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CT-VIRTUAL ENDOSCOPY OF THE URINARY TRACT

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ABSTRACT

Objective: To demonstrate the various applications of CT-virtual endoscopy, for the assessment of urinary tract abnormalities

Materials and Methods: Sixty-three patients were evaluated by CT-virtual endoscopy (49 CT-cystoscopy; 14 CT-pyeloureteroscopy). CT-cystoscopy was obtained for follow-up of bladder tumor (n=21), radiologic suspicion (n=12) or radiologic evidence of urinary tract lesion (n=16). CT-pyeloureteroscopy was done due to neoplasm (n=5), calculi (n=3) and extrinsic compressions (n=3).

Results: In 49 patients submitted to CT-cystoscopy, 27 tumors were detected intraoperatively (ranging 0.5-4.8cm). CT-cystoscopy revealed 21 tumors (78%); all tumors larger than 0.6 cm were detected. Tumor within a bladder diverticulum was seen by CT-cystoscopy but not by endoscopy, in two patients. Useful additional information such as extension of tumors into the anterior portion of the bladder neck (n=2) and adequate characterization of bladder diverticulum in a child (n=1) was also obtained. CT-pyeloureteroscopy detected 6 of 9 tumors (67%), and was useful in the differential diagnosis of pelvic/ureteral tumor *versus* calculi (n=8) and intrinsic versus extrinsic ureteral lesion (n=3).

Conclusion: CT-virtual endoscopy is a useful procedure, particularly in the following situations: a)- Follow-up of bladder tumors; b)- Complimentary evaluation of areas of difficult approach by endoscopy; c)- Differential diagnosis of intrinsic versus extrinsic lesion of the renal pelvis and ureter.

Key words: urinary tract, imaging; bladder; ureter; neoplasms; diagnostic imaging; CT, endoscopy
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INTRODUCTION

Recently CT-virtual endoscopy has been introduced to the imaging armamentarium for use in the evaluation of urinary bladder (1-7). CT-virtual endoscopy in the evaluation of bladder (CT-cystoscopy), has been described in several studies in the literature but its utility for evaluation of the pelviocaliceal system (CT-pyeloureteroscopy), has illustrated only sporadically (8,9). Our purpose is to demonstrate the various applications of CT-virtual endoscopy, for the assessment of the abnormalities found in the bladder, pelviocaliceal system, and ureter.

MATERIALS AND METHODS

CT-cystoscopy

Was performed in 49 patients. After voiding, a 12F Foley catheter was inserted into the bladder and residual urine withdrawn. The bladder was then distended with 300-400mL of air. After a scout view for adequate planning, helical CT of the bladder was then obtained with patient in the supine and prone position (3mm in thickness, reconstructed at 1.5mm, "pitch" 1, and 120 kV-230 MA). The data was sent to an independent workstation for evaluation of the 2-D axial scans and to generate intraluminal views of the bladder (CT-endoscopic navigator system and the use of a threshold surface rendering technique).

CT-pyeloureteroscopy

This procedure was utilized as a complimentary technique of CT-urography in 14 patients with signs of urinary tract obstruction (dilation larger than 0.5cm). CT-urography was performed with intravenous administration of 150mL of nonionic low osmolarity contrast agent, enabling homogeneous, dense opacification by contrast material of the pelviocaliceal system and ureters. Using a CT endoscopic navigator system at a computer workstation and a 100 to 150 HU of the lower threshold and upper threshold maximum the CT-pyeloureteroscopic images were generated .All intraluminal navigation study was performed by the same radiologist (author). A complete CT-cystoscopic or ureteroscopic examination, including the acquisition and interpretation of images, required approximately 30 minutes. Images were then correlated with surgical and pathological findings in all patients.

RESULTS

CT-cystoscopy

Forty-nine patients presenting 27 tumors at surgery (ranging 0.5-4.8cm), were submitted to CT-cystoscopy. Twenty-one (78%) of 27 lesions detected intra-operatively were visualized with this technique. This procedure allowed readers to identify 21 of 21 masses (100%) larger than 0.6cm. On the other hand, 6 lesions ranging from 0.25 to 5.5mm were missed. Our results were distributed according to their main clinical applications:

a)- Follow-up of bladder tumor: 8 tumors were detected in 19 patients in the follow-up for bladder cancer (Figure-1);

b)- Patients with hematuria presenting radiologic suspicion or normal findings on axial CT images. In this group consisting of 16 patients, we detected 6 tumors. Three patients showed tumor in bladder dome and bladder base, which was not visualized in axial CT, images (Figure-2);

c)- Complimentary study of areas of difficult evaluation by conventional cystoscopy. This was the indication of CT-cystoscopy in 8 patients. Useful additional information such as extension of tumors into the anterior portion of the bladder neck was demonstrated in 3 patients (Figure-3);

d) Evaluation of bladder diverticulum with small opening. Three tumors within a bladder diverticulum were seen by CT-cystoscopy but not by endoscopy, in 2 patients (Figure-4). Adequate characterization of bladder diverticulum in a child (n=1) was also obtained (Hutch diverticulum);

e) Differentiation between intraluminal and extraluminal bladder wall mass: In this group, 4 tumors were identified and in 3 patients, it was difficult to establish the origin of the bladder mass based on conventional radiologic procedures. CT-cystoscopy accurately demonstrated the intraluminal origin or component of the mass in these patients by showing either a irregular surface of the lesion or the presence of a lesion with a narrow base (Figure-5).

CT-pyeloureteroscopy

The presence of minimal dilatation was sufficient for adequate intraluminal evaluation of the pelviocaliceal system and ureter, which was done in 14 patients (Figure-6). In 11 of these patients, a filling defect in the renal pelvis, or ureter, or ureteral strictures was observed. Gross examination of 6 resected kidneys and ureters, and 3 ureters revealed 9 tumors (0.3 to 1.7cm) and 2 intrinsic, and 1 extrinsic ureteral strictures. CT-pyeloureteroscopy detected 6 of 9 tumors (67%), all larger than 0.4cm in diameter and was useful for the correct diagnosis of intrinsic versus extrinsic ureteral lesions in these 3 patients and for the demonstration of urinary calculi as the cause of the filling defects in the remaining 2 patients.

DISCUSSION

Conventional endoscopy plays a key role in the diagnosis of urinary tract tumors due to its capability of detect subtle alterations in mucosal-texture and to allow direct resection with or without mucosal biopsy.

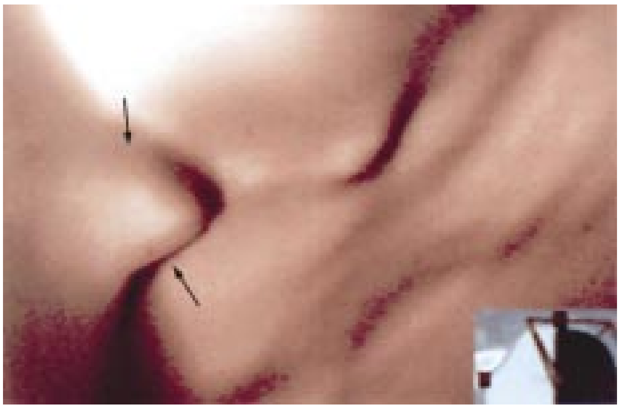

***Figure 1** - CT-cystoscopy in a 53-year-old man in the follow-up for bladder cancer, demonstrates a sessile 0.6cm in diameter lesion (arrows), confirmed as transitional cell carcinoma.*

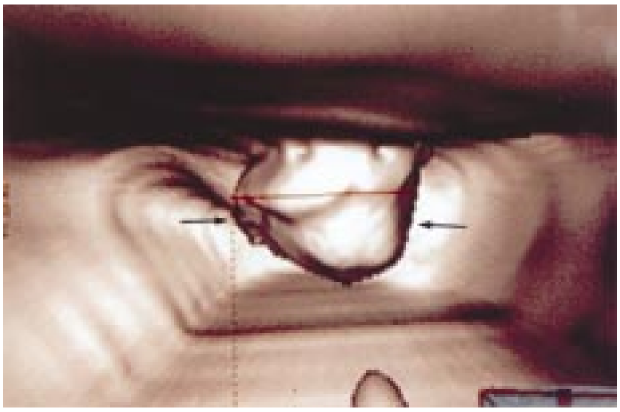

***Figure 2** - A sessile lesion with irregular surface (arrows) on the bladder dome is identified on CT- cystoscopy but was not detected on axial sections of helical CT.*

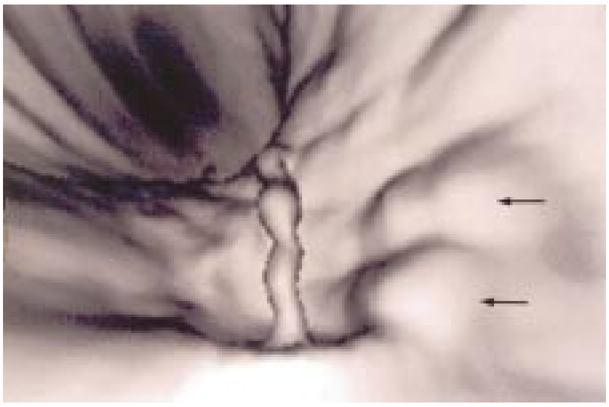

***Figure 3** - An irregular, flat-solid infiltrating tumor (arrows) close to the bladder neck is very well demonstrated by CT-cystoscopy.*

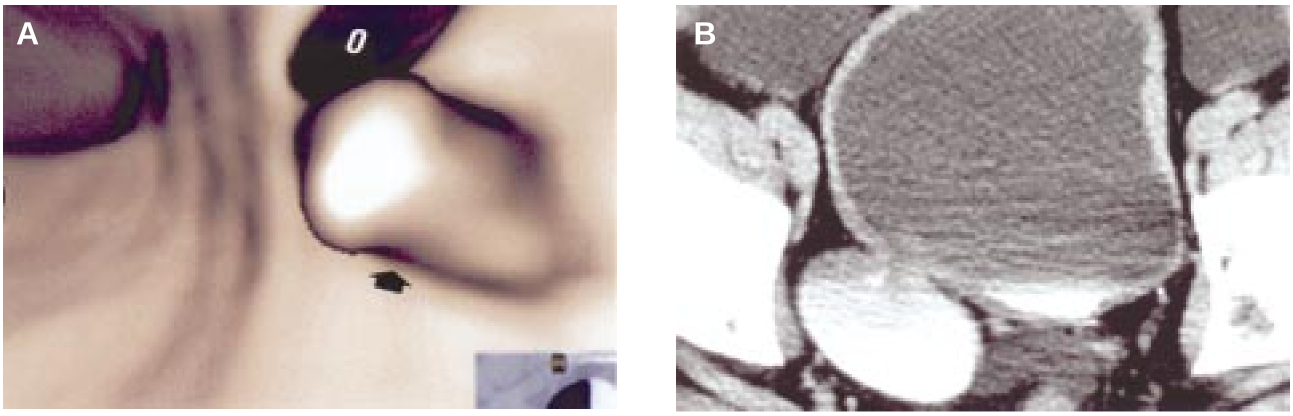

***Figure 4** - A)- CT-cystoscopy of a bladder diverticulum in a 48-year-old-man with hematuria, reveals a smooth surfaced polyp (arrow), within the diverticulum and close to its opening (O). B)- This polyp was not identified on axial CT images or on conventional endoscopy.*

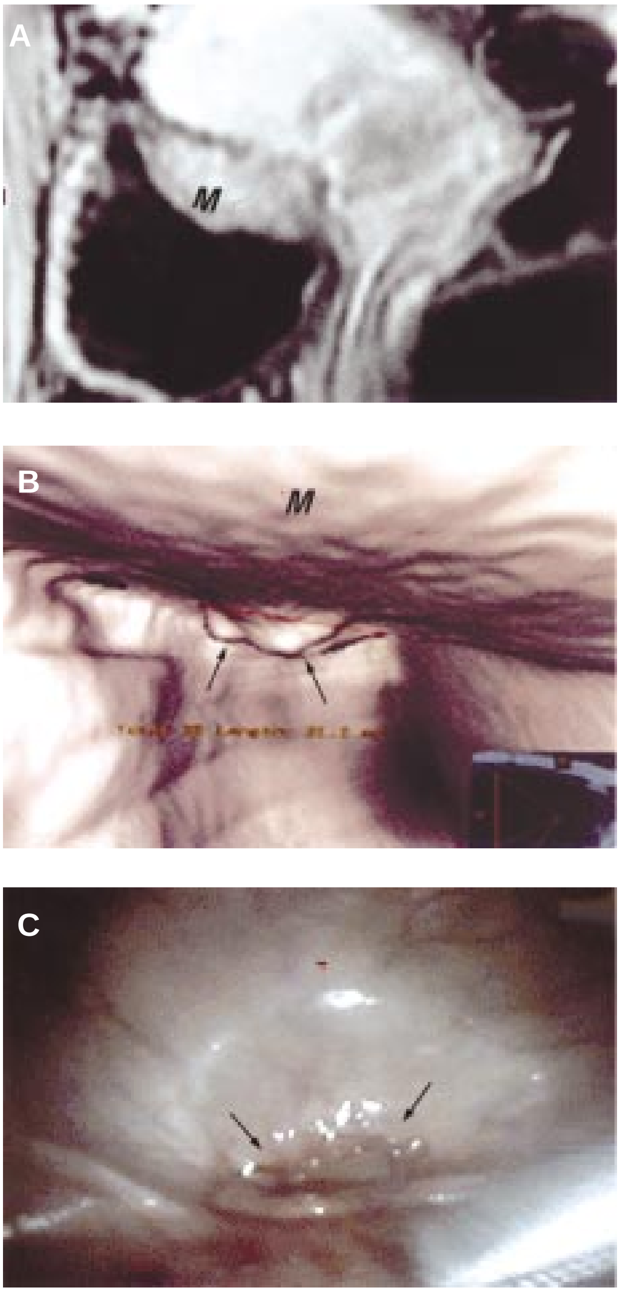

Figure 5 *- A 32-year-old-woman with hematuria during menstrual periods. A)- Magnetic resonance imaging of the pelvis (sagital, T1W-fat sat post-gadolinium image) shows the presence of a solid and enhanced mass (M), with a broad base located in the posterior bladder wall suggestive of extraluminal origin B)- CT-cystoscopy confirmed the broad base mass but revealed the irregular surface of the lesion representing mucosal irregularities. C)- This feature was confirmed by conventional endoscopy and represented an ulcerated (arrows) endometriosis of the bladder wall.*

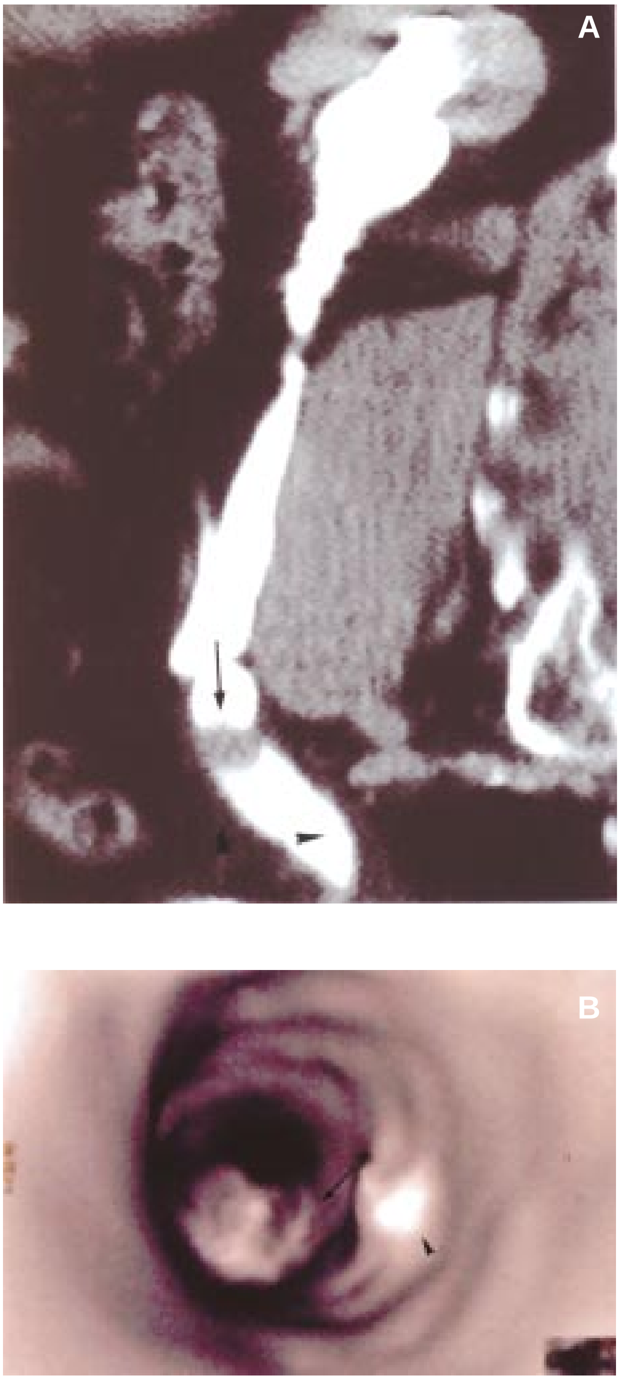

Figure 6 *- A 58-year-old-man with acute flank pain and hematuria. A)- CT-urography reveals mild pelviocaliceal and ureteral dilatation and a filling defect (arrow) in the lower third of right ureter. Signs suggestive of a second smaller lesion close to vesico-ureteral-junction was observed (arrowhead). B)- CT-ureteroscopy confirmed the presence of 2 sessile irregular lesions (arrow and arrowhead), confirmed as pT2 transitional cell carcinoma.*

Helical CT with its continuous acquisition of volumetric data enables the presentation of acquired data in three-dimensional images. CT-virtual endoscopy using surface rendering techniques enables imaging of the interior of a hollow viscera or organ by extracting CT numbers only from the boundary regions between the organ walls and the contrast agent. A great difference in CT attenuation between the exterior and lumen of the organ is necessary to generate CT endoscopic images. For virtual cystoscopy, inflated air is used and for the CT-pyeloureteroscopy, the high CT attenuation of the intraluminal contrast. With a CT endoscopic navigator system in the workstation, standard axial, sagital coronal and oblique reference images are automatically obtained. Using an appropriate threshold level in order to avoid artificial defects, and adequate trackball real-time angles and cut planes of the interiors of the organ of interest are displayed. By this technique the viewpoint of the observer can be manipulated through 360 degrees in any axis and within the bladder (CT-cystoscopy) all the internal surface of the organ can be evaluated, particularly the anterior bladder neck and the bladder base which are difficult areas for the conventional cystoscopy. Other applications of CT-cystoscopy are in patients with urethral stricture (which precludes conventional cystoscopy) and in the follow-up of bladder tumors since its recurrence is common mainly in cases of multifocal or high-grade lesion. In this clinical setting, CT-cystoscopy depicted in our study all lesions larger than 0.5cm.

Since lesion on the dome or base of the bladder can be missed in axial images (due to the limitation of Z-axis resolution of CT), sets of axial images and intraluminal views must be used for accurate radiologic detection of these lesions. Axial images are essential for evaluation the extraluminal component of the tumor and the presence of nodal metastasis. CT-virtual endoscopy offers the possibility of evaluate the surface morphology of the lesion, this is an important additional radiologic finding that must be reported since polypoid pedunculated lesion is usually low grade cancer and mostly flat solid infiltrating tumors are high grade lesions (10). CT-cystoscopy has important limitations such as detect subtle mucosal color changes (carcinoma ”in situ”) and impossibility to provide tissue analysis by the biopsy.

CT-pyeloureteroscopy may occasionally be possible in normal structures, but has better results in patients with some degree of urinary tract dilation (above 0.5cm). The use of furosemide has been shown useful for distinguishing ureteral tumors from ureteral strictures. Since we performed virtual endoscopy only in patients with sufficient urinary tract dilatation, the use of furosemide, was not necessary.

With this technique, sensitivity and specificity for detecting ureteral tumors and carcinoma were 81% and 100% respectively (9).

We considered our clinical data set too small to determine the overall accuracy of this method.

CONCLUSION

CT-virtual endoscopy (CT- cystoscopy, CT-pyeloureteroscopy) is not a competitive technique to conventional endoscopy of the urinary tract; on the contrary, it has been proved a useful complementary tool. CT-virtual endoscopy can be helpful for visualizing the complex morphology of urinary tract tumors (particularly lesions larger than 0.5 cm in diameter) and distinguishing tumor from calculi or from strictures. Other important application is for the differential diagnosis of intrinsic versus extrinsic lesion of the renal pelvis, ureter, and bladder. CT-virtual endoscopy is a promising and evolving technique ant its role is still to be determined, but this technique probably will have an important role in the diagnosis of urinary tract tumors because an increase number of ideal surgical candidates for uretero-nephroscopic resection will be identified.

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