Evaluation of the Role of Computer Tomography Virtual Cystoscopy in Diagnosis of Carcinoma of the Bladder

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Abstract: ***Objectives:*** To investigate the utility, advantages and limitations of computed topographic (CT) virtual cyctoscopy in the detection and diagnosis of bladder tumors in comparison to conventional cyctoscopy. ***Patients and methods****:* Fifty patients were included in our study, 39 of them presented with haematuria and a recent diagnosis of bladder carcinoma, and 11 patients with a history of previous transurethral resection of superficial bladder cancer in their follow up period. They ranged in age 42 years to 75 years with a mean of 58.5; while male to female ratio was 5.25:1.The main steps to perform virtual cyctoscopy incorporate proper bladder distention with air after draining the residual urine through Foley´s catheter and scanning the patient in both supine and prone positions. An excellent overview of the bladder masses was obtained in all cases and the results of virtual cyctoscopy and conventional one were comparable with excellent sensitivity rates of virtual cyctoscopy in detection, localization and morphology description of the bladder lesions at variable sizes. ***Results****:* For detection of all lesions (n=62), virtual cyctoscopy alone showed sensitivity :98.4%, specifity:81.81% with two false positive and one false negative in comparison to conventional cyctoscopy which detected 61 lesions while in axial CT alone the sensitivity was73.8%, and specifity 100%. ***Conclusion:*** CT virtual cystoscopy is a promising technique for use in bladder tumor detection of lesions larger than 5 mm. optimal evaluations requires adequate bladder distention with the patient in both supine and prone positions and interpretation of both transverse and virtual images.
[RababShimy, Ahmed Mehena, Mohamed Wishahi, HossamElganzour, Ahmed M. Kamal, Mohamed Badawy, KhaledElesseily, FatenKamel, Susan Ali, LobnaHabib. **Evaluation of the Role of Computer Tomography Virtual Cystoscopy in Diagnosis of Carcinoma of the Bladder.** *Life Sci J* 2015;12(6):6-14]. (ISSN:1097-8135). http://www.lifesciencesite.com. 2

Keywords: Virtual cyctoscopy, bladder tumor, computed tomography, cancer.

1. Introduction

Bladder cancer is one of the most common neoplasms of the urinary tract. It is responsible for 4.5% of all newly diagnosed malignant neoplasms and 1.9% of cancer deaths in the United States (1). In Egypt, bladder cancer has been the most common cancer during the past 50 years (2). In 2002, Egypt's world-standardized bladder cancer incidence was 37/100,000, representing approximately 30,000 new cases each year (3).

The patient usually presents with hematuria, gross hematuria is an important finding that requires complete evaluation of the entire urinary tract. Intravenous urography(IVU), ultrasonography and computed tomography(CT), although until now have been used as the first step in evaluating urinary tract, they have limitations such as low sensitivity for small lesion detection(4). For evaluation of the urinary bladder, conventional cyctoscopy is a standard diagnostic approach, however this procedure is invasive and costly and may lead to iatrogenic bladder and urethral injury, and possibly urinary sepsis(5).

Computed tomography is a useful radiologic approach for assessing hematuria, previous reports have shown that CT has low sensitivity for small bladder lesions (6). Computed tomography and magnetic resonance (MR) imaging are used mainly to demonstrate extravesical extension of the tumor and distant metastasis (7).

Recently, three-dimensional computer-rendering techniques with rapid image acquisition have led to the development of virtual-reality imaging. With commercially available software, The virtual-reality imaging allows interactive intraluminal navigation through any hollow viscus, simulating conventional endoscopy (8). The urinary bladder is an ideal organ for virtual endoscopy which is attributed to its simple luminal morphology, relatively small volume, and the absence of involuntary peristalsis. Also, CT virtual cystoscopy it is safe technique for diagnosis and follow up of bladder cancer patients (2). CT virtual cyctoscopy images are generated from dedicated multislice helical CT data sets and various three-dimensional reconstruction techniques. These images of the urinary tract provide high spatial resolution

images helping overcome some of the limitations of IVU and ultrasonography (4).

2. Patients and Methods

Fifty patients, 42 men, and 8 women; age range, 42–75 years (mean age, 58.5 years) were referred from the urology department, Theodor Bilharz Research Institute. This study was performed between 2009 and 2012. The patients are classified into two groups, the first group (39 patients) presented by hematuria with recent diagnosis of bladder masse. The second group (11 patients) having a history of bladder carcinoma underwent virtual cystoscopy in their follow up period.

All patients were subjected to: full history, general, abdominal, and local clinical examination. Laboratory investigations including kidney functions, urine analysis and complete blood picture. Radiological and imaging studies including: plain x-ray radiogram (KUB), IVU and real time abdominopelvic ultrasound(US).

CT virtual cystoscopy using 16-MDCT scanner (Toshiba Activion 16) was done for all patients followed by conventional cystoscopy with rigid cystoscope under general anesthesia with either transuretheral resection or cold cup biopsy for all lesions. The interval time between the two studies was less than 7 days.

The technique for CT virtual cystoscopy began with the placement of a 14-F self-retaining Foley`s catheter in the bladder to drain residual urine. The bladder is insufflated with300–500 ml of room air through the catheter, the volume insuflated depended upon patient tolerance. An anteroposterior scout view was obtained with the patient in the supine position to locate the bladder and confirm its adequate distention. The patients were examined in both the supine and prone positions. Scanning of the urinary bladder was performed with a minimal field of view according to the following parameters: 120KV;detector collimation, 16x0.75 mm; section thickness, 1 mm; rotation time,0.5 second; pitch,1.2 and 156mAs.

Images were reconstructed at 1-mm intervals by using the minimal field of view measured from the inner aspect of the middle of the pelvis. Scanning of the region of the urinary bladder lasted 4 seconds on average, and the time for the whole procedure was approximately 5 minutes. Multiplaner reconstruction (MPR) images were obtained in transverse, coronal, and sagittal planes. Virtual cyctoscopic images were obtained and the average time for the creation of these images and start navigation of the urinary bladder was approximately 2 minutes.

The axial, MPR and virtual images were interpreted prospectively, both separately and in combination. The lesions which located at dome and neck of the bladder were detected in reformatted images, which are difficult to detect by transverse image alone. Also the reformatted images used to detect tumor invasion in adjacent organs.

The bladder wall was divided into six segments: anterior, posterior, superior, inferior, right and left sides. The camera for virtual cyctoscopy was placed in the center of the bladder lumen and thereafter was advanced to each of the six locations in turn.

The number, size, location, and morphologic features of the lesions were evaluated on transverse and virtual images obtained with the patients in both the supine and prone positions. Tumor size was classified into lesions with a diameter of 0.5 cm or less and those larger than 0.5 cm. Each lesion was characterized as a focal polypoid lesion, a sessile mass, or wall thickening. Discrete lesion was considered polypoid if it was taller than it was wide, while a sessile mass was defined as a lesion that was wider at the base. A lesion was characterized as wall thickening when there was elevation of the bladder wall without discrete mass. The total time of the study interpretations was average 10 minutes.

The quality of each image was also evaluated in terms of the residual urine, which may obscure the bladder mucosa, and the degree of distention. Complications due to virtual cystoscopy were recorded.

The results of virtual cystoscopy were compared with the findings of conventional cystoscopy, which is considered the standard. The lesions that were not prospectively identified at virtual cystoscopy were retrospectively evaluated for visibility on transverse and virtual images. The pathology report in each patient was also reviewed for further correlation.

3. Results

Fifty patients enrolled in the study and divided in two groups; the first one (39 patients) presented by hematuria and suggested that they have new bladder lesions, the second group (11 patients),with history of previous superficial cancer bladder that was resected with trans-urethral resection of bladder tumor(TURB)and they are in follow up period. Sixty two lesions were detected in both groups; with failure rate of 3/62 (4.8%) with 2 false positive and one false negative lesions. Sixty one lesions were detected by convention cyctoscopy which is considered as a standard reference for our study.

Images in 46 (92%) of the 50 virtual cystoscopy examinations (in both groups) were of excellent or good quality, with adequate bladder distention and minimum residual urine. Images in four examinations were suboptimal due to either moderate residual urine or poor bladder distention. The results are assisted in both groups.

A-First group: 39 patients with bladder masses:

Comparative study between the findings of axial CT (conventional) images and virtual images was done. As regard the no. of the detected lesions;**59** were in the virtual cyctoscopy(VC) images while only **51** were detected in axial and reconstructed CT images.

Table (1) shows the localization and the number of lesions in different bladder walls.

Tumor Localization	No of lesions	
	Virtual cystoscopy	Axial CT
Bladder dome	6	4
Right lateral wall	12	12
Left lateral wall	11	11
Base	12	7
Anterior wall	7	6
Posterior wall	11	11

Table (2) shows the the different lesions in the bladder according to their morphology.

Morphological appearance	No of lesions	
	Virtual cystoscopy	CT
Polypoidal*	26	17
Sessile**	22	22
Wall thickness***	11	12
Total	59	51

*Picture 1(A,B,C,D,E), **picture2(A,B,C,D),***picture 3(A,BA,C,D)According to the table 2, the total mass lesions detected by virtual cystoscopy were 48, and wall thickening areas were 11. While 46 lesions and 12 areas of wall thickenings were proved by conventional cystoscopy.

Table (3) will show the distribution of the size of the sessile and polypoid lesions in both axial and virtual images:

size	Lesions ≤5mm		Lesions ≥5		Total no. of masses	
Morphology	VC	Axial CT	VC	Axial CT	VC	Axial CT
Polypoidal	18	11 (7F-ve)	11 (2+ve)	9	29	20
sessile	0	0	19	19	19	19

Combination between supine and prone positions:

Scanning in both supine and prone positions proved necessary to avoid missing lesions obscured within the residual urine. Eleven lesions (17.7%) located on the posterior wall of the urinary bladder were detected only on prone scanning, and seven lesions (11.29%) involving the anterior wall of the urinary bladder, were seen only in supine images.

Associated Findings:

Table (4) shows association of lesions.

Associated Findings	No of Patients
Bladder diverticulum	5
Hydroureter: a) unilateral b) bilateral	21 a)11 b)10
Renal stones	5
Simple renal cyst	3
Liver metastasis	3
Liver cirrhosis	1
Regional lymph nodes	2

Table (5) shows the findings in the 11 follow up patients as shown by VC, axial CT and conventional cyctoscopy.

No of patients	Findings	Percentage from total (11 patients)
2	***Case 1*:** Polypoid mass (13x12 mm) wall thickening mainly posteriorly ***Case 2***: small polyp 5mm in the posterolateral aspect of the bladder	18.18%
9	No abnormality detected	81.8%

Second Group: Case of follow up patients:

These patients had previously superficial superficial bladder cancer which resected transuretherally and in follow up period.

There were no differences in the findings detected in this group between both VC and Axial CT, and all lesions proved to be recurrent urothelial carcinoma (UC) by conventional cyctoscopy and biopsy.

Correlation between the results of virtual cyctoscopy and conventional cyctoscopy:

1) Number of lesions:

These correlations were summarized in the table (6).

Technique / No.	Cystoscopy	VC	Axial CT
No. of lesions in group A	58	59 (3 misdiagnosed lesions:2 F+ve&1 F-ve)	51 (7 F-ve)
No. of lesions in group B	3	3	3
Total No. of lesions	61	62	54

Table (6) shows the following. there were 3 misdiagnosed lesions: two false positive and one false negative that were detected by Virtual Cystoscopy. The two false positive lesions were as follows: one proved to be a stone bladder by conventional cyctoscopy and Axial CT (picture 4, A, B, C, D). The other lesion which was seen by virtual cystoscopy as psudo polyp lesion that simulated an intravesical mass, was seen by Axial CT and proved by conventional cystoscopy as posterior wall thickening which attributed to some wall projection and irregularities (picture 5, A,B, D).

2) On the other hand, VC missed one lesion of wall thickness which proved by both axial CT and CC as bladder lesion.

2) Size of the lesions:

Table (7) shows the number of masses regarding their size at conventional cystoscopy, virtual cystoscopy, and axial CT:

Size / Technique	Masses≤5mm	Masses>5mm
Conventialcyctoscopy	18	28
Virtual cyctoscopy	18	30(28 true positive+2F+ve)
Axial CT	11	28

Small mass lesions (≤5mm) were equally detected by both virtual cystoscopy and conventional cystoscopy while the axial CT shows less sensitivity for detecting small lesion (61%). While in mass lesions >5mm they were equally detected by conventional cystoscopy and axial CT, while there were 2 false positive lesions detected by virtual cystoscopy.

3) Morphology of the lesions:

Table (8): shows comparison between confentional cystoscopy(CC), virtual cystoscopy(VC), and axial CT regarding the morphological description of the lesions detected in both groups:

Morphology	Number of lesions		
	Cystoscopy	VC	Axial CT
Polypoid	25	27(2 F +ve)	18(7F-ve)
Sessile	23	23	23
Wall thickness	13	12(1F-ve)	13

Table (9): showed the sensitivity of conventional cystoscopy (CC), virtual cystoscopy (VC), and axial CT regarding the morphological description of the lesions:

		Sensitivity	Morphology
Cystoscopy	VC	Axial CT	
100%	100%	72%	Polypoid
100%	100%	100%	Sessile
100%	92.3%	100%	Wall thickness

Virtual cystoscopy detected both polypoid and sessile bladder lesions with sensitivity 100% while it has defect in detection of wall thickness of urinary bladder. On the other hand, Axial CT had a higher sensitivity in detection the wall thickness and sessile lesions with sensitivity of 100%. So combined VC and axial CT raised the sensitivity of the study.

Table (10): showed the predictive values, sensitivity and the specificity of both virtual cystoscopy(VC) and axial CT:

Result / Technique	Positive predictive value	Negative predictive value	Sensitivity	specificity
VC	96.7%	90%	98.4%	81.81%
Axial CT	88.5%	65%	73.8%	100%

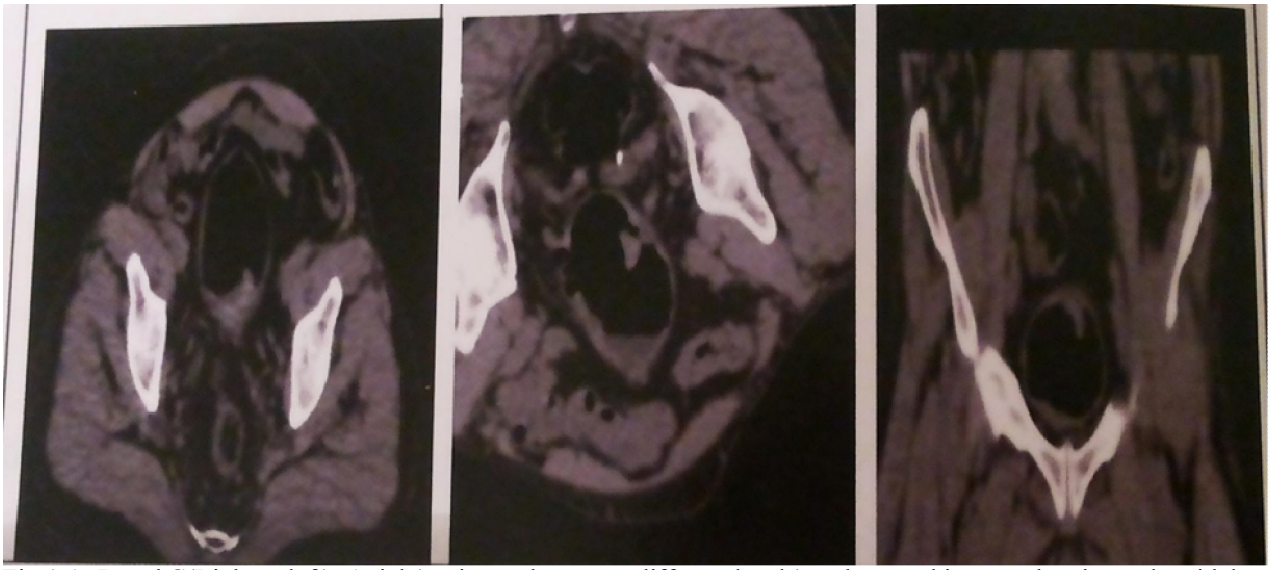


Fig 1 A, B and C(Right to left): Axial (supine and prone at different levels) and coronal images showing polypoidal mass at the left superior bladder wall with trabiculations.

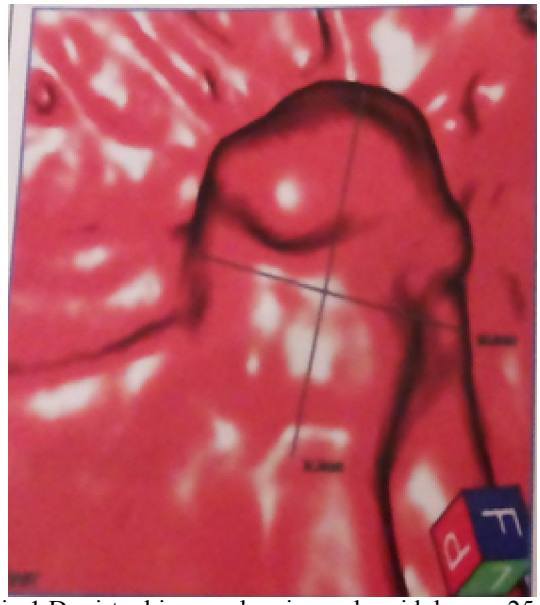


Fig 1 D: virtual image showing polypoidal mass 25x24 mm.

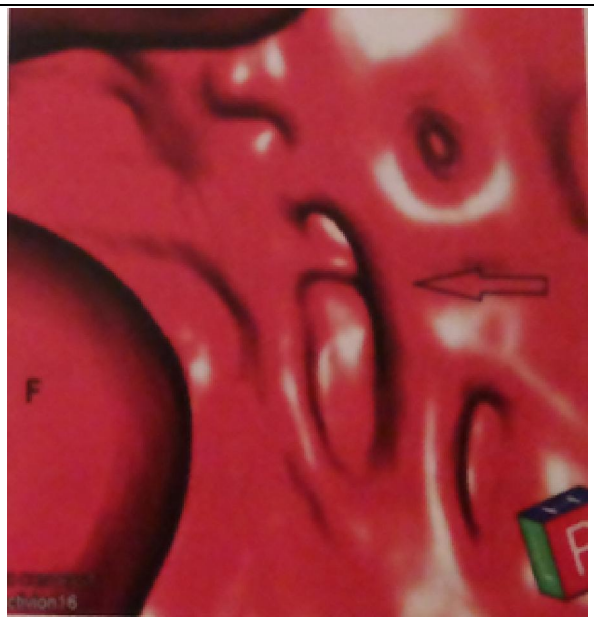


Fig 1 E: Bladder wall trabiculation as seen by virtual cystoscopy (arrow).

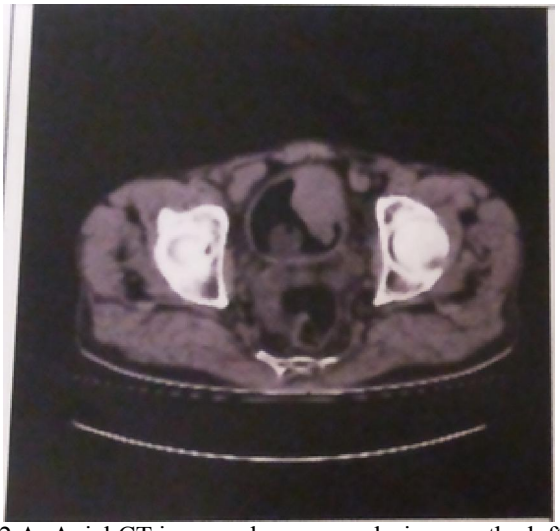


Fig.2 A: Axial CT images shows mass lesions on the left anterolateral aspect of the urinary bladder.

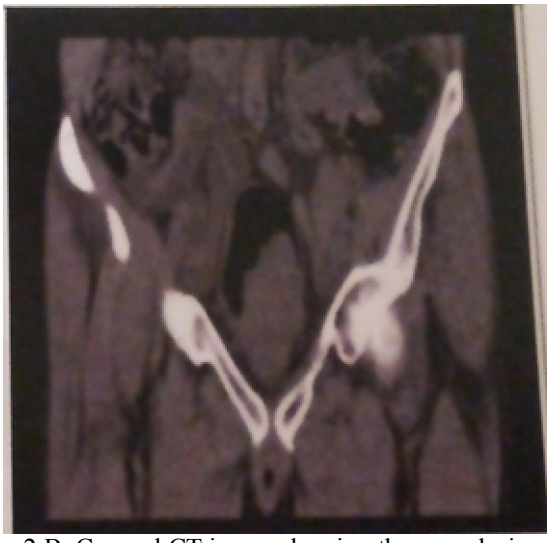


Fig. 2 B: Coronal CT image showing the same lesion extending to the bladder base.

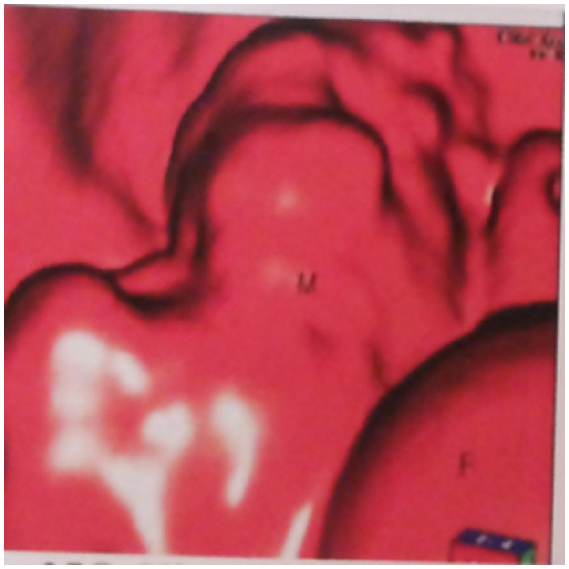


Fig.2 C : Virtual image clearly shows sessile mass (M). F; Foly's catheter.

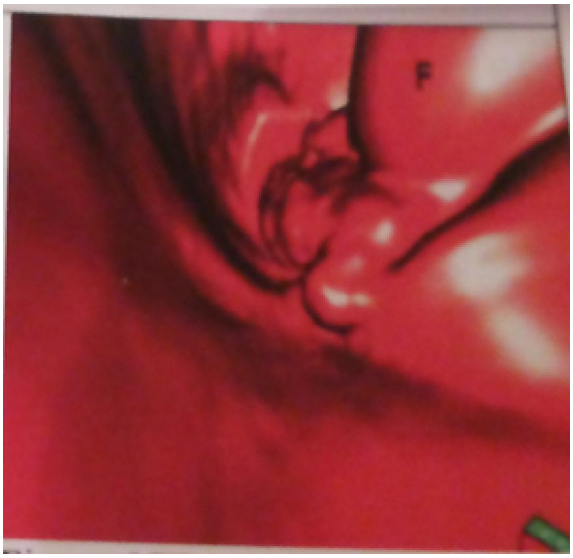
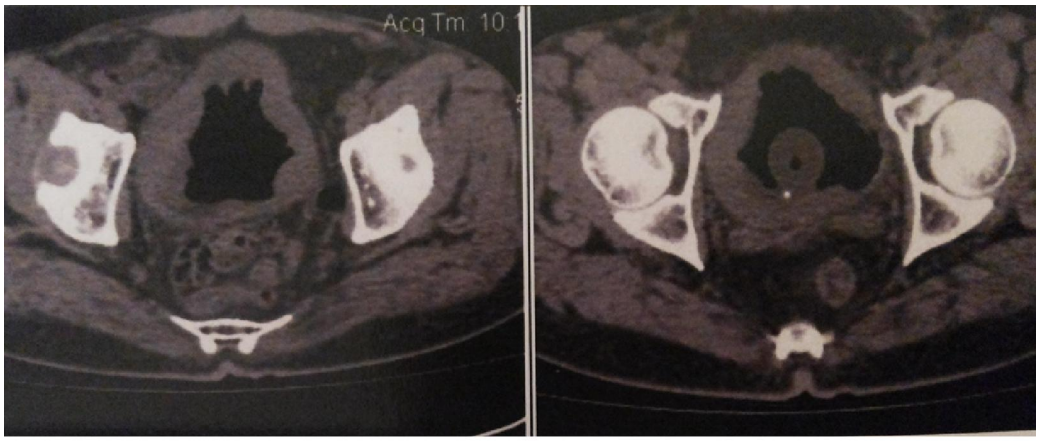


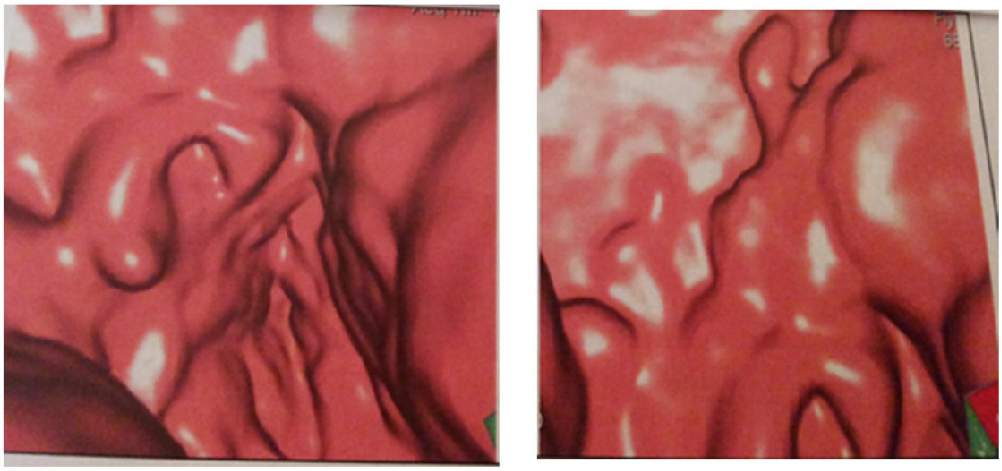
Fig. 2 D: Another view of the same lesion. F; Foly's catheter.

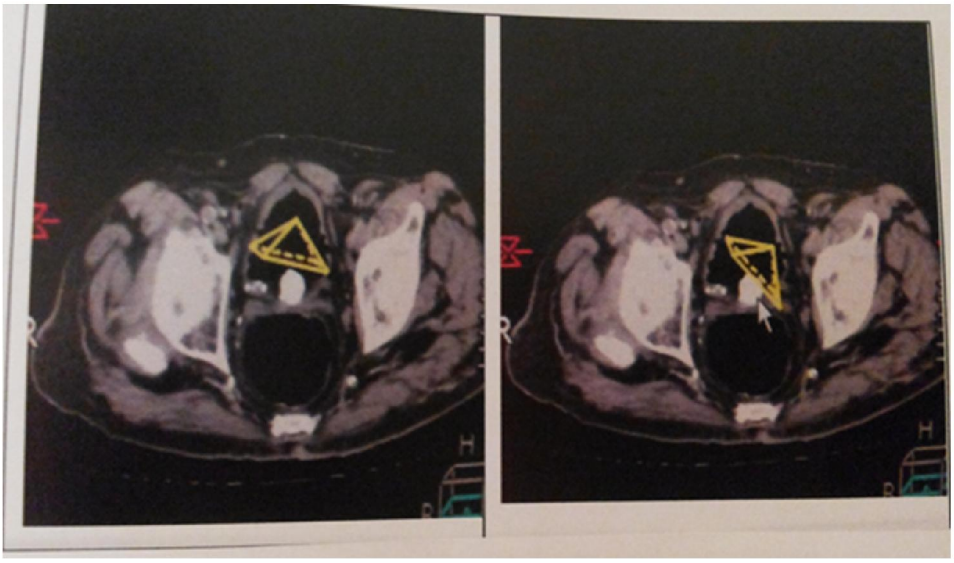
Histopathology:

Table (11): shows the histopathological diagnosis of the true positive lesions in 50 patients:

Tumor Pathology	No. of lesions	Percentage from total
Urothelial carcinoma	42	68.8%
Sqamous cell carcinoma	14	22.9%
Adinocarcinoma	1	1.6%
Benign Bilharzial Polyp	4	6.56%

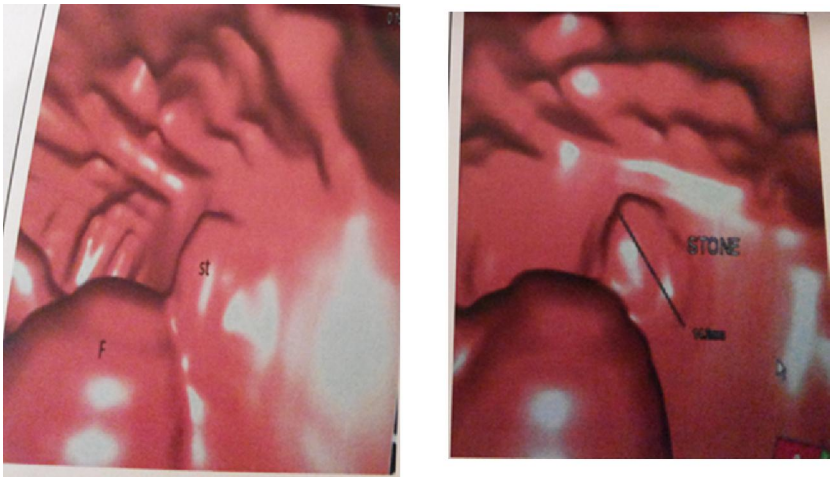






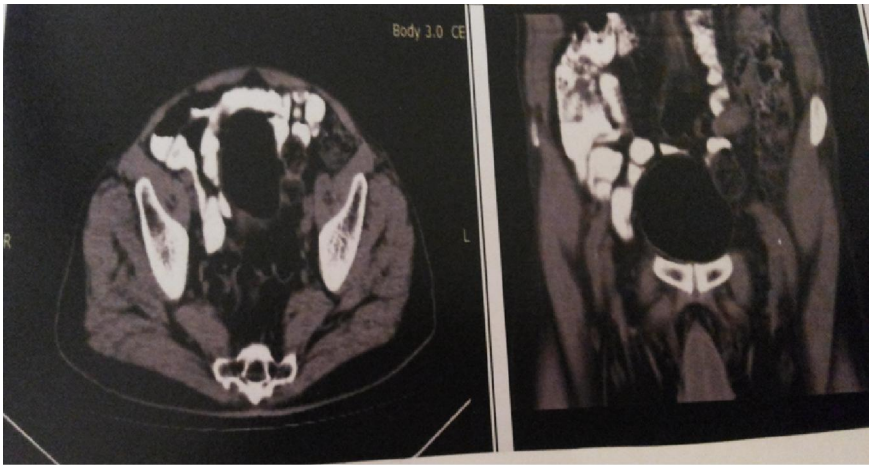
A **B**

Fig.4 A&B: Stone at the bladder base. Wall irregularities are also noted



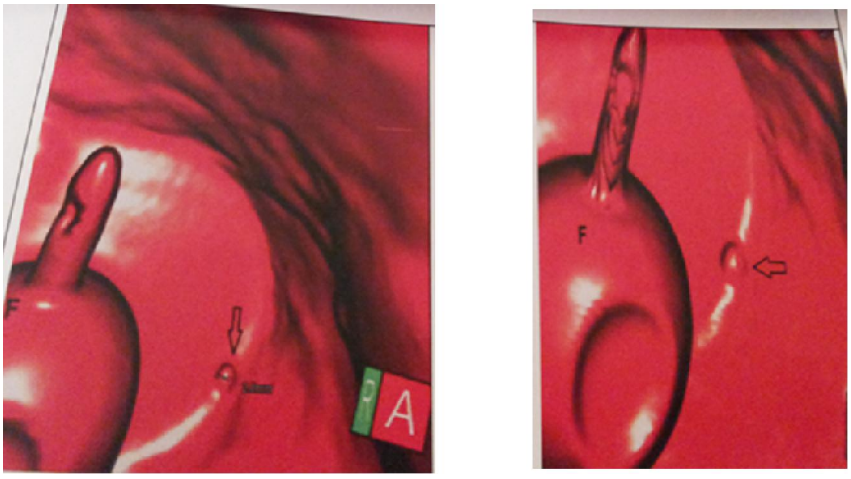
C D

Fig 4 C&D: pseudopolyp 14 mm at the bladder base F: Folly's catheter st: stone. Wall irregularities are also seen



A B

Fig.5 A&B: Axial and coronal reconstruction CT images revealed no mass lesion detected at different levels.



C D

Fig.5 C&D: Small polypoid lesion 2.8mm (arrow) from different views was clearly detected at the anterior bladder wall as seen by virtual cyctoscopy images. F: Foly's catheter.

4. Discussion

In our study we tried to investigate of the utility of CT virtual cystoscopy in the detection of bladder masses and compared the findings to the gold standard conventional cystoscopy.

Our studies included 50 patient, 39 of them presented with hematuria and 11 patients with a history of previous transurethral resection of superficial bladder cancer in the follow up period. They ranged in age from 42 years to75 years with mean of 63.12; while male to female with ratio was 5.25:1.

An excellent overview of the bladder masses was obtained in all cases and the results of virtual cystoscopy and conventional cystoscopy were comparable with excellent sensitivity rates of virtual cystoscopy in detection, localization and morphology description of the bladder lesions at variable sizes. The size of masses in both groups (n=50) ranged from 2.5 to 90 mm in diameter, including 18 lesions with a diameter of 0.5 cm or less.

The high detection rate of lesions is mainly attributed to CT protocol used. Acquisition with thin collimation, creation of MPR images with no artifacts and virtual images of very good quality and excellent anatomic detail facilitating detection of large number of small tumor with a 16- MDCT scanner.

Our study showed that the combined evaluation of axial, MPR, and virtual images should be used to increase the performance of the technique, especially in recognition of small tumors with high sensitivity and specificity.

For detection of all tumors (n=62), virtual cystoscopy alone showed sensitivity 81.81%with tow false positive and one false negative in comparison to the conventional cystoscopy which detected 61 lesions.While in axial CT (+MPR) alone the sensitivity was 73.8 and the specificity was 100%, with a 7 false negative findings. Generally speaking virtual cystoscopy has several advantages over conventional cystoscopy specially after the advances of 3D postprpssing techniques.it is less invasive less time consuming require less equipment with fewer patient preparation steps,allowing imaging of the urinary bladder in multiple planes and bypassing any obstruction if present. Also it can be used to evaluate areas of urinary bladder difficult to evaluate by cystoscopy such as anterior bladder neck and narrow mouth diverticulum.

On the other hand virtual cystoscopy have some limitations it is unable to depict flat lesions and mucosal colors changes(9), does not allow for biopsy(9,10) ,thus alone impractical for staging.

Conclusion

Virtual CT cystoscopy is a promising technique for detection of tumors and some lesions such as diverticula however it is unlikely to replace conventional cystoscopy.

Virtual cystoscopy is valuable in evaluation of urinary bladder wall thickness that indicates underlying disease. This minimally invasive technique can be of value for, primary diagnosis and follow-up of bladder lesions. Virtual cystoscopy has the advantage of detecting small lesions which should be looked for during conventional cystoscopy. Virtual cystoscopy may be indicated in clinical situations where conventional cystoscopy is not feasible as in cases where there is risk of hemorrhage, perforation, or patient refusal to have conventional cystoscopy.

Virtual cystoscopy is a new armamentarium in urology, it will aid in the diagnosis of carcinoma of the bladder and bladder lesions, but it will not replace definite diagnosis by taking a biopsy and histopathological examination.

Conflict of interest:

Nothing to declare

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5/7/2015