Virtual cystoscopy: the evaluation of bladder lesions with computed tomographic virtual cystoscopy

Osman Raif Karabacak, MD;[*] Esin Cakmakci, MD;[†] Ufuk Ozturk, MD;[*] Fuat Demirel, MD;[*] Alper Dilli, MD;[†] Baki Hekimoglu, MD;[†] Ugur Altug, MD[*]

See related article on page 38.

Abstract

Purpose: Our objective was to assess the accuracy of computed tomographic virtual cystoscopy (CTVC) in the detection of urinary bladder lesions.

Methods: Twenty-five patients were examined using CTVC. Bladder scanned using multislice CT at a slice thickness of 1 mm. The data were transferred to a workstation for interactive navigation using surface rendering. Findings obtained from CTVC were compared with results from conventional cystoscopy and with pathological findings.

Results: Thirty-eight lesions were identified. The smallest was 0.2 × 0.3 cm; the largest was 7 × 4.5 cm. Both CTVC and conventional cystoscopy were used. Conventional cystoscopy detected the same number of lesions that were detected by CTVC. On morphological examination, 26 of the lesions were polypoid, 7 were sessile and 5 were bladder wall-thickening. While one of the polypoid lesions was reported as an inverted papilloma, 2 of the 5 lesions that were identified as wall-thickening were malignant and 3 were benign. The sensitivity of using CTVC to identify neoplasias was 100%; the accuracy was 89%.

Conclusion: Although the definitive diagnosis of some suspected urinary bladder tumours is only possible with conventional cystoscopy and biopsy, CTVC is a minimally invasive technique which provides beneficial information about urinary bladder lesions.

Cite as: *Can Urol Assoc J* 2011;5(1):34-7; DOI:10.5489/cuaj.10002

Résumé

Objectif : Notre objectif était d'évaluer l'exactitude d'une cystoscopie virtuelle avec tomographie par ordinateur (CVTO) pour le dépistage de lésions de la vessie.

Méthodologie : Vingt-cinq patients ont été examinés par CVTO. Les vessies ont été examinées par TDM multicouches par coupes de 1 mm. Les données ont été transférées à un poste de travail pour navigation interactive à l'aide d'un rendu de surface. Les résultats obtenus par CVTO ont ensuite été comparés aux résultats obtenus par cystoscopie classique et aux résultats histopathologiques.

Résultats : Trente-huit lésions ont été observées. La plus petite mesurait 0,2 x 0,3 cm, et la plus grande, 7 x 4,5 cm. On a eu recours à la CVTO et à la cystoscopie classique. Le même nombre de lésions a été décelé par cystoscopie classique et par CVTO. Lors de l'examen morphologique, 26 lésions se sont révélées polypoïdes, 7 étaient sessiles et 5 étaient des épaississements de la paroi vésicale. L'une des lésions polypoïdes a été classée comme un papillome inversé; 2 des 5 lésions classées comme des épaississements de la paroi vésicale étaient malignes et 3 étaient bénignes. La sensibilité de l'examen par CVTO dans le dépistage des néoplasies était de 100 %, alors que l'exactitude était de 89 %.

Conclusion : Même si le diagnostic définitif de certaines tumeurs vésicales potentielles n'est possible que par cystoscopie classique et biopsie, la CVTO est une technique minimalement invasive offrant des informations utiles sur les lésions situées dans la vessie.

Introduction

In western countries, urinary bladder tumours are the fourth most common cancers in men (after prostate, lung and colon cancers); in women, bladder cancer ranks eighth.[1] Bladder tumours are 4 times more common in men. A classic sign of bladder cancer is painless hematuria. During the initial diagnosis, 70% of the cases are superficial, whereas in the remaining 30% the neoplasia has invaded the muscle.[2] One of the most important problems with urinary bladder tumours is disease recurrence. These recurrences could be due to advanced stages and grades. Tumours, which are limited to the mucosa, have a recurrence rate of 50% to 70% and a progression rate of 5% to 20%.[3,4] Therefore, close monitoring of the patient is required. Conventional cystoscopy is the mainstay of diagnosis and follow-up of bladder neoplasia.

Radiological imaging is usually used for the staging and follow-up of bladder tumours.[5-7] Cross-sectional imaging has had little or no role in the definitive diagnosis of patients in whom a bladder lesion is suspected. Computed tomography (CT) and magnetic resonance imaging (MRI) are used mainly to demonstrate extravesical extension of the tumour and distant metastasis.[8,9]

Computed tomographic virtual endoscopy, a three-dimensional rendering technique based on helical computed tomographic data, is a recently developed imaging modality. This virtual endoscopic technique has been applied to many organs including the colon, stomach, bronchus and bladder.[10-13]

The aim of our study was to investigate the value of virtual cystoscopy to detect bladder lesions.

Methods

We enrolled 25 patients who had been referred to our clinic between March 2003 and June 2004 due to hematuria and who were suspected to have a urinary bladder lesion. Conventional cystoscopy was first performed on all patients. After that, each patient underwent a virtual cystoscopy with multislice CT (CTVC) within 1 to 3 days. No patient had been previously diagnosed with a urinary bladder tumour. Written informed consent was obtained from each patient. Our study was approved by our institutional ethics committee.

The procedure was started with the catheterization of the urinary bladder using a 14-F Foley catheter and the drainage of residual urine. The bladder was insufflated with 200 to 600 cc (mean 350 cc) of room air according to the patient's tolerance. After a scout view obtained of the patient in the supine position to locate the bladder and confirm its distention, we performed a helical CT scan (Philips MX8000, Marconi, Amsterdam, The Netherlands) with the following parameters: 1 mm collimation, 120 kV, 250 mA and 7 to 10 mm/sec table speed. Thereafter, the patient was turned to the prone position and a helical CT scan of the bladder was repeated with the same parameters. Images were reconstructed using 0.6 mm intervals, and CT data were transferred to an independent workstation equipped with software for interactive intraluminal navigation with a surface-rendering algorithm. The same radiologists who performed the cystoscopy interpreted the results of the virtual cystoscopy; each radiologist had at least 3 years of experience in virtual cystoscopy. The radiologists did not know the results of conventional cystoscopy. Also, we did a conventional cystoscopy procedure blinded of the results of the CTVC.

The number, size, location and morphologic features of the lesions were evaluated on transverse and virtual images obtained from the patients both in supine and prone positions. Lesions were characterized as polypoid, sessile or wall-thickening. Results of the virtual cystoscopy were compared with findings from the conventional cystoscopy for each patient.

Results

Twenty-five patients (21 males, 4 females), aged 41 to 79 (mean 61.9) were included in the study. A total of 38 lesions in the 25 patients were detected with virtual cystoscopy. The sizes of the lesions were between 0.2 × 0.3 cm and 7 × 4.5 cm (Fig. 1) (Fig. 2).

Twenty-six polypoid lesions, 7 sessile lesions and 5 wall-thickenings were detected with CTVC. All lesions were confirmed by conventional cystoscopy. However, it was not possible to evaluate the urinary bladder with conventional cystoscopy in 2 of the patients due to severe hematuria and blood clots. For these patients, the urinary bladder could only be evaluated during transurethral resection, which was done within 10 days. During conventional cystoscopy, biopsies were done for lesions considered wall-thickenings. Two lesions turned out to be transitional cell carcinomas and 3 were inflammation. One of the polypoid lesions was an inverted papilloma.

Table 1. Size of the lesions.

17 lesions < 1 cm
1 cm < 15 lesions < 3 cm
3 cm < 6 lesions

Seventeen of the lesions were smaller than 1 cm (Table 1). The pathological results of the patients are shown in Table 2.

There were no false positive findings in our series. Every lesion observed on virtual cystoscopy was confirmed on conventional cystoscopy. For the group of 25 patients, CTVC had a sensitivity of 100% for detecting neoplasms and an accuracy of 89.47%.

Malignant cells were detected in the cytological examination of three patients. These patients had polypoid tumoural lesions with the sizes of 2 × 2, 4 × 3 and 4 × 4 cm.

Discussion

Several imaging techniques are available to detect bladder neoplasia. However, there is no reliable method for tumour detection, and negative findings are required cystoscopy.[14-16] Suspected lesions detected by radiological methods should be identified by conventional cystoscopy and biopsy. Conventional cystoscopy is still the main method for investigating bladder abnormalities. We found wall-thickenings in 5 of the 25 patients and a superficial nodular irregularity in 1 patient. It was not possible to determine whether they were malignant or benign using only the CTVC. The differential diagnosis of these lesions, 2 of which 2 were malignant, could be done only with conventional cystoscopy and biopsy.

Also, cystoscopy has some limitations. It is invasive, time-consuming and expensive. It requires sedation or anesthe-

Table 2. Histopathological results of the patients, n = 25.

Precancerous	1
Benign	3
Ta	11
T1	6
T2	4

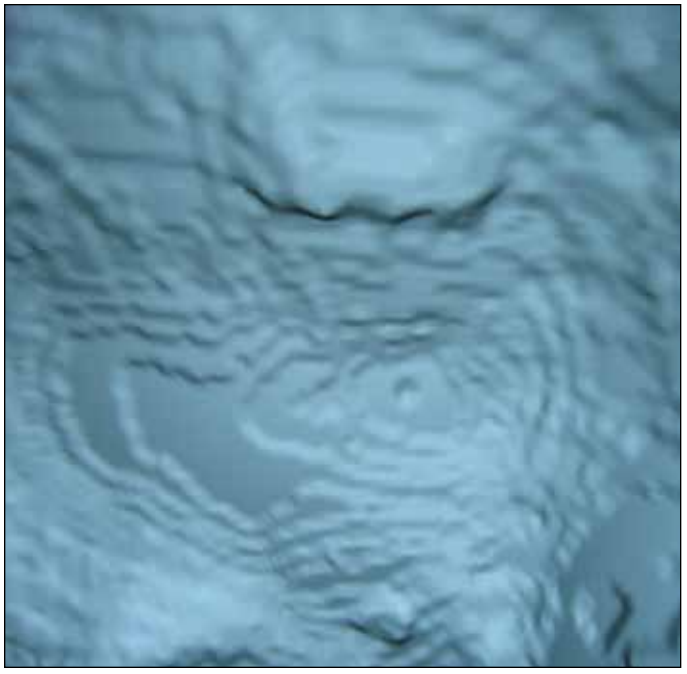

Fig. 1. A virtual cystoscopic image of a 0.2 × 0.3 cm lesion in the superior wall of the bladder.

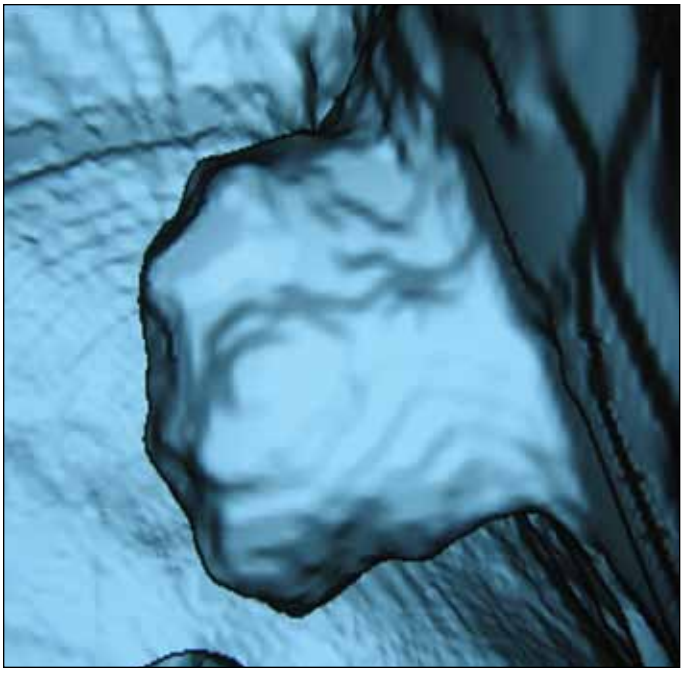

Fig. 2. Virtual computed tomography image of a large mass of the lateral wall of urinary bladder.

sia and sometimes iatrogenic injury occurs. The evaluation of bladder neck and bladder diverticulum is difficult.[17,18] Infection, which is seen after the procedure, is another problem.[17] In addition, usage in urethral stenosis and in the presence of a blood clot is limited. Thus, conventional cystoscopy was not possible for 2 of our patients due to hemorrhaging and a blood clot in the acute phase. Even though ultrasonography is a noninvasive, inexpensive and relatively easier technique employed to evaluate bladder tumours, it has some limitations and lacks in sensitivity. An ultrasonography may be inadequate to detect a tumours in the bladder dome, due to artifacts caused by intestinal loops, obesity and reverberation. Since ultrasonography is a real-time imaging method, it is essential that the user be experienced. Such disadvantages of conventional cystoscopy and ultrasonography have led to a search for noninvasive and reliable imaging techniques. Recently introduced, virtual endoscopy seems to be an advantageous tool to detect and evaluate urinary bladder lesions.

Virtual cystoscopy was first used in 3 patients by Vining and colleagues.[14] Following this initial study, it has been used in various other studies.[19-22] In the earlier studies on virtual cystoscopy, low sensitivity rates were reported, particularly for lesions smaller than 1 cm. Fenlon and colleages reported a 63.6% sensitivity for lesions smaller than 10 mm.[17] Narumi and colleagues were able to detect 77% of lesions smaller than 10 mm.[18] The slice thickness was 3 mm in both studies. Song and colleagues reported that lesions up to 5 mm could be detected with CTVC and that CTVC has a higher sensitivity for lesions up to 10 mm.[23] Later, Kim and colleagues upgraded the sensitivity of the method by using thin slices. They identified lesions less than 5 mm using a slice thickness of 1.25 mm.[16] In their study, Browne and colleagues found an abnormality in 23 of the 25 patients' urinary bladder with CTVC; the findings were confirmed by conventional cystoscopy. Researchers reported that lesions up to 2 mm could be detected with CTVC.[24] In addition, in a recent study by Tsili and colleagues, it was reported that the method is beneficial in demonstrating urinary bladder lesions.[25] Lesions in 3 patients that were not observed by conventional cystoscopy were demonstrated with virtual cystoscopy.

Virtual cystoscopy has several advantages. The method is minimally invasive. Also, since a virtual cystoscopic rendering of the bladder takes a short time to navigate, it does not require a high level of competency on the part of the operator. However, the experience level of the radiologist with the virtual cystoscopy makes a difference, though not as much as with the ultrasonography. Virtual cystoscopy allows us to accurately measure the dimensions of the tumour. Both axial and virtual images are useful to evaluate extravesical invasion and involvement of other pelvic organs. Additionally, it is applicable to the evaluation of such areas as the bladder neck and diverticula, which are hard to evaluate with conventional cystoscopy. Virtual cystoscopy is also beneficial in conditions, such as urethral obstruction, active bleeding and blood clots, as well as in advanced benign prostatic hyperplasia, in which the evaluation of the urinary bladder

is difficult with conventional cystoscopy.[24,25] Consequently, the evaluation of the 2 patients was done only by virtual cystoscopy at an early period due to hematuria and blood clots; conventional cystoscopy was not diagnostic for these 2 patients.

The CTVC does have its limitations. One of them is in the diagnosis of patients with metallic hip prosthesis. The identification of small mucosal lesions, particularly carcinoma in situ, in the bladder and prostatic urethra is difficult. We have not been able to identify carcinoma in situ in any of our cases regardless of whether CTVC or convetional cystoscopy was used. The virtual cystoscopy does not allow for biopsy. Therefore, it is difficult to distinguish neoplastic lesions from inflammation and fibrosis.[26,27] Radiation exposure should also be considered.[25] Requiring catheterization and not having the capability of evaluating the color of the urinary bladder wall are other disadvantages.[28,29]

In the present study, which was designed for patients suspected of having a primary urinary bladder neoplasm, the findings detected with CVTC were confirmed by conventional cystoscopy. In conventional cystoscopy, no different lesions were determined other than those detected by CTVC. In the present study, which was similar to some studies in the literature, lesions up to 2 mm at 1 mm slice thickness could be detected. Even in 2 patients,m for which conventional cystoscopy gave no diagnostic information, findings about location and the size of the tumour could be obtained with CTVC. It was found that CTVC is a feasible technique to detect and evaluate bladder lesions.

Conclusion

The results of our study suggest that CTVC cannot completely take the place of conventional cystoscopy. Nevertheless, CTCV is an effective method for the pre-diagnostic detection of the location and size of tumours in patients with suspected urinary bladder lesions. Studies using a larger group of patients are now needed to determine the clinical value of CTVC.

*Ministry of Health, Ankara Dışkapı Yıldırım Beyazit Education and Research Hospital, Department of Urology, Ankara, Turkey; †Ministry of Health, Ankara Dışkapı Yıldırım Beyazit Education and Research Hospital, Department of Radiodiagnostic, Ankara, Turkey

Competing interests: None declared.

This paper has been peer-reviewed.

References

1. Jemal A, Tiwari RC, Murray T, et al. Cancer statistics, 2004. *CA Cancer J Clin* 2004;54:8-29.
2. Kirkali Z, Chan T, Manoharan M, et al. Bladder cancer: epidemiology, staging and grading, and diagnosis. *Urology* 2005;66:4-34.
3. Josephson DY, Pasin E, Stein JP. Superficial bladder cancer: part 1. Update on etiology, classification and natural history. *Expert Rev Anticancer Ther* 2006;6:1723- 34.
4. Schmidbauer J, Lindenau G. Follow-up of nonmuscle invasive transitional cell carcinoma of the bladder: how and how often? Curr Opin Urol 2008;18:504-7.
5. Blanco Díez A, Ruibal Moldes M, Suárez Pascual G, et al. Staging of infiltrating bladder cancer. Role of C.T. scan [article in Spanish]. *Arch Esp Urol* 2003;56:23-9.
6. Ng CS. Radiologic diagnosis and staging of renal and bladder cancer. *Semin Roentgenol* 2006;41:121-38.
7. Zhang J, Gerst S, Lefkowitz RA, et al. Imaging of bladder cancer. *Radiol Clin North Am* 2007;45:183-205.
8. Tekes A, Kamel I, Imam K, et al. Dynamic MRI of bladder cancer: evaluation of staging accuracy. *AJR Am J Roentgenol* 2005;184:121 -7.
9. Baltaci S, Resorlu B, Yagci C, et al. Computerized tomography for detecting perivesical infiltration and lymph node metastasis in invasive bladder carcinoma. *Urol Int* 2008;81:399-402.
10. Yun JY, Ro HJ, Park JB. Diagnostic performance of CT colonography for the detection of colorectal polyps. *Korean J Radiol* 2007;8:484-91.
11. Inamoto K, Kouzai K, Ueeda T, et al. CT virtual endoscopy of the stomach: comparison study with gastric fiberscopy. *Abdom Imaging* 2005;30:473-9.
12. Lacasse Y, Martel S, Hébert A, et al. Accuracy of virtual bronchoscopy to detect endobronchial lesions. *Ann Thorac Surg* 2004;77:1774-80.
13. Panebianco V, Osimani M, Lisi D, et al. 64-detector row CT cystography with virtual cystoscopy in the detection of bladder carcinoma: preliminary experience in selected patients. *Radiol Med* 2009;114:52-69.
14. Vining DJ, Zagoria RJ, Liu K, et al. CT cystoscopy: an innovation in bladder imaging. *AJR Am J Roentgenol* 1996;166:409-10.
15. Regine G, Atzori M, Buffa V, et al. Virtual CT-pneumocystoscopy: indications, advantages and limitations. Our experience. *Radiol Med (Torino)* 2003;106:154-9.
16. Kim JK, Ahn JH, Park T, et al. Virtual cystoscopy of the contrast material-filled bladder in patients with gross hematuria. *AJR Am J Roentgenol* 2002;179:763-8.
17. Fenlon HM, Bell TV, Ahari HK, et al. Virtual cystoscopy: early clinical experience. *Radiology* 1997;205:272-5.
18. Narumi Y, Kumatani T, Sawai Y, et al. The bladder and bladder tumours: imaging with three-dimensional display of helical CT data. *AJR Am J Roentgenol* 1996;167:1134-5.
19. Gualdi GF, Casciani E, Rojas M, et al. Virtual cystoscopy of bladder neoplasms. Preliminary experience. *Radiol Med (Torino)* 1999;97:506-9.
20. Calhoun PS, Kuszyk BS, Heath DG, et al. Three-dimensional volume rendering of spiral CT data: theory and method. *Radiographics* 1999;19:745-64.
21. MasulovićD, SaranovićDj, SagićD, et al. CT endoscopy in urinary bladder lesions detection. *Acta Chir Iugosl* 2007;54:63-6.
22. Marini M, Stasolla A, D'Aprile MR, et al. CT cystoscopy in the evaluation of bladder tumours. *J Exp Clin Cancer Res* 2003;22:35-9
23. Song JH, Francis IR, Platt JF, et al. Bladder tumour detection at virtual cystoscopy. *Radiology* 2001;218:95-100.
24. Browne RF, Murphy SM, Grainger R, et al. CT cystography and virtual cystoscopy in the assessment of new and recurrent bladder neoplasms. *Eur J Radiol* 2005;53:147-53.
25. Tsili ACh, Tsampoulas C, Chatziparaskevas N, et al. Computed tomographic virtual cystoscopy for the detection of urinary bladder neoplasms. *Eur Urol* 2004;46:579-85.
26. Fielding JR, Hoyte LX, Okon SA, et al. Tumour detection by virtual cystoscopy with color mapping of bladder wall thickness. *J Urol* 2002;167:559-62.
27. Bernhardt TM, Krause UW, Philipp C, et al. Virtual cystoscopy with reduced tube current: an alternative to cystoscopy [article in German]? *Rofo* 2003;175:1106-11.
28. Hussain S, Loeffler JA, Babayan RK, et al. Thin-section helical computed tomography of the bladder: initial clinical experience with virtual reality imaging. *Urology* 1997;50:685-8.
29. Allan JD, Tolley DA. Virtual endoscopy in urology. *Curr Opin Urol* 2001;11:189-92.

Correspondence: Dr. Osman Raif Karabacak, Ministry of Health, Ankara Dışkapı Yıldırım Beyazit Education and Research Hospital, Ankara, Turkey; osmanraifkarabacak@mynet.com