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CT Virtual Cystoscopy on 128slice MDCT: Preliminary experience, results and possibilities

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Abstract

Background: Urinary Bladder Cancer is the tenth most common cancer worldwide with high mortality. It has a high rate of recurrence after transurethral resection which mandates a vigilant follow-up with conventional cystoscopy every 3 months. Virtual Cystoscopy can be used in situations where conventional cystoscopy is contraindicated; not possible; or when frequent examinations are required.

Objective: This study aims at determining the role of 128 slice virtual cystoscopy in evaluation of bladder tumors.

Methods: All patients with suspected bladder tumour meeting the inclusion criteria were included in the study. CT Virtual Cystoscopy was performed and findings recorded. Subsequently conventional cystoscopy was performed and the findings of both modalities were compared with respect to number, site, size and morphology of the lesion. Sensitivity of VC was calculated assuming CC as gold standard.

Results: Overall sensitivity of VC was found to be **97.05%.** The findings were in good agreement with the CC findings. VC missed a lesion in our study that was present on the superior wall, sessile on morphology, measuring <5mm.

Conclusion: We conclude that Virtual Cystoscopy is a safe technique with high sensitivity that can be used to supplement and complement CC especially, In follow-up after TURBT when repeated cystoscopy are required. It can be useful for areas where the cystoscope cannot navigate: Like stricture, narrow bladder neck, narrow neck diverticula, etc. or when CC is contraindicated.

Keywords: Urinary bladder, bladder tumor, Urothelial Carcinoma, Cystoscopy, Virtual Cystoscopy, TURBT, Follow-up.

Introduction

Urinary bladder cancer is the tenth most common cancer worldwide[1] and eighth highest in cancer-related mortality with an estimated 549,000 new cases and 200,000 deaths. Bladder cancer is more common in men than in women, with respective incidence and mortality rates of 9.6 and 3.2 per 100,000 in men: about 4 times those of women globally. Thus, the disease ranks higher among men, in whom it is the sixth most common cancer and ninth leading cause of cancer death.[2]

The biggest challenge for improving prognosis is high rate of recurrence. About 75-80% cases are diagnosed as non-muscle invasive bladder cancer, with an estimated recurrence of 50-70%[3]. Transurethral Resection (TUR) is the widely accepted treatment, however recurrence rate as high as 60% within 5years is estimated even after resection.[4]

The key to reducing mortality due to recurrence lies in the early detection of recurrence. This mandates regular vigilant follow-up of post-TUR patients for detection of recurrence.[4]

Along with clinical and urine examination, Conventional Cystoscopy (CC) every 3 months is the traditionally used diagnostic modality for follow-up of patients after TUR, however it has many disadvantages.[5]

As CC is an invasive procedure it has complications like risk of urinary infections, sepsis and urethral injury which can later lead to urethral strictures. Apart from being invasive, expensive and time consuming it also has contraindications that include bacteriuria, acute cystitis, urethritis, obstructive hypertrophy, haematuria, stricture. The procedure also requires sedation.[5] In addition, the patient needs to undergo frequent and multiple invasive examinations on follow-up.

Also, it has limited role in evaluation of bladder neck and narrow neck diverticular tumors as the cystoscope cannot navigate narrow neck diverticula.[5]

Recently, with computer assisted rapid image acquisition and 3-D image reconstruction, virtual reality imaging has been developed. It allows intraluminal interactive navigation imitating conventional endoscopy. This can be applied to many organs including colon, bronchus and bladder.[6]

The bladder is an ideal candidate owing to its simple intraluminal morphology, small volume, and absence of involuntary peristalsis.[6]

VC may hence be a complimentary investigation to the existing CC and in situations where repeated examinations are required like follow-up, or where CC is not possible like strictures, infections, diverticula it can be used as an effective substitute to the existing invasive CC.

This study summarises the results of first experience with virtual cystoscopy in SMS Medical College and Hospital Jaipur in patients with suspected bladder tumors.

Materials and methods

After approval from Institutional ethical committee, patients were selected after applying inclusion and

exclusion criteria. Prior to examination, written and informed consent was taken from the patient/guardian (in case of minor). MDCT-VC was performed on 128 slice MDCT Philips Ingenuity machine and reconstruction on workstation- 'Philips extended brilliance workspace- v4.5.51035'

Subsequently CC was performed. CC findings were used as reference standard to evaluate the sensitivity, specificity, positive predictive value, and negative predictive value of CT VC for detection and characterization of bladder tumors.

Technique

Just prior to scanning, the patient was asked to empty the bladder. Unenhanced CT scan covering the entire urinary tract was obtained. Intravenous injection of 80–100 ml of water-soluble non-ionic contrast medium was injected at a dose of 2 ml/kg of body weight at a rate of 3 ml/s.

Contrast-enhanced scanning covering the abdomen, pelvis at a scan delay of 60-90 s.

After the first two scans, patient waited until he/she had desire to void (60–90 min after IV injection of contrast material). Patient was asked to alternately take supine and prone positions four times to obtain adequate mixing of the contrast material and urine in the bladder. Scan was obtained with the patient in supine position covering entire urinary bladder.

(Tube Voltage: 120kV, Slice thickness: 0.9mm, Tube Current: 150 mAs)

Data was then transferred to a workstation for multiplanar reconstruction (MPR) images and 3-D virtual reconstruction. Three-dimensional (3D) volume-rendering algorithms were used to generate intraluminal views of bladder.

The central observation point was kept as the centre of the bladder, and then the virtual camera advanced to the six segments of the bladder wall: the superior, inferior, anterior, posterior, right and left lateral walls and findings were recorded.

Results

Good quality images were obtained in 25 patients. As few patients had multiple masses, 33 bladder masses were studied.

Out of the 25 patients, we found that males were more commonly affected than females, 22 were males (88%) and 3 were females (12 %).

Table 1: Age and Sex Distribution of cases

Age In Years	Male	Female	Total
<40	-	-	-
40-50	2	-	2
50-60	5	2	7
60-70	13	1	14
>70	3	-	3
	22	3	25

Graph 1: Age and sex distribution of cases

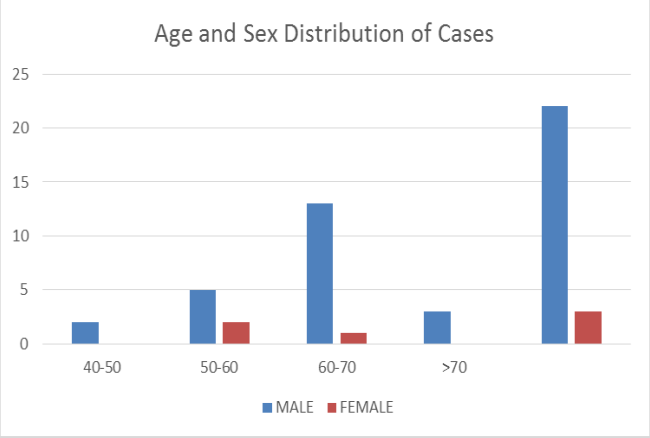

Table 2: Comparison of Total No. of lesions on VC with CC taking CC as gold standard

	VC	**CC**
Total No of Lesions	33	34

The sensitivity of VC was thus calculated as **97.05%.**

Discussion

Bladder cancer is the 10th most common form of cancer worldwide[1], with an estimated 549,000 new cases and 200,000 deaths. Bladder cancer is more common in men than in women, with respective incidence and mortality rates of 9.6 and 3.2 per 100,000 in men: about 4 times those of women globally. Thus, the disease ranks higher among men, in whom it is the sixth most common cancer and ninth leading cause of cancer death[2].

Cancer pattern in different geographical regions may vary depending on genetic, environmental, dietary, social and other factors and so it is also important to know the differential disease pattern in a population.

The Epidemiology of bladder cancer in Indian population was studied by ***Biswas et al[12]***, they published a retrospective epidemiological study of 88 patients diagnosed with carcinoma bladder at the Departments of Urosurgery and Pathology from CNMC, Kolkata, from December 2007 to November 2009. They found that the median age of bladder cancer was 65–70 years.

In our study we found that the distribution was similar, the range was 40-80years

Biswas et al[12] also reported a male preponderance (86.4% male vs. 13.6% female). In the present study, we also found that the males were more commonly affected than females as, 22 were males (88%) and 3 were females (12 %).

The magnitude of morbidity and mortality due to bladder cancer is high as discussed above, therefore it is necessary to improve its prognosis. The biggest challenge for improving prognosis is its high rate of recurrence.

The key to reducing mortality due to recurrence lies in the early detection of recurrence. This mandates a regular and vigilant follow-up of post-TUR patients for early detection of recurrence.[4]

Along with clinical and urine examination, CC (CC) every 3 months is the traditionally used diagnostic modality for follow-up of patients after TUR, however it has many disadvantages.[5]

As CC is an invasive procedure it has complications like risk of urinary infections, sepsis and urethral injury which can later lead to urethral strictures. Apart from being invasive, expensive and time consuming it also has contraindications that include bacteriuria, acute cystitis, urethritis, obstructive hypertrophy, haematuria, stricture. It requires sedation.[5] In addition, the patient needs to undergo frequent and multiple invasive examinations on follow-up.

In present times of technological advancements, we can try to provide lesser invasive options to our patients, especially to the ones undergoing repeated frequent invasive cystoscopic examination and resulting infections, strictures. Fortunately, with advent of computer assisted rapid image acquisition and 3-D image reconstruction, virtual reality imaging has been developed. It allows intraluminal interactive navigation that imitates conventional endoscopy. This can be applied to many organs including colon, bronchus and bladder and allows lesions protruding into the lumen of a hollow viscus to be well visualized. Bladder is an ideal candidate owing to its simple intraluminal morphology, small volume, and absence of involuntary peristalsis.[6]

Vining et al[10] was the first to innovate the use of virtual imaging to bladder in 1996, and postulated that it was possible in principle.

Many studies have thereafter evaluated the role of VC. Previous studies had reported lower sensitivity on 16 slice MDCT scanners especially for smaller lesions, as

compared to studies done on 64 slice scanner. ***Panebinaco et al***[11] said that the 64 slice scanners provided excellent spatial resolution and therefore higher sensitivity. Results on 128 slice MDCT scanners have yet not been reported in literature, the current study was conducted to evaluate the same.

With this aim we performed VC in patients with suspected bladder mass and then compared with the CC with respect to number, site, size and morphology.

We found that the technique was well tolerated by all the patients as it was non-invasive. Only one complication has been reported so far in literature by ***song et al***[12] in 2001, which was related to catheterization and resolved conservatively. As catheterization in itself is invasive we chose the contrast technique.

Good quality images were obtained in our study in majority of patients with adequate bladder distension of good capacity bladder. Adequate bladder distension was a necessary pre requisite for optimal images and the importance of this cannot be stressed enough. Adequate bladder distension can be achieved by either air insufflation or contrast, as both techniques allow for distension of bladder with difference in attenuation values allowing for optimal reconstruction. Image quality was reduced in restricted capacity bladders and we found that these bladders were poor candidates for VC. Similar findings were reported by our referral study by ***Teama et al***[13].

An exception to this found in our study was, sub-optimal images were obtained in one patient even after adequate distension of a smooth-walled and good capacity bladder due to dilution of contrast with residual urine decreasing the attenuation difference. This can be a potential pitfall, and the best technique that we found was to ask the patient to void before contrast injection and take delayed scan when the patient has urge to void. ***Merkle EM et al***[14], in 1998 had reported best images were obtained at a delay of 30 mins.

The patient should take supine and prone positions alternatively, to ensure proper mixing and to prevent sedimentation of contrast. This simple manoeuvre can prevent potential missing of small lesions, especially on the superior wall which was found to be the wall where CT had least sensitivity in our study.

Sensitivity Of VC

Overall sensitivity of VC was found to be **97.05%.** VC missed a lesion in our study on the superior wall, sessile on morphology, measuring <5mm and in a bladder with a total of 2 mass lesions.

Sensitivity With Respect To Size

In our current study, we found that lesions smaller than 5mm were not well visualized on axial and multiplanar images however these were detected on the virtual images.

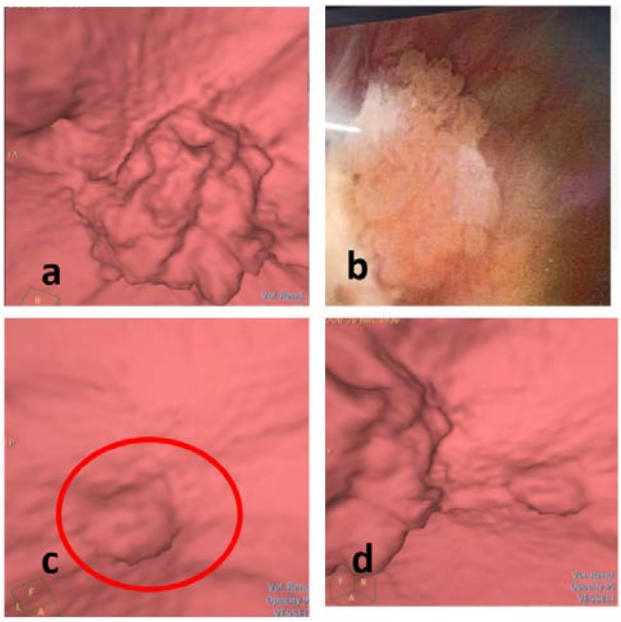

Figure : a - d

Figure : e

Fig.1: A 86 year old chronic smoker, previous TURBT for low grade non urothelial carcinoma presented with recurrence of haematuria. A single mass lesion was identified on the ultrasound, however on VC not only the lesion was well visualised (a) but also another small 3x3mm lesion(c) was seen in close proximity to the first lesion(d). Histopathology proved low grade urothelial carcinoma (e)

This is particularly significant as the previous studies had reported that lesions smaller than 5mm were not well depicted on the virtual images on 64 slice MDCT machines, however in our study on 128 slice MDCT the smallest lesion detected measured 2.6x1.5mm in size. This illustrates that the small lesions can also be well visualized if the bladder is well prepared and the procedure is performed meticulously.

This becomes clinically significant in the follow-up of patients after TURBT when we want to relieve the patient of repeated invasive cystoscopies while providing a sensitive modality that can detect early and small recurrent lesions. When a lesion is found on VC, then the patient can be taken up for CC for biopsy and resection. The aim therefore is not to replace CC that remains the gold standard, however repeated invasive examinations can be prevented by providing a sensitive virtual examination that imitates the conventional one.

Apart from the advantage of being non-invasive, it also provided precise localization of the lesion, and the ability to navigate the bladder in various projections and good visualization of the areas that were difficult to access with conventional cystoscope as it can bypass any obstruction if present.[6] Therefore, the diverticula, areas beyond strictures, bladder neck were well visualized. Stasis in diverticula can lead to development of intra-diverticular tumors, which can be very difficult to detect which CC especially in narrow neck diverticula.

In addition, as it a post scan reconstruction procedure, the axial transverse images were also assessed which depicted extravesical extension, pelvic lymph nodes and other pelvic pathologies that is not possible with the CC.[6] This also ensured that the false positives like enlarged median lobe of prostate, any extrinsic masses, and false positive due to air bubble as was reported by ***Kim et al***[18]in 2002 were effectively ruled out.

Not only this, other pathological and not-pathological structures were well visualized on the virtual images as well like diverticula, cystocele, trabeculations of the wall. ***Stenzl et al***[19] had reported the usefulness of virtual images for internal anatomy.

Conclusion

We conclude that Virtual Cystoscopy is a safe technique with high sensitivity that can be used to supplement and complement CC especially, In follow-up after TURBT when repeated cystoscopy are required. It can be useful for areas where the cystoscope cannot navigate: Like stricture, narrow bladder neck, narrow neck diverticula, etc. or when CC is contraindicated.

Sensitivity of VC for detection of urinary bladder masses was found to be **97.05%** in our study.

The idea is not to replace conventional cystoscopy which remains the gold standard but to complement and supplement it.

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