Assessment of ureteral obstruction in patients with compromised renal function: Value of Curved Planar Reformations in MDCT

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Abstract  Objective: To evaluate the usefulness of MDCT using a curved planar reformation technique for the noninvasive assessment of the causes and level of ureteral obstruction in patients with compromised renal function.

Patients and methods: Between January 2012 and February 2013, 50 patients with clinical and sonographic manifestations of ureteral obstruction underwent non-contrast multidetector CT (MDCT) using a 16-slice machine. A total of 65 ureters were examined. Curved planar reformation images were performed to display the entire course of ureters in the same image. All patients had renal impairment with serum creatinine greater than 2.0 mg/dl. The gold standard for diagnosis of the cause of obstruction was ureteroscopy and/or open surgery. The sensitivity, specificity and overall accuracy of MDCT using curved planar reformation in the diagnosis of ureteral obstruction were calculated in comparison with the gold standard.

Results: A total of 65 ureters were examined (35 unilateral, 15 bilateral). The most common cause of ureteric obstruction was ureteric stone representing 27/65 (41.5%), followed by ureteric stricture representing 23/65 (35.4%). The lower third was the most affected in our study, it was encountered...
in 38/65 ureters (58.46%). The total sensitivity, specificity and accuracy of CPR for the cause of the ureteric obstruction were 98.5%, 98.5% and 97.8%, respectively (P value >0.05). CPR also was more sensitive and accurate for the level of ureteral obstruction with a total sensitivity of 100% and accuracy of 100% (P value >0.001).

Conclusion: Curved planar reformation MDCT is a useful noninvasive technique which is accurate in diagnosing the cause and level of ureteral obstruction in patients with compromised renal functions and is helpful for planning the therapeutic management of such patients.

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1. Introduction

Ureteric obstruction with subsequent hydronephrosis is the terminal outcome of most urological disorders. It can be classified into congenital and acquired, intraluminal or extraluminal. Many imaging modalities are used to evaluate the obstructive uropathy such as plain X-ray of the urinary tract combined with abdominal gray-scale ultrasonography and excretory urography, other methods of visualizing the ureteric obstruction e.g. retrograde or antegrade pyelography or ureteropyeloscopy, are invasive (1). In the last decades some recent noninvasive investigations have been introduced for the diagnosis of ureteral obstruction, e.g. the renal resistive index,(2) non-contrast MDCT(3–5) and magnetic resonance urography with their ability to image the urinary tract in ways that exceed the excretory urography (6).

With the revolution of multidetector technology, multidetector CT urography has become the imaging modality of choice for many urologic problems (7). The main advantage of multidetector CT urography is its ability to provide a detailed anatomic depiction of each part of the urinary tract (8). It also offers several advantages for imaging of the obstructive uropathy including: single breath-hold coverage of whole urinary tract and the possibility to use different post processing techniques in addition to native axial images such as multiplanar reformation, curved planar reformations, maximum intensity projections and volume rendering technique (9,10).

MDCT has gradually evolved as an accepted method for an assessment of patients with flank pain or hematuria (11,12). The main advantage of CT urography over excretory urography is its ability to show the intraluminal, mural and extraluminal of the urinary tract (13,14).

Curved planar reformations are single images obtained by tracing a curved path through the imaging volume along the course of a particular anatomic structure of interest. The volumetric data set is displayed by a path-tracing tool into a 2D image representing the tortuous plane described by the structure of interest. The exact algorithm used to create the image

![Fig. 1](image-url) 59-Year-old male patient with right loin pain. Multidetector computed tomography axial (A and B) and curved planar reformation images (C) show atrophic left kidney, dilated right pelvicaliceal system and right ureter down to the lower third due to obstructing radiodense stone.
can vary, but in general, once a path has been traced, data points for the image are generated using linear interpolation in three dimensions. The output is a single image in which the resultant pixel dimension is equal to the smallest pixel dimension in the native acquisition (15).

Curved planar reformations permit even the most tortuous anatomy to be unwound and displayed along its long axis while preserving the gray-scale contrast of the original data acquisition. Curved planar reformations can illustrate complex anatomy and pathology in a single image, thus serving as a useful tool. Our referring clinicians typically want to view only a few illustrative images of their patients rather than the large data sets of the native acquisition, and curved planar reformations have become essential for that purpose (15). The aim of our study was to evaluate the usefulness of MDCT using a curved planar reformation technique for the noninvasive assessment of the causes and level of ureteral obstruction in patients with compromised renal function.

2. Patients and methods

2.1. Patient population

This study was approved by the local research ethics committee of our institution, and informed consent for the procedure was obtained from each patient.

Between January 2012 and February 2013, 50 patients (30 males and 20 females, age range, 28–64 years; mean age, 45.0 years ± 12.8[SD], were referred from Urology Clinic with a diagnosis of unexplained ureteral obstruction based on ultrasound and plain radiography findings, with unilateral or bilateral ureteral obstruction and IVP was contraindicated due to renal impairment with elevated renal function tests (serum creatinine level >2.0 mg/dL). Patients were referred for MDCT as a part of investigatory work up.

2.2. MDCT technique

MDCT examinations were performed for all patients using a 16-detector CT scanner (Somatom, E-motion 16, Siemens Healthcare; Germany). Patients were prepared by giving 800–1000 mL of water over a 20- to 30-min period before the start of a renal CT examination and no intravenous contrast material was administered. The acquisition parameters were 120 kVp, 350 mAs, a helical pitch of 1.375:1, 0.6-s gantry rotation time, table speed of 53 mm per rotation, 16×0.625 mm detector configuration, 18.4-s total exposure time, 0.625 mm helical slice thickness, and 0.625 mm reconstruction interval with a large FOV. The axial source images with a 0.625-mm slice were transferred to a dedicated workstation (Wizard, Siemens Healthcare), and curved planar reconstructions were performed by specially trained CT technologists. Curved planar reformatted (CPR) images were performed to display the entire length of ureters in the same image. It was obtained manually by drawing a line over the course of the ureter.

2.3. Image analysis

The non-contrast axial, coronal and post-processing images of CPR were reviewed for the detection of the cause and level of ureteral obstruction. There were certain diagnostic criteria to differentiate intrinsic from extrinsic causes of ureteral obstruction as reported by Shokeir et al. (1): an abrupt change in ureteral caliber on axial as well as reconstructed images was suggestive of intraluminal lesion, while gradual tapering of...
the ureter with no intraluminal mass or filling defect was indicative of mural or extraurinary cause. On NCCT a hyperdense focus within the ureter was diagnostic of a calculus, while an intraluminal mass of soft tissue density was considered a sign of tumor. Extra-ureteral lesion was diagnosed according to the mass effect, and the specific density on NCCT.

2.4. Statistical analysis

The diagnostic efficacy of the MDCT with curved planar reformation images was evaluated and compared with ureteroscopy and/or open surgery findings, which is considered the gold standard of reference. The sensitivity, specificity and overall accuracy of CPR in the assessment of the cause and level of ureteral obstruction were calculated in comparison with the gold standard. Data entry was done by SPSS version 13 and analyzed by the same software. A \( P \) value > 0.05 was considered significant.

3. Results

This study included 50 patients (30 males, 20 females), age range was from 28 to 64 years (mean age was 45 years). All patients had renal impairment with serum creatinine greater than 2.0 mg/dl. Therefore, IVP and CT with contrast medium were contraindicated. The most common clinical presentation of ureteric obstruction was loin pain representing 70%. The clinical data and relevant patient’s past history are listed in Table 1.

A total of 65 ureters were examined (35 unilateral, 15 bilateral). The most common cause of ureteric obstruction was ureteric stone representing 27/65 (41.5%), followed by ureteric stricture representing 23/65 (35.4%). The lower third was the most affected in our study, it was encountered in 38/65 ureters (58.46%). The cause and level of ureteral obstruction as detected by MDCTU are listed in Tables 2 and 3.

According to the final ureteroscopy and surgical findings, the sensitivity, specificity and accuracy of CPR in detecting the cause and level of ureteric obstruction were calculated. The total sensitivity, specificity and accuracy of CPR for detecting the cause of ureteral obstruction were 98.5%, 98.5% and 97.8%, respectively (\( P \) value < 0.05). Regarding the detection of ureteral obstruction level, CPR was more sensitive and accurate with a sensitivity of 100% and accuracy of 100% (\( P \) value > 0.001) Results are listed in Table 4, Figs. 1–5.

4. Discussion

Since the introduction of MDCT technology, CT urography is gaining a dominant role as fast, accurate, and comprehensive imaging technique for the entire urinary system, including native and transplanted kidneys, collecting systems, ureters, and the urinary bladder (12).
Fig. 3  75-Year-old female patient with left loin pain. Multidetector computed tomography axial (A–C) and curved planar reformation images (D) show atrophic right kidney with marked left hydro-uretero-nephrosis and curved planar reformation determines clearly the cause and level of obstruction (stricture lower third left ureter). Non obstructing two stones; seen at the mid-third and lower third left ureter.

Fig. 4  35-Year-old female patient with bilateral loin pain. Multidetector computed tomography axial (A and B) and curved planar reformation images (C) shows atrophic hydronephrotic left kidney, hyperdense stone impacted in the upper third right ureter with proximal marked hydro-ureteronephrosis.
A wide variety of pathological processes, intrinsic and extrinsic to the ureter can cause ureteric obstruction, the kidneys and bladder are commonly well seen in a variety of planes, but the ureter is rarely seen in its entirety on a single image. Curved planar reformations can be useful in illustrating the presence of stones, intraluminal and extraluminal lesions in the ureters (15).

In the present study, curved planar reformatted images were used to display the entire course of the dilated ureters in a single longitudinal uninterrupted image and hence better intraluminal and extraluminal assessment and accurate detection of the level of obstruction. Cademartiri et al., (16) stated that the most important advantage of this technique is visualization of both opacified and unopacified ureters. He postulated that CPR images could be obtained manually by drawing a line over a structure of interest or it can be produced automatically by a dedicated software. In this study curved planar reformatted images were obtained only manually by drawing a line over the dilated ureters using workstation (Wizard, Siemens Healthcare).

In this study the most common cause of ureteric obstruction was the ureteral stone which represented 41.5% of all cases. This was in agreement with Chevalier et al., and Shokeir et al., (17,1) who reported that ureteral obstruction is usually a consequence of nephrolithiasis which is the most common cause of urinary obstruction.

This not in agreement with Basiri, et al. (18) who reported that the incidence of ureteral stones ranges between 2% and 20%, this discrepancy can be explained by the fact that 42.0% of our patients had a previous history of bilharziasis, a common association of bilharziasis and stones was addressed by Shokeir et al., and Ghoneim, (1,19) who reported that urinary stasis in dilated atonic ureter invites secondary bacterial infection and stone formation.

The second most common cause of obstructive uropathy in our study was the ureteric stricture with an incidence of 35.4%, this can be attributed to the high incidence of bilharziasis (42.0%). In Egypt; the prevalence of Schistosomiasis hematobium in endemic areas in Egypt ranged from 4.8% to 13.7% and averaged 7.8% (20). Ghoneim, (19) postulated that bilharzial ureteritis healed with variable degrees of mural fibrosis with a loss of muscle and peri-ureteric adhesions that lead to ureteric stricture.

In the current study, the lower third ureter was the most common level of obstruction (58.46%), this was in agreement with several authors who reported that the main site of bilharzial strictures occurred in the lower third of the ureter (20–22). The current study demonstrated that CPR exhibits a higher sensitivity and accuracy in depicting the cause of ureteric obstruction, this was statistically significant (P > 0.05). The total sensitivity and accuracy of CPR for the determination of the cause of the ureteric obstruction were 98.5% and 98.5%, respectively. We believe that the most important advantage of CPR is that it could clarify the unopacified ureters, thus it could be used in the case of severe urinary obstruction with
non-excretory function, in addition to visualization of the ureteral environment including, soft tissue and associated extraluminal pathology.

In this study, CPR could not detect the cause of obstruction in one patient (false negative) which is interpreted as normal, showed normal ureteric wall, with no thickening or evident stricture and mild backpressure changes, by ureteroscopy ureteric stricture was detected.

CPR was highly sensitive (100%) in detecting the level of ureteric obstruction with an accuracy of 100%, this was statistically highly significant ($P < 0.001$). This was in accord with data published by Kim et al., (23) who reported that if contrast material does not adequately fill the dilated ureter in the case of severe obstruction, CPR is more helpful.

In conclusion, curved planar reformations MDCT is a useful noninvasive technique which is accurate for diagnosing the cause and level of ureteral obstruction in patients with compromised renal functions and is helpful for planning the therapeutic management of such patients.

**Conflict of interest**

Authors reported agreement and no conflict of interest.

**References**