Computed tomography virtual cystoscopy for follow-up of patients with superficial bladder tumours in comparison to conventional cystoscopy: An exploratory study

Hossam Elawady, Mahmoud A. Mahmoud, Diaaeldin M.A. Mostafa, Alaa Abdelmaksoud, Mohamed W. Safa, Remon Z. Elia

Department of Urology, Faculty of Medicine, Ain Shams University, Cairo, Egypt
Department of Radiodiagnosis, Faculty of Medicine, Ain Shams University, Cairo, Egypt

Received 30 March 2016, Received in revised form 18 May 2016, Accepted 8 June 2016
Available online 25 July 2016

Abstract Objective: To evaluate and analyse the efficacy of computed tomography (CT) virtual cystoscopy in comparison to conventional cystoscopy for the follow-up of patients with non-muscle-invasive bladder cancer.

Patients and methods: The study was done over 3 years, from April 2010 to June 2013, and included 30 patients who all had non-muscle-invasive transitional cell carcinoma (Ta, T1). The patients all underwent complete transurethral resection of the tumour and presented for first follow-up check cystoscopy. The examination was performed using a 16-slice multi-detector (MD) CT scanner. The results were compared for sensitivity and specificity in relation to the site, size, and shape of the tumour.

Results: In all, 20 lesions were detected by CT virtual cystoscopy in 18 patients, whilst the remaining 12 were lesion free. Conventional cystoscopy detected 23 lesions in 19 patients. The sensitivity of the virtual images was 87%; its specificity in identifying lesions was 100%, with a positive predictive value of 100% and negative predictive value of 78.5%.
Introduction

Bladder cancer is the second most common genitourinary malignancy, the fourth most common male cancer accounting for 7% of all cancers, and has the eighth highest cancer-related mortality rate worldwide [1]. About 75–80% of all bladder cancer cases are diagnosed as non-muscle-invasive bladder cancer (NMIBC) [2]. Transurethral resection of bladder tumour (TURBT) eradicates all visible tumours and provides tissue for pathological analysis and determination of histological type, grade, and depth of invasion [1].

The overall rate of recurrence for NMIBC is 60–70%, and the commonly used follow-up strategy includes cystoscopy and urine cytology every 3 months for the first 2 years, then every 6 months for the next 2 years, and then follow-up is scheduled annually [1].

CT virtual cystoscopy is focused on evaluating the bladder mucosal surface thus it is superior to multiplanar reconstruction or source CT images in detecting superficial lesions. Furthermore, through virtual cystoscopy the operator can navigate the bladder mucosal surface in various projections [3]. The minimally invasive nature and patient comfort are major advantages of CT virtual cystoscopy in comparison to conventional cystoscopy [3].

The aim of the present prospective study was to evaluate and analyse the efficacy of CT virtual cystoscopy in the follow-up of the patients with NMIBC and this was achieved by comparing the results of CT virtual cystoscopy with conventional cystoscopy. The goal of CT virtual cystoscopy being to spare patients with NMIBC frequent cystoscopies, especially pertinent in those with high anaesthetic risk, urethral obstruction, and patients with advanced BPH in which the evaluation of the urinary bladder is difficult with conventional cystoscopy. Thus, patients can safely undergo CT virtual cystoscopy with the use of a small infant feeding tube to instil air or contrast medium into the bladder [4].

Patients and methods

Patients were selected from inpatients of EL-Demerdash Hospital Ain Shams University and Ain Shams University Specialized Hospital from April 2010 to June 2013. The examination was performed by the same operator using the same 16-slice multi-detector (MD) CT scanner (GE Healthcare BrightSpeed 16). Our study included 30 patients, 27 men and three women with a mean (SD; range) age of 60.83 (11.24; 30–87) years.

The inclusion criteria were all patients with non-muscle invasive TCC (Ta, T1) who underwent complete TURBT, and presented for first follow-up check cystoscopy. Patients with histopathology other than TCC or who underwent incomplete resection of Ta, T1 tumours were excluded, as were patients whose specimens did not contain muscle layer.

All patients had a detailed history taken including a review of their prior cystoscopy report(s) and the pathology of prior TUR procedure(s), a physical examination including DRE. Laboratory tests (including: complete blood count, liver and kidney functions, coagulation profile, complete urine analysis and culture, also urine cytology) and pelvi-abdominal ultrasonography were undertaken for all patients, then virtual CT cystoscopy and conventional cystoscopy were performed.

Data collected from our patients were analysed using PASW version 18, qualitative data are expressed as numbers and percentages of cases, whilst quantitative data are represented by the median, minimum and maximum values of the data.

The results were subdivided into two groups based on the diagnostic method used (conventional vs virtual cystoscopy), comparative statistics were done using the chi-square and Mann–Whitney tests for qualitative and quantitative data, respectively. The diagnostic value of CT virtual cystoscopy was analysed in relation to the ‘gold standard’ test of conventional cystoscopy by cross tabulation with estimation of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Receiver operating characteristic curve analysis was used to estimate the best tumour size threshold value for diagnosis with CT virtual cystoscopy.

CT virtual cystoscopy protocol

All patients underwent an air-filled technique except four patients who refused urethral catheter application and underwent a contrast-filled technique by i.v. injection of contrast material.

Contrast-filled technique

A scout view of the bladder was obtained with the patient in a supine position. A wide-bore i.v. line was
placed in the antecubital fossa. The patient was asked to void before the examination then a dose of 40–60 mL non-ionic low osmolar contrast media was administered (i.v.). Before starting the procedure, patients were asked to change their position from supine to prone four times in order to mix the contrast medium with urine homogeneously. The CT examinations needed for virtual cystoscopy were obtained when the patient expressed a desire to void.

**Air-filled technique**

In all, 26 patients underwent this technique; a 14-F Foley urethral catheter was inserted under aseptic conditions. The bladder was then distended with 300–400 mL room air through the Foley catheter according to patient tolerance. The examination of all patients was done in both supine and prone positions.

**Image reconstruction**

Bladder scanning was performed using a minimal field of view MDCT, using the following settings in all patients: 120 kV; detector collimation 16 × 0.75 mm; section thickness 1.25 mm. A volume rendering technique was used to obtain virtual cystoscopic images.

**Conventional cystoscopy**

Regional anaesthesia was usually used in the procedures. The patients were placed in the lithotomy position. We used rigid cystoscopy (22 F) for all patients and recurrent tumours or any detected lesions or abnormalities were biopsied using cold cup biopsy forceps, or resected using a 24-F resectoscope with monopolar diathermy.

The lesions were defined as: sessile mass lesion, if the lesion was connected to the bladder wall by a broad base; polypoid, if the lesion was attached to the bladder wall by a narrow stack; or wall thickening, when the bladder wall is elevated with no definite mass lesion.

**Results**

In all, 20 lesions were detected by CT virtual cystoscopy in 18 patients, whilst the remaining 12 patients were lesion free. Conventional cystoscopy, which was considered as the standard reference for our study detected 23 lesions in 19 patients and all lesions were biopsied (Fig. 1). In all, 16 lesions from the 20 lesions detected by CT virtual cystoscopy were TCCs, whilst three lesions proved to be inflammatory reactions and the last lesion an organised blood clot (Figs 2–4).

For the number of the lesions detected, the sensitivity of the virtual images was 87%; whilst its specificity in identifying lesions was 100%, the PPV was 100% and NPV 78.5%.

Conventional cystoscopy detected 23 lesions. Thus, CT virtual cystoscopy missed three lesions (three false negative results), one of them was a bladder wall thickening confirmed to be an inflammatory bilharzial reaction and the other two were villous polypoidal growths at the bladder neck, which in one patient was confirmed to be non-muscle invasive TCC. There was no significant difference between the two methods for the number of detected masses (Table 1).

For the size of the detected masses, lesions of >5 mm were equally detected, whilst three tumours of <5 mm were missed by CT virtual cystoscopy. It was obvious that its sensitivity in the detection of bladder masses increased as the size of the mass increased. CT virtual cystoscopy detected all masses of >5 mm (100% sensitivity). When using a lesion size threshold of 3.5 mm the predictive accuracy, sensitivity, specificity, PPV, and NPV of CT virtual cystoscopy was 95%, 90%, 100%, 100%, and 60%, respectively.

CT virtual cystoscopy was able to detect all the lesions in any part of the bladder except in two cases.
One patient who on conventional cystoscopy was found to have two lesions in the form of focal bladder wall thickening in the right and left lateral bladder wall, the virtual images detected only the left lateral lesion later confirmed to be non-muscle invasive TCC and missed the right lateral one, which appeared to be an inflammatory reaction. The other patient had two lesions missed by virtual cystoscopy and diagnosed by conventional cystoscopy in the bladder neck at the 10 and 12 o’clock positions; histopathological examination showed non-muscle invasive TCC.

Discussion

For evaluation of the urinary bladder tumours, the ‘gold standard’ for diagnosis, as well as follow-up is direct visualisation of the bladder mucosa with the use of a flexible/rigid cystoscopy [4]. Recently, virtual–reality imaging has been introduced using three-dimensional computer-rendering techniques with rapid image acquisition [4]. In the present study, both conventional and virtual techniques were used. For CT virtual cystoscopy the air-filled technique was used in most of the patients,
as it is fast and easy with suitable patient compliance, and provided excellent virtual images. In four patients, the contrast-filled technique was used, it was not invasive and easier in patients who refused catheter application. However, it was more time consuming and cannot be used in patients with nephropathy.

Tsampoulas et al. [5] stated that virtual images are ideally produced by using the air-filled technique due to the high attenuation gradient between the air and bladder mucosa, whereas, Kim et al. [3] reported that filling the bladder with i.v. contrast material was easily achieved and more comfortable for patients as bladder catheterisation was not necessary, also CT data are obtained only once with no need for examinations in the prone and supine positions.

In our present study, we used 16-MDCT to perform urinary bladder scanning, with a section thickness of ~1.25 mm and virtual reconstruction using a volume-rendering technique. Lalondrelle et al. [6] suggested that the optimum slice thickness is 1.2 mm, as it usually results in the best image quality. On the other hand, decreasing the slice thickness (0.6 mm), leads to loss of tumour definition and results in appearance of dimpling artefacts due to increased noise. Arslan et al. [7] reported that they identified 10 of 11 bladder tumours in 18 patients, two lesions were <5 mm, they used a 4-MDCT with a slice thickness of 1 mm.

Our present study, with results for 30 patients, demonstrated excellent sensitivity and specificity scores of combined axial CT and virtual cystoscopy for the localisation and morphological description of bladder tumours in comparison to conventional cystoscopy. In all, 20 lesions were detected by CT virtual cystoscopy of the 23 lesions confirmed by conventional cystoscopy, 12 lesions were ≤5 mm, with only nine of them detected by CT virtual cystoscopy giving a sensitivity of 75% for the detection of small lesions.

For bladder wall thickening, in our present study three areas of irregular wall thickening could be detected by combined axial CT and virtual cystoscopy with excellent sensitivity and specificity. For the detectable size of the mass, many different studies have reported different results. In the earlier studies on virtual cystoscopy, low sensitivity rates were reported, particularly for lesions of <10 mm [4]. But recently, Gabr et al. [8] reported a sensitivity of 100% for detecting bladder masses of 5–10 mm and 90% sensitivity in detecting tumours of <5 mm.

However, there are some limitations of our present study. CT virtual cystoscopy is still unable to detect mucosal colour changes, which were detected only on conventional cystoscopy [7,9]. In addition, the calcifications associated with masses or stones were seen only on the axial images but not on virtual images due to the threshold selection that was optimised to depict soft tissue abnormalities. Another important factor is that virtual images alone cannot determine the nature of the mass, if it is neoplastic or inflammatory; or the origin of the mass, vesical or extravesical, as exemplified by Song et al. [9] where an enlarged median lobe of the prostate gland simulated an intravesical lesion in their study. This was seen in our present study in three patients, two of them had three lesions which were confirmed by conventional cystoscopy to be inflammatory and the other one was confirmed to be organised blood clot adherent to the bladder wall.

**Conclusion**

CT virtual cystoscopy is a minimally invasive diagnostic tool that can be added to the inventory of bladder tumour detection and surveillance. It is a promising technique that could have great value in the management of bladder tumours incorporated into the follow-up scheme of NMIBCs, especially in low-stage low-grade tumours (TaG1). However, at the moment the detection rate for recurrent NMIBC does not appear to be adequate to replace conventional cystoscopy, but it could be utilised in lengthening the period between conventional cystoscopies for such tumours and consequently may encourage patients to be more compliant with their follow-up schedules.

**Conflicts of interest**

None declared.
Source of funding

None.

References

[1] Aldousari S, Kassouf W. Update on the management of invasive bladder cancer. *Can Urol Assoc J* 2010;4:56–64.

[2] Kassouf W, Kamat A, Zlotta A, Aprikian A. Canadian guidelines for treatment of non-muscle invasive bladder cancer: a focus on intravesical therapy. *Can Urol Assoc J* 2010;4:168–73.

[3] Kim JK, Park SY, Kim HS, Kim SH, Cho KS. Comparison of virtual cystoscopy, multiplanar reformation, and source CT images with contrast material-filled bladder for detecting lesions. *AJR Am J Roentgenol* 2005;185:689–96.

[4] Karabacak OR, Cakmakci E, Ozturk U, Demirel F, Dilli A, Hekimoglu B, et al. Virtual cystoscopy: the evaluation of bladder lesions with computed tomographic virtual cystoscopy. *Can Urol Assoc J* 2011;5:34–7.

[5] Tsampoulas C, Tsili AC, Giannakis D, Alamanos Y, Sofikitis N, Efremidis SC. 16-MDCT cystoscopy in the evaluation of neoplasms of the urinary bladder. *AJR Am J Roentgenol* 2008;190:729–35.

[6] Lalondrelle S, Sohaib S, Castellano I, Mears D, Huddart R, Khoo V. Investigating the relationship between virtual cystoscopy image quality and CT slice thickness. *Br J Radiol* 2012;85:1112–7.

[7] Arslan H, Ceylan K, Harman M, Yilmaz Y, Temizoz O, Can S. Virtual computed tomography cystoscopy in bladder pathologies. *Int Braz J Urol* 2006;32:147–54.

[8] Gabr AH, Elbadry M, Elsherief A, Tawfick ER. Computed tomography-virtual cystoscopy in the evaluation of a bladder mass: could it replace standard conventional cystoscopy? *Arab J Urol* 2013;11:369–74.

[9] Song JH, Francis IR, Platt JF, Cohan RH, Mohsin J, Kielb SJ, et al. Bladder detection at virtual cystoscopy. *Radiology* 2001;218:95–100.