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# Role of Multisclice And Virtual Cystoscopy Versus Ultrasound and Color Doppler Study in Evaluation of Urinary Bladder Neoplasms

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**Abstract:**

**Introduction:** the virtual cystoscopy and the color Doppler examinations are good modalities in assessment of the urinary bladder neoplasms. This study is done to assess the accuracy of CTVC and color Doppler ultrasound in detection of the urinary bladder neoplasms.

**Patients and methods:** The examination was done between June 2010 and December 2012 on 60 patients known or suspected to have urinary bladder neoplasm. They were examined using CTVC and color Doppler ultrasound. Bladder scanned using multislice CT at a slice thickness of 1 mm. The data were transferred to a workstation for interactive navigation. Findings obtained from CTVC and ultrasound were compared with results from conventional cystoscopy and with pathological findings.

**Results:**

By the conventional cystoscopy; the 43 patients in the **group A** showed 53 lesions. There were (35/43 patients) with single lesion while there were (8/43 patients) more than one lesion. While the other 17 patients in **group B** showed 11 patient with no focal lesions and 6 patients with 6 focal lesions.

By virtual cystoscopy; 56 lesions were detected in both groups; 51 plus 5 lesions in group A and B respectively. There were 3 false negative lesions with a failure rate of 3/56.

By ultrasound; 56 lesions were detected in both groups; 53 plus 3 lesions respectively.

So in virtual cystoscopy and ultrasound the results were as follows: positive predictive values: 100%; negative predictive value: 78.6 %; sensitivity: 94.9%; specificity: 100%

**Conclusion:** Although the definitive diagnosis of some suspected urinary bladder tumors is only possible with conventional cystoscopy and biopsy, CTVC and color Doppler ultrasound are a minimally or non-invasive techniques which provide beneficial information about urinary bladder lesions.

**Keywords:** CTVC, color Doppler ultrasound, bladder neoplasm.

## Introduction:

The function of the lower urinary tract is basically storage of urine in the bladder and the at-will periodic evacuation of the stored urine. The urinary bladder is a musculo-membranous sac which acts as a reservoir for the urine.

Cancer of the urinary bladder is one of the most common urothelial neoplasms. It has high rates of recurrence at the initial tumor site and elsewhere throughout the transitional epithelium (30–80% of cases) and of multi-focal manifestations (as many as 50% of cases). Gross painless haematuria is the classic clinical sign of bladder carcinoma.

Conventional cystoscopy plays a key role in the diagnosis and follow-up of bladder cancer.

Virtual endoscopy is a minimally invasive technique that has promising results in the evaluation of the entire urinary tract. CT virtual cystoscopy has been proposed as an alternative imaging technique with potential advantages in the detection of urinary bladder neoplasms and has good patient acceptance. Multi-detector row CT is the most recent advance in CT technology. An increased number of detector rows and more powerful x-ray tubes result in faster scanning time, increased volume coverage, and improved spatial and temporal resolution. MDCT (multi-detector computed tomography) technology allows superior image quality, decreased examination time, and the ability to perform complex multiphase vascular and three-dimensional examinations.

Ultrasound is an inexpensive and allow visualization of the bladder. With advent of color Doppler ultrasound determination of vascularity within a lesion is possible.

**Pathology of the urinary bladder neoplasm:**

Carcinoma of the urinary bladder is one of the most common malignant tumors of the urinary tract.



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Histopathological types of bladder tumors are based on the WHO classifications that are classified bladder tumors into epithelial and non epithelial tumors. The Bladder Neoplasia is classified into;

**A- Benign Neoplasia**

**1- Mesenchymal:** These include leiomyoma, neurogenic tumors (neurofibroma, and pheochromocytoma), vascular lesions (hemangioma and lymphangioma), lipoma, hamartoma and a range of fibrous tumors (fibroma, fibrous hisitocytoma, fibroma and fibroepithelial polyp).

**2- Epithelial:** Papilloma and inverted papilloma.

**B- Malignant Neoplasia**

| A- Epithelial | B- Non Epithelial |
|---|---|
| • Carcinoma in situ | • Neuofibroma |
| • Transitional cell Carcinoma | • Pheocromocyotoma |
| • Squamous cell Carcinoma | • Primary lymphoma |
| • Adenocarcinoma | • Plasmacytoma |
| • Small cell Carcinoma | • Sarcoma |
| • Carcinosarcoma | • Myoblastoma |
| • Metastatic | |

Technique of the virtual cystoscopy involve one of the following two methods;

**A- Air filled technique of the CTVC:**

Placement of 12-F Foley catheter into the bladder to drain residual urine. The bladder is then insufflated with 300-500 ml of carbon dioxide through the Foley catheter, according to patient tolerance. After a scout view is obtained with the patient in the supine position to locate the bladder and confirm its adequate distention, single breath-hold helical CT is performed, with 3mm collimation (section thickness), pitch of 1:1, 110-120 KVp, 70-230 mA, and a 512 x 512 matrix. Images are reconstructed at 1-1.5 mm interval by using the minimal field of view. The patient is then turned to the prone position, and helical CT of the bladder is repeated with use of the same parameters. The data is downloaded to an independent work station equipped with software for interactive intra-luminal navigation.

**B- Technique of virtual cystoscopy of the contrast material- filled bladder:**

This technique begins with intravenous injection of 120 ml of contrast material or may be performed by instilling contrast material into the bladder via a Foley catheter prior to CT scanning. Before undergoing virtual cystoscopy, all patients are asked to be alternate taking supine and prone positions four times so that the contrast material and urine in the bladder could be adequately mixed. Then the bladder is scanned by the same manner in the air filled technique.

After acquiring data; the processed dataset may be rendered for visualization of which there are many available; four main 3-D visualization techniques are used on clinical 3-D workstations: Multiplanar reformation (MPR) (used and represents a simple recordering of the image voxels) (fig 1), maximum intensity projections (MIP) (the maximum voxel intensity along a line of viewer projection in a given volume) (fig 2), shaded surface displays (SSD) (accurate 3-D representations of anatomy, relying on the gray scale to encode surface reflections from an imaginary source of illumination) (fig 3), and a volume rendering technique (VRT) (all attenuation values within a voxel are used to obtain the final image) (fig 4).

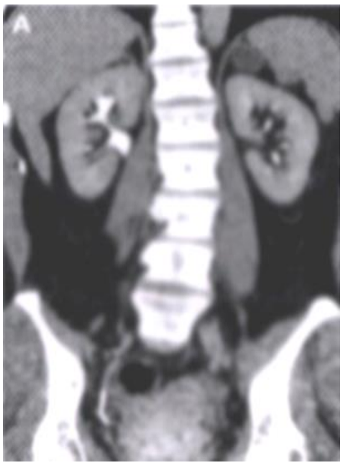



**Fig 1** : post processing image MPR


**Fig 2 :** post processing image MIP

**Fig 3** : post processing image SSD

**Fig 4** : post processing image VRT

**The use of ultrasound and color Doppler study in evaluation of the bladder neoplasm**

Usually a mid-range of 3.5 – 5 MHz convex or sector transducer is used in adults. High frequency (more than 5 MHz) yields the greatest special resolution; although restricted by limited penetration and are effective in most children.

**Subjects and methods:**

The examination was done between June 2010 and December 2012 on 60 patients known or suspected to have urinary bladder neoplasm. These patients are referred from urology department or outpatient clinic in police authority hospital; as well as other private radiology centers (such as Dokki radiology center, Omega radiology center and others). The study was done on 60 patients; 43 suspected patients **(group A)** and 17 follow up patients **(group B)**. The study contains 53 males and 7 females ranging from 17 years to 88 years (mean 61.275 years). All patients were subjected to conventional cystoscopy with maximum two weeks intervals which was considered the standard of reference for assessing the efficacy of virtual cystoscopy in the detection of urinary tumors and were confirmed by histopathological analysis.

**Results:**

Between June 2010 and December 2012, sixty patients were recruited for the study. All patients were examined by color Doppler ultrasound (either by convex 3.5- 5 MHz transducer or endocavitary 4-10 MHz transducers), as well as 4 or 16 multi-detector CT (MDCT) scan and virtual cystoscopy were elaborated from the acquired CT raw data.

**By the conventional cystoscopy**; the 43 patients in the **group A** showed 53 lesions; There were (35/43 patients) with single lesion while there were (8/43 patients) more than one lesion. While the other 17 patients in **group B** showed 11 patients with no focal lesions and 6 patients with 6 focal lesions. So, collectively 59 lesions were detected in the conventional cystoscopy which considered as a standard reference for this study.

**By virtual cystoscopy;** 56 lesions were detected in both groups; 51 plus 5 lesions in **group A and B** respectively. There were 3 false negative lesions with a failure rate of 3/56 with. (fig 5-10)

Fig 5: MPR bladder polyp sag. Plane

Fig 6: MPR bladder polyp cor. plane

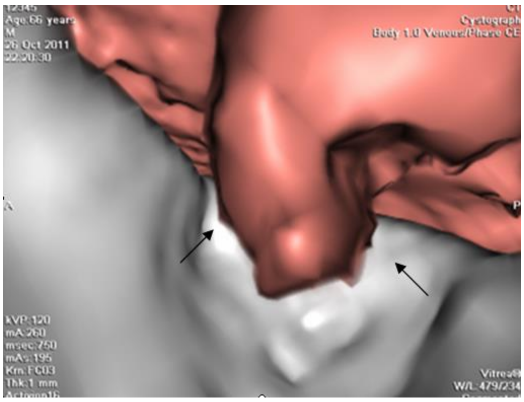


Fig 7: CTVC showing polyp

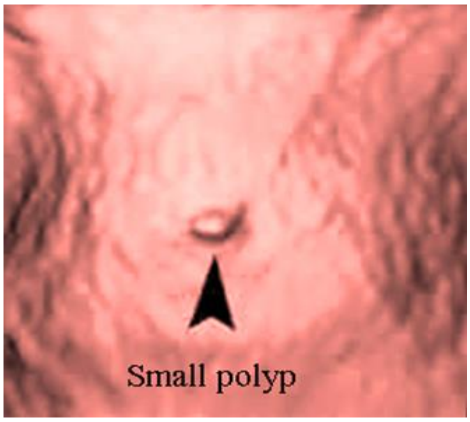



Fig 8: CTVC showing another tiny polyp

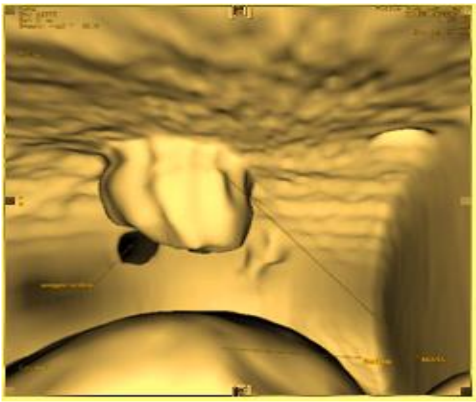


**Fig 9:** VC showing polyp

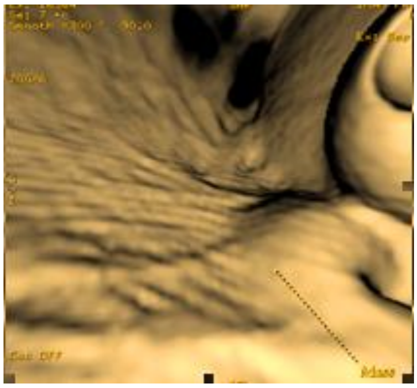


**Fig 10**: VC showing another wall thickening

**By ultrasound**; 56 lesions were detected in both groups; 53 plus 3 lesions respectively. (fig 11,12)

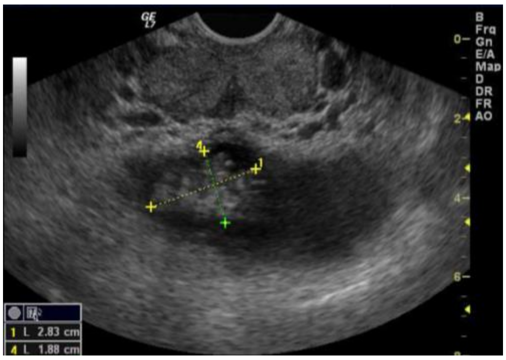


**Fig 11**: US showing small lesion

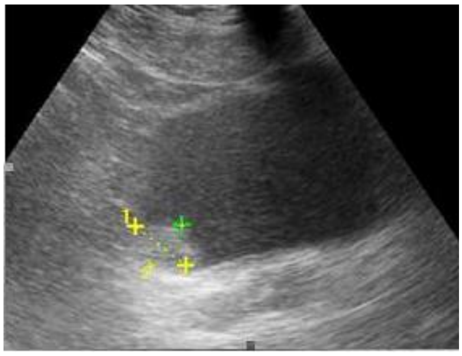
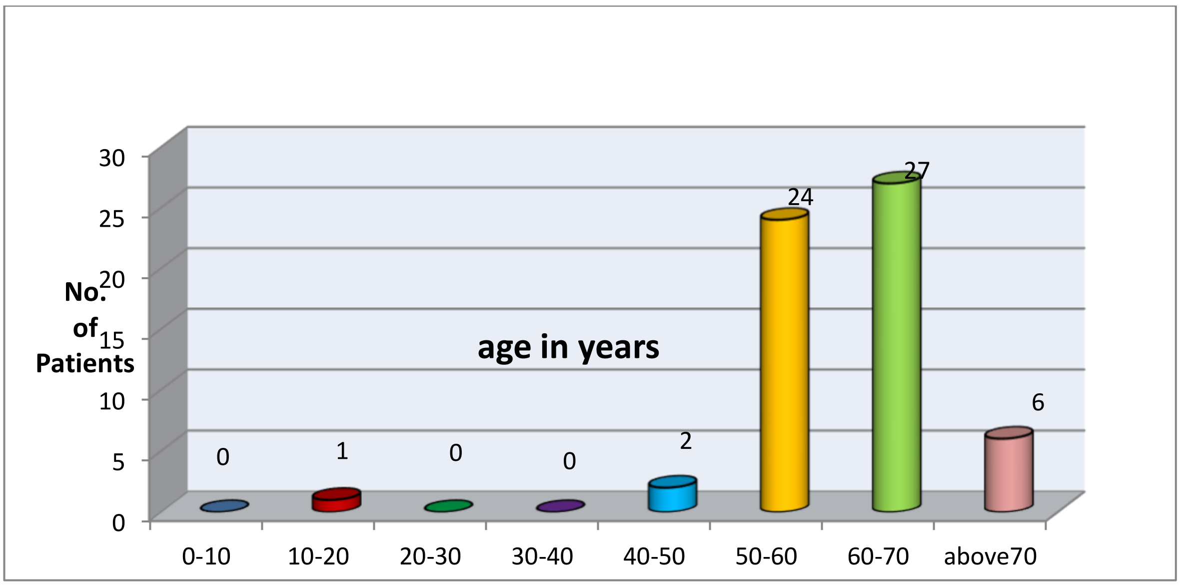


**Fig 12:**US showing small polyp

**Analysis of the data acquired:**

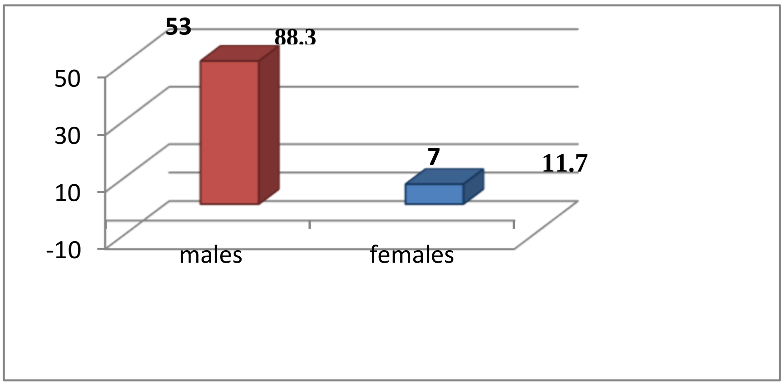
**Patient's age:**

The patient ages in this study ranged from 17 years to 88 years with a mean of 61.275 $\pm$ 11.142 the main age group is seen in 5th and 6th decades (figure 13).




**(Fig. 13):** number of patients in relation to age.

**Male to female ratio:**
Among 60 patients included in this study 53 were males (88.3%) and 7 were females (11.7%) with male to female ratio 7.57/1, (figure 14)




**A- In group A:**
**1- Number of detected lesions:**
51 lesions were detected in the virtual images. There were (35/43 patients) "81.4%" with single lesion while there were (8/43 patients) "18.6%" more than one lesion.
**2- Anatomical distribution:**
The localization of the detected lesions in different bladder walls via virtual cystoscopy and Doppler ultrasound; as well as the conventional cystoscopy are shown in the following (table 1)

| Tumor localization | No. of lesions in CC | No. of lesions in VC | No. of lesions in US |
|---|---|---|---|
| Base | 5 | 2 | 5 |
| Dome | 4 | 5 | 4 |
| Trigone | 3 | 3 | 3 |
| Right lateral wall | 12 | 12 | 12 |
| Left lateral wall | 11 | 11 | 11 |
| Anterior wall | 3 | 3 | 3 |
| Posterior wall | 4 | 4 | 4 |
| Circumferential wall thickening | 11 | 11 | 11 |

**(Table 1):** Shows the number and localization of the lesions at virtual images and ultrasound in comparison with conventional cystoscopy

**3- Shape:**
The lesions were characterized as mass lesion (if the lesion is connected to the bladder wall by a broad base), polypoid (if the lesion is attached to the bladder wall by a narrow stack) or wall thickening (when the bladder wall is elevated with no definite mass lesion) according to the following (table 2).

| Morphological appearance | No. of lesions by CC | No. of lesions by VC | No. of lesions by US |
|---|---|---|---|
| **Polypoidal** | 24 | 22 | 24 |
| **Mass lesion** | 18 | 18 | 18 |
| **Wall thickness** | 11 | **11** | 11 |

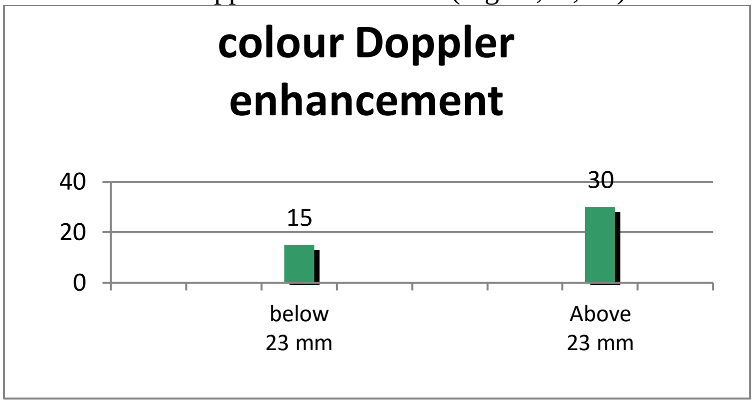
**(Table 2):** Shows the number of lesions according to their morphological description.

**4-Size:**

The diameter of the mass lesions detected by virtual imagesn and ultrasound was ranged from 4-69 mm (mean size; 28.32 mm), (25%) of those detected on virtual CT cystoscopy and ultrasound had a diameter of 10mm or less; and the rest of the lesions (75%) were more than 10 mm.

**5-colour Doppler assessment:**

The color Doppler enhancement is noted within 30 patients. All the lesions were above 23 mm, while the lesions less than 23 mm showed no Doppler enhancement. (Fig 15,16, 17).




(Fig. 15): Shows the number of enhanced lesions by Doppler in comparison to size.

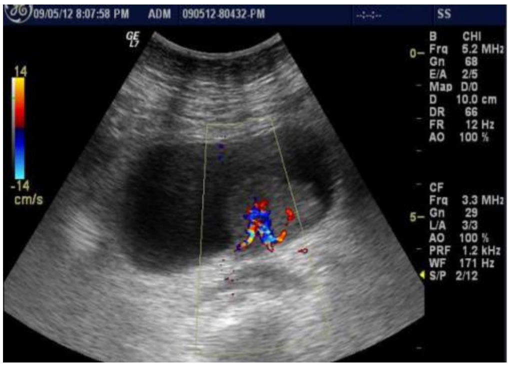


Fig 16:Color Doppler showed enhanced lesion

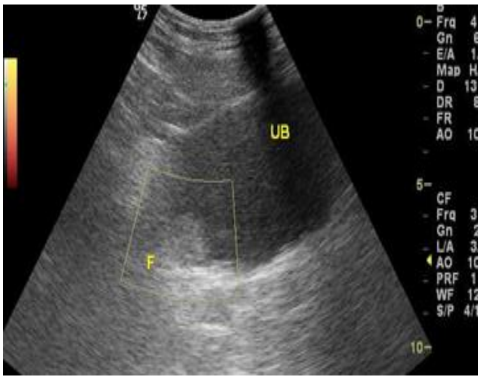



Fig 17: Color Doppler showed non-enhanced lesion

**B- Second group:**

These patients had history of transurethral resection (TUR) of previous superficial bladder cancer in their follow up period.

The virtual cystoscopy images detected 5 lesions in the **2nd group**; wall thickening in 3 patients and 2 patients with 4 mm polyp. While by ultrasound it depicted 3 lesions in the 2nd group; wall thickening in 3 patients.

These findings were confirmed by conventional cystoscopy and proved to be recurrent TCC; 3 patients with wall thickening and 2 patients with polypi.

In addition; the conventional cystoscopy revealed one patient in the 2nd group with colour change and proved to be Carcinoma in situ (CIS) grade I TCC by histopathology and this lesion was not visualized by virtual images.

Virtual CT and ultrasound were able to depict the morphology of the bladder mass lesions either polypoid, mass lesion or wall thickening with specificity of 100%, while VC and ultrasound did not detect the one lesion with mucosal color change in the UB wall.

So in virtual cystoscopy and ultrasound the results were as follows: positive predictive values: 100%; negative predictive value: 78.6 %; sensitivity: 94.9%; specificity: 100%.

## Discussion:

Carcinoma of the urinary bladder is one of the most common malignant tumors of the urinary tract in male and female patients.

Patients with urinary bladder neoplasms should undergo conventional cystoscopy to monitor for disease recurrence. Cystoscopy for possible recurrence is recommended at 3 months intervals for the first year, 6 months for the second year and annually thereafter.

The golden role for optimization of a good CTVC beside the requirement to distend the bladder properly is to increase the contrast difference between the bladder wall and the lumen in order to optimize the virtual endoscopy independently of the type of contrast used. Two techniques have been used to obtain the CT source data for reconstructed virtual cystoscopic images, scanning the bladder that has been filled with either air or contrast material. Requirement of two sets of CT data obtained with the patient in both the supine and prone positions is another disadvantage of the air-filled bladder method as said. In this study, we found also in the air filled technique that because of the incomplete evacuation of the bladder we have to scan the patient in the prone position; especially when the lesion is noted at the base of the bladder. However the urine and contrast could not be mixed properly with this method for virtual cystoscopy in patients who cannot easily change position, so the image quality of virtual cystoscopy is inevitably sub-optimal because of inadequate mixing of the contrast material and urine and this is one of the disadvantages. Inadequate distension and waiting for bladder filling are also disadvantages. In air virtual cystoscopy the bladder can be distended to almost the maximum capacity, on the other hand in IV method the bladder expansion depends on the maximum desire to void of each patient.

After acquiring the data and send to the workshop; the following images were obtained; (1) Volume rendering (VR): A histogram of attenuation values is generated from a given volume of the multislice CT data set, (2) Multiplaner reformation (MPR): Is the most simple and allows viewing of single scans in multiple planes (coronal and sagittal) others than axial scans and (3) Surface shaded techniques (SSD): Allow the reconstruction of the urothelium by extracting the computed tomography data from only the boundary region between the urothelial wall and the contrast medium.

After sending the data to the workstation we got the multi-planar reformatted coronal and sagittal images which help in the localization of the lesion and getting the volume rendering images which showed the bladder lesions and give informations about the size and shape of the lesions. Also the VC was sensitive to noise and artifacts with decrease in quality of mucosal detail.

The painless and non-invasive ultrasound examination without preparation can sometimes provide a great deal of useful information which will help a doctor arrive at a diagnosis and a treatment plan. we scanned the bladder in longitudinal and oblique axis; as well as oblique axis and of course the ultrasound is a subjective module of examination depending on the doctor evaluation.

The CTVC has the following obstacles;

Still VCCT is unable to detect the mucosal color changes which are detected only on conventional cystoscopy

In addition the calcifications associated with masses or stones were seen only on the axial images but not on virtual images.

Another important fact is that virtual images alone cannot make sure of the nature or the origin of the mass.

The CTVC and color Doppler study have the following limitations:

The differentiation between small tumors and inflammatory swelling of the mucosa could be difficult.

In addition, mucosal thickening secondary to fibrosis cannot be distinguished from a neoplasm.

Virtual cystoscopy may be potentially criticized because of increased radiation dose as the thin section thicknesses increase the radiation dose.

The obtained results for the 60 patients demonstrate excellent sensitivity and specificity score either by combined axial CT and virtual cystoscopy or by ultrasound examination in localization and morphological description of bladder tumors in comparison to conventional cystoscopy.

We could detect lesions up to 3 mm especially when the bladder is well distended and this is applicable for the virtual cystoscopy and ultrasound examinations.

Also 4 and 16 MDCT was used. 59 lesions were detected, 8 lesions out of them were 5 mm or less and were all proved with conventional cystoscopy with two other lesions not seen by

VC having sensitivity 80%. Ultrasound has the same sensitivity percentage.

The results of this study suggest that the color Doppler ultrasound and CTVC cannot completely take the place of conventional cystoscopy. Nevertheless, the Doppler ultrasound and CTVC are effective methods for detection of the location and size of tumors in patients with suspected urinary bladder lesions. Doppler ultrasound and CTVC will play a role as a follow up examination between conventional cystoscopy in bladder cancer patients who are under treatment

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