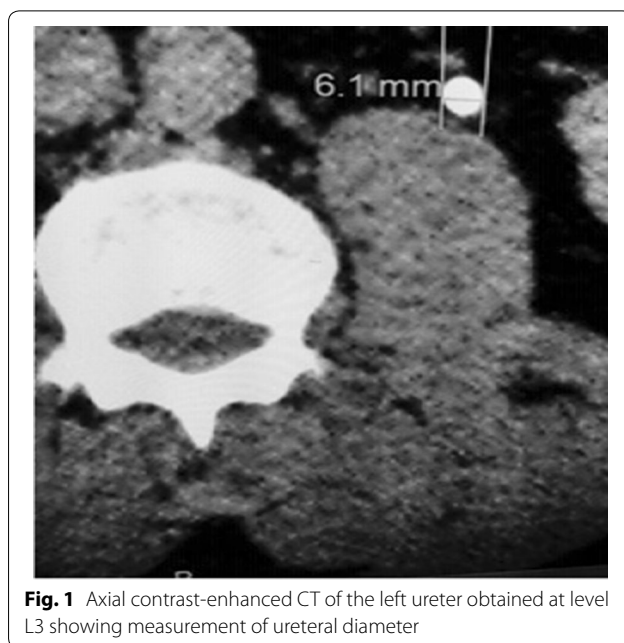

Fig. 1 Axial contrast-enhanced CT of the left ureter obtained at level L3 showing measurement of ureteral diameter

Table 1 Baseline characteristics for age

Characteristic	All 170 (100%)	Female 76 (44.4%)	Male 94 (55.6%)	P value
Age, years				
Mean ± SD	47.9 ± 16.6	47.4 ± 17.5	48.2 ± 16.0	0.7593
Min	1.0	1.0	3.0	
Max	94.0	94.0	85.0	
Mode	50.0	38.0	59.0	

P value is two-sample *t* test for comparison of mean values between sexes

Cary, North Carolina, USA) version 9.4. Graphical illustration was done with MS Excel. Excluded from the study were patients with clinical and radiologic impressions of urinary tract pathologies, obstructive, inflammatory or intra-abdominal pathologies which can affect the size of the ureters.

3 Result

A total of 170 patients out of 212 patients studied within the period satisfied our criteria and were analyzed. Each patient had two ureters; therefore, 340 ureters were studied since there was no case of ureteric duplication. The proportions of male-to-female participants in the study were about the same with a ratio of 1.2:1. Generally, the mean age of all patients was 47.9 years (range 1.0–94.0 years) with majority between the ages of 41–60 years ($n = 74$, 43.3%). There was no significant difference between the mean age of female (47.4 years) and male patients (48.2 years) (Table 1).

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Table 2 Characteristics of ureteric diameter among patients

Characteristic	All 170 (100%)	Female 76 (44.7%)	Male 94 (55.3%)	P value
Left ureter (mm)				
Mean ± SD	4.3 ± 1.4	4.3 ± 1.6	4.3 ± 1.2	0.3650
Min	1.7	1.7	2.1	
Max	8.0	8.0	8.0	
Mode	3.0	3.0	3.0	
Right ureter				
Mean ± SD	4.4 ± 1.4	4.4 ± 1.5	4.4 ± 1.3	0.4395
Min	1.5	1.5	2.2	
Max	8.0	7.7	8.0	
Mode	3.0	3.7	3.0	

P value is MWW two-sample test for comparison of mean values between sexes

Table 3 Comparison of mean ureteric diameter by age group of patients

Characteristic	N	Left ureter (mm) Mean ± SD	P value	Right ureter (mm) Mean ± SD	P value
Age group (years)					
1–20	7	4.6 ± 1.3	0.6937	5.0 ± 1.1	0.1276
21–40	54	4.5 ± 1.5		4.7 ± 1.4	
41–60	73	4.3 ± 1.3		4.2 ± 1.4	
61 and older	36	4.1 ± 1.4		4.2 ± 1.4	

The mean left ureteric diameter of all patients was 4.4 mm, SD 1.4 (range 1.7–8.0 mm) with 3.0 mm having the most occurrence (9.9%). Thirty-nine patients (22.8%) had left ureteric diameter that measured 3 mm or less. There was no significant difference between the mean left ureteric diameter of female (4.3 mm) and male patients (4.4 mm). The mean right ureteric diameter of all patients was 4.4 mm (range 1.5–8.0 mm) with 3.0 mm having the most occurrence (8.2%) with no significant difference between the mean right ureteric diameter of female (4.4 mm) and male patients (4.4 mm) (Table 2), with approximately 95% of all ureters measuring less than 7 mm.

An analysis of variance (ANOVA) indicated that age group had no significant effect on ureteric size (both left and right) of the patients (Table 3).

4 Discussion

The need for a definition of what constitutes ureteral dilatation cannot be overemphasized in view of the fact that correctly identifying ureteral obstruction may be crucial in arriving at a diagnosis. Direct visualization of the cause and level of obstruction with subsequent secondary effects like hydronephrosis and periureteral stranding ordinarily makes diagnosis straight forward. This picture is, however, not obtainable in all patients. Although urolithiasis is the commonest cause of acute obstructive disease, reports indicate that 5% of ureteral stones will not be revealed on CT [4].

It is equally very important to recognize ureteral dilatation in other non-obstructive causes of distension such as congenital anomalies of the urinary tract, chronic vesicoureteral reflux, urinary tract infections and inflammatory processes from organs adjacent to the ureter. Specifically, the cecum, appendix and ascending colon lie over the right ureter, and the descending and sigmoid colon lie over the left ureter [5]. The ureters also lie in close relation to the ovarian, uterine and iliac vessels placing them at risk of compression. Though a dilated ureter is a non-specific finding, the pattern of dilatation (unilateral vs bilateral) and other associated findings can help narrow the differential diagnosis [6].

Historically, urologists have used a variety of imaging modalities for evaluation of the ureters. These include plain radiography of the kidneys, ureters and bladder (KUB), intravenous urography, ultrasound, magnetic resonance urography (MRU) and CT, each with its advantages and limitations [7].

Over the past decade, CT urography has emerged as the primary imaging modality for evaluating the urinary tract in various clinical settings [8]. This is because of its ability to depict urinary tract anatomy and associated pathologies and its high sensitivity (97%) and specificity (96%) for detecting ureteral stone disease [4] which is the commonest cause of obstructive uropathies. Intravenous urography, the mainstay of urinary tract imaging for most of the twentieth-century, requires rigorous bowel preparation for evaluation of the anatomy [9] and is limited by the inability to visualize and evaluate the surrounding anatomy especially in cases of extraluminal compression and infections. Sonography, though cheaper, non-ionizing and readily available, is operator dependent, and the excess gas from the surrounding bowel limits the visualization of the mid- and distal ureters, thereby limiting its use in evaluation of ureteric size. Studies have shown excellent capabilities of MR urography in diagnosing urinary tract obstruction in adult and pediatric populations in view of its high soft tissue resolution [10, 11]. Its application is, however, limited because of the technical rigors of producing a high-quality examination and limited availability of expertise needed [11].

Previous studies and texts with some of them as ancient as 1970 and which were not based on modern modality like enhanced computed tomography have shown that ureteric diameters of less than 8 mm are generally considered to be normal [12–14]. Harnessing the advantages

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of CT has given us the direct evaluation of ureters which have been barely distended by the intravenously administered nonionic contrast medium. The mean ureteric diameter of 4.3–4.4 mm (95% confidence interval, 4.25–4.55) in our study is comparable to a later study by Wong et al. [15] which showed a mean diameter of the abdominal ureter to be 4.19 mm and upper limit of 4.5 using a 95% confidence interval. It is instructive to note that the absolute range is same for both studies. Like our study, there was no significant difference between the right and left ureteric diameter in both female and male subjects and no significant correlation between ureteric diameters and the age of subjects, from the second to the eighth decades. We can draw the conclusion that unlike the biliary tree which dilates with age, the ureters are expected to remain basically same through life. Although this investigation was done using conventional intravenous urogram, there is a strong correlation with our study. The similarity is most likely based on the fact that both studies unlike the earlier ones still involved the use of low osmolar intravenous contrast medium which exerts less osmotic effect on the ureteral lumen. However, our study went further to add a sectional or tomographic component. This added more credence to the obtained values since CT has an inbuilt arithmetic objective measurement of any desired parameter like abdominal ureteric diameter. Our technique also allowed us to exclude other causes of non-obstructive ureteromegaly which would ordinarily not be well evaluated with conventional IVU. Potenta et al. [6] in their published article mentioned ureteric diameter to be 3 mm using CT urography although the exact technique and level of measurement were not stated. Despite our mean value 4.3–4.4 mm, the mode of ureteric diameter is 3 mm. Our study differed from the study of Zelenko et al. [3] which showed mean unobstructed ureteric size of 1.8 mm (range 1–6 mm) with a standard deviation of 0.9 mm. They concluded that 3 mm should be used as upper limit of normal since 96% of the ureters measured 3 mm or less. Contrariwise, 95% of ureters in our study measured 6.9 mm and less while only 23% measured 3 mm and less. Unlike their study, our protocol involved the use of intravenous contrast which causes distension and opacification of the ureteric lumen, thus enabling better assessment of ureteric size and differentiation from surrounding soft tissue.

Although patients with clinical indications and radiologic evidence of urinary pathology were excluded from this study, it is still limited by the fact that bacteriologic investigations were not carried out to exclude covert urinary tract infections which can cause ureteral dilatation. Another limitation is the use of visual inspection and direct measurement with electronic callipers which may give room for individual variations in the assessment of ureteral diameter. There is therefore need for validation of an accurate and a more reproducible method of measurement to provide a more objective differentiation between non-dilated and dilated ureters.

Despite the limitations, the significance of this study is that we were able to assess the ureteric diameters without fear of incorporation of adjacent soft tissue structures. This is facilitated with the use of enhanced CT enabling us to establish our local normogram and contribute significantly to the existing literature.

5 Conclusion

The mean normogram for ureteric caliber in our environment using contrast-enhanced computed tomography is 4.3–4.4 mm. Using the same technique, 7 mm is proposed as the upper limit of normal for ureteric diameter on contrast-enhanced CT. No significant differences exist with age, sex or the right and left ureteric calibers.

Author details
[1] Department of Radiology, Faculty of Clinical Sciences, University of Abuja, Gwagwalada, Nigeria. [2] Department of Radiology, Faculty of Clinical Sciences, University of Uyo, Uyo, Nigeria. [3] Department of Radiology, University of Abuja Teaching Hospital, Gwagwalada, Nigeria.

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