COMPUTED TOMOGRAPHIC VIRTUAL CYSTOSCOPY IN BLADDER TUMORS

THESIS
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in Radiodiagnosis

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بسم الله الرحمن الرحيم

﴿قَالُواْ سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ﴾

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List of Abbreviations

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AP: Anteroposterior
ADC: Adenocarcinoma
AJCC: The American Joint Committee on Cancer
BC: Bladder cancer
Ca: Cancer
CIS: Carcinoma in situ
CT: Computed Tomography
CTVE: CT Virtual Endoscopy
Conv.Cyst.: Conventional Cystoscopy
2-D :2-Dimentional
3-D :3-Dimentional
EBCT; Electron Beam CT
FNAC; Fine needle aspiration cytology
G(I,II.III): Grade (I,II,III)
IV: Intravenous
IVU: IntraVenous Urography
LN: Lymph node
Lt: Left
MIP: Maximum projection
MPR: Multiplaner reconstruction
MRI: Magnetic Resonance Imaging
MSCT: Multislice CT
PET: Positron Emission Tomography
PR: Per Rectal (examination)
Rt: Right
SCC: Squamous cell carcinoma
SSD: Surface shaded disply
TCC: Transitonal cell carcinoma
TV: Transverse
US: Ultrasound
UICC: The union Internationale Contre le Cancre
VC: Virtual Cystoscopy
VE: Virtual Endoscopy
VR: Volume rendering

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Introduction and Aim of the work

INTRODUCTION

Bladder cancer is one of the most common neoplasms of the urinary tract .Two out of three malignances of the urinary tract are located in the bladder .carcinoma of the urinary bladder comprises nearly 7% of all malignant tumours in men and 4% in women .**(Merkle , 1998 and Song, 2001).**

The patient usually presents with haematuria, and the initial evaluation consists of cytologic analysis of a urine specimen. Routine surveillance consists of excretory urography, trans-abdominal ultrasound, Cystoscopy, CT and MRI .**(Song , 2001)**.

This several imaging techniques are available for use in the detection of bladder neoplasms, the American College of Radiology recommended excretory urography as the imaging modality of choice in the evaluation of haematuria , yet no reliable radiological study is available for the use in bladder tumour detection and negative findings still warrant cystoscopy.**(ACR, 1999).**

The location, number, size, gross appearance, and staging of bladder tumours are important for clinical management and prognosis. Conventional cystoscopy is the first and mainstay modality in the identification and prognosis of bladder tumours.however, in addition to a lack of extravesical information, conventional cystoscopy is invasive and has alimited field of view. **(Wang , 2004)**.

CT and MRI are used mainly to demonstrate extravesical extension of the tumour and distant metastasis of the tumors, both have significant limitations for detecting smaller lesions and the surface morphology of the bladder tumors. **(Kim , 2003).**

Recently, three dimensional computer rendering techniques with rapid image acquisition have lead to the development of virtual reality imaging. With commercially available software, virtual reality imaging allows interactive intraluminal navigation through any hollow viscous, simulating conventional endoscopy. This technique of virtual endoscopy has been applied to many organs including the colon, bronchus, stomach and bladder. **(Song ,2001)**.

Multidetector CT with volume acquisition and rapid scan speed, can avoid motion artifact and the retrospective thin slice reconstruction is useful in detection smaller lesions. Contrast enhanced studies facilitate the evaluation of the relation between the tumours and their surrounding structures and the confirmation of pelvic lymphadenopathy. **(Wang , 2004)**.

Bladder pathology is frequent and the lesions are of different etiology. To make their diagnosis, the imaging modalities compete with cystoscopy. Despite of being invasive, cystoscopy is a simple and accurate tool in exploration of the bladder wall and trigone.

Cystoscopy remains the mainstay for diagnosis of bladder masses. US, CT and MRI imaging are performed mainly for assessment of related extravesical pelviabdominal manifestations; specially for tumoral processes, the role of imaging modalities is limited to locoregional extension, tumour staging, and follow up **(Husband et al., 1989 and Roy et al., 2000).**

Recent studies reported the feasibility of 3-D rendering of the urinary bladder ; 3-D cystoscopy simulates the endoluminal view seen at conventional cystoscopy **(Vining et al., 1996/Fenlon et al., 1997/Hussain et al.,1997).**

Virtual CT cystoscopy represents a promosing approach for bladder lesions diagnosis, with potential advantages in sensitivity, specificity and patient acceptability **(Narumi et al., 1996).**

The critical size for mass detection at virtual CT cystoscopy was shown at 5 mm, using protocols for CT and MRI cystoscopy **(Bernhardt and Rapp-Bernhardt, 2001).**

As a new diagnostic tool, virtual cystoscopy provides many advantages. It allows accurate localization of the lesion due to its wide field of view and depiction of extravesical anatomic landmarks.The size of a mass is measured objectively, and virtual cystoscopy can be used to monitor treatment response in a patient with a nonresectable tumour(**Gualdi et al., 1999/ Bernhardt and Rapp-Bernhardt, 2001).**

On the other hand, as a minimally invasive procedure, it is much more acceptable by the patients, specially those who cannot tolerate conventional cystoscopy, and it is of great value for those who may be poor candidates for conventional cystoscopy (in whom neoplasia, infection, inflammation, stricture, marked Prostatic hypertrophy or any other condition would compromise conventional cystoscopy). It also overcomes the drawbacks of routine endoscopy, as requirement of anaesthesia, risk of viscous perforation, and inability to assess beyond areas preventing passage of cystoscope **(Vining,1997/Gualdi et al., 1999).**

Therefore, despite the fact that it cannot provide tissue biopsy, and that its sensitivity for detection of small masses(<5mm)decreases, it still could be of great use and benefit for patients with bladder masses, comparable with results of conventional cystoscopy **(Narumi et al, 1996 / Fenlon et al ,1997/ Song et al,2001).**

Aim of the Work

The main purpose of this study is to determine the diagnostic potential and role of the CT virtual cystoscopy in the detection and evaluation of bladder masses, compare to the standard conventional cystoscopy.

ANATOMY

The urinary bladder is a hollow muscular organ situated anteriorly in the pelvis, deeply immediately behind the pubic bones. When empty it is wedged deeply in the forward part of the pelvis. During filling, the bladder rises up extraperitoneally and extends cranially into the abdomen, while the bladder base remains fixed **(Michael et al., 1997)**.

The bladder varies in size and shape according to the amount of urine it contains (normal capacity up to 400-500ml.). The empty bladder is described as having an apex, superior surface, left and right anterolateral surfaces and neck **(Michael et al., 1997).**

(I) Anatomic relations:

The apex is directed forwards and upwards to lie behind the upper border of the symphysis pubis. It the most superior and anterior portion of the bladder **(Michael et al., 1997/ Vinnicombe and Husband, 1999).**

The superior surface (dome) is triangular, bounded on each side by a lateral border that runs from the apex to the entrance of ureter into the bladder and by a posterior border joining the entrance of the ureter into the bladder **(Krueger and Bo, 1999).**

The posterior surface (dome) is triangular, directed backwards and downwards; in male, it is related to the rectum separated from it by rectovesical pouch above, seminal vesicles and vasa differentia below; in females it is closely related to the cervix and anterior vaginal wall separated from these by vesicocervical and vesicovaginal spaces **(Michael et al., 1997).**

The anterolateral surface is related to retropubic space of Retzius containing retropubic fat, perivesical venous plexus, and further posteriorly and laterally to the obturator internus muscle above and the levator ani below **(Michael et al., 1997/ Vinnicombe and Husband, 1999).**

The bladder neck is the most fixed part of the bladder, it lies 3-4cm. behind the lower part of the symphysis pubis. It rests directly on the prostate gland in male, and it is related to the pelvic fascia in females, and gives rise to the urethra **(Krueger and Bo, 1999).**

(II) Ligaments:

The bladder is firmly fixed in place in the pelvis by a number of true ligaments and peritoneal folds. The true ligaments include the puboprostatic ligament fixing the bladder neck, and lateral ligaments. Fibrous facial sheets fix the base to the fascia of the levator ani. From the apex, the median umbilical ligament extends extraperitoneally to the umbilicus. False ligaments connect the bladder to rectum in male, and uterus and rectum in females, and to the lateral walls of the pelvis in both sexes. In males, the rectovesical fascia of Denonvilliers, separating these from the rectum, reinforces the bladder base and prostate **(Lipson and Hricak, 1997).**

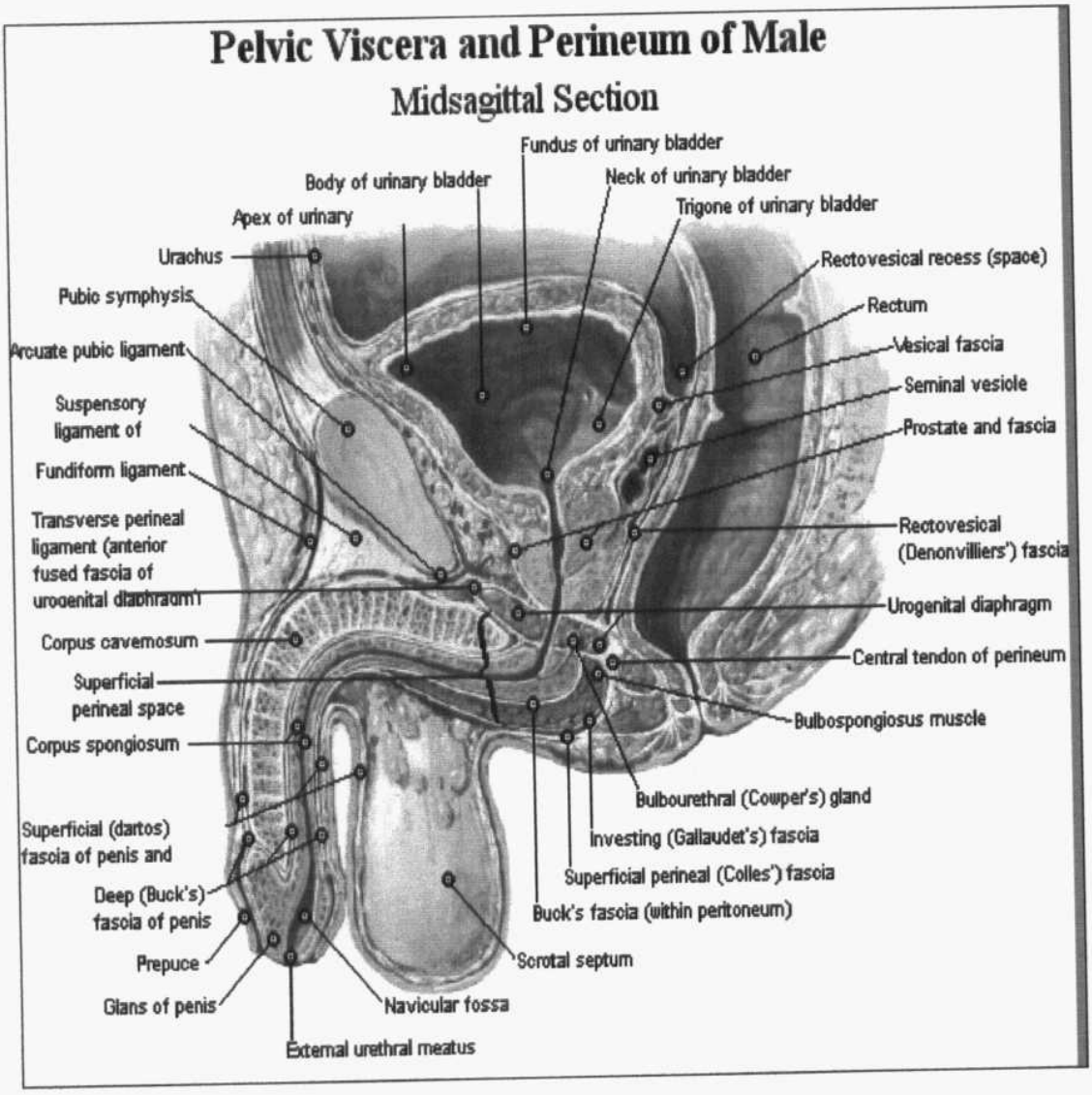

Fig. (1) Median sagittal section of male pelvis **(After Gray's 2000).**

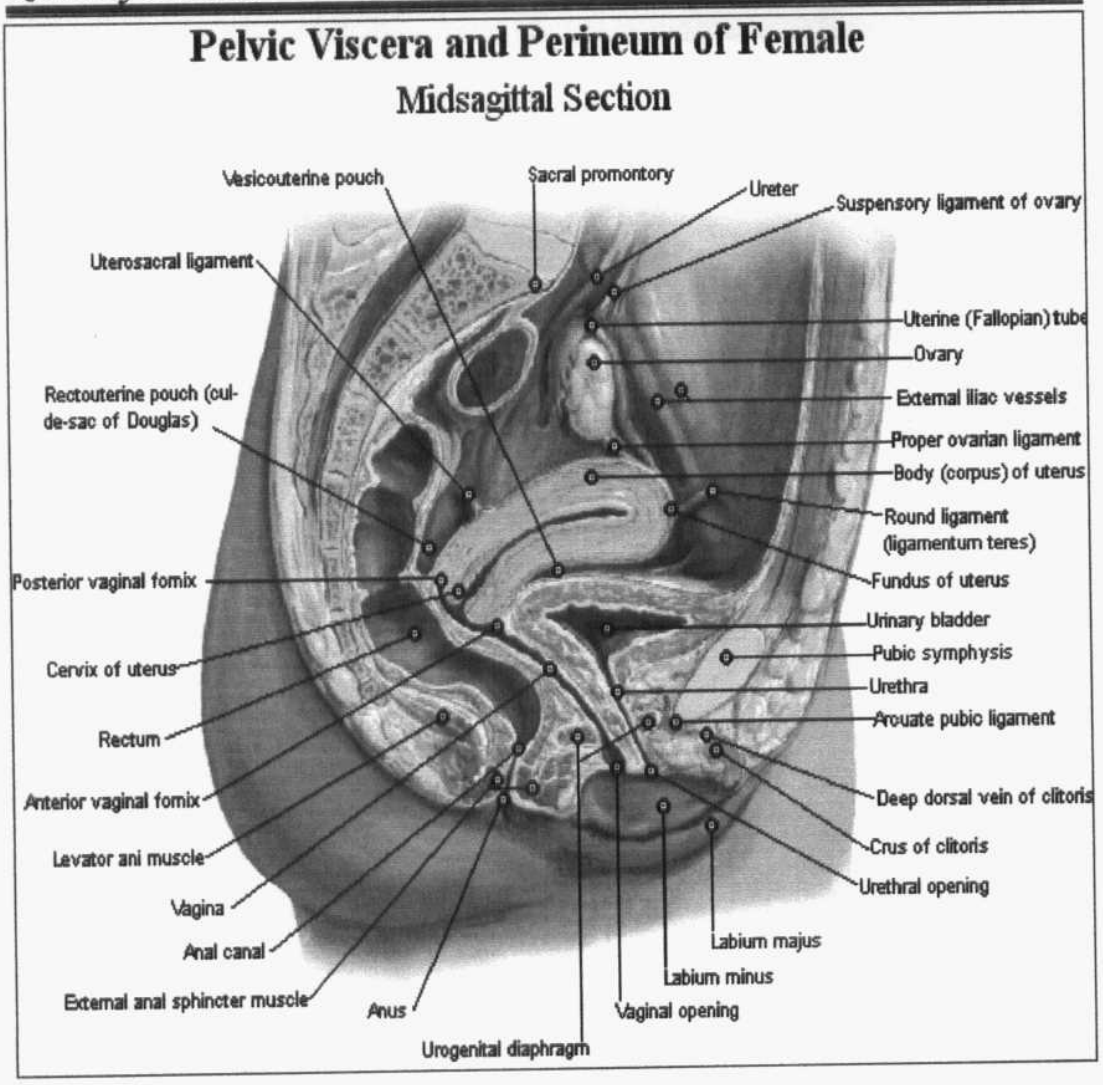

Fig. (2) Median sagittal section of female pelvis **(After Gray's 2000).**

(III)Arterial supply, venous and lymphatic drainage:

Arterial blood supply: superior vesical artery is a branch of internal iliac artery; it supplies the bladder body and neck. Inferior vesical artery may be a branch of internal iliac artery, internal pudendal, or inferior gluteal artery; it supplies the bladder base and proximal urethra. In female, the uterine and vaginal arteries also provide some supply to the bladder base **(Michael et al., 1997).**

Venous blood drainage: the venous blood from the bladder collects in a rich venous plexus, between the muscular wall of the bladder and the adventitia, which drains into the internal iliac vein **(Michael et al., 1997).**

Lymphatic drainage: A rich Lymphatic network within the bladder wall collects lymph to drain into the obturator, internal iliac and external iliac nodes, and ultimately to the paraaortic nodes **(Michael et al., 1997).**

Nerve supply: parasympathetic fibers reach the bladder via the pelvic splanchnic nerve; the motor fibers concerned with bladder evacuation, and the sensory fibers with sensation of distention. Sympathetic fibers come from L1 and L2 segments of the cord, via the superior hypogastric and pelvic plexuses; it appears that pain stimuli are conducted via both sympathetic and parasympathetic fibers **(Mc Minn, 1994).**

(v) Internal anatomy:

Internally, the bladder wall is trabeculated by criss-cross muscle fibers, except at the trigone, which is smooth triangular area between the ureteric orifices superiorly, and the urethral orifice inferiorly **(Ryan and McNicholas, 1994).**

(VI) Histological anatomy:

Bladder wall is made up of four layers:

- **The mucosa:** consists of transitional epithelium like that of ureter and urethera.

- **The submucosa** :(the lamina propria), containing vessels, lymphatics and nerves.
- **The musculosa:** which is the detrusor muscle, consisting of three layers of smooth muscle fibres: external and internal longitudinal fibres and middle circular fibers; the later forming the sphincter vesicae at the internal uretheral opening.
- **The serosa:** the outermost layer derived from the peritoneum and only presents on the superior surface of the bladder **(Krueger and Bo, 1999)**.

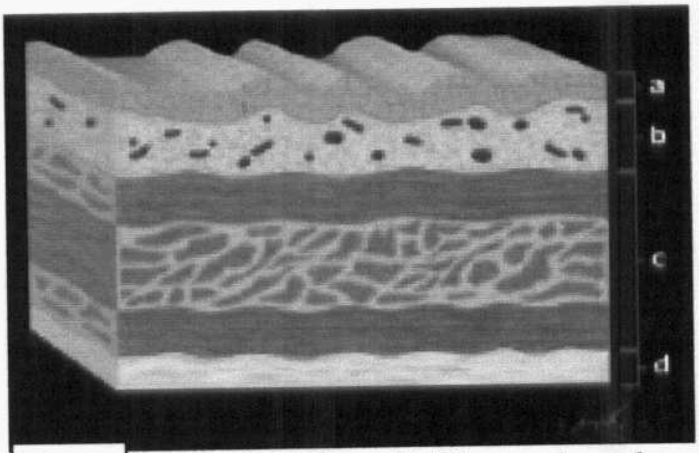

Fig 3 Normal bladder wall. Diagram shows the urothelium *(a)*, lamina propria *(b)*, muscularis propria (detrusor muscle) *(c)*, and adventitia *(d)*.

(VII) Normal CT anatomy of the bladder:

On CT scans, the urinary bladder appears as a homogenous midline structure of the pelvis, whose size and configuration vary greatly depending on the amount of urine present **(Lee, 1998).**

When empty, the urinary bladder is flattened against the posterior aspect of pubis, confined to the true pelvis and only a small portion of it would be visible on CT scans **(Schneck et al., 2000).**

Assessment of the bladder is sometimes complicated by the effect of compression from the loops of the bowel, especially when not distended **(Wegener, 2002).**

As the bladder distends, it expands posterosuperiorly to fill more of true pelvis and anterosuperiorly to extend across the plane of the pelvic inlet into the lower abdomen, gaining more close relationship to rectus abdomens muscles anteriorly, iliopsoas and their related external iliac vessels anterolaterally, and the obturator internus laterally, displacing small bowel loops up into abdomen and tending to compress the rectosigmoid **(Schneck et al., 1990).**

Proper distention allows better evaluation of anatomical relationships to pelvic genital organs, separating the bladder from the rectum; in male, the prostate is seen as an oval soft tissue structure posteroinferior to the bladder and seminal vesicles may be seen lying above the prostate dorsal to the bladder separated from it by a thin layer of fat; in females, demonstration of the uterine corpus and cervix as an oval soft tissue posterior to the bladder depends greatly on the degree of filling of the bladder, that is when full, the uterine axis tilts upwards and the circumference of the uterus can be scanned making measurements of the uterus reliable **(Wegener, 2002).**

The bladder wall thickness varies from 2-5 mm. according to the degree of distention; it appears as a rim of soft tissue whose inner margins are better identified, if the bladder contains only urine, or if air, or carbon dioxide is instilled into it. In contrast enhanced CT scans, the opacified urine usually occupies the dependant portion of the bladder, and unopcified urine layers above it. The outer margin of the bladder wall is smooth and usually well delineated by perivesical fat **(Lee, 1998).**

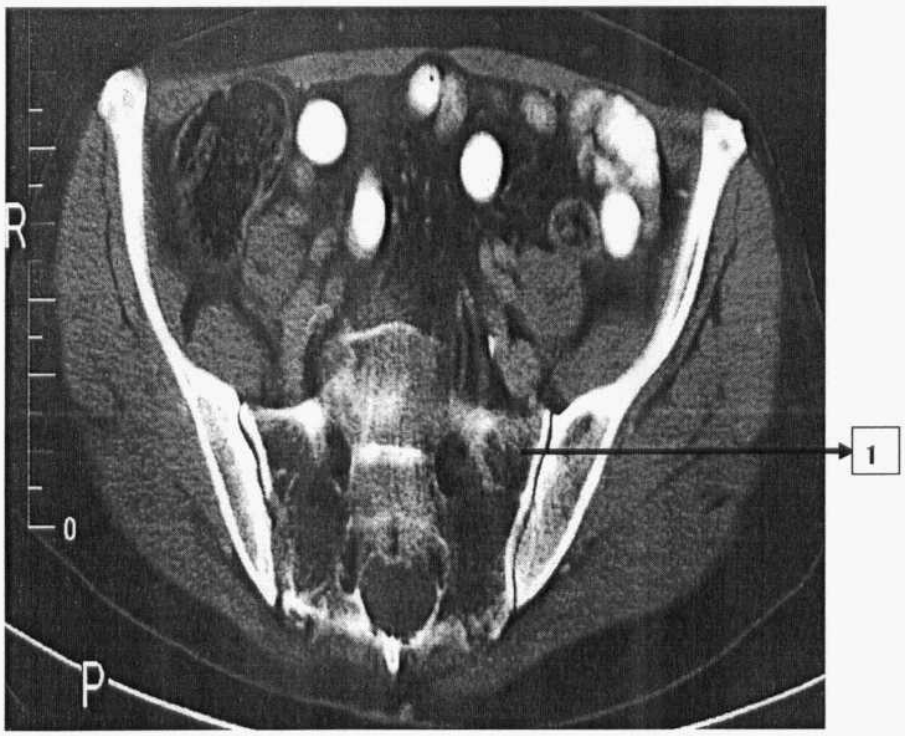

Fig. (4a): Axial CT of female pelvis

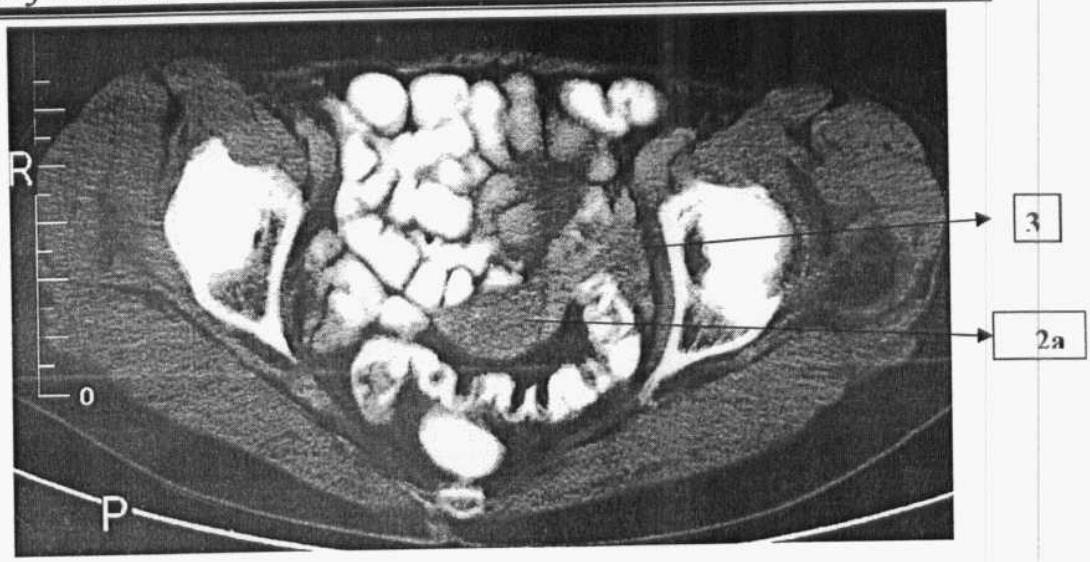

Fig. (4b): Axial CT of female pelvis

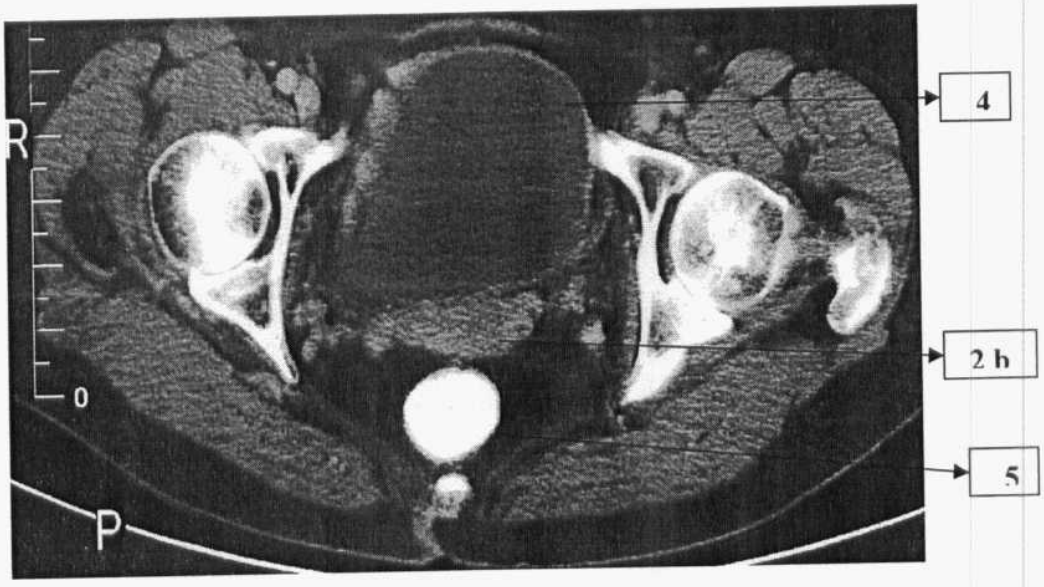

Fig. (4c): Axial CT of female pelvis

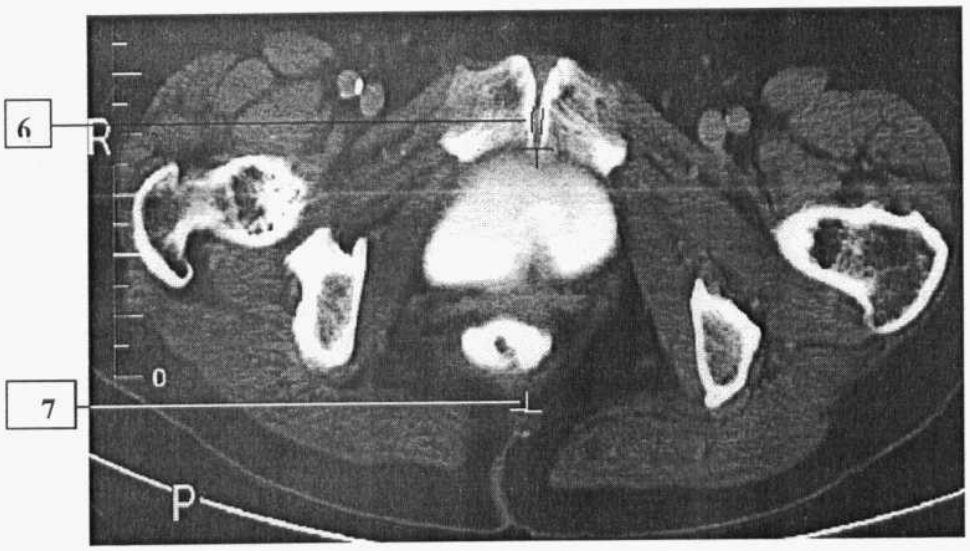

Fig. (4d): Normal axial CT anatomy of female pelvis

Important Data

1 **Sacroiliac joint spaces:**
- Cartilage thickness 2–5 mm (anterior and inferior: 2–3 mm)

2 **Uterus:**
- Size (variable): Prepubescent: length up to 3 cm, transverse diameter ca. 1 cm
- Nullipara: length up to 8 cm, transverse diameter ca. 4 cm
- Multipara: length up to 9.5 cm, transverse diameter ca. 5.5 cm
- Postmenopausal: length up to 6 cm, transverse diameter ca. 2 cm

a Transverse diameter of upright uterus (= well-distended bladder) ≤ 5 cm

b Uterine cervix: transverse diameter ≤ 3 cm

3 **Ovaries:**
- Prepubescence: a, length up to 2.5 cm; b, transverse diameter ca. 2.5 cm
- Sexual maturity: a, length up to 4 cm; b, transverse diameter ca. 2.5 cm
- Postmenopausal: a, length up to 3 cm; b, transverse diameter ca. 1.5 cm

4 **Urinary bladder:**
- Wall thickness (of well-distended bladder): ca. 3 mm

5 **Rectum:**
- Wall thickness ≤ 5 mm

6 **Symphysis pubis:**
- Width < 6 mm

7 **Pelvic dimensions:**
- Pelvic outlet: anteroposterior (= coccyx to posterior edge of symphysis): ca. 9 cm

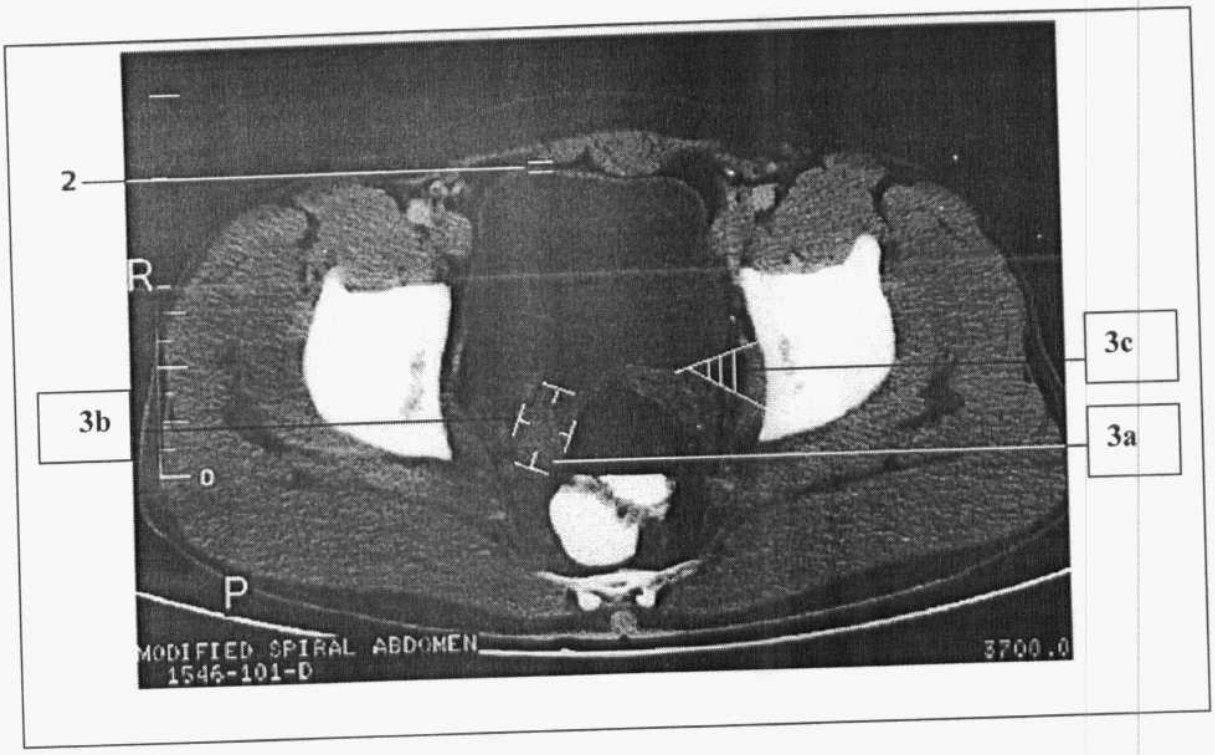

Fig. (5a): Normal axial CT anatomy of male pelvis

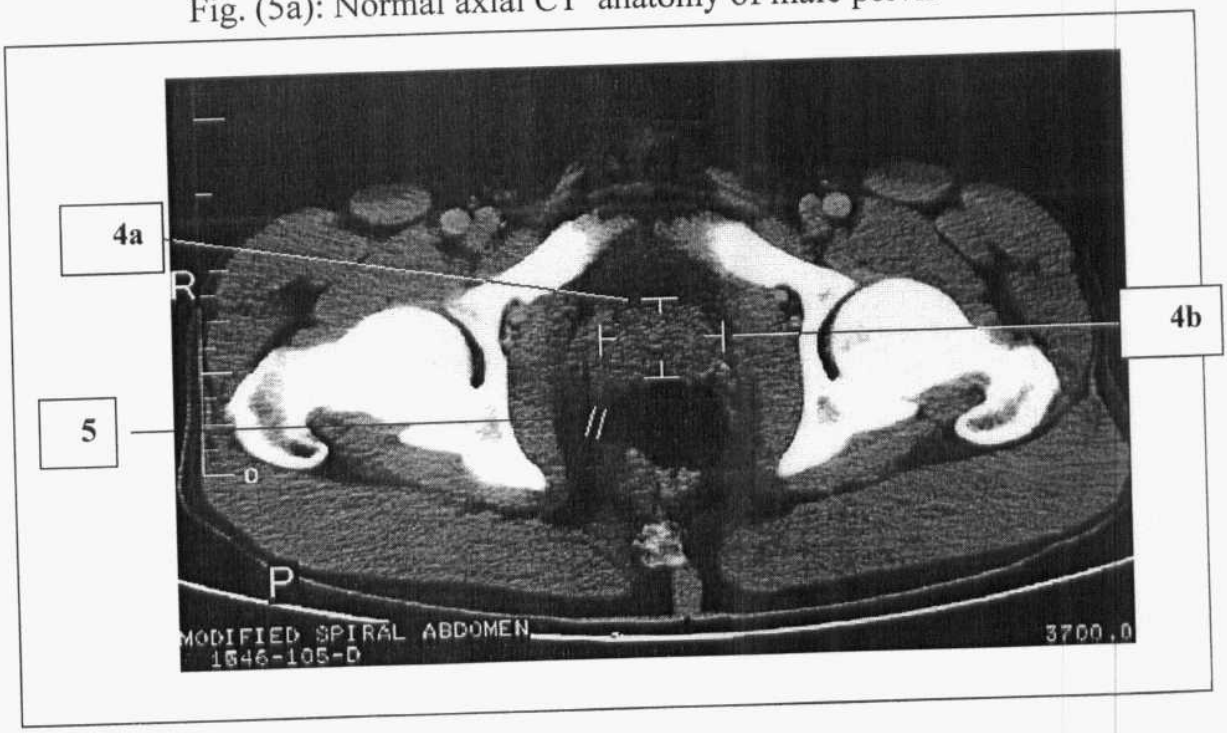

Fig. (5b) Normal axial CT anatomy of male pelvis

Important data :

1 **Sacroiliac joint spaces:**
- Width 2–5 mm (anterior and inferior: 2–3 mm)

2 **Urinary bladder:**
- Wall thickness (of well-distended bladder): ca. 3 mm

3 **Seminal vesicles:**
- Size (highly variable):

a Length up to 5 cm
b Width up to 2 cm, height up to 2.5 cm
c Angle between bladder and seminal vesicle: clear on each side

4 **Prostate:**
- Size (varies with age, 20–70 years):

a Anteroposterior diameter 2.5–3 cm
b Lateral (and craniocaudal diameter) 3–5 cm

Attenuation value: 40–65 HU

5 **Rectum:**
- Wall thickness ≤ 5 mm

Pathology of Urinary Bladder Tumors

About 95% of bladder tumors are of epithelial origin, the remainder being mesenchymal tumors (Table 1). Most epithelial tumors are composed of urothelial (transitional cell) type and are thus interchangeably called urothelial or transitional tumors, but squamous and glandular carcinomas also occur **(Cotron et al., 1999).**

In Egypt, Bladder Cancer is the most common cancer, squamous cell carcinoma is the most common type of bladder cancer but recently transitional cell carcinoma show definite rise over the year. **(Fettouh et al.,1994).**

Epidemiology and Etiology of bladder tumors:

Both benign and malignant tumors of either epithelial or mesenchymal origin occur in the bladder. The vast majority of bladder malignancies are malignant transitional cell tumors. The other epithelial malignancies occasionally encountered are squamous cell carcinoma and adenocarcinoma. Mixed carcinomas, Carcinoid tumors,Lymphomas, carcinosarcomas, melanomas and others are rarely encountered in the bladder, as well as mesenchymal neoplasms. While bladder is a frequent site of direct spread from neighboring primary tumors, it is an uncommon site of metastasis from distant primary tumors **(Seidmon and Friedman, 1990).** Considering bladder cancer, it is the 11^{th} most frequent cancer in the world **(Zhang and Steineck, 1997).** The importance of bladder cancer in Egypt is demonstrated by the fact that it is the site the most frequently affected in males (46.5 % of male malignancies) and ranks after breast cancer in female patients (16.6% of female malignancies **)(E1 Sebai and Ibrahim, 1983).**

More than 90% of cancer bladder are epithelial in origin in

industrialized countries **(Clark, 1994).**

The transitional cell carcinoma is considerd typical for chemically induced bladder cancers.; in areas with schistosomiasis, squamous cell carcinoma, is predominant **(El Sebai and Ibrahim, 1983).**

Predisposing factors:

A spectrum of hyperplastic and metaplastic changes of urothelium occurs throughout the urinary tract, from the renal pelvis to the urethra, these non-neoplastic lesions of urothelium are characterized either by hyperplasia or by combined hyperplasia include simple hyperplasia, Burn's invaginations nests, and cystitis cystica. The urothelial changes that combine hyperplasia and concurrent metaplasia include cystitis glandularis, mucinous metaplasia, nephrogenic metaplasia, and squamous metaplasia. These proliferative and metaplasia lesions are found in association with chronic inflammation, caused by urinary tract infection, calculi.(**Petersen, 1994**) .

*** Simple hyperplasia :**

It refers to an increased number of cell layer in mucosal transitional epithelium . This change has a flat configuration, with neither papillary features nor invaginations into lamina propria.

- **Burn'S Buds :**

These are bulbous invagination of surface urothelium into lamina propria .

*** Burn's nests :**

They are similar to Burn's buds, but in this case, the urothelial cells have detached from the surface and are seen within the lamina propria.

Table (1) Classification of Bladder Tumors. **(Bernstien et al., 1992).**

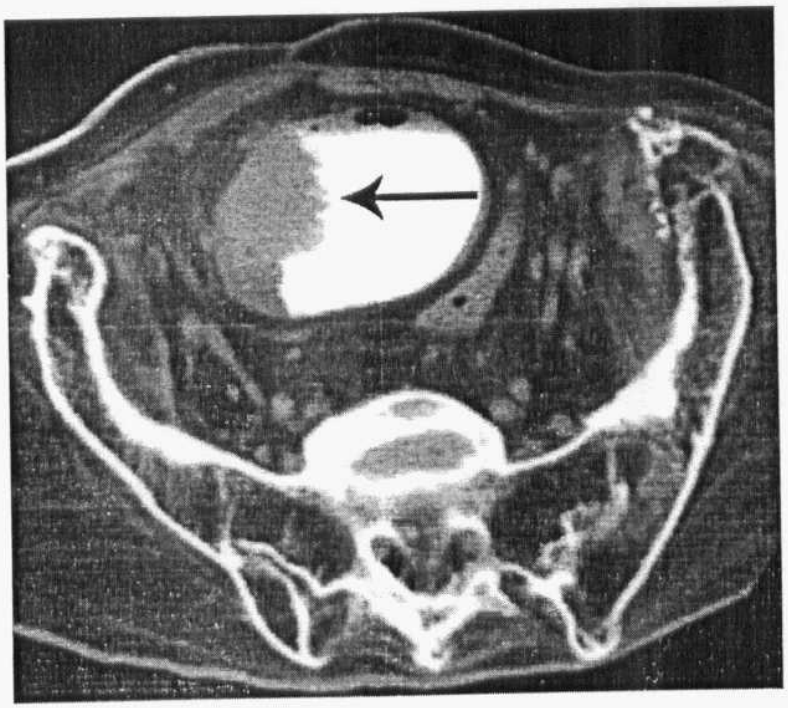

Fig.(6) Axial enhanced CT cystogram shows a large mass on the right lateral wall.

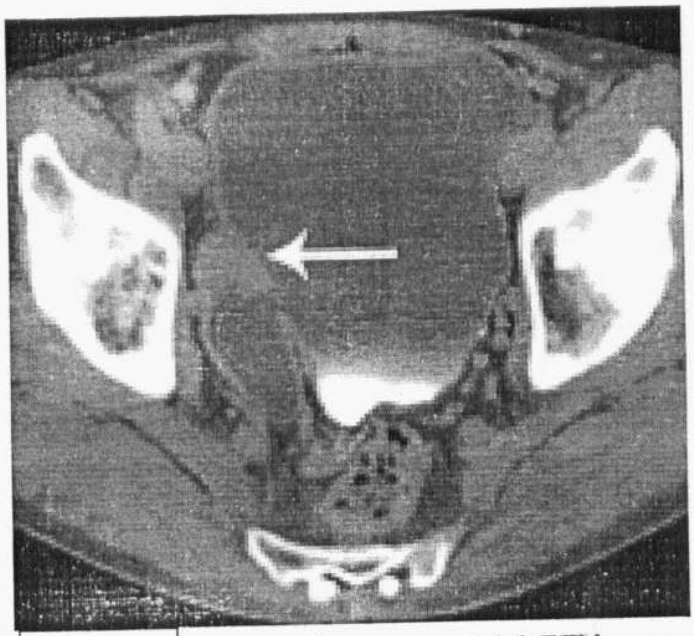

Fig. 7 Diverticular tumor. Axial CT image shows a urothelial tumor (arrow) within a bladder diverticulum. Urinary stasis occurs with bladder diverticula, thus predisposing them to tumor development.

Neoplasns of Urinary Bladder
Epithelial neoplasms • Benign neoplasms Papilloma PUNLMP* • Malignant neoplasms Urothelial carcinoma Squamous cell carcinoma Adenocarcinoma Metastases Small cell carcinoma Carcinoid Melanoma **Non Epithelial neoplasms** • Benign neoplasms Leiomyoma Paraganglioma Fibroma Plasmacytoma Hemangioma Lipoma • Malignant neoplasms Rhabdomyosarcoma Leiomyosarcoma Lymphoma Osteosarcoma Angiosarcoma
* **PUNLMP**=Papillary Urothelial Neoplasm of Low Malignant Potential.

*** Cystitis cystica :**

Are characterized by small slits or round space in otherwise solid Burn's nests. Cystica is actually very common occurring in 60 % of otherwise normal adult bladder (**Peterson , 2001).**

*** Cystitis glandularis :**

Refers to a lesion of the bladder mucosa characterized by metaplastic geophytes structures lined by mucin - secreting columnar epithelial cells. Cystitis glandularis differs from cystitis cystica only in the nature of the lining cells; In cystitis glandularis, the overlying suface epithelium usually remains one of transitional cells . Yet, metaplastic mucous structures may also be observed in the surface epithelium .

*** Mucinous (Colonic) metaplasia :**

Particularly conspicuous glandular metaplasia of urinary tract is referred to as mucinous metaplasia and occurs most frequently in the bladder . In glands are lined by an epithelium resembling that of the colon composed of goblet cells and occasionally paneth cells .

*** Squamous Metaplasia:**

Nephrogenic metaplasia, which occurs most frequently in the urinary bladder, consists of a papillary exophytic nodule containing numerous small tubules clustered in the lamina propria. Nephrogenic metaplasia is often associated with chronic cystitis. It has no age predilection and is reported from infancy to the eighth decade of life there is a pronounced male predominance (3 : 1) . Transurethral resection is the most common form of therapy, but recurrences are not uncommon.. Patient with proliferative and metaplastic lesion of the urothelium have significantly increased risk for the development of transitional cell carcinoma of the bladder and in case of cystitis

glandularis, adenocarcinoma as well as . However , there is no evidence to suggest that these lesions are preneoplastic. Rather, persistence of the injury related to the development of proliferative and metaplastic urothelial lesions is more likely the important factor in the pathogenesis of bladder cancer. **(Peter, 1994).**

Urothelial Dysplasia

Preneoplastic proliferalive abnormalities :

Atypical hyperplasia similar to epithelial hyperplasia except there are also nuclear abnormalities and partial derangement of the umbrella cell layer (**Koss et al., 1974**) . In patients with superficial bladder cancer, the presence of atypia in adjacent urothelium is associated with a 35% to 40% risk of developing invasive disease **(Althausen et al., 1976).**

Dysplasia :

The term dysplasia denotes epithelial changes that are intermediate between normal urothelium and carcinoma in situ. There are three categories of dysplasia, mild, moderate, and severe. Dysplastic cells have large, round, notched, basally situated nuclei that do not exhibit the normal epithelial polarity (**Murphy and Soloway, 1982**). It is difficult to make a sharp distinction between severe dysplasia and carcinoma in situ **(Friedell et al., 1986**) . As a general rule, mild and moderate dysplasia, even when associated with a history of bladder cancer, warrant careful follow-up but no particular specific therapy, whereas severe dysplasia / carcinoma in situ requires aggressive treatment. (**Messing and Catalona, 1998).**

*** Inverted Papilloma :**

An inverted Papilloma is benign proliferative lesion caused by chronic inflammation or bladder outlet obstruction . Most commonly, it occurs in the trigone and bladder neck areas in men with

prostatitis (**Demeester et al., 1975).**

Papillary fronds project into the fibrovascular stroma of the bladder rather than into the bladder lumen. The lesion is usually covered by a thin layer of normal urothelium. Two different type of inverted Papilloma occur, trabeculer and plandular. rare cases of malignant transformation of inverted papillomas have been reported (**Lazarevic and garret, 1978)** . There is a more common association of inverted Papilloma, however, occurring in patients with coexistent transitional cell carcinoma elsewhere in the bladder or with histories of such tumors **(Cheon et al., 1995).** Because the overlying epithelium is normal, inverted papillomas appear as small raised nodules rather than as papillary or frond - like tumors **(Messing and Catalona, 1998).**

*** Vesical Leukoplakia :**

Leukoplakia is defined as cornification of normal noncornified epithelium. The histopathologic criteria include squamous metaplasia with marked keratinization downgrowth of the rete pegs (acanthosis) cellular atypia , and dysplasia . Leukoplakia is believed to be a response of the normal urothelium to anxious stimuli and generally is considered a premalignant lesion or a lesion that heralds the presence of malignant disease elsewhere in the bladder **(Benson et al., 1984)** . Vesical leukoplakia may progress to squamous cell carcinoma in up to 20% of patients with chronic cystitis, bladder calculi, long-term indwelling catheters, or schistosomiasis **(Messing and Catalona, 1998) .**

Urothelial Carcinoma

Carcinoma in situ :

Carcinoma in situ may appear as a velvety patch of erythematous mucosa on cystoscopic examination, although quite often it is endoscopically invisible. Histologically, it consists of poorly

differentiated transitional cell carcinoma confined to the urothelium. Carcinoma in situ may be asymptomatic or may produce severe symptoms of urinary frequency, urgency, and dysuria **(Utz et al., 1977 ; Utz and Farrow, 1984)** . Urine cystopathology study results are positive in 80% to 90% of patients with carcinoma in situ because of the poor cohesiveness of the tumor cells, carcinoma in situ occurs more commonly in men . Its symptoms may be mistaken for prostatism, urinary tract infection, neurogenic bladder, or interstitial cystitis . Carcinoma in situ occurs only rarely in patients with well -differentiated, superficial bladder tumors, but it is present in 25% or more of patients with high - grade superficial tumors **(Koss et al., 1974 ; Flamn and Dona, 1989)** . It carries a poor prognosis. Patients with carcinoma in situ have higher tumors recurrence rates **(Flamm and Dona , 1989) ;** and with just endoscopic resection as treatment, between 40% and 83% progress to muscle - invasive cancer by different studies **(Althausen et al., 1976 ; Daly , 1976)**.

Some patients have protected courses lasting for more than a decade without developing muscle - invasive bladder cancer **(Riddle et al., 1976 ; Weinstein et al., 1979)** .

Others progress rapidly to invasive bladder cancer that has a poor prognosis despite definitive therapy **(Utz et al., 1970)**

Some investigators have characterized carcinoma in situ as a peculiar cancer with aggressive morphologic features but having a limited capacity to invade and metastasize (**Weinstein et al., 1980**) .

Patients with marked urinary symptoms generally have a shorter interval preceding the development of muscle invasive cancer . About 20% of patients treated with cystectomy for diffuse carcinoma in situ are found to have microscopic muscle -invasive cancer (**Farrow el al.,1976).**

*** Transitional cell papilloma:**

Transitional cell papilloma of urinary is an uncommon benign lesion, which is often encountered incidentally or after painless hematuria . Papillomas comprise 2% to 3% of bladder epithelial tumors and occur most frequently in men older than the age of 50 years. The papillary fronds of this tumor are lined by a transitional epithelium that is virtually indistinguishable from normal urothelium . Papillary tumors that meet this criterion are uncommon, and they have been accepted as Papillomas, rather than as low-grade transitional cell carcinomas, only in the past 2 decades. On cystoscopy, the majority of cases show single lesions 2 to 5 cm in diameter, but multiple lesions are developed in 7% of patients . Although transitional cell Papillomas are not malignant, they arise in a urothelial mucosa that is not at rest and evolving tumors can be detected only by repeated examinations for many years. In most instances" recurrence " represent new tumors that develop elsewhere in the urinary bladder **(Petersen, 1994) .**

Pathology of Transitional Cell Carcinoma of the Bladder

Epidemiology and risk factors :-

The incidence of carcinoma of the bladder resembles that of bronchogenic carcinoma, being more common in men than in women , in industrialized than in developing nations , and in urban than in rural dwellers . The male to female ratio for transitional cell tumors is approximately 3:1 about 80% of patients are between the ages of 50 and 80 years **(Cotran et al., 1999).**

A number of factors have been implicated in the causation of transitional cell carcinoma . Some of the more important contributors include the following :

Cigarette smoking is clearly the most important influence increasing the risk three folds to seven folds, depending on the back - years and smoking habits . Fifty percent to 80% of all bladder cancers among men are associated with the use of cigarettes . Cigars, pips, and smokeless tobacco invoke a much smaller risk **(Cotran et al., 1999).**

Occupational exposure to certain organic chemicals among workers in the german ***aniline*** dye industry was described in 1895 and it was subsequently confirmed among similar workers in the United State . Later, an increased risk of bladder cancer was identified among workers in the leather, rubber, and organic chemical industries (**Peterson , 2001).**

Schistosoma haematobium infections in areas where these are endemic (Egypt, Sudan) are established risk . The ova are deposited in the bladder wall and incite a brisk chronic inflammatory response that induces progressive mucosal squamous metaplasia and dysplasia and, in some instances, neoplasia seventy percent of the cancer squamous, the remainder being transitional cell carcinoma (**Cotran et al., 1999) .**

Transitional cell cancer of bladder, ureters, and renal pelvis have been reported in the setting of ***analgesic abuse,*** particularly with phenacetin . Most cases, however, are not associated with known risk factors (**Peterson, 2001).**

Heavy long - term exposure to ***cyclophosphamide,*** an immunousuuppressive agent, induce hemorrhagic cystitis and increases the risk of bladder cancer (**Cortan et al., 1999) .**

Pathogenesis :

Two variants of urothelial carcinoma are recognized with distinctly different histogenetic origin and biologic profile, namely, the superficial papillary and the muscle invasive type. Superficial papillary

transitional carcinomas are tumors arising from papillary non-invasiv(Ta) tumors, show exophytic growth and exhibit deletions a recurrence rate of 98 % conversely, invasive transitional carcinoma in situ (Cis), exhibit endophytic growth and show P53 tumor suppressor gene mutations, with a high recurrence rate (85 %)and 10 years survival of 30% **(El-Bolkainy, 1998).**

Macroscopic appearance :

The gross pattern of urothelial cell tumors vary from purely papillary to nodular or flat to mixed papillary and nodular, the tumors may also be invasive or non-invasive . The papillary lesions appear as red elevated excrescences varying in size from less than 1 cm in diameter to large masses up to 5 cm in diameter . Overall, about half of bladder cancers are high grade lesions . **(Cotran et al., 1999).**

Microscopic appearance:

Transitional cell carcinoma of bladder are classified according to World Health Organization grading system :

Grade 1: Papillary projections lined by neoplastic transitional cells that show minimal nuclear pleomorphism and mitotic activity, the papillae are long and delicate, and fusion of papillae is focal and limited .

Grade 2: The histologic and cytologic features are intermediate between those of grade 1 (the best differentiated) and grade 3 (the poorest differentiated).

Grade 3 : Significant nuclear pleomorphism, frequent mitoses, and fusion of papillae are typical . Occasional bizarre cells may be present, and focal sites of squamous differentiation are often seen . Although invasion of the underlying bladder wall may occur with any grade of transitional cell carcinoma, it is most frequent in grade 3 tumors (**Petersen, 1994).**

A more recent classification, based on consensus reached at a conference by the International Society of Urologic Pathology (**ISUP**) in 1998, is currently being prepared . Two grades of carcinoma (low and high grade) as seen in the following table.

Table (2) :

A comparison of the WHO grading and the ISUP consensus **(Cotran et al., 1999).**

WHO grading papilloma	**ISUP** urothelial papilloma
TCC Grade I	Urothelial neoplasm of low malignant potential
TCC Grade II	Urothelial carcinoma , low grade
TCC Grade III	Urothelial carcinoma , high grade

Pathology of Squamous Cell Carcinoma of bladder

Carcinoma of bladder is one of the most common malignant diseases in Egypt. It also occur in high frequency in some parts of Africa and middle east. Because of the geographic coincidence of bladder cancer and endemic bilharziasis, a causal relationship has long been speculated and established between the tumor and S. haematobium infestation. This association defines a distinct clinicopathologic entity quite different from that experienced in the western world. The tumor is found mostly in relatively young age groups. It is usually consisting of solitary fungating masses. It is commonly a well-differentiated squamous

carcinoma with a limited tendency to lymphatic and blood stream spread . The patients usually present in an advanced stage of the disease with the systems of cystitis (**Elsebai, 1981).**

These are virtually always invasive at the time of diagnosis, and the majorities have invaded deep into the muscle layer or beyond (T3 and T4) (**Peterson, 1994).**

Squamous carcinoma probably account for no more than 5% of bladder carcinoma where schistosomiasis is not endemic non schistosomal squamous carcinoma of the bladder is often associated with chronic urinary tract infection and bladder calculi . It may also arise in bladder diverticulae Squamous carcinoma of the bladder may be of low or high grade that is, showing marked keratinization, prickle cell differentiation and limited cellular pleomorphism on the hand, or showing obvious anaplasia with numerous mitoses and only slight keratinization on the other (**Bernstein et al., 1992) .**

Adenocarcinoma

Adenocarcinoma of the bladder is uncommon and most cases have been reported in the last 2 decades. As with the other forms of bladder carcinoma, Adenocarcinoma shows a pronounced male predilection. Bladder adenocarcinoma must be distinguished from urachal adenocarcinoma and from prostatic carcinoma. The histologic patterns encountered in primary adenocarcinoma of the bladder include papillary, glandular, mucinous, adenoid cystic, signet ring cell and clear cell types, foci of transitional cell with or without areas of cases of bladder adenocarcinomas (Mixed histological pattern). The majority of adenocarcinoma are deeply invasive at time of initial presentation and are not curable **(Petersen, 1994) .**

Metastatic Spread

Roughly 5% of patients with well-differentiated and moderately differentiated superficial papillary cancer and approximately 20% with high - grade superficial papillary disease (including carcinoma in situ) have vascular or lymphatic spread . Presumably metastases occur with superficial tumors because of invasion into lymphatic and vascular channel within the lamina propria although, realistically, some patients with superficial malignancies already have developed latent metastases, the majorities of such individuals have their bladder lesion pathologically under staged and already harbour muscle-invasive lesion (**Freeman et al., 1995) .**

(I) Lymphatic spread :

Lymphatic metastases, occur earlier and independent of hematogenous metastases in some patients (**Lerner et al., 1993).**

The most common sites of metastases in bladder cancer are the pelvic lymph nodes, occurring in about 78% of patients with nodal metastases. Among these paravesical L.Ns are involved in 16%, the obturator nodes in 74% , the external iliac nodes in 65% , and presacral nodes in roughly 25%. Juxtaregional common iliac lymph nodes are involved in about 20% of patients but almost always with involvements of the above mentioned regional sites as well (**Sm0ith and Whitmore 1981).**

(II) Vascular Spread :

The common sites of vascular metastases in bladder cancer are liver 38%, lung 36%, adrenal glands 21% , and intestine 13% . Any other organ may be involved (**Bebaian el al., 1980).**

(III) Implantation :

Bladder cancer also, spreads by implantation in abdominal

wounds, denuded urothelium, the resected prostatic fossa, or traumatized urethra (**Weldon and Soloway, 1975**). Implantation occur more commonly with high — grade tumors (**Vanderwerf — Messing, 1984).**

Staging of bladder cancer

Jewett and strong in 1946 examined autopsy material from 107 patients and analyzed the relation of depth of penetration (stage) to the incidence of local extension and metastases0. Form these studies, they concluded that,

(1) stage A (submucosal infiltration) disease was not associated with dissemination.

(2) stage B (muscular infiltration) disease was associated with dissemination in 13% of cases (2 of 15 patients).

(3) stage C (Perivesical infiltration) exhibited dissemination in 74% of cases (64 of 89 patients).

In 1952, Jewett refined his initial staging system based on 80 patients who had complete extirpation of the primary tumors . The bladder muscle was arbitrarily divided at the midway level into superficial **(stage Bl)** and deep **(stage B2).**

In 1950 , The Union International Centre Le Cancer (**UICC**) appointed a committee on tumor nomenclature and statistics to develop a classification system that embraced the status of the primary tumor, lymph nodes, and metastases **(T . N . M . classification)** . The American Joint Committee on Cancer **(AJCC)** approved this staging that comprises both clinical and pathological staging (**Droller, 1997) .**

Superficial bladder tumors are largely grade I or II papillary transitional cell carcinoma that may or may not invade that lamina propria. Approximately 70% of the tumors are non invasive **(Anderstoma**

et al., 1989) .

Prognostic factors :-

The probability of tumor extension and subsequent recurrence is associated with a number of factor :

- Large size
- High stage
- High grade
- The presence of multiple tumors
- Vascular or lymphatic invasion
- Urothelial dysplasia, including carcinoma in situ, at other sites in the bladder **(Petersen, 1994) .**

The prognosis depends on the histologic grade of the tumor and on the stage when it is first diagnosed. Papillomas and grade I cancer (those of low malignant potential) yield 98% 10 - years survival rate regardless of the number of recurrences; only a few patients (< 10 %) have progression of their disease to higher grade lesions . In contrast, only about 40% of individuals with a grade III cancer survive 10 years ; the tumor is progressive in 65% . Approximately 70% of patients with squamous cell carcinoma are dead within the year **(Cotran et al., 1999) .**

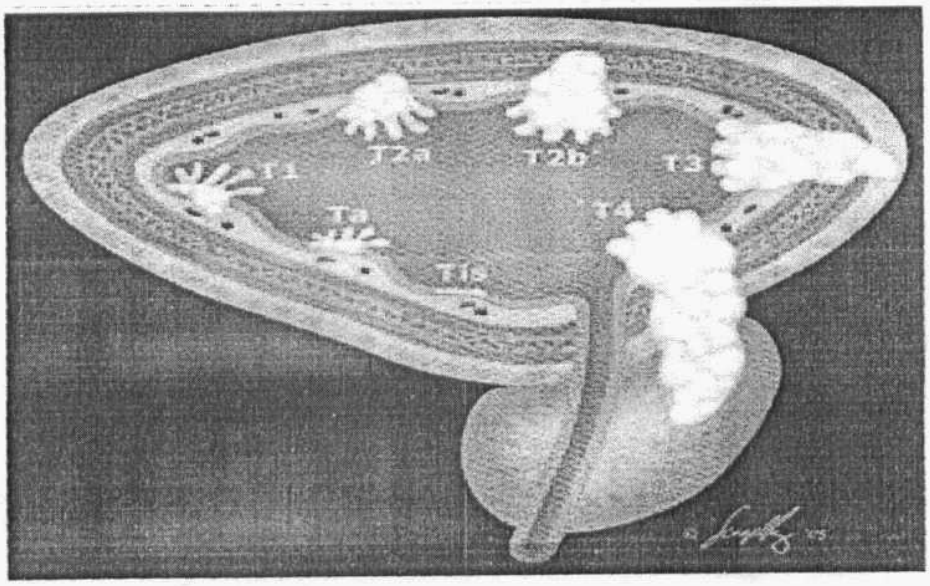

Fig.(8) Diagram shows the stages of bladder cancer

Mesenchymal Tumor

Benign :

A great variety of benign mesenchymal tumors may arise in the bladder . Collectively, they are rare . The most common is leiomyoma. They all tend to grow as isolated, intramural, encapsculated, oval to spherical masses, and varying in diameter up to several centimeters .

Sarcomas :

True sarcomas are distinctly uncommon in the bladder . As agroup, sarcomas tend to produce large masses(varying up to 10 to 15 cm in diameter) that protrude into the vesical lumen. Their soft, fleshy, gray - white gross appearance suggests their sarcomatous nature. Rhabdomyosarcoma takes one of two forms . The *" adult "* form occurs mostly in adults older than 40 years and shows a rare of histology similar to rhabdomyosarcomas of striated muscle. The other variant is the *embryonal* rhabdomyosarcomas of striated muscle, or sarcoma botryoides,

encountered chiefly in infancy or childhood, and similar to tumors those occur in the female genital tract **(Cotran et al., 1999).**

Secondary Tumors of the Urinary Bladder

Secondary tumors may invade by direct extension from neighboring structures (cervix, uterus, prostate, and rectum) or by discrete, usually blood-born metastases. Prostatic carcinoma often involves the base of the urinary bladder by direct extension. This should not, as a rule, be a diagnostic problem, because immunohistochemical stains for specific prostate antigens can be demonstrated in most primary prostatic carcinomas. However, some adenocarcinomas of the bladder (in both male and females) may show immunoreactivity to prostate-specific acid phosphatase, and this fact needs to be born in mind when determining the origin of a tumor at this site . Direct spread may also occur from ovarian carcinoma or adenocarcinoma of colon. Urinary symptoms are occasionally the first manifestation . Apart from direct spread, the bladder may be the site of metastases from remote primary tumors (e.g.,lung, bronchus, stomach, and breast). There is a predilection for infiltrating lobular carcinoma of the breast to metastasize to unusual sites (including the bladder), with diffuse infiltration (**Bernstein et al., 1992).**

Table (3): AJCC - UICC TNM Staging Protocol For Bladder Carcinoma **(Droller et al., 1992) .**

Stage	Extent of invasion
T : Primary	
-Tis	Carcinoma in situ (flat tumor)
-Ta	Papillary non invasive carcinoma
-To	No evidence of primary tumor
-T1	Invasion limited to lamina propria
-T2	Invasion limited to superficial muscle
-T2a	Invasion to superficial muscle (inner half)
-T2b	Invasion to superficial muscle (outer half)
-T3	Invasion to deep muscle or perivesical fat
-T3a	Invasion to deep muscle (outer half)
-T3b	Invasion to perivesical fat
-T4	Contiguous spread to adjacent organs
-T4a	Uterus , vagina , prostate
-T4b	Pelvic or abdominal wall
-TX	Extent of invasion can not be determined
N : Regional and Juxta regional Lymph nodes	
-No	- No regional lymph metastases.
-N1	- Metastases in a single lymph node that is 2 cm. or smaller in greatest dimension.
-N2	- Metastases in a single lymph node that larger than 2 cm. but not larger than 5 cm in largest dimension or multiple lymph node non of which is larger than 5 cm.
-N3	- Metastases in a lymph node that is larger than 5 cm. in greatest dimension.
-Nx	- lymph node metastases cannot be assessed
M : Distant Metastases	
-Mo	No evidence of distant metastases.
-M1	Evidence of distant metastases.
-Mx	Distant metastases cannot be determined.

Table (4) : Comparison of the UICC and Jewett - Strong - Marshall Classification (**Cummings et al,. 1992).**

Level of infiltration	Jewett - strong -Marshall	UICC
- Epithelial only	-0	-Tis
-papillary carcinoma confined to mucosa	-0	-Ta
- lamina propria	-A	- T1
- Superficial muscle	- B1	-T2
- Deep muscle	-B2	-T3a
- perivesical fat	-C	-T3b
- Adjacent organ	- D1	- T4 b
- Lymph nodes	- D1	-N1-3
- Distant metastases	-D2	- M

Diagnosis Of Urinary Bladder Cancer

1 –Symptoms and Signs:

The most common presenting symptoms of **BC** (bladder cancer) is painless gross hematuria, which is often intermittent, leading to occasional delays in consulation. Bladder cancer will be found in approximately 25% of adult patient with gross hematuria **(Jung et al., 2001).**

In almost all patients with cystoscopically detected cancer microhematuria will be found if enough consecutive testings are performed. On the other hand, BC will be detected in only 2% to 4% of all adult patients presenting with microhematunia which represents a dilemma to physicians in recommending investigation for such low yield **(Bard et al., 1988).**

The same is true for the second most common presenting symptoms of bladder irritability, urinary frequency, urgency and dysuria. Although this symptom complex will be most commonly associated with diffuse carcinoma in situ or invasive BC, depending on the severity of the symptoms, BC will only be found in approximately 5% of these patients bladder cancer will more rarely present with flank pain from uretheral obstruction or other symptoms of more advanced disease such as weight loss and abdominal or bone pain **(Jung et al., 2001) .**

2 – Urine Cytological Studies:

Microscopic cytology is more sensitive in high grade tumors as cells from well differentiated tumors are more cohesive and do not shed easily even in high grade tumors, urine cytology may be falsely negative

in 20% of cases whereas false positive results may occur in 1-12% **(Koshikawa et al., 2002) .**

False positive results are usually due to severe atypia, inflammation or changes caused by radiation or chemotherapy. These usually appear after several months of therapy and may persist for more than a year after therapy **(Jung et al., 2001) .**

Cytology specimens obtained by bladder barbotage are more accurate than voided samples. In a study sensitivity of urinary cytology was 59% but increased to 66% using bladder washing cytology. The urine specimen should be fresh and morning sample are avoided. The accuracy of urine cytology in **C**is (Carcinoma in Situ) exceeds 80% in all lesions and more than 90% in symptomatic lesions **(Murphy, 2000)** .

A cytology specimen obtained by bladder barbotage would be expected to be positive in 10% of patients with **GI** (Grade I) tumors, 50% of those with **G III** (Grade III) tumors **(Soloway et al., 2002) .**

Cytologic examination of urine provides an accurate means for the diagnosis of carcinoma in the bilharrzial series varies from 26.1% to 91.3% . This compares favourably with countries. In such cases, the sensitivity of the test varies between 44.7% and 97.3% **(El – bolkainy et al., 2001) .**

Cytology is not a cost – effective means of screaning unless high risk populations are evaluated **(Gamarra and zein, 2000)** .

3 – Cystoscopy and Biopsy:

The diagnosis of bladder cancer ultimately depends on cystoscopic examination of the bladder and pathologic evaluation of the respected lesion . Cystoscopy may initially be performed without anesthesia in assessing a patient for bladder cancer . If a bladder cancer has been visualized on earlier imaging studies, or if urinary cytology has previously been found to be positive, diagnostic cystoscopy can be omitted and the patient scheduled instead for cystoscopy and biopsy or tumors resection under anesthesia **(Droller , 1997) .**

With the patient anesthetized, a bimanual examination should be performed first to assess whether a mass is palpable in the bladder and, if so, whether it is fixed to the pelvic wall **(Fossa et al., 2003) .**

Bimanual examination may be perform both before and after transurethral resection . The presence of a palpable mass after resection implies that there is extravesical tumor to a greater extent than the residual exophytic tumor that can be visualized endoscopically . Conversely, negative bimanual examination or only the impression induration without a palpable mass implies that the invasive tumor may be more superficial and potentially associated with a better outcome . Previous pelvic surgery, irradiation, or inflammatory disease may limit interpretation of bimanual examination . Moreover, small tumors may not be palpated, even if they extend extravesically. Obesity and areas that are inaccessible to palpation can also compromise bimanual examination **(Gospodarowicz et al., 2001) .**

Cystoscopy can then be used to examine the gross appearance of the tumor (i . e ., papillary or nodular), the extent and multiplicity of the tumor, and the presence of any other abnormal areas in the bladder or prostatic urethra . Papillary tumors generally are more superficial, even

when invasive, than nodular tumors. In addition, papillary tumors that are confined to the bladder mucosa are generally associated with normal bladder wall thickness, whereas more deeply invasive nodular or papillonodular tumors are often assisting in the assessment of the potential behaviour of the cancer, these considerations may aid determining how aggressive transurethral resection should be **(Droller , 1997) .**

High–grade tumors are more likely to be associated with abnormal areas elsewhere in the bladder, whether these areas appear normal or abnormal endoscopically . Biopsy specimens of malignant urothelial change in these instances . Systematic biopsy of endoscopically normal areas of the bladder mucosa may also be useful in this regard . It should include specimens of mucosa immediately lateral to each ureteral orifice, of the posterior bladder floor, of the lateral walls on each side posteriorly, and of the prostatic urethra when done . A clinical staging can be obtained by bimanual palpation and positive biopsy **(Vicente et al., 2000) .**

It is important to realize that cystoscopy is not 100% sensitive or specific . For example, it will not recognize carcinoma in situ that does not have the typical red velvety appearance . It may also miss some tumors when performad in patients who are actively bleeding or with enlarged prostates and trabeculated bladders **(Jung et al., 2001) .**

Transurethral resection of the bladder tumor should be done so as to maximize the preservation of architectural detail and the relation of the tumor to the various layers of the bladder wall that has traditionally been used as a means of staging bladder cancer and determining prognosis .

For pathologic evaluation, the more superficial component of the tumor should be resected separately from its deeper component . Use

of cautery current should be minimized to preserve pathologic detail and avoid cautery artifact . For tumors that appear to be papillary and superficial, complete resection may require only resection into the lamina propria or possibly into the superficial muscularis into the lamina propria or possibly into the staginf assessment . In contrast, tumors that appear to be more nodular may require a more extensive resection that extends deeply into the muscularis and even into the perivesical fat . This will not only provide more accurate staging information but may also serve adjuctively in the treatment of this type of malignancy **(Droller et al., 1997)** .

Some surgeons suggest that a second transurethral resection should be performed in patients thought to have superficial disease who are found on pathologic evaluation of the initial resection specimen to have tumor infiltration into the lamina propria . In this regard, tumor grade has also been considered as an important indicator of potential understating by initial transurethral resection **(Klan et al., 2001)** .

Renal pelvis and ureters, and hydronephrosis, which may indicate the presence of ureters cancer or a muscle – invasive bladder cancer at the ureteral orifice **(See and Fuller, 2002) .**

Since small urothelial neoplasms of the collecting system and ureter may occur synchronously with a bladder tumor, it is important to demonstrate these structures . Urography remains a sensitive method for detection small upper tract lesions that are often clinically occult . Since urography provides visualization of the lumen of the bladder it is not as effective as CT, Ultrasound and MRI for showing the extent of disease . Urographic findings such as hydronephrosis and ureteral displacement are generally associated with more advanced disease . Papillary tumors produce intraluminal filling detects that have an irregular surface which has been described as stippled. This appearance is due to the presence of

contrast material between the founds of tissue . Because of the large volume of the filled bladder small papillary lesions may be missed by urograohy . In fact, an attempt to demonstrate small bladder lesions urographically is rarely made since they are usually directly visualized at cystoscopy . Tumors that are more infiltrative tend to produce a contour detect in the bladder wall which is manifested as a flattening at the site of tumor growth **(Ladetsky et al., 2001) .**

4. ULTRASOUND:

Transabdominal, transurethral, transvaginal and transrectal ultrasound have been used to stage bladder cancer, although non – invasive transabdominal ultrasound is seldom used today because the results are inaccurate in the assessment of tumor spread beyond the bladder wall and visualization of the tumor is often obscured in obese patients, and by air– containing bowel loops adjacent to the bladder wall . Further problems relate to inaccessibility of tumors arising in the region of the bladder neck and to the evaluation of lymph node metastases **(Husband, 1998) .**

Transabdominal ultrasound is limited in its ability to detect and stage bladder tumors . One study reported a false–negative rate of 24% of cystoscopically detected tumors . Tumors located in the lateral walls are easier to visualize . Larger size tumors, above 2 cm, are more easily detected than those measuring less than 5 mm **(Ladetsky et al., 2001) .**

Transrectal ultrasound provides good quality images of the trigone but bladder dome and anterior wall tumors are poorly sualized and this technique is therefore seldom used . Intravesical ultrasound is superior to the transabdominal approach with reported accuracies ranging from 62 – 92% . The accuracy depends upon the local stage of disease

because intravesical ultrasound is more accurate for staging superficial than advanced tumors due to poor penetration of the ultrasound beam beyond the bladder wall. Since clinical staging is also highly accurate for staging early tumors, transvesical ultrasound is rarely performed routinely **(Husband, 1998) .**

Distensibility of the bladder wall is assessed during filling of the bladder with irrigation fluid . Superficial tumors do not cause fixation or distortion of the bladder distensibility. Muscle invasive tumors, limit distensibility of the bladder wall and cause fixation distortion of the bladder wall. Bladder tumors appear on ultrasound as echogenic lesions . The bladder wall has a more intense echopattern than tumor tissue, thus permitting distinction of early superficial lesions from those invading the deeper layer of he bladder lumen and are nonmobile as opposed to stone and clots . Invasion of muscle layer appears as interruption of the smooth and curved echopattern of the bladder wall . One particular advantage of transurethral ultrasound is the detection of tumor within diverticula, which might not be seen with cystoscopy **(Ladetsky et al., 2001) .**

5. COMPUTED TOMOGRAPHY:

There is currently no role for diagnostic imaging in screening for bladder carcinoma or staging superficial disease . Cystoscopy, transurethral resection and bimanual examination are more accurate than imaging for staging T1 and T2 lesions. However once invasive bladder carcinoma is detected there is a role for imaging . Traditionally this has been performed with CT . Both CT and Magnetic resonance imaging overstage tumor when imaging occurs after intervention imagings. CT is usually more accessible and cost effective than MRI . A major drawback of CT is its inability to depict the extent of intramural invasion due to the

similar attenuation of the bladder wall and carcinoma **(Ladetsky et al., 2001) .**

On CT, bladder tumors appear as soft tissue density lesions. Tumor may be represented as a localized area of thickening of the bladder wall or as a definite sessile or pedunculated soft tissue mass arising from the bladder wall with or without perivesical extension. Occasionally, the surface of the tumor may be encrusted with calcium or with blood clot **(Husband, 1997) .**

Tumors enhance following injection of intravenous contrast medium, usually to a greater degree than the adjacent normal bladder wall . Early tumors confined to mucosal layer of the bladder can only be identified on CT if scaning is undertaken before cystoscopic resection and even then small lesions less than 1–2 cm. are likely to be missed particularly at the bladder base **(Husband, 1998)**

Bladder cancers invading superficial and deep muscle usually produce bladder wall thickening but distinction between T2a and T2b lesions is impossible on CT. Residual bladder wall thickening following resection of Ta and T1 lesions due to oedema or inflammatory reaction is also indistinguishable from muscle invasive disease **(Husband et al., 1992) .**

The most important role of CT is to distinguish those tumors confined to the bladder wall from those which spread into the perivesical fat . An irregular ill–defined outer edge to the bladder wall with soft tissue stranding into the pervesical fat is highly suspicious of perivesical disease (Stage – T3b) . Tumor enhancement is helpful for delineating such early perivesical spread because contrast enhancement increase the tissue contrast between tumor and fat . In more advanced disease, an

obvious soft tissue mass extending beyond the bladder wall is seen as well as infiltrating strands of tumor tissue **(Husband, 1998).**

Spread to the pelvic side wall is diagnosed if tumor extends through the pelvic fat and is contiguous with the pelvic side wall muscles. These muscles may even be enlarged by tumor infiltration or oedema . Early organ invasion can be difficult to detect if the only sign is loss of the fat plane between the bladder wall and an adjacent structure. Enlargement of the structure or organ and contrast enhancement of tissue within the organ in direct contiguity with the primary tumor are strong evidence of tumor invasion **(Husband et al., 2002)** .

However, Invasion of the seminal vesicles is identified because the fat angle between the posterior bladder wall and the anterior surface of the seminal vesicles is lost. It is not a reliable sign of tumor extension as over distension of the rectum may cause the angle to be distored in some normal patisnts. False positive results may occur when a distinct fat plane between contiguous organs is not visulalized and early invasion is suspected. Perivesical inflammation and fibrosis is indistinguishable from tumor and a frequent cause of overstaging . The overall staging accuracy for primary tumors with CT ranges from 40 – 92 % (mean 74%). Finally, CT plays an important role in detection of lymph node and distant metastases . Lymph nodes measuring less than 1 cm are considered normal, nodes measuring 1.0 and 1.5 cm are indeterminate and nodes greater than 1.5 cm are abnormal **(Ladetsky et al., 2001).**

6. MAGNETIC RESONANCE IMAGING :

MRI has unique advantages, including multiplanar capabilities and superior tissue contrast . Because the bladder wall and the perivesical fat are wall defined and have characteristic signals on

different sequences bladder wall invasion of tumor and extension into perivesical fat can be well visualized . Multiplanar capabilities allow three dimensional lymph node measurements as well as better visualization of tumor involving, the bladder dome or base **(Ladetsky et al., 2001).**

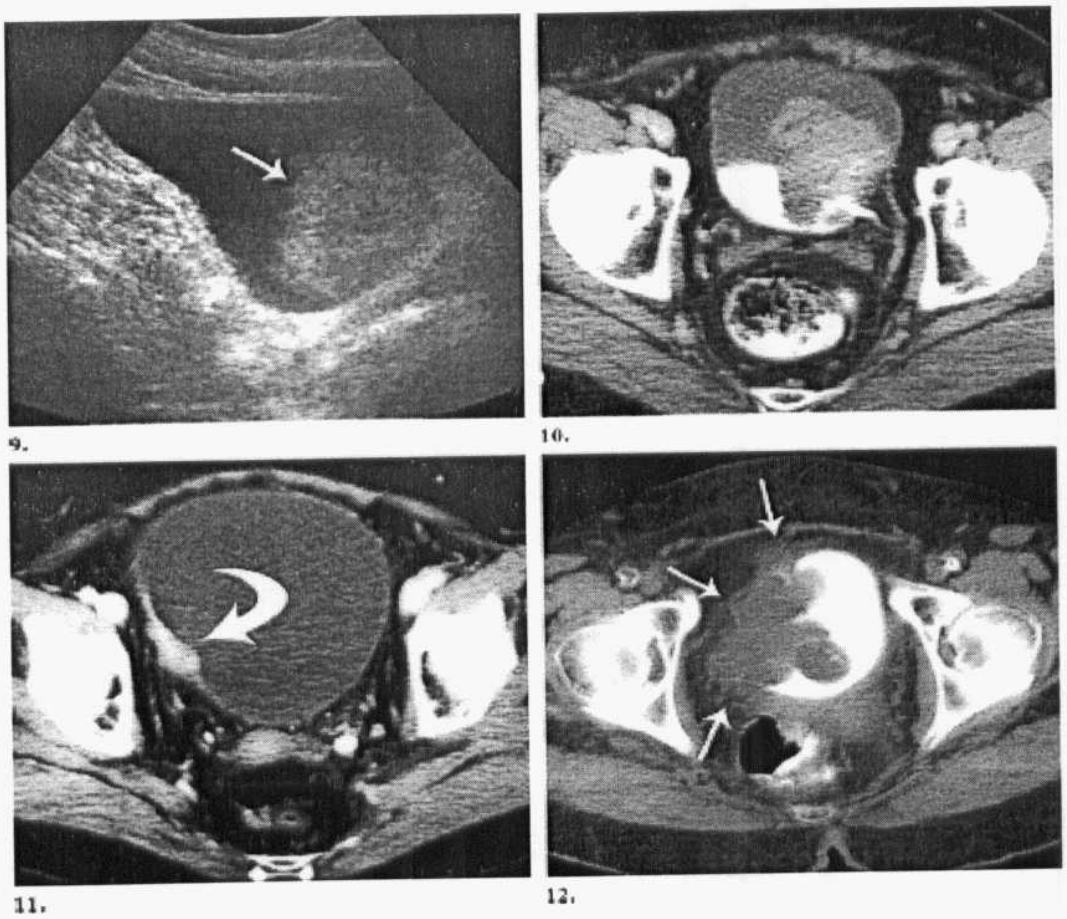

Fig. (9) Longitudinal US section showing a large mass on bladder base .

Fig. (10) Axial CT with contrast showing a large polypoidal mass on base and Lt . lateral wall .

Fig. (11) Axial CT with contrast showing a small sessile mass on Rt. Lateral wall.

Fig.(12) Axial CT with contrast showing a large polypoidal mass on Rt. Lateral wall.

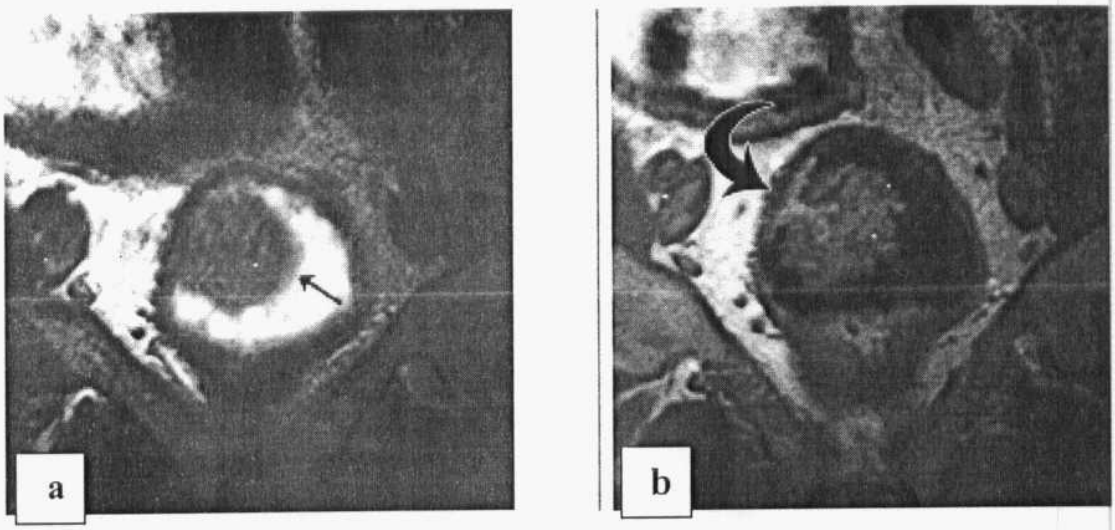

Fig. (13) (a) T2 WI shows an intermediate signal intensity within the bladder lumen (non invasive papillary urothelial tumor) .
(b) Coronal early phase gadolinium enhanced dynamic T1-weighted MR image shows that the tumor enhance more than the wall (arrow) .

Virtual Endoscopy
Physical and Technical Background

In recent years the computerized postprocessing of image data from cross sectional imaging modalities has received progressively increasing recognition in the field of medicine. This development has various reasons. **Firstly**, the technical developments of examination modalities such as CT and MRI, as well as PET and ultrasound, have swiftly improved along with continuously increasing spatial resolution, which means not only a growing memory capacity for the computer, but also that additional image information is included in each slice. For any given volume, more slices can be produced in an ever-decreasing amount of time. **Secondly**, rapidly growing computer performance has created the opportunity to display complex relations, be it anatomical structures or functional information, in a simplified and comprehensible manner. For example, the new multislice CT scanners allow examination protocols of the chest, which produce more than 500 slices per examination; in comparison, chest CT 10 years ago with 10 mm slice thickness consisted of about 25 slices. The explanation for this impressive difference is the current capacity of the multislice CT scanner to produce a 1 mm slice thickness along with overlapping reconstruction intervals of 0.5 mm. In addition, modern modalities produce data sets which, when obtained in a single breath hold (in otherwords, without any pause or movement artifacts), represent the examined volume relatively well. Such data sets are therefore referred to "volume datasets" **(Scheltinga, 2000).**

Virtual endoscopy is one of the most recent innovations in the spectrum of post processing techniques. The predominant motive here is, similarly, to present the image data included in the original slices in such a fashion that the viewer or radiologist is able to differentiate between

that which is healthy and that which is pathological. In this state of rapidly progressing technical developments in computers and software, it is difficult to provide an up-to-date report on the technical background of virtual endoscopy. Furthermore, the terminology has become so extensive that a normal human being is hardly capable of understanding the slew of jargon without an accompanying dictionary. It is therefore a goal to provide a basic understanding of the technical background and terminology of virtual endoscopy. A further aim is to put professionals who are interested in the technical details in a position to become better informed about problems, and possible improvements in volume visualization technology **(Rogalla and Meiri, 2000).**

Volume Data:

Modern CT and MRI scanners produce a set of contiguous cross-sectional images. When these individual slices are combined, a gray level volumetric dataset of voxels is formed. Voxels (volume elements) are the basic elements of volumetric data, similar to picture elements, which are called pixels. Volume visualization techniques visualize such a volumetric data set as a whole, producing a single projected image of the volume data.

The volume data can be regarded as a discrete sampling of a continuous intensity field, which can be reconstructed by an interpolation function. By selecting only one specific intensity value it is possible to define an iso-surface in this continuous field. This is the basic method that is used to select the visible data from the volume data. In certain instances and iso-surface selection may not be sufficient, for example, when certain structures are blocking the view. In this situation, the iso-surface selection can be restricted solely to the structures of interest,

thereby making the structures that originally obstructed the view invisible. This is handled via a segmentation process **(Scheltinga, 2000).**

Why CT?

CT is robust, widely available, intermediately priced and relatively simple to use. The CT characteristics of soft tissue and contrast media are well established and artifacts can be clearly distinguished. The prevailing three CT procedures are incremental CT, spiral CT and multislice CT. The next section discusses the technical aspects of the examination protocols **(Rogalla and Meiri, 2000).**

I) Incremental CT

In incremental CT, a slice is imaged in the axial or paraxial orientation, after which the table shifts to the next position in order to image the next slice. CT devices using the incremental technique, although still in use, are no longer being manufactured **(Naidich et al., 1997).**

II) Spiral CT

Spiral CT was discovered in the late 1980, and quickly proved superior to incremental CT. The continuous table advancement during the gantry rotation (tube-detector system) has made examinations of large anatomical regions during one breath hold possible. Only with the advent of the spiral CT has it become possible to continually examine any region without anatomical misregistration **(Naidich et al., 1997).**

III) Multislice CT

The multislice CT that are currently available are 8 times faster than a 1-s scanner; four simultaneous slices are imaged in 0.5 s rotation time **(Wang and Vannier, 1999).**

IV) Electron-Beam CT

Originally developed for cardiac imaging, electron-beam CT (EBCT) can also be implemented for general diagnosis of the thoracic and abdominal cavities **(Wang and Vannier, 1999).**

Segmentation

To display specific structures present in the volume data, they first need to be identified. The intensity value is often a good indicator for the presence of structure. Thus a basic selection method is thresholding: the voxels or points with intensity value within an intensity range are selected. Sometimes this thresholding is part of the rendering method itself, so that no explicit segmentation step is required. When only a threshold is used, an iso-surface image is generated.

Thresholding is often just the basis for further segmentation based on this initial selection. Well known techniques are selecting connected regions via a seed point; or regions can be expanded (via a dilation operation) or shrunken (via an erosion operation). Other post processing operations include or exclude regions based on properties like size, shape, location or other characteristics, or by manual editing.

Segmentation methods often label individual voxels as belonging to a certain region or not. These binary segmentation methods approach difficulties at the borders of regions. Because only a fraction of each voxel at the border is occupied (the partial volume effect), the intensity of such a border voxel quickly falls outside the selected threshold range. As a result such a border voxel is not included in the selection. This may translate into a false appearance of holes in thin structures.

Advanced segmentation methods not only include or exclude voxels, but are also able to label individual voxels as partly occupied by a

certain region. This probabilistic segmentation is often used in volume rendering methods **(Scheltinga, 2000).**

View Projections

Since the volume data are three-dimensional, they cannot be viewed directly. In order to visualize the volume data in a single (2D) image, a projection of the volume data onto a projection plane is needed. This projection plane is similar to a film in a camera **(Foley et al., 2000).**

Every point of the volume data is transformed to a point on the projection plane. This transformation is defined by a straight projection ray (projector), which starts at a center of projection and passes through the volume point that is projected. The intersection point of this projector, or ray, with the projection plane is the projected position. Under certain circumstances parts of the volume data may not be visible; this occurs when the projector does not intersect with the projection plane. Normally the center of projection, or viewpoint, is positioned at a certain distance on a line perpendicular to the projection plane and through its center. So the viewpoint, together with the position, orientation and size of the projection plane, define the view **(Foley et al., 2000).**

View projections can be divided into two basic classes: parallel projection, where the viewpoint is positioned at an infinite distance, and perspective projection. When separate view projections for both eyes are used this is called **stereoscopic projection**. It gives one the illusion of being able to perceive differences in depth, as in real life. With stereoscopic projection two actual projections (for the left and right eye) are needed.

I) Parallel projection

When the view point is positioned at an infinite distance, the projection rays are parallel to each other. Parallel projection has certain characteristics. The projection is generally faster than perspective projection, as it is simpler to perform. Furthermore, the relative sizes and angles of objects are preserved in the final image. For example, parallel lines remain parallel in the projected image. This absence of distortion in the produced images is an advantage of parallel projection because it allows measurement to be performed on the projection plane **(Scheltinga, 2000).**

II) Perspective projection

With perspective projection, objects are projected towards a single point behind the projection plane. This is referred to as the center of projection or the viewpoint. Perspective projection causes a distortion of object shapes. The reason for the distortion is that objects that are located closer to the viewpoint appear larger in the projected image than objects that are located further away. In this respect, perspective projection is similar to viewing in real life. It results in realistic images and can provide essential depth cues. However, the perspective distortion precludes accurate, direct measurements of objects in the projected plane **(Scheltinga, 2000).**

III) Steroscopic projection

Steroscopic projection is not an additional projection method, but rather, a combination of two normal perspectives instead of one.

In the human visual system, the eyes view ascene from slightly different positions. the two projection planes mainly overlap each other, but are shifted partially to the left and right. These left and right images are fused in the brain, thereby giving the projection of depth **(Scheltinga, 2000).**

Surface shading

The intensity and colour visible at a specific surface location is determined by the surface shading model. This process of surface shading adds realism to an image, so it is a very important aspect of volume visualization.**(Gordon and Reynolds,2003).**

Depth Cueing

A simple but effective means to enhance the notion of depth is called **depth cueing** ;in fact, in the early days of volume visualization, this was the only method available for surface shading .with depth cueing, points closer to the viewer appear brighter than points farther away. This simulates the effect of atmospheric attenuation **(Scheltinga, 2000).**

Reconstruction

For interpreting volume data two classes of rendering techniques are applicable. Surface rendering requires a surface description, which is extracted from the volume data. volume rendering directly renders the volume data, without the need for such an intermediate description.

(1) Surface Rendering

Surface rendering is a conventional computer graphics technique that is widely supported by specialized graphics hardware. It uses a surface description to model the object Surface. This description normally consists of a mesh of polygons. To visualize this Surface, individual polygons are projected and combined with previously projected polygons, resulting in the final image, which depicts the surface. The position of the intersection along the edge is found by an interpolation of the vertex intensities. Up to four triangles may be needed to describe the iso-surface in the cube. Finally surface normals for each

triangle vertex are calculated by interpolating the volume gradients at the cube vertices. Using the symmetry of the cube, the 256 possible cases of isosurface intersection can be reduced to 14 **(Scheltinga, 2000).**

(2) Volume Rendering

With volume rendering, the volume data itself is directly interpreted, without an explicit surface representation. A classification function defines the visible and invisible parts of a volume, based on the intensity values in the volume. Many variants of volume rendering exist, So there is not a single true volume rendering method. Although volume rendering is often associated with translucent images, it is also capable of creating surface shaded images**(Hopper et al., 2000).**

(3)Ray Casting

A commonly used volume rendering method to project the volume data is ray casting **(Levoy, 1998).**With ray casting the volume data is processed in image (pixel)order. A ray is cast through the volume data for each pixel of the output image. Along this ray, opacity and color values are calculated at evenly spaced sample positions. When all sample points of the ray are composited, the result is a single image pixel**(Scheltinga, 2000).**

(4)Rendering Artifacts

Several artifacts may occur when rendering volume data; examples are staircasing, aliasing ,rippling, slicing and highlight flashing. These artifacts are mainly caused by interpolation errors. The avoidance of these artifacts is often a trade-off between image quality and speed.

***Staircasing:**

When the staircasing slice distance is large compared to the pixel size, a staircasing effect may occur. Normally interpolation of the volume data results in a smooth iso-surface, but with a large slice distance this is a problem. To prevent this staircasing effect the slice distance of the volume data should be similar to the slice pixel size**(Rogalla and Meiri, 2000).**

***Aliasing:**

Aliasing occurs as a result of interference between the resample grid and the voxel grid. When the resample grid resolution with ray casting is too small with respect to the voxel grid, ringing artifacts can occur. Enlarging the resolution of the image can prevent this. With virtual endoscopy aliasing is not a problem, as the images are normally zoomed and thus have a high resolution compared to the volume data **(Scheltinga, 2000).**

***Rippling:**

With volume rendering individual voxels are sometimes visible via rippling artifacts when an image is zoomed-in. These artifacts are caused by an incorrect order of operations**(Scheltinga, 2000).**

***Slicing:**

When with ray casting the sampling distance along a ray is too large, slices may appear in the image. The discrete depth locations at which samples are taken then become visible as slices. This effect occurs

when the sample rate is not adjusted while zooming-in on the image **(Rogalla and Meiri,2000).**

*Highlight Flashing:

With Surface rendering, the specular highlights may suddenly flash on or off during interaction. Because shading is only performed at vertices, specular shading is not always correct for the other pixels of the polygon. Instead of interpolating colors over the polygon, the surface normal should be interpolated. But this also requires shading for every polygon pixel, a costy affair**(Scheltinga, 2000).**

Virtual Endoscopy

Virtual endoscopy visualizes the inner surfaces of the structures present in volumetric data in 3D images. To simulate true endoscopy, surface shaded images are generated using a perspective projection. As navigating through the inner structures quickly becomes a complicated procedure, often a (possibly branched) path through the structure is used. This path can be used to interactively investigate the inner structure or to generate an animation along the path **(Rogalla and Meiri, 2000).**

1) Visualization Settings

To visualize the interior surface of tubular structures, the visible surface needs to be selected. Normally a simple threshold is sufficient, Resulting in an iso-surface display. A segmentation step may sometimes be necessary, however, to remove blocking structures.

For virtual endoscopy, the parallel projection is not very useful.

The explanation is that only a small part of the surface wall is visualized, and it is very hard to observe the depth in such images. Because branches are hardly detectable, they are easily missed. The perspective projection shows much more of the surface of tubular structures than the parallel projection. In addition the perspective distortion gives valuable depth cues **(Scheltinga, 2000).**

2) Path Planning

Navigation through the inner structures is often a problem, especially when these structures are strongly curved. With full control over a camera, it is easily moved out of this inner structure; comparatively, a simple solution is to use a guiedance path for easy navigation. The path adds constraints, which are useful in guiding the viewer through the structure . An effective path needs to have certain properties:

- The path must remain inside the structure and avoid collisions with the wall.
- It should follow the centerline of the structure as closely as possible, as this provides the best visualization of the surrounding wall.
- The path should also be smooth without unnecessary kinks.

Once a path is created, navigating is simply a matter of positioning the view along the path. The viewing direction is adjusted to the local path orientation. It remains possible to look around by adjusting this viewing direction, in order to obtain a better impression of interesting features. To generate an animation, a series of images is generated along the path at small distances **(Palk et al.,1998).**

Out of forty eight examined individuals, forty six patients clinically presenting with bladder mass(es), were selected from the outpatients clinics and inpatients departments of Al Hussein University Hospital, AL Azhar University, over a period from 5/2007 to 12/2007. All radiological investigations were done in the radio diagnosis department of Al Hussein University Hospital (CT &MRI unit).

The examined individuals could be classified into the following groups:

*** Group 1 (30 cases):**

Subjected to spiral CT of the bladder after air insufflation, with virtual CT cystoscopy reconstruction, and to real conventional cystoscopy. The virtual pictures, the CT findings, as well as real cystoscopy pictures and reports were compared to each other and to the obtained postcystectomy pathology.

*** Group 2 (12 cases):**

Subjected to spiral CT of the bladder when full of urografin contrast, with virtual CT cystoscopy reconstruction, and to real conventional cystoscopy. The virtual pictures, the CT findings, as well as real cystoscopy reports were compared to each other and to the obtained postcystectomy pathology.

*** Group 3 (4cases):**

Subjected to spiral CT of the bladder full of urine (and real cystoscopy); however no virtual images could be obtained for these cases.

*** Group 4 (2 volunteers):**

Two candidates with completely healthy free bladder were subjected to spiral CT of the bladder (after air insufflation), to obtain

virtual imaging describing the normal internal anatomy of the bladder cavity.

Each case from group 1 and 2 was subjected to the following:

1- Detailed history taking with special emphasis on complains of the patient and present illness.

2- Full general examination and local examination (including PR examination).

3- Routine laboratory investigations, including urine analysis, full blood picture, and renal functions tests.

4- Routine cystoscopy (conventional cystoscopy examination) was performed for every patient, under general/spinal anesthesia with biopsy specimens obtained from the bladder masses.

5- Conventional radiological examinations, including routine chest X-ray, and routine IVU to evaluate the excretory functions of the kidneys.

6- CT scanning of the abdomen and pelvis:

*** For cases examined with air contrast :**

(The bladder should be catheterized first)

- Routine CT scanning of the abdomen and pelvis till the level of the bladder, after IV injection of 80-100 ml of urografin.
- Just prior to scanning of the urinary bladder, the catheterized bladder should be completely evacuated from urine or contrast , followed by insufflation of the bladder with 100-300 ml room air via the catheter, using a 60 ml syringe and a clamp (according to the capacity of the bladder and patient's tolerance).
- Spiral (helical) axial CT scanning of the bladder is then performed using the following parameters:

-280 mAs and 120 Kvp.

-Slice thickness of 3 mm / a pitch of 1 / and reconstruction index of 1 mm

*** For cases examined with urografin contrast :**

- Prior to any scanning by half an hour, about 100 ml of urografin are injected IV to the patient.
- Routine CT scanning of the abdomen and pelvis till the level of the bladder is performed after IV injection of 100 ml of urografin, to distend the bladder properly with urografin contrast.
- Spiral axial CT scanning of the bladder is then immediately performed, using the same parameters as described before.

All CT examinations were done with the patients placed in the supine position, and using the same helical CT scanner (GE Multislice 4 Detectors).

Image processing:

The obtained axial CT images of the bladder were transferred to a special workstation (Millentech workstation) for review and postprocessing.

The cross sectional image data were processed and the signal intensities were converted into anatomic surface for later display.

The first step towards surface rendering was segmentation. Segmentation is the method by which we could generate stereoscopic images of the inner wall of the bladder cavity from the original axial images, similar to those visualized using an endoscope. By this method we used the thresholding which extracted the region of interest on basis

of the set of thresholds. Morphologic operators were used to isolate most tissues

On the monitor, 3 windows simultaneously displayed the global view (the 3D picture), the local view (the virtual image), and the nearest CT imaging slice, with the camera positioned as indicated.

The virtual camera had 3 functions simulating the translations and rotations of a real endoscope: It advances along the z-axis, rotates around the z-axis and it pivots around the x-axis.

Both the global (surface rendered outside surface) and the local (virtual endoscopy view of the inside surface) views could be displayed from various angles and details could be zoomed in.

Camera tracking on cross sectional slices was achieved through the window that shows the location of the endoscope as a marker on the original CT imaging slices: This view localized the endoscope within the familiar cross sectional CT image On the other hand; the endoscope was represented as a moving cylindrical structure on the 3D picture.

Manual or automatic path planning through the lumen, from head to feet and from feet to head was made, and CT virtual images were taken from both directions (cranio-caudal and caudo-cranial).

Three-dimensional and multiplaner reconstructions (using different threshold values, cutting methods and planes) were done for the majority of cases.

Table (5) sex distribution

Sex	No. of Patients	Percentage
Male	41	89.1
Female	5	10.9

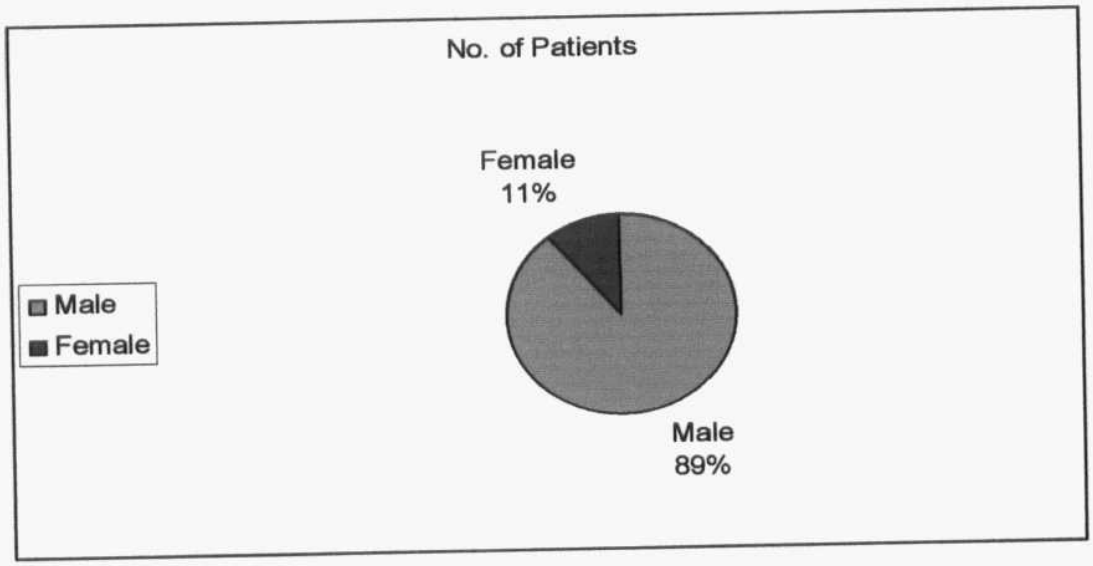

Fig. (14) Diagrammatic representation of sex distribution

Table (6) : Age distribution

Age	No. of patients	Percentage
40th	3	7
50th	18	39
60th	22	47
70th	3	7

The majority of cases , is lying in the range of 50-70 years old.

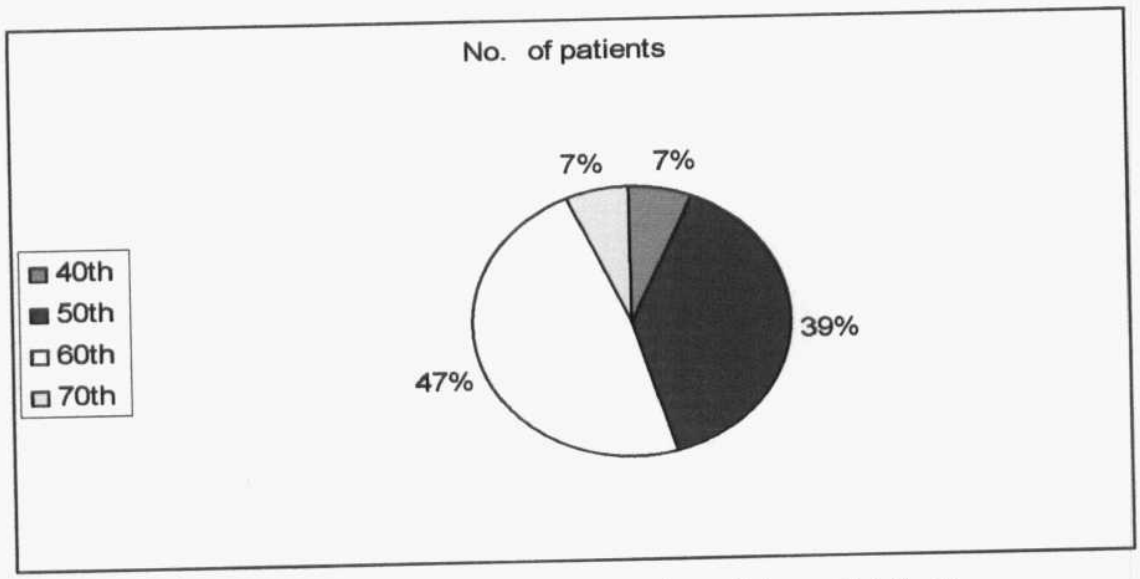

Fig. (15) Diagrammatic representation of Age distribution

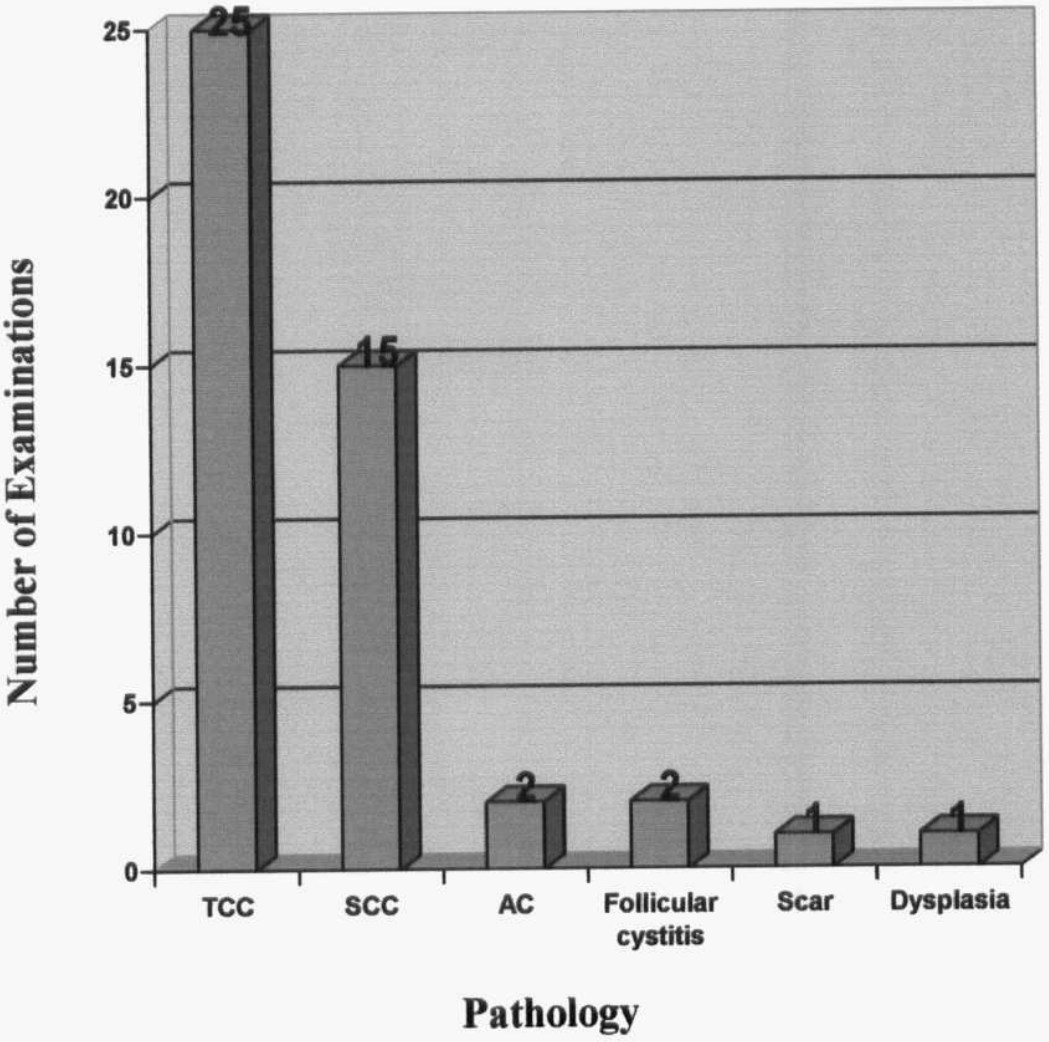

Fig. (16): Pathology of lesion detected by conventional cystoscopy. Transitional cell carcinoma (TCC), Sequamous Cell carcinoma (SCC) and Adenocarcinoma (AC).

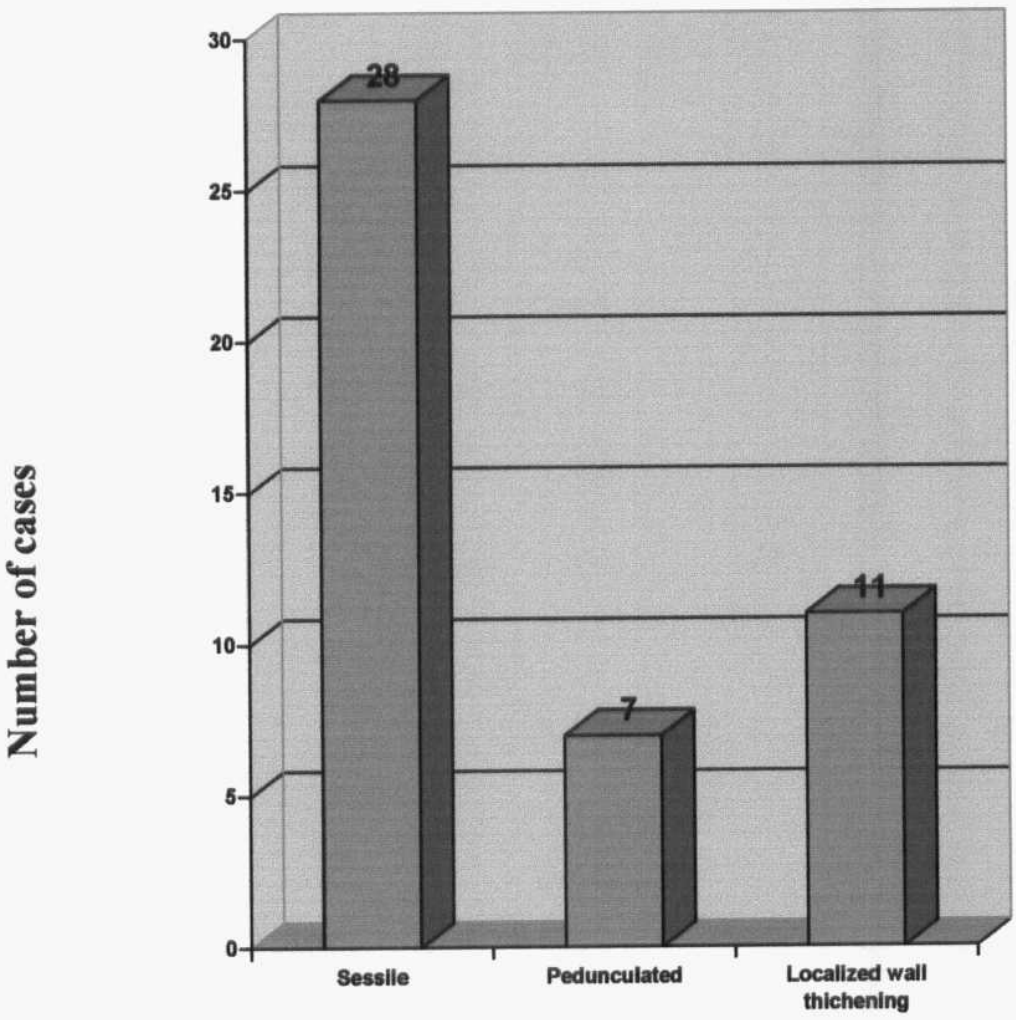

Fig. (17): Shape of lesions detected by CT virtual cystoscopy.

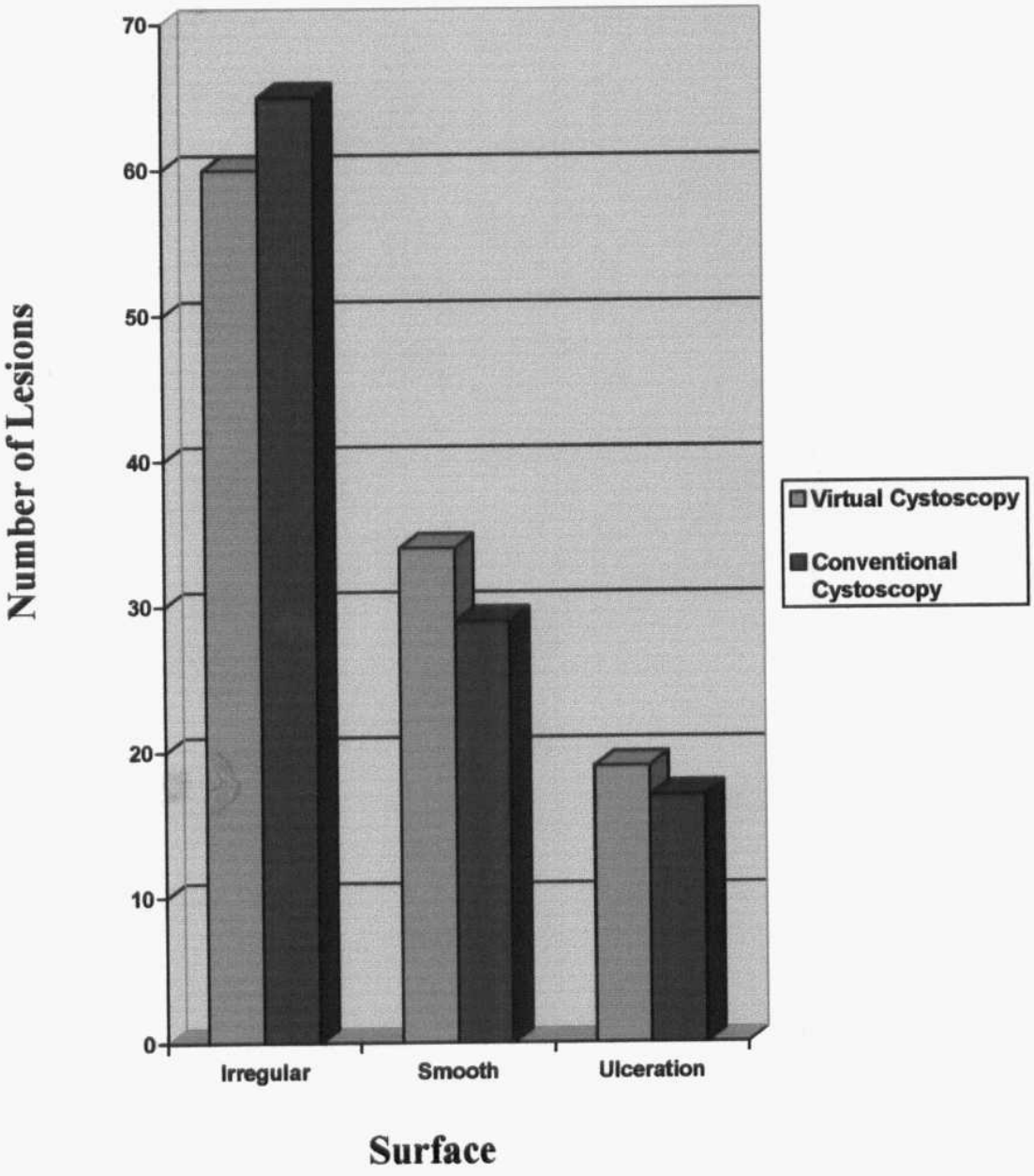

Fig. (18): Comparison of lesion surface estimated by conventional and CT virtual cystoscopy images.

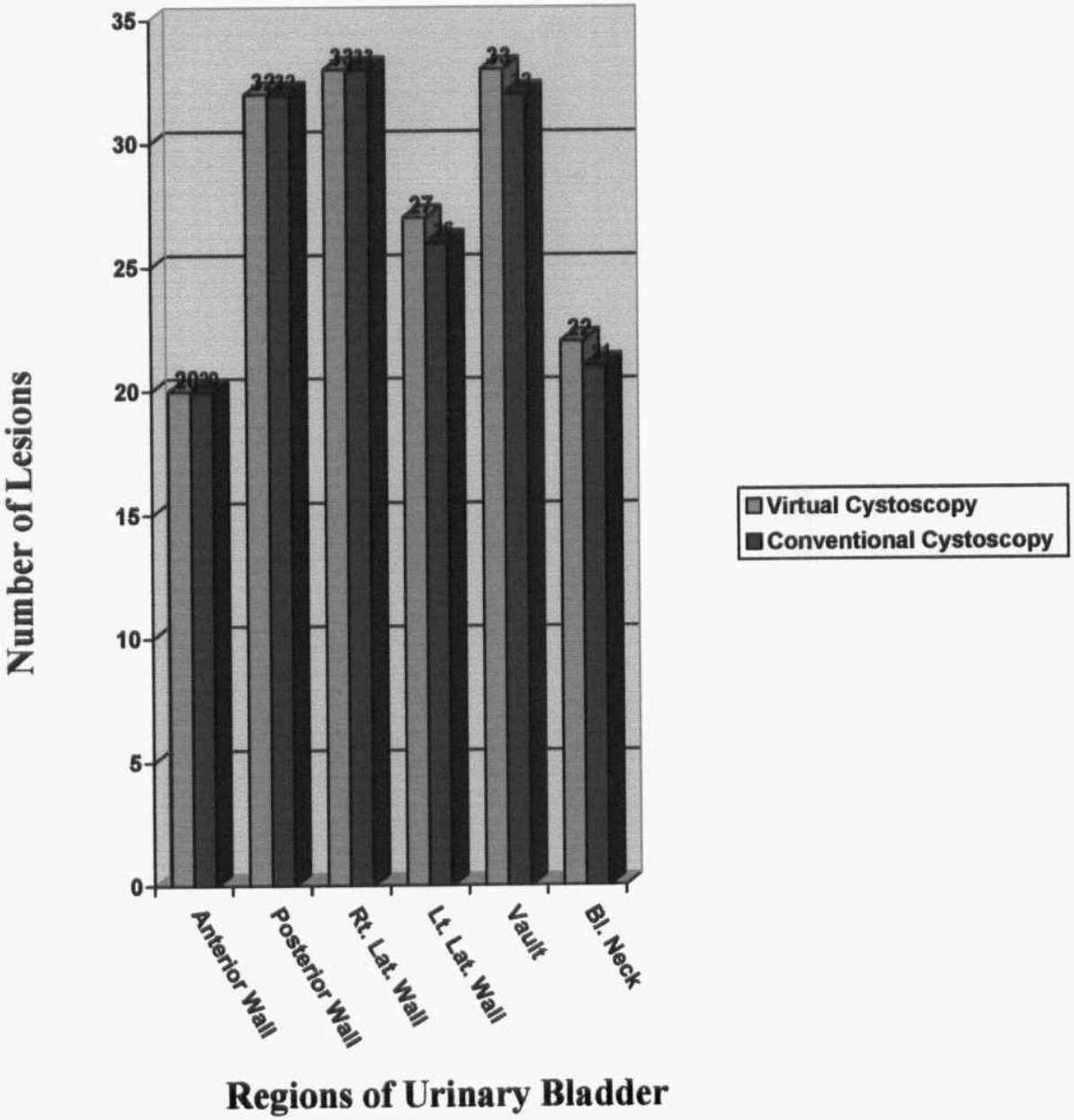

Fig. (19): Number of lesions detected by CT virtual and conventional cystoscopy for each urinary bladder region.

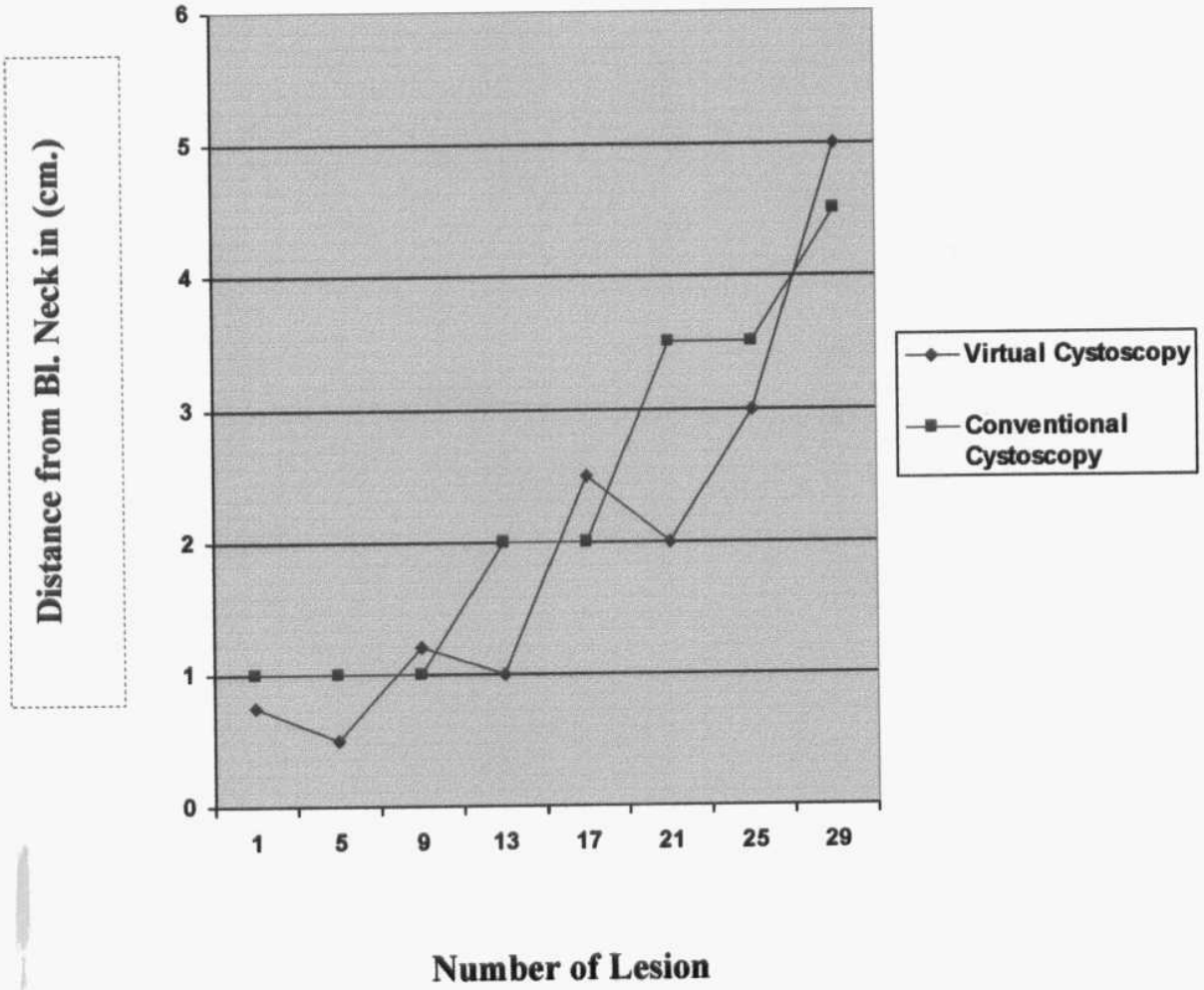

Fig. (20): Comparison of lesion surface estimated by conventional and CT virtual cystoscopy images.

Table (7): Comparison Between Sensitivity And Specificity Of Cyst., VC And CT In Detection Of Tumor Location

Tech / wall	Conv. Cyst.		VC		CT	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Dome	100 %	100 %	100 %	100 %	100 %	100 %
Rt. Lat.	100 %	100 %	100 %	100 %	100 %	100 %
Lt. Lat.	100 %	100 %	100 %	100 %	66.7 %	100 %
Base	100 %	100 %	100 %	100 %	100 %	100 %

Conventional Cystoscopy and VC showed equal sensitivity (100%) and specificity (100%) in identification of the wall(s) involved by the tumor , as previously found for cases studied with air contrast in the bladder.

Again CT showed a certain deficiency in exact localization of the tumor.

Size

Table (8): Number Of Masses Detected By Cyst., VC, Spiral CT, According To Its Size (Depth) Out Of A Total Number Of 16 Masses Found In 12 Cases.

Size of mass / Tech	Mass ≥ 10 mm	5mm<Mass<10mm	Total number of masses
Conv. Cyst.	12	4	16
VC	12	4	16
CT	12	2	14
Gross Pathology	12	4	16

Table (9): Comparison Between Sensitivity Of Cyst., VC And CT In Detection Of The Mass According To Its Size

	Sensitivity	
	Mass ≥ 10 mm	5mm<Mass<10mm
Conv. Cyst	100 %	100 %
VC	100 %	100 %
CT	100 %	50 %

The results obtained for cases with urografin contrast in the bladder, regarding sensitivity in detection of mass according to its size, were comparable to those obtained for cases with air contrast in the bladder: VC showed a 100% sensitivity in detecting masses greater than 5mm in size, while sensitivity of CT for masses comprised between 10 to 5mm decreased significantly.

(No masses< 5mm were encountered among these cases).

Morphology: A comparative study between Cystoscopy, VC and spiral CT was undertaken, regarding morphology description of the tumor as found by Gross pathology; the following sensitivity arid specificity rates were obtained.

Table (10): Comparison Between Sensitivity And Specificity Of Cyst., VC And CT In Morphology Description Of The Tumor.

Tech / Morphology	Conv. Cyst.		VC		CT	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Sessile	100 %	100 %	100 %	100 %	66.7 %	66.7 %
Pedunculated	100 %	100 %	100 %	100 %	66.7 %	66.7 %
Localized wall thickening	100 %	100 %	100 %	100 %	100 %	100 %

As for cases studied with air contrast, VC was also able to demonstrate the morphology of the bladder pathology in the 12 cases studied with urografin.

Size

Table (11): Number Of Masses Detected By Cyst., VC, Spiral CT, According To Its Size (Depth) Out Of A Total Number Of 46 Masses Selected From 30 Cases.

Size of mass / Technique	Mass ≥ 10 mm	5mm<Mass<10mm	Total number of masses
Conv. Cyst.	34	12	46
VC	34	12	46
CT	34	8	42
Gross Pathology	34	12	46

Table (12): Comparison Between Sensitivity Of Cyst., VC And CT In Detection Of The Mass According To Its Size.

	Sensitivity	
	Mass ≥ 10 mm	5mm<Mass<10mm
Conv. Cyst	100 %	100 %
VC	100 %	100 %
CT	100 %	66.7 %

VC showed excellent sensitivity (100%) in detection of bladder masses greater than 5mm, comparable to that of Conventional Cystoscopy while sensitivity of spiral CT ,in detection of bladder masses comprised between 10 to 5mm , decreased to 66.7%.

(No masses< 5mm were encountered among these cases).

Table (13): Comparison Between Sensitivity And Specificity Of Cyst., VC And CT In Morphology Description Of The Tumor.

Tech / Morphology	Conv. Cyst.		VC		CT	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Sessile	100 %	100 %	100 %	100 %	71.4 %	100 %
Pedunculated	100 %	100 %	100 %	100 %	100 %	100 %
Localized wall thickening	100 %	100 %	100 %	100 %	100 %	100 %

VC was always able to depict the morphology of the bladder pathology in all these cases, with 100% sensitivity and specificity; CT was somehow deficient in morphology description of the bladder lesions , with decreased sensitivity to papillary lesions , as found in our study.

Table (14): Comparison Between Sensitivity And Specificity Of Cyst., VC And CT In Detection Of Tumor Location.

Tech / wall	Conv. Cyst.		VC		CT	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Dome	100 %	100 %	100 %	100 %	80 %	80 %
Rt. Lat.	100 %	100 %	100 %	100 %	100 %	100 %
Lt. Lat.	100 %	100 %	100 %	100 %	100 %	100 %
Base	100 %	100 %	100 %	100 %	90.9 %	100 %

Conventional Cystoscopy and VC showed equal sensitivity (100%) and specificity (100%) in identification of the wall(s) involved by the tumor.

However spiral CT showed a decreased sensitivity and specificity in detection of bladder dome involvement, as well as decreased sensitivity in detecting base involvement by the tumor.

Results for cases with air contrast

Site of involvement: Table (14) provide a comparative study between Cystoscopy, VC, spiral CT regarding detection of tumor location as found by Gross pathology.

Table(15): Results Obtained Regarding Tumor Localization By Ctst., VC, CT And Pathology

Cases	Conv. Cyst.				VC				CT				Gross Pathology
	Dome	Rt. Lat Wall	Lt. Lat Wall	Base	Dome	Rt. Lat Wall	Lt. Lat Wall	Base	Dome	Rt. Lat Wall	Lt. Lat Wall	Base	
Case 1	-	+	+	+	-	+	+	+	+	+	-	+	All walls except dome
Case 2	+	-	+	+	+	-	+	+	-	-	+	-	Lt. lat. Wall (+extension to dome and base
Case 3	+	+	+	-	+	+	+	-	+	+	+	-	Dome + lat. walls
Case 4	+	+	+	+	+	+	+	+	+	+	+	+	All walls
Case 5	-	-	+	+	-	-	+	+	-	-	+	+	Base + Lt. lat wall
Case 6	+	-	-	-	+	-	-	-	+	-	-	-	Dome
Case 7	+	+	+	-	+	+	+	-	+	+	+	-	Dome (+ extension to lat walls)
Case 8	-	-	+	+	-	-	+	+	-	-	+	+	Lt. lat wall + base
Case 9	+	+	+	+	+	+	+	+	+	+	+	+	Base + dome (+ extension to lat. Walls)
Case 10	-	-	+	+	-	-	+	+	-	-	+	+	Lt. lat. Wall + base
Case 11	+	+	+	+	+	+	+	+	-	+	+	+	All walls
Case 12	-	+	-	+	-	+	-	+	-	+	-	+	Rt. Lat. Wall + bass
Case 13	+	+	+	+	+	+	+	+	-	+	+	+	All walls
Case 14	+	+	+	+	+	+	+	+	+	+	+	+	All walls
Case 15	+	+	+	-	+	+	+	-	+	+	+	-	Dome (+ extension to lat. Walls)

Table (16): Distributions According To Grading

Grading	n° of patients	percentage
G I	2	4
G II	34	74
G III	10	22

The Majority of cases were proved to be grade II by Histopathology.

Table (17): Distributions According To T-Staging

T-Staging	n° of patients	percentage
Tis	0	0
Ta	0	0
T1	0	0
T2	4	9
T3a	22	48
T3b	18	39
T4a	2	4
T4b	0	0

The majority of patients were proved to be T3 stage by Histopathology (T3a > T3b); Tis, Ta and T2 stages were not encountered among the studied cases.

Case No. (1)

*** Clinical picture:** Male patient, 62 years old, presenting by hematuria and frequency (PR examination: Bulky mass felt at the base of the bladder).

*** Conventional Cystoscopy:**

- Extensive muscle invasive, high-grade tumor involving the bladder base.
- The Base is the site of a large bulky polypoidal mass compromising the luminal space.

*** Spiral CT study of the abdomen and pelvis:**

- The urinary bladder shows a large polypoidal soft tissue mass arising from its base (measuring about 3 x 4.5 cm in its AP and transverse diameters respectively) with irregular circumferential thickening of all bladder walls
- No definite pelvic or abdominal lymphadenopathy noted.
- No pelvic or abdominal collections noted.
- No other organ involvement noted (CT staging: T3bNoMo)

*** Virtual Cystoscopy:**

- A large bulky mass lesion is seen involving nearly whole bladder base.
-The mass showing rather smooth glistening surface denoting polypoidal morphology.
- Irregular thickening of base and lat. walls is also noted.

*** Pathology:**

- Gross pathology:

Radical cystectorny specimen showing a large polypoidal mass (4x 4 x 5 cm in dimensions) occupying bladder base, infiltrating the perivesical fat; with wall thickening; dome is free.

- Histopathology:

Transitional cell carcinoma grade II b/ T3bN1Mo.

Case No. (1)

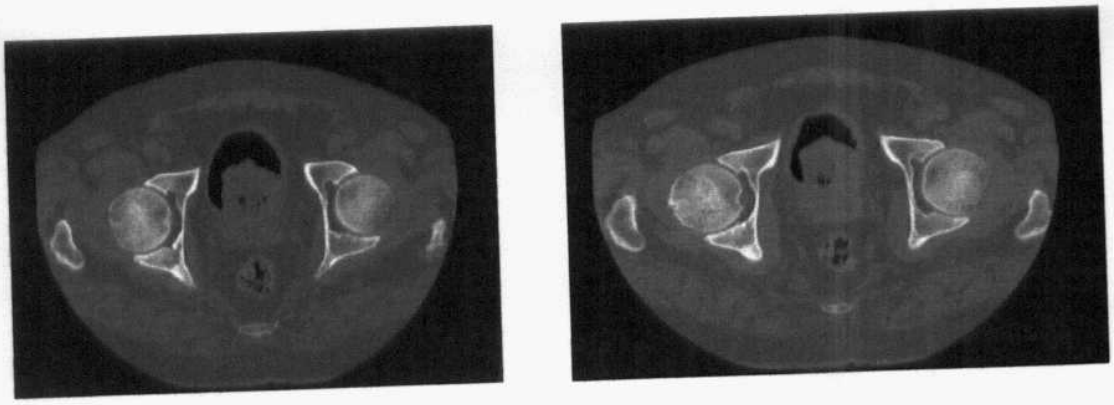

Fig. (21): Axial CT scan (air contrast)

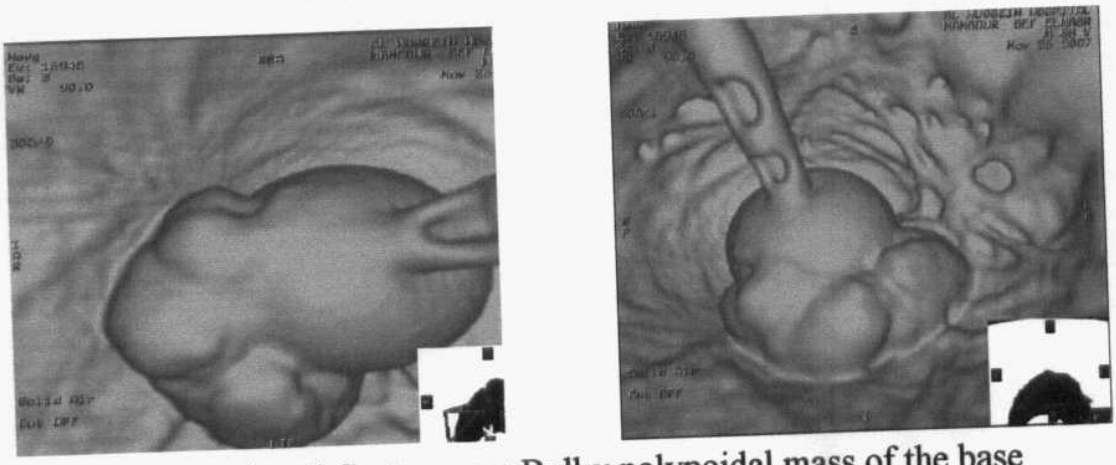

Fig. (22) Virtual Cystoscopy: Bulky polypoidal mass of the base

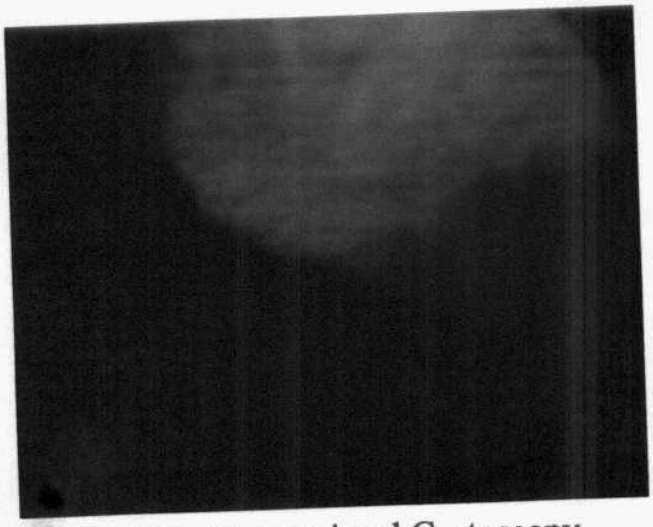

Fig. (23): Conventional Cystoscopy.

Case No. 2

*** Clinical picture:** Female patient, 53 years old, presenting with hernaturia and dysuria .

*** Conventional Cystoscopy:**

-Two Invasive, papillary tumors involving the left lateral bladder wall.

*** Spiral CT study of abdomen and pelvis:**

- The urinary bladder shows irregular papillary thickening of the left lateral wall with two papillary mass lesions the largest about 6 x 7 cm. and the smallest about 3 x 2 cm. no evidence of extravesical extension.
- No pelvic or abdominal lymphadenopathies.
- No pelvic or abdominal collections.
- No other organ involvement (CT staging: T3aNoMo).

*** Virtual Cystoscopy:** Two large papillary lesions are seen at the left lateral wall

*** Pathology:**

- **Gross pathology:** Radical cystectomy specimen showing papillary invasive tumor involving the left lateral bladder wall in the form of irregular papillary mural thickening; no gross infiltration of perivesical fat.
- **Histopathology**: Squamous cell carcinoma / grade I / T3aNoMo.

Case No. (2)

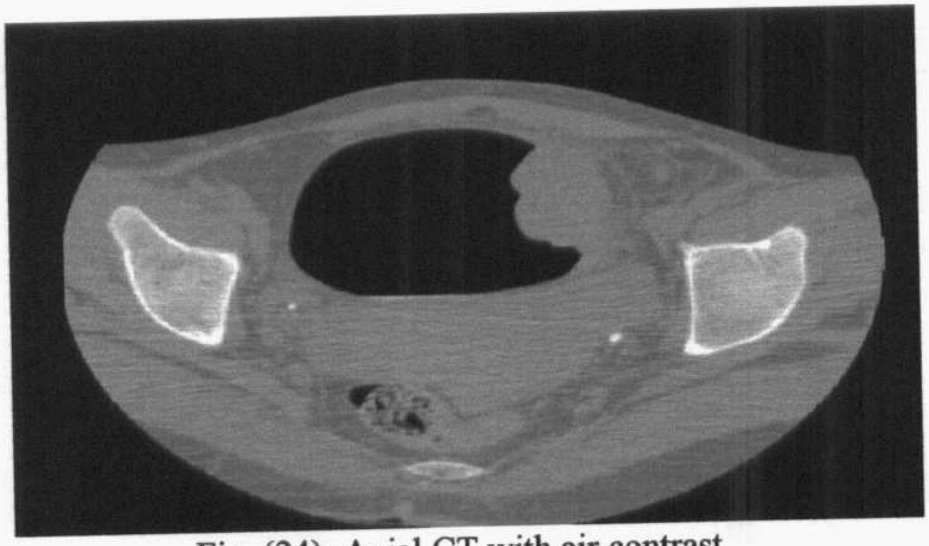

Fig. (24): Axial CT with air contrast

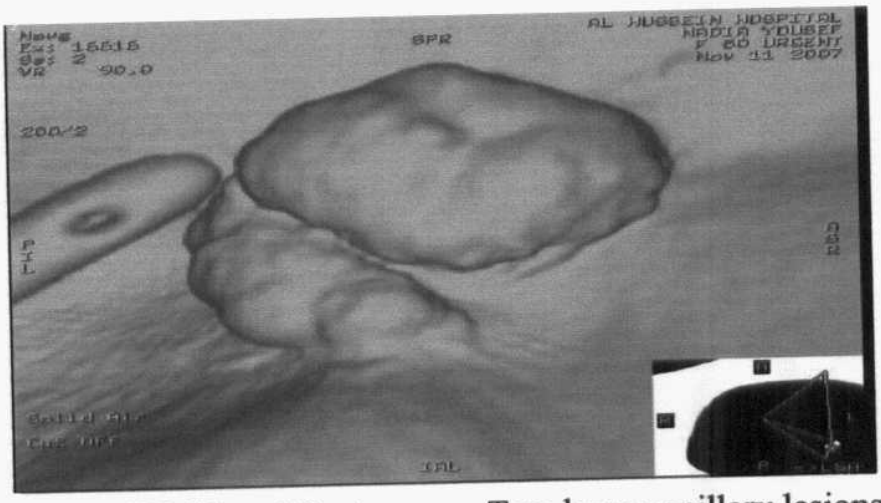

Fig. (25) Virtual Cystoscopy: Two large papillary lesions are seen at the left lateral wall.

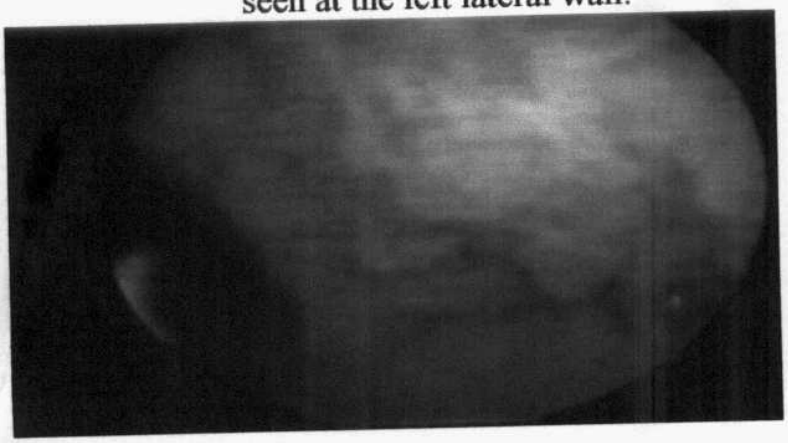

Fig. (26): Conventional Cystoscopy.

Case No. (3)

*** Clinical picture:** Male patient 47 years old, presenting with hematuria and dysuria (PR examination: Bulky mass felt).

*** Conventional Cystoscopy:** Two sessile masses are seen at the bladder base and extending to the right lateral wall (clinical staging: T2).

*** Spiral CT study of the abdomen and pelvis:**

- The urinary bladder shows a large soft tissue mass lesion (7 x 6.5) at the bladder base and extending to the right lateral wall. No evidence of extravesical extension.
- No pelvic or abdominal collections.
- No other organ involvement (CT staging: T3aN0Mo).

*** Virtual Cystoscopy:**

- Two sessile masses are seen arising from the bladder base and right lateral wall.
- Irregular fine mural thickening noted involving all walls.

*** Pathology:**

- **Gross pathology:** Radical cystectorny specimen showing invasive tumor causing circumferential irregular thickening of bladder walls; two sessile tumor projections of the bladder base noted; no gross infiltration of perivesical fat.
- **Histopathology:** Papillary invasive transitional cell carcinoma / grade II / T3aN1Mo.

Case No. (3)

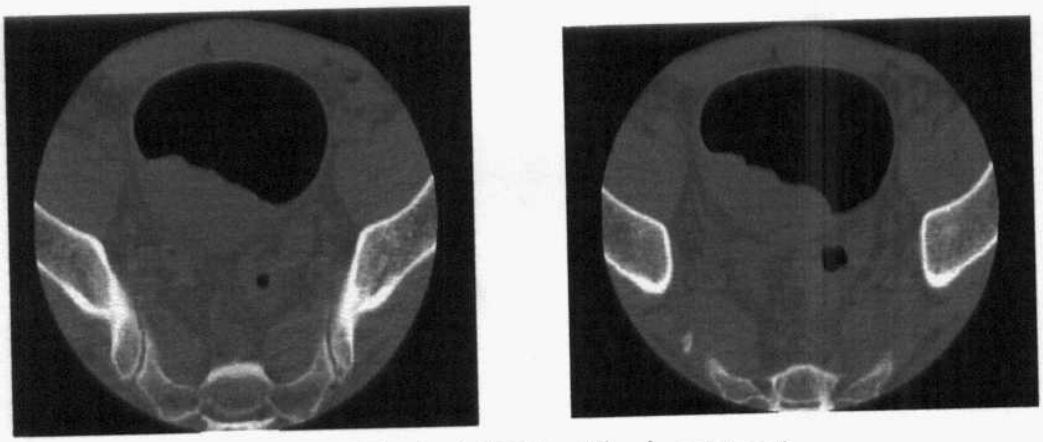

Fig. (27): Axial CT with air contrast

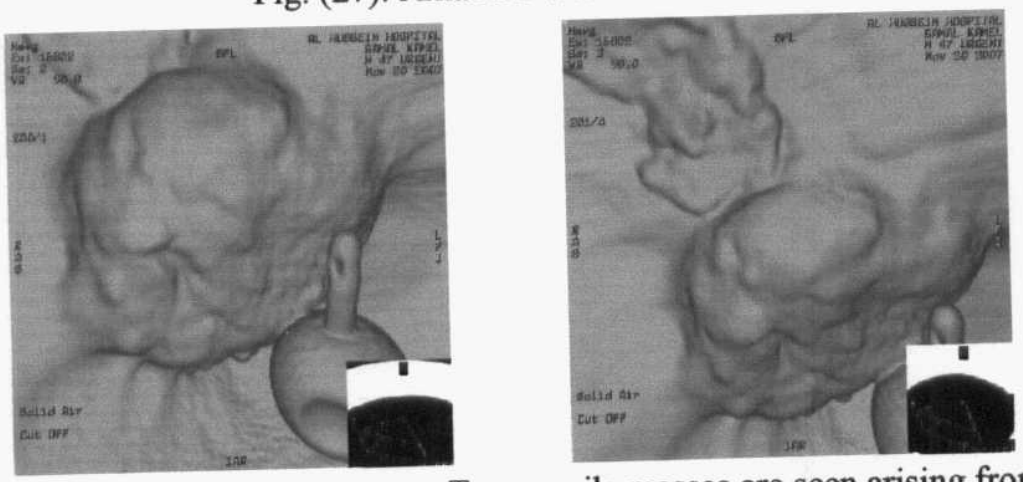

Fig. (28) Virtual Cystoscopy: Two sessile masses are seen arising from the bladder base and right lateral wall.

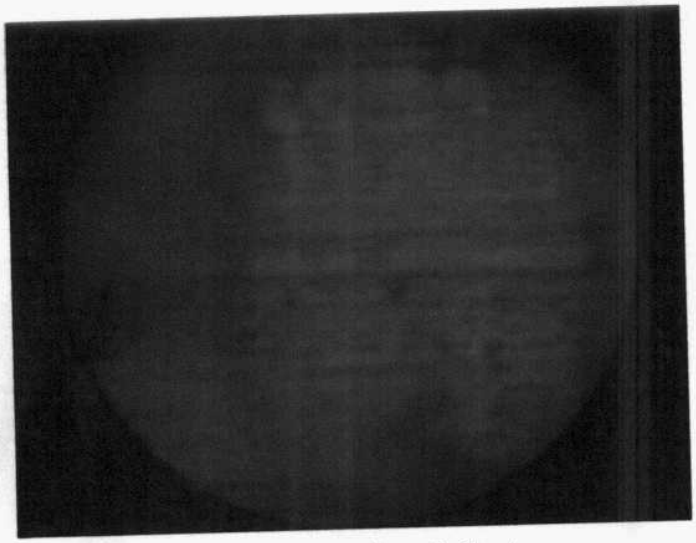

Fig. (29): Conventional Cystoscopy.

Case No. (4)

*** Clinical picture:** Male patient 38 years old, presenting with hematuria and dysuria (PR examination: No mass felt).

*** Conventional Cystoscopy:**

- Two small polypoidal tumors involving the left lateral wall.

*** Spiral CT study of the abdomen and the pelvis:**

- The urinary bladder shows two small polyps arising from the left lateral wall (0.5 x 1 cm.) / No extra vesical extension.
- No definite pelvic or abdominal lymphadenopathy.
- No pelvic or abdominal collections.
- No other organ involvement (CT staging: T1bNoMo).

*** Virtual Cystoscopy:**

- Two small polypoidal masses are seen involving the left lateral wall.

- **Histopathology:** Transitional Papilloma grade I / T2bN1Mo.

Case No. (4)

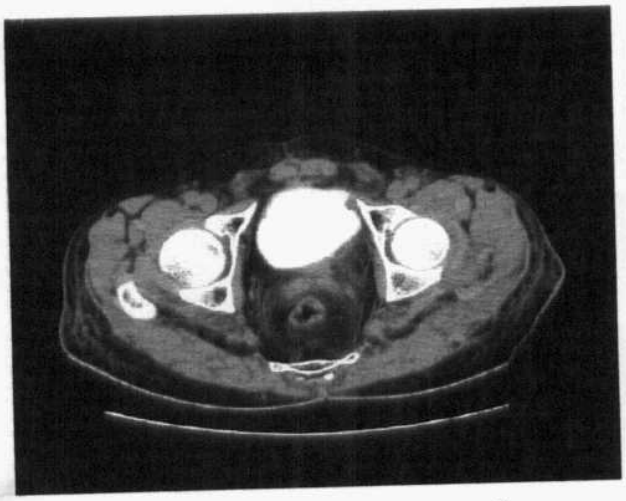

Fig. (30) : Axial CT with urografin contrast.

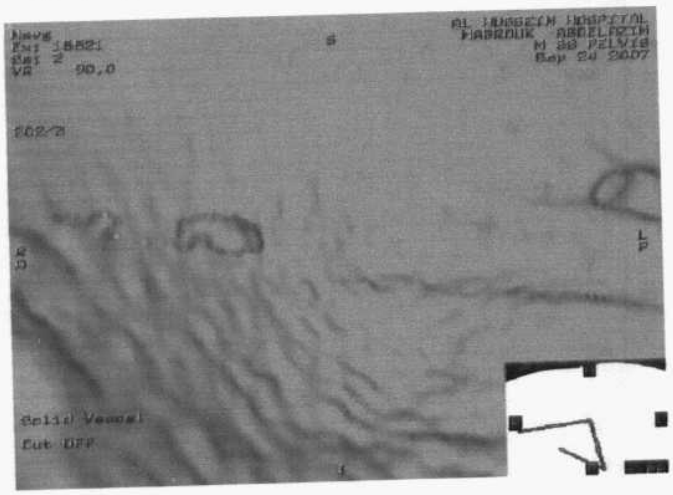

Fig. (31) Virtual Cystoscopy: A small polypoidal mass is seen involving the left lateral wall.

Fig. (32): Conventional Cystoscopy.

Case No. (5)

*** Clinical picture:** Male patient, 70 years old, presenting with hematuria, dysuria, necroturia and frequency (PR examination: Bulky mass felt at Lt Lateral wall and base).

*** Conventional Cystoscopy:** Revealed fungating bulky papillary mass of the base and Lt lateral wall, likely of high grade muscle infiltrating nature, extending to the dome and base (clinical staging : T3).

*** Spiral CT study of abdomen and pelvis:**

- The urinary bladder shows a large enhancing rather invasive soft tissue mass, involving the thickened base and Lt. lateral wall (measuring about 5.5 x 7.5 cm in its TV and AP diameters respectively) / no definite extravesical extension; No pelvic or abdominal lymphadenopathy; No pelvic or abdominal collections; No other organ involvement (CT staging: T3a No Mo).

***Virtual Cystoscopy:** Revealed a bulky, rather papillary mass, involving mainly the base & Lt. Lateral wall and extending mildly to the dome.

Pathology: **Gross pathology**: Radical cystectomy specimen showing invasive papillary tumor (6x6.5x 8 cm in dimensions) occupying the base and Lt. lateral wall of the bladder, with extension to the dome; no gross infiltration of perivesical fat.

- **Histopathology:** Squamous cell carcinoma (with bilharzial infestation) / grade 2 / T3a No Mo.

Case No. (5)

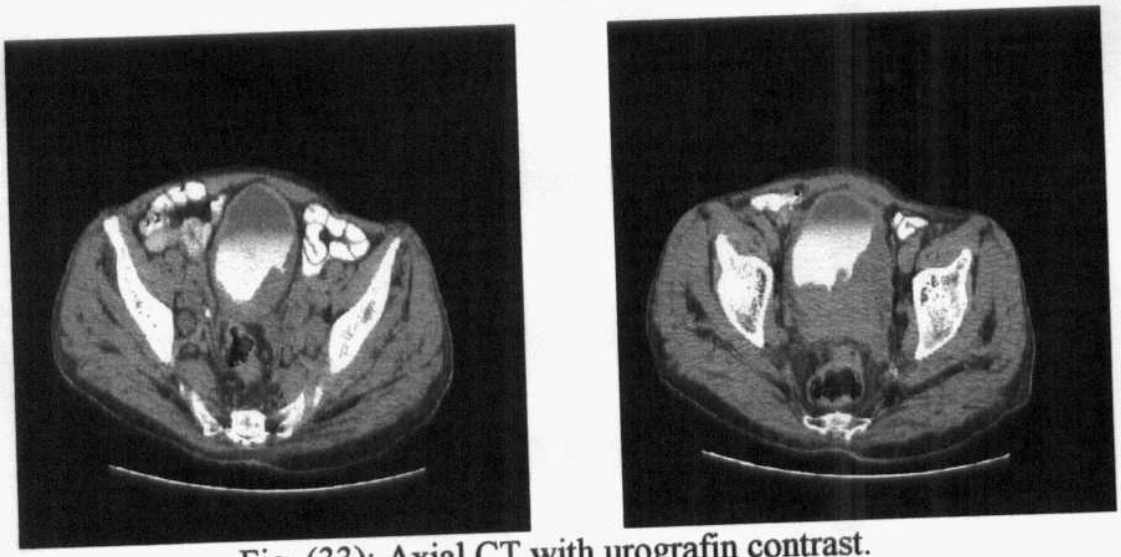

Fig. (33): Axial CT with urografin contrast.

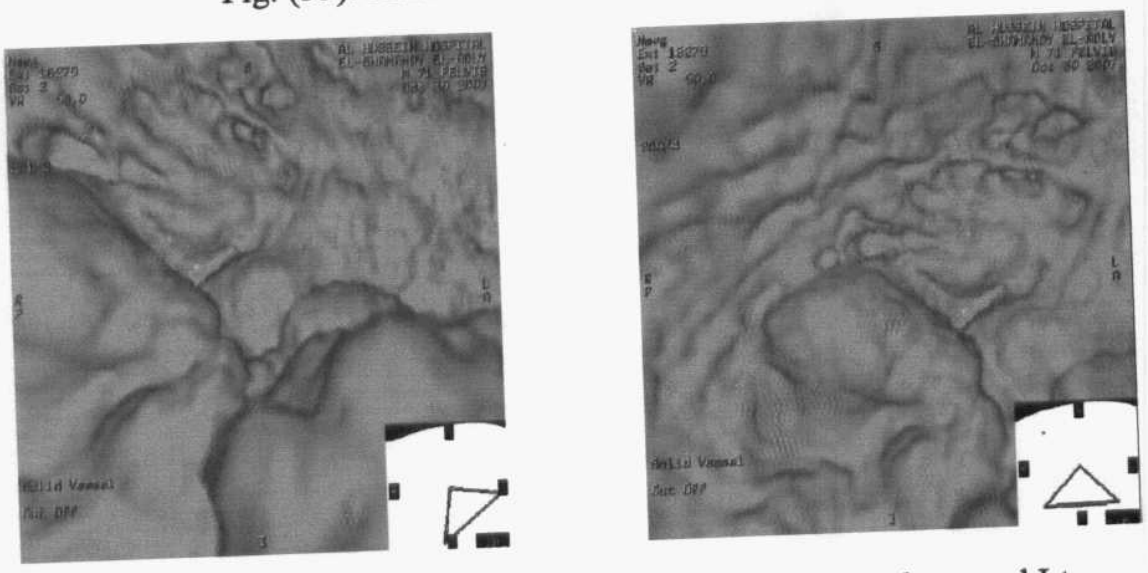

Fig. (34) Virtual Cystoscopy: large papillary masses of the base and Lt. lateral wall

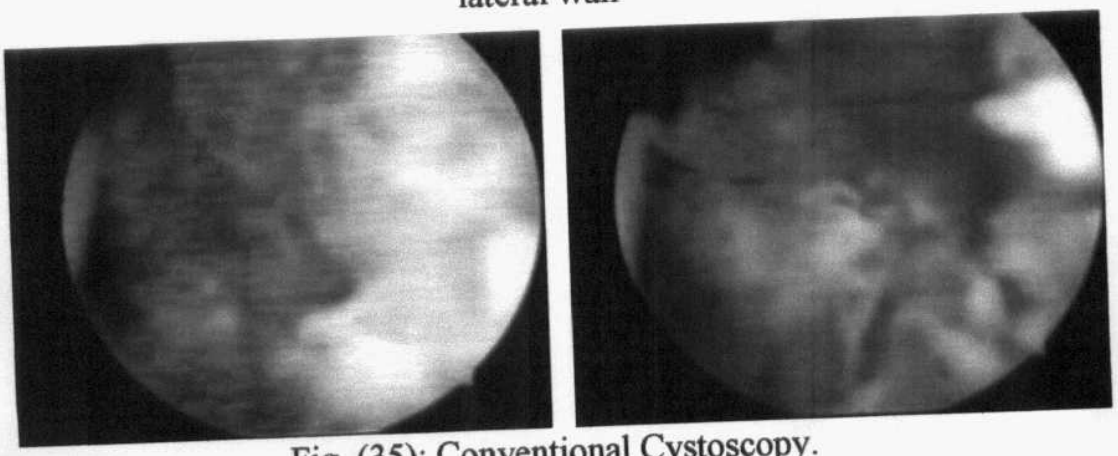

Fig. (35): Conventional Cystoscopy.

Case No. (6)

*** Clinical picture:** Male patient, 61 years old, presenting with hematuria , pyuria, necroturia and frequency (PR examination: Bulky mass felt).

*** Conventional Cystoscopy:** Revealed a large fungating tumor involving bladder base (clinical staging: T3).

*** Spiral CT study of the abdomen and pelvis:**

- The urinary bladder shows a large fungating mass at the bladder base with irregular circumferential thickening involving apparently whole bladder walls (average thickness = 1.2 cm / thickest region = 2 cm) no extravesical extension; No pelvic or abdominal lymphadenopathy; No pelvic or abdominal collections; No other organ involvement (CT staging: T3a No Mo).

*** Virtual Cystoscopy:** A large pedunculated fungating mass is seen involving mainly the base and extending to the neck.

*** Pathology:**

- **Gross pathology:** Radical cystectomy specimen showing a large fungating mass at the bladder base with mural thickening; No gross infiltration of perivesical fat.
- **Histopathology:** Invasive transitional cell carcinoma / grade2 / T3a No Mo

Case No. (6)

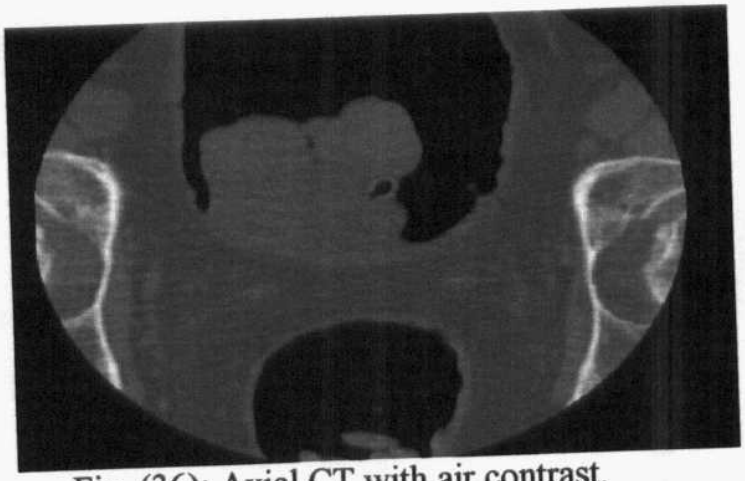

Fig. (36): Axial CT with air contrast.

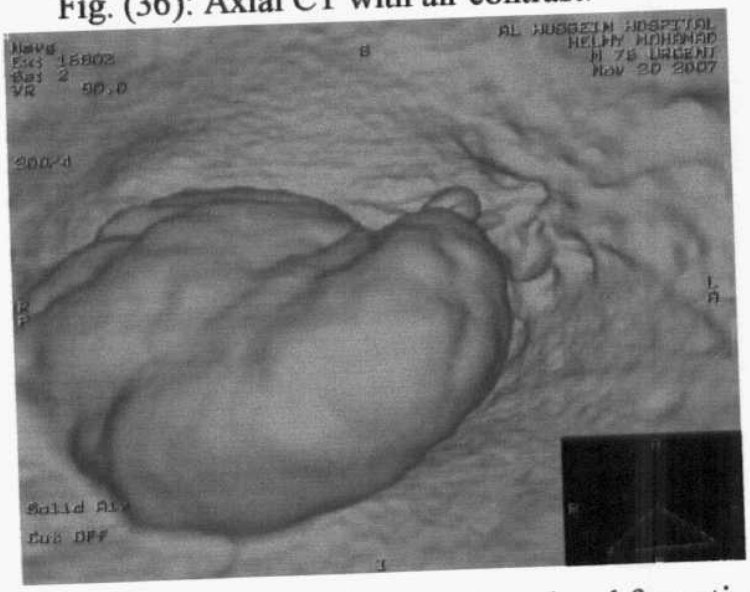

Fig. (37) Virtual Cystoscopy : A large pedunculated fungating mass is seen involving mainly the base and extending to the neck.

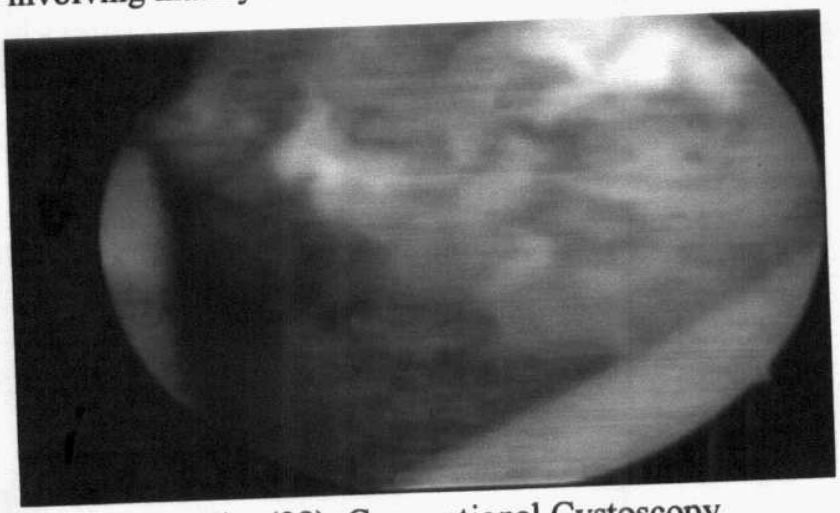

Fig. (38): Conventional Cystoscopy.

Case No. (7)

*** Clinical picture:** Male patient 65 years old, presenting with hematuria and pyuria (PR examination: Small mass felt at bladder base).

*** Conventional Cystoscopy:** Revealed a small papillary tumor arising from Lt. aspect of bladder base (clinical staging: T3).

*** Spiral CT study of abdomen and pelvis:**

- The urinary bladder shows a small papillary tumor arising from Lt. aspect of bladder base (measuring about 1.8 x 3.7 cm in its AP and transverse diameters respectively) / the base also showing irregular thickening /no extravesical infiltration of fat planes by the tumor is noted; No definite pelvic or abdominal lymphadenopathy; No pelvic or abdominal collections; No other organ involvement (CT staging: T2bNoMo).

*** Virtual Cystoscopy:** Revealed a small papillary mass projecting from the Lt. Aspect of the bladder base.

*** Pathology:**

- **Gross pathology**: Radical cystectomy specimen showing a small papillary tumor (2 x 4 cm in dimensions), at the junction of the bladder base with the Lt. Lateral wall; prostate and seminal vesicles are grossly free.
- **Histopathology:** Papillary transitional cell carcinoma / grade 2/T2bN1Mo.

Case No. (7)

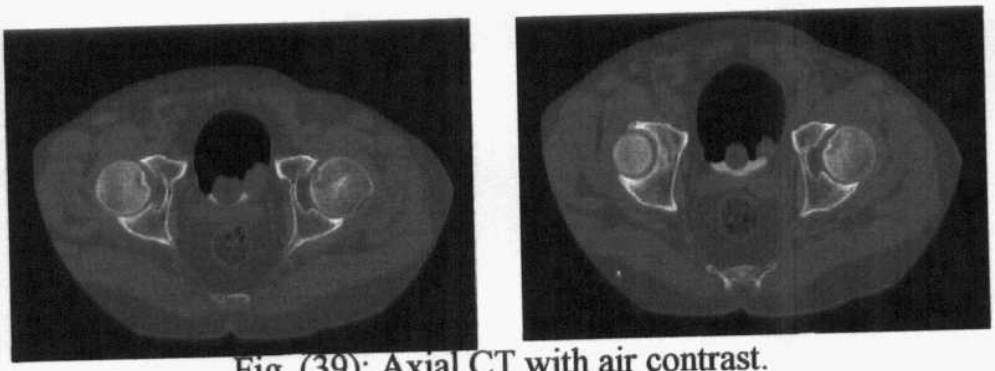

Fig. (39): Axial CT with air contrast.

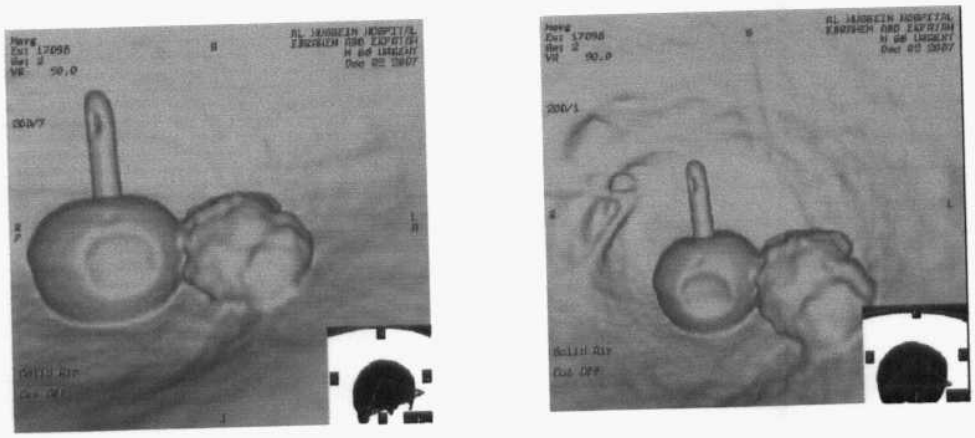

Fig. (40) Virtual Cystoscopy: Papillary mass projecting from the lt. Aspect of the bladder base.

Fig. (41) :Conventional Cystoscopy.

Case No. (8)

*** Clinical picture:** Female patient 65 years old, presenting with hematuria and pyuria (PR examination: No mass felt).

*** Conventional Cystoscopy:** Revealed a small papillary tumor arising from Rt. aspect of bladder base (clinical staging: T3).

*** Spiral CT study of abdomen and pelvis:**

- The urinary bladder shows a small papillary tumor arising from Rt. aspect of bladder base (measuring about 1.8 x 3.7 cm in its AP and transverse diameters respectively) / the base also showing irregular thickening /no extravesical infiltration of fat planes by the tumor is noted.
- No definite pelvic or abdominal lymphadenopathy.
- No pelvic or abdominal collections.
- No other organ involvement (CT staging: T2bNoMo).

*** Virtual Cystoscopy:** Revealed a small papillary mass projecting from the Rt. aspect of the bladder base near its neck.

*** Pathology:**

- **Gross pathology**: Radical cystectomy specimen showing a small papillary tumor (2 x2cm in dimensions), at the junction of the bladder base with the Rt. lateral wall.
- **Histopathology:** Papillary transitional cell carcinoma / grade 2/T2bN1Mo.

Case No. (8)

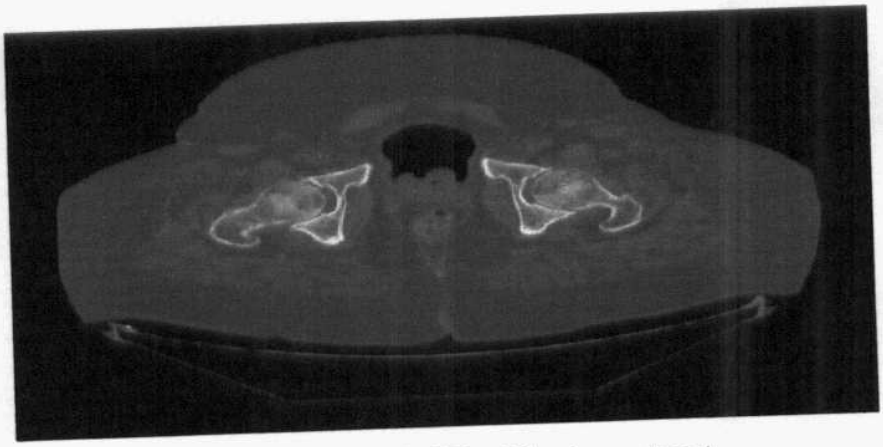

Fig. (42): Axial CT with air contrast.

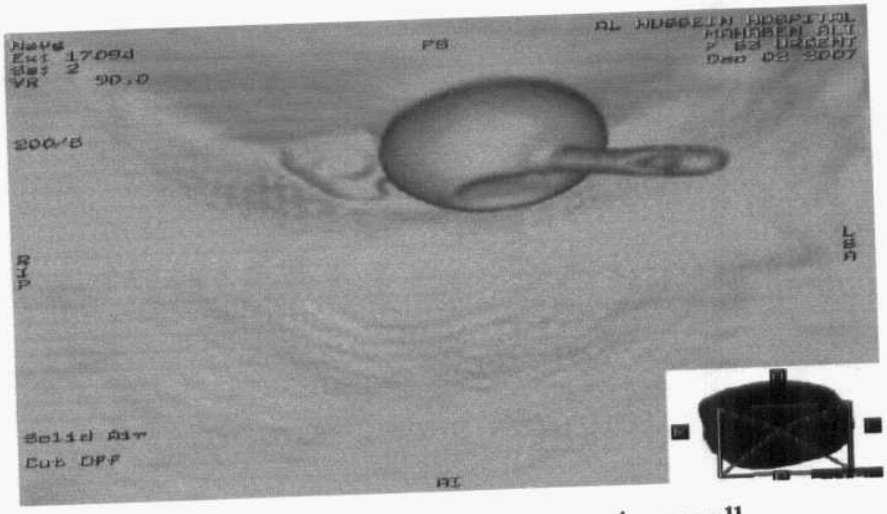

Fig. (43) Virtual Cystoscopy: A small papillary mass projecting from the Rt. aspect of the bladder base near bladder neck.

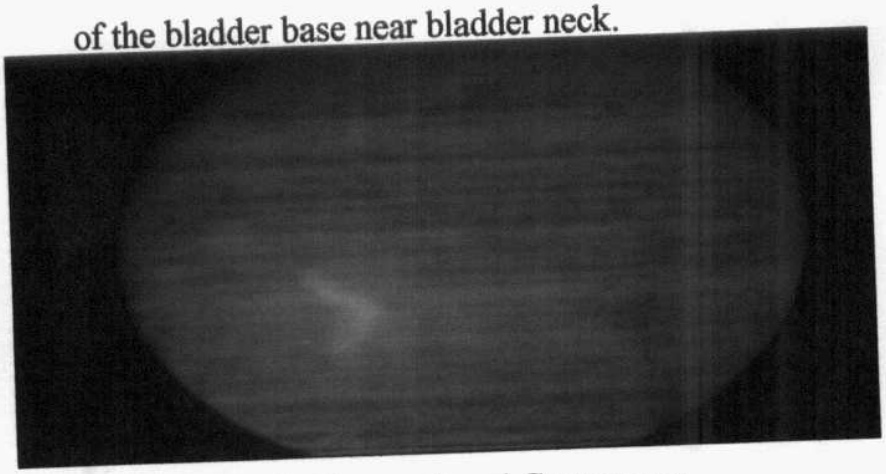

Fig. (44): Conventional Cystoscopy.

Case No. (9)

*** Clinical picture:** Male patient 67 years old, presenting with hematuria and dysuria (PR examination: No mass felt).

*** Conventional Cystoscopy:** Revealed a large papillary tumor arising from Rt. Lateral wall of bladder (clinical staging: T3).

*** Spiral CT study of abdomen and pelvis:**

- The urinary bladder shows a large sessile tumor arising from Rt. Lateral wall of bladder (measuring about 5.8 x 4.7 cm in its AP and transverse diameters respectively) / the base also showing irregular thickening /no extravesical infiltration of fat planes by the tumor is noted.
- No definite pelvic or abdominal lymphadenopathy.
- No pelvic or abdominal collections.
- No other organ involvement (CT staging: T2bNoMo).

*** Virtual Cystoscopy:** Revealed a large fungating papillary mass projecting from the Rt. lateral wall of the bladder.

*** Pathology:**

- **Gross pathology**: Radical cystectomy specimen showing a large papillary tumor (6x5cm in dimensions), at the Rt. lateral wall.
- **Histopathology:** Papillary transitional cell carcinoma / grade 2/T2bN1Mo.

Case No.(9)

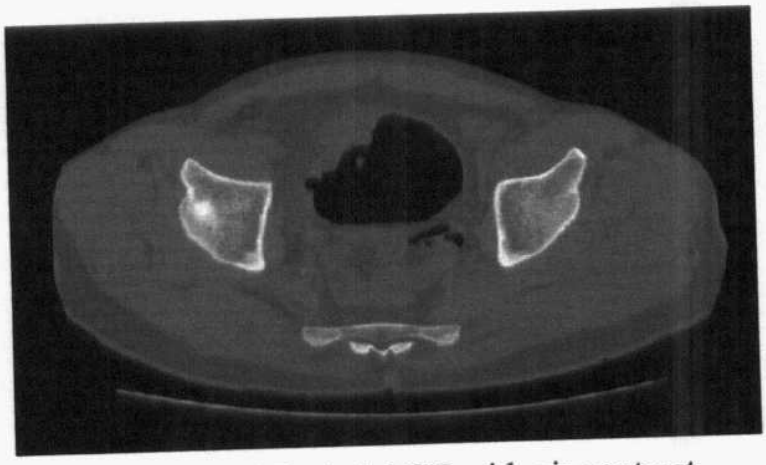

Fig. (45): Axial CT with air contrast.

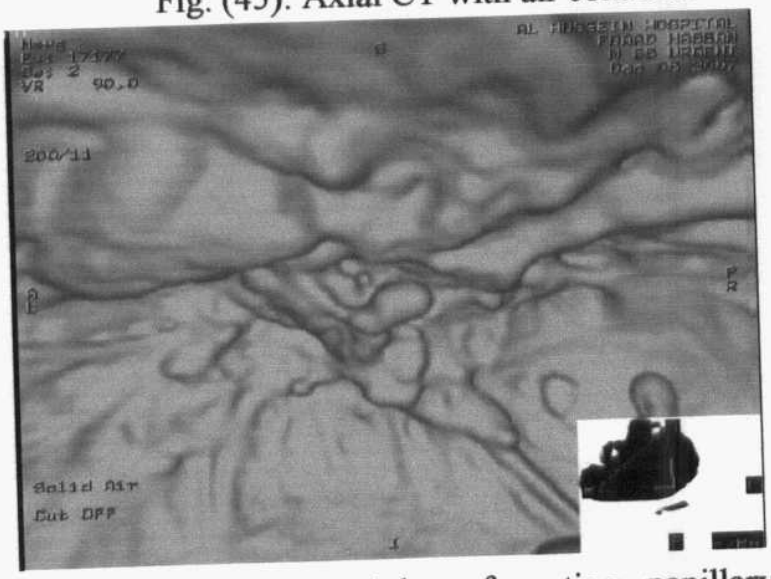

Fig. (46) Virtual Cystoscopy: A large fungating papillary mass projecting from the Rt. lateral wall of the bladder.

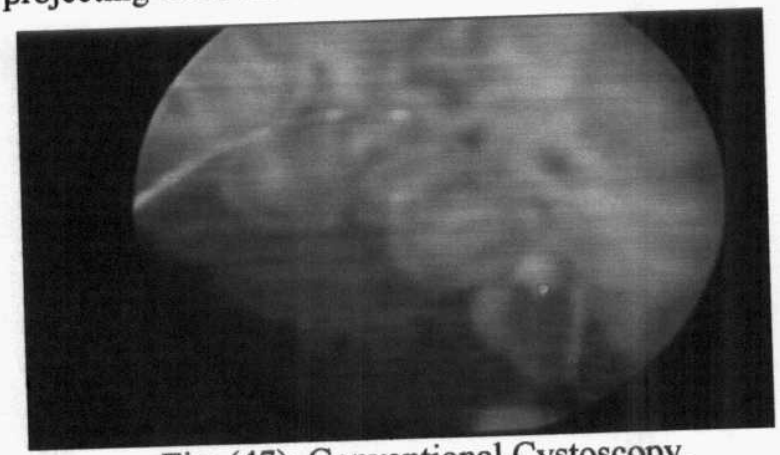

Fig. (47): Conventional Cystoscopy.

Among the different pathologically described bladder masses, whether tumor, proliferative, inflammatory masses or others, the most commonly encountered are bladder tumors and precisely the primary epithelial malignant tumors, which are carcinomas of the urinary bladder.

Carcinoma of the urinary bladder is the most common malignant tumor of the urinary tract, accounting for approximately 7% of all malignant tumors in men and about 4% in women **(Parker et al., 1996).**

In Egypt, the condition is more serious because of prevalence of bilharziasis. Bilharziasis is not only endemic in our country but also considered to be a historical disease **(El Bolkainy et al., 2001).**

About 90 % of all malignant epithelial tumors of the bladder are transitional cell carcinoma. Adenocarcinomas account for only 2% of bladder cancers, and squamous cell carcinoma accounts for 5-10% **(Teeger and Sica, 1996).** The later is predominant with schistosomal bladder cystitis **(El Bolkainy et al., 2001).**

The major factors influencing prognosis and management of bladder neoplasms are Depth of bladder wall invasion, grade of malignancy, tumor size, growth pattern, and presence or not of lymphatic and/or distant metastases **(Husband, 1995).**

The most important characteristics of the tumor, which influences its curability, are the depth of wall infiltration and the extent of metastases **(Putman et al., 1994).**

The correct evaluation and staging of the bladder tumors is essential in planning therapy, establishing prognosis and assessing the results of therapy **(Bullock et al., 1990).**

Radiologists and urologists alike have frequently studied and compared the accuracy of many clinical and radiological tools used for assessment of bladder masses. Various imaging methods including

ultrasonography, CT and MR imaging, have been introduced to improve the assessment of bladder lesions **(Kim et al., 1994).**

Yet no reliable radiological technique is available for use in bladder lesions detection **(Rubin et al., 1996).** Cystoscopy remains the mainstay for diagnosis, proper evaluation and follow-up of bladder lesions. Once the diagnosis of a bladder tumor has been established CT, MRI, and US are performed for staging **(Hayashi et al., 2000).**

Recent studies reported the feasibility of 3-D rendering of the bladder, which provides an image format familiar to the urologist **(Fenlon et al., 1997).**

The recent introduction of virtual endoscopy adds to the imaging armamentarium for use in bladder evaluation. The volumetric data obtained with helical CT (or MR) imaging are computer rendered to generate 3-Dimensional images and with commercially available software, intraluminal navigation through any hollow viscous is possible **(Calhoum et al., 1999).**

Ryan et al. (1999) stated that CTVE (CT Virtual Cystoscopy) could demonstrate normal anatomical structures and reproduce the views produced by standard conventional endoscopy.

Since the original article by **Vining et al. (1996),** there have been several studies of the utility of virtual endoscopy of the bladder. Although the reports published about virtual cystoscopy, the indications are still limited **(Narumi et al., 1996).**

As cystoscopy still plays the key-roll in the diagnosis of tumors of bladder, virtual cystoscopy may be the less invasive alternative in diagnostic work up **(Olcott et al., 1998).**

In our study, we tried to demonstrate that virtual cystoscopy is a feasible technique for use in the detection of bladder masses, and to compare between it and real cystoscopy.

Regarding patient's preparation for virtual CT cystoscopy examination:

Meticulous bladder preparation is necessary for an accurate interpretation. Beside the requirement to distend the bladder properly, it is important 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 **(Fleiter et al., 2000).**

There are 2 different principles for distending the bladder and increasing the intraluminal contrast: retrograde via a Foley's catheter with insufflations of air or CO_2 or contrast medium **(Vining et al., 1997/ Fenlon et al., 1997)**; or using the excretory function of the urinary system to fill the bladder with IV injected contrast material **(Merkle et al., 1998)**, according to the bladder capacity.

As the second method does not require placement of any tubes, it is the least invasive, and is the preferred one for daily routine work but it requires detailed preparation and sharp timing. Proper distention of the bladder should better be checked by ultrasound prior to scanning.

The trials using the urine-filled bladder for virtual endoscopy were unsuccessful, because the low contrast attenuation between the urine and the bladder walls resulted in noisy images that were unusable for diagnostic purposes.

From the technical point of view:

Virtual endoscopy is a post processing technique performed on a 3-D workstation, which allows the creation of endoluminal views because of high-resolution 3-D datasets.

Only datasets fulfilling three requirements can be used for virtual endoscopy:

* Only 3-D datasets can be used (continual image acquisition during one breath hold period).

* Spatial resolution should be very high and nearly equal in all three dimensions (to keep the voxel size very small).

* Contrast between the hollow organ lumen and the adjacent structures have to be very high for optimal segmentation of the surface of the examined organ.

There are several possibilities for acquiring such datasets; most commonly single or multislice helical CT scanners are used **(Heinz-Peer et al., 2003). Fletcher and Luboldt (2000)** pointed out that the higher resolution inherent to CT, results in a better quality of the endoluminal view.

Bernhardt et al. (2003) performed CT cystoscopy with the same scanning parameters as we did. However, several examination techniques have been reported in the literature for virtual cystoscopy.

Whatever the used protocol and parameters, an AP scout view of the pelvis is first obtained with the patient in supine position to plan for helical CT scan; this is followed by helical CT scanning of distended bladder **(Song et al., 2001).** Scanning should be performed during one breath hold to prevent breathing artifacts **(Fleiter et al., 2000).**

Certain authors (such as **Song et al., 2001/ Bernhardt and Rapp-Bernhardt, 2001/ Heinz-Peer et al., 2003)** claimed that, for proper evaluation of the bladder and detection of bladder lesions, scanning of the air-distended bladder in both supine and prone positions is preferred. Performing cystoscopy in prone and supine positions will shift retained fluids into other segments of the bladder as **Fletcher et al. (1999)** show in their study.

Moreover, the internal structure of the bladder is rather complicated due to the functional status and the filling. That is why repositioning is performed, since there is always despite of the drainage, a minimal amount of urine in the bladder. In addition, adequate distention with air has to be controlled after repositioning, since the repositioning maneuvers between supine and prone may lead to leakage of the insufflated air **(Bernhardt and Rapp- Bernhardt, 2001).**

Based on a 3-D dataset, several possibilities for post-processing are available:

* Multiplanar reformation **(MPR)**: Is the most simple and allows viewing of single scans in multiple planes (Coronal and Sagittal) others than axial scans **(Heinz-Peer et al., 2003).**

* Maximum intensity projection **(MIP)**: The entire volume is projected into one viewing plane with depiction of only the highest density value in the viewing direction .The limitation is that MIP offers just a 2-D character of the image **(Heinz-Peer et al., 2003).**

* Surface shaded display **(SSD)**: Computer processing in SSD involves manipulation of CT data by means of marching cubes algorithm to create a «wire frame» model the surface of which is filled in. Depending on the CT attenuation threshold, selected tissues of different densities can be either included or removed. The net effect is the display of a tissue interface that simulates a flat opaque anatomic specimen. Light and shade from a simulated light source are used to achieve a 3-D perspective.

Although SSD allows a rapid 3-D reconstruction and is less demanding computationally than volume rendering, SSD uses only 10% of the available helical CT data and compared with volume- rendered images, lacks depth and details **(Heinz-Peer et al., 2003).**

* Volume rendering **(VR)**: VR images are "data rich" they use 100% of the available CT data for 3-D reconstruction and have a "fluoroscopic"

appearance rather than the flat opaque appearance of images created with SSD. In addition to showing greater anatomic details, volume rendered images contain, fewer smoothing and blurring artifacts. A sense of depth, distance, and motion is also achieved by using perspective algorithm (perspective volume rendering). This algorithm is a computer graphics technique that causes the object to grow larger as the observer approaches. When combined with real time viewing (5-30 frames/second), use of this technique conveys the effect of travelling through the bladder lumen in-vivo. Volume rendering algorithms generate a tissue volume by assigning varying degrees of opacity based on CT attenuation coefficient of each voxel **(Heinz-Peer et al., 2003).**

The changeable perspective of the virtual camera can be used to generate "fish eye" perspectives of the bladder lumen and this improves orientation compared to conventional cystoscopy **(Fleiter et al., 2000).**

In addition **Schreyer et al. (2000)** developed an algorithm for color mapping the thickness of the bladder wall, and by using a color range, even subtle thickness changes appeared very clearly.

However although volume rendered images provide more information than surface rendering since the entire datasets are used this technique requires more powerful computers, which would increase the cost of virtual endoscopy **(Rapp-Bernhardt et al., 2000).**

On the other hand technical advances regarding 3-D workstations have led to a considerable reduction of the post-processing time required for production of virtual endoscopy views, including interactive intraluminal navigation through the bladder. Variation of postprocessing times ranging from 7 to 8 hours, and 12 to 15 min, has been reported in literature and is dependant on the available 3-D hard and software. Today postprocessing can be performed in few minutes after transfer of the 3-D

datasets to the workstation **(Hussain et al., 1997/Heinz-Peer et al., 2003).**

Concerning the diagnostic potential of Virtual cystoscopy in detection and characterization of bladder masses:

Results of most of the carried out studies indicated that virtual cystoscopy allows the accurate assessment of localization and morphology of bladder masses **(Heinz-Peer et al., 2003).**

In our study, the obtained results for the forty two patient, demonstrated excellent sensitivity and specificity scores (up to 100%) of VE, **in localization and morphology** description of bladder tumors; the results were comparable to those of real conventional cystoscopy, and superior to those of spiral CT of the bladder.

Concerning wall thickening, as we mentioned before Schreyer et al.(2000) and Fielding et al. (2002) developed an algorithm for color mapping the thickness of the bladder wall (source images were transformed into 3-D models , and the thickness of the bladder wall was demarcated by using a computer algorithm and a fixed color scale).

In our study the majority of cases showed irregular wall thickening of the bladder, The VE was always able to depict those areas of wall thickening in the bladder (with a sensitivity and specificity of 100%).

Concerning the size (depth) of the mass, many different studies reported different results. **Narumi et al. (1996)**, found detection and characterization of masses less than 10 mm to be difficult with 3-D display of helical CT data, while **Fenlon et al.(1997)** reported that all of bladder masses detected at conventional cystoscopy were visualized at CT cystoscopy, and pointed out in their study that all tumors less than 10 mm were identified, although this group did not report how many of their masses were less than 5 mm. In their study, **Song et al. (2001)**

demonstrated that virtual cystoscopy is a feasible technique for use in detection of bladder masses greater than 5 mm, but for lesions less than or equal to 5 mm, the detection rate was 60%.

Our study demonstrated a sensitivity of 100% in detection of bladder masses including those smaller than 10 mm and greater than 5mm by VE in all cases, (while spiral CT was sometimes defective in depiction of masses ranging from 5-10 mm in size) . Actually, sensitivity of VE to masses smaller than 5 mm could not be evaluated since no such small lesions were encountered in the studied cases.

However, the majority of the authors concluded that reliable and consistent visualization of lesions less than 5 mm was problematic **(Narumi et al., 1996 / Fenlon et al., 1997 / Merkle et al., 1998 / Song et al., 2001).**

Many studies have been introduced that change these findings. **Kim et al., (2002)** demonstrated excellent agreement between virtual cystoscopy and conventional cystoscopy with high sensitivity and specificity, and the detection rate for lesions smaller than 5mm was 88% in their study.

On the other hand, virtual cystoscopy at different mAs settings has been compared to conventional cystoscopy in patients with tumors of the bladder; for the protocol with reduced radiation exposure, the authors reported a sensitivity and specificity of 96.5% and 100% respectively, for tumor detection; preliminary results of these studies show excellent detection rates, including for lesions less than 5 mm **(Bernhardt et al., 2003 / Mang et al., 2003).**

To compare between air contrast and urografin contrast virtual CT cystoscopy, we examined in our study 30 cases using air contrast to distend the bladder, and 12 cases using urografin contrast agent to distend the bladder.

The results obtained for cases with urografin contrast were adequately similar to those obtained for cases with air contrast; VE of the bladder, whether distended with air or with urografin contrast was comparable to real cystoscopy in detection, localization and morphology description of bladder masses.

Many authors beginning with **Vining et al. (1997)** as well as **Song et al. (2001), Bernhardt et al. (2003)** and others carried out virtual CT cystoscopy using air contrast. They all reported adequate sensitivity of tumor detection (up to 100% for masses greater than 10 mm / 92 % for masses less than 10 mm as described by (**Song et al.2001)**, as well as localization and morphology description.

Many others, performed virtual CT cystoscopy using contrast media to distend bladder, such as **Vining et al. (1997), Fenlon et al. (1997), Merkle et al. (1998) and Kim et al. (2002),** that demonstrated also adequate sensitivity for identification of bladder lesions (up to 95% in **Kim et al. (2002)** study, with a detection rate of 88% for lesions smaller than 5mm), as well as localization and morphology description.

Globally a high accuracy of both, scanning the contrast material filled bladder, and gas-distended bladder, has been reported **(Heinz-Peer et al., 2003).**

However, using the air insufflations technique, imaging in both prone and supine position is recommended for visualization of the entire mucosa **(Heinz-Peer et al., 2003).**

On the other hand, the technique with contrast media filled bladder has the advantage of being completely noninvasive and hence much more

acceptable to the patient (not requiring catheterization or air insufflations).

The only disadvantage of the use of urografin as contrast material was the presence of fine faint artifacts within the obtained virtual images .Therefore the images obtained with air distended bladder were a bit clearer and sharper than those with urografin distended bladder.

Finally, in addition to bladder masses detection, we were able to obtain adequate virtual imaging for the internal trabeculated anatomy of the bladder, in our study, through performing virtual cystoscopy (with air contrast) for two volunteers with completely healthy bladder. Excellent evaluation of trabeculary bladder was also reported by (**Heinz-Peer et al. 2003**). In fact (**Stenzl et al. 1998**) **and** (**Frank et al. 1998**) described the usefulness of virtual cystoscopy in visualization and interpretation of any intra-luminal changes as pouchocele , diverticulosis, voiding problems, and in understanding of the post operative evolution of orthotropic intestinal bladder substitution.

However many drawbacks of VE were met during the study, that were already described by the authors.

Still virtual cystoscopy is unable to depict mucosal color changes (such as leucoplakia) detected only on conventional cystoscopy, as reported also by **Song et al. (2001) and Heinz-Peer et al. (2003).**

In addition, the calcifications associated with masses were seen only on the axial images but not on the virtual images due to the threshold selection optimized to depict soft tissue abnormalities as reported also by **Song et al. (2001).**

Another important fact is that virtual cystoscopy cannot make sure of the nature, or the origin of the mass. **Song et al. (2001)** reported that

extravesical pseudolesions that simulated intraluminal masses on virtual views, were then correctly identified as a phlebolith and an enlarged median lobe of the prostate gland on the axial images; and **Heinz-Peer et al. (2003)**, reported that mucosal thickening secondary to fibrosis cannot be distinguished from neoplasm.

Therefore, although **Song et al. (2001)** and others reported that the sensitivity of virtual cystoscopy is higher than that of axial images due to the different way of image presentation, the authors agreed that transverse axial together with virtual images are complementary for lesion detection and characterization, and to obtain optimum results **(Heinz-Peer et al., 2003).**

Regarding the results of T-and pelvic nodal staging:

Spiral CT gave an adequate sensitivity (80.95%) for T-staging and an acceptable accuracy (62%) for pelvic N-staging, in bladder neoplasms.

It is known that the T-stage is the most important factor influencing management and prognosis of bladder tumors; However virtual cystoscopy fails to assess bladder wall invasion, while conventional cystoscopy is properly able to estimate wall infiltration by the tumor (**Song et al., 2001).**

However, when interpreted together, in a complementary way, virtual cystoscopy with axial CT images become comparable to conventional cystoscopy in tumor detection and evaluation of bladder wall invasion.

In addition, CT is adequately able to evaluate extravesical tumor extension and presence or not of regional pelvic lymphodenopathies, an advantage that conventional and virtual cystoscopies lack.

Generally speaking, as one of the most important innovations in the spectrum of the postprocessing diagnostic techniques, virtual CT cystoscopy provides many advantages:

* Noninvasive, or minimally invasive technique, with minimum discomfort and risks for the patients, especially that there is no requirements for anesthesia **(Song et al., 2001).**

* Much less time consuming **(Heinz-Peer et al., 2003).**

* Virtual CT cystoscopy improves the value of axial CT images and allows utilization of the largest amount of CT data **(Song et al., 2001).**

* Ability of imaging of the bladder in multiple planes and intraluminal viewing of the bladder from any angle (the 360° view.

* It lacks ability to identify origin and nature of bladder masses **(Heinz-Peer et al., 2003).**

* In addition, the exposure to X-ray and the possibility of hypersensitivity reactions to contrast media should not be neglected **(Song et al., 2001).**

* The cost: Virtual endoscopy requires specialized software and hardware that are expensive **(Rodenwaldt et at., 1997).**

On the other hand, there are also some limitations of conventional cystoscopy:

* It is an invasive technique, uncomfortable to the patient, and time consuming **(Heinz-Peer et al., 2003).**

* It is sometimes difficult to be performed or restricted: In case of bacteriuria, acute cystitis, urethritis, prostatitis, obstructive prostatic hypertrophy, stricture or rupture of the urethra **(Heinz-Peer et al.,2003).**

* It may cause many complications such as: Severe pain, infection, iatrogenic injury, hemorrhage and perforation of the bladder or urethra, in addition to risks of anesthesia **(Heinz-Peer et al., 2003).**

* It may also be limited by diminished visualization of some areas, such as mucosa within diverticula **(Heinz-Peer et al., 2003).**

* In addition conventional cystoscopy proves to be technically very difficult in patients with neobladder reconstruction **(Heinz-Peer et al., 2003).**

However, in hands of an experienced urologist, the rate of complications with conventional cystoscopy is very low and serious complications have rarely been reported **(Curley et al., 1995).**

Regarding the previously described factors, and although the clinical utility of CT virtual cystoscopy has not been yet established, it may have several potential roles.

The authors propose that virtual cystoscopy may be an alternative to conventional cystoscopy in selected cases: It could be useful when conventional cystoscopy is difficult to perform, or contra-indicated as previously described, and in patients who are at risk of the described complications, or in young patients (pediatric age group).

In addition, it has a good accuracy in the depiction of the topographic anatomy of transposed structures, so it could be useful in patients with neobladder reconstructions.

The modality may also be used at the patient's request **(Heinz-Peer et al., 2003).**

Finally, Virtual cystoscopy should always be interpreted with the complementary axial CT images for the optimum and maximum possible results.

Recent advances in computed tomography (CT) hardware and software have led to the development of various forms of virtual reality imaging techniques.

Since **Vining et al.(1996)** first described the method, virtual endoscopy of the urogenital tract has enormously improved; contributing to this progress is the advent of multislice CT (MSCT). Recently commercially available highly advanced 3-D workstations have been introduced.

Many investigators have evaluated the usefulness of virtual cystoscopy for detecting bladder lesions.

At present virtual cystoscopy based on volumetric data obtained with thin section multislice CT and the use of perspective volume rendering technique, seems to be the most accurate method regarding lesion detection in the urinary bladder.

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

Forty six patients clinically diagnosed as bladder cancer patients were examined in the Radiology department of Al Hussein University Hospital, between May / 2007 and December / 2007 . They were all subjected to spiral CT of the bladder and virtual CT cystoscopy study: virtual images were reconstructed from cross sectional CT images sent to a separate workstation using a special software. Then comparison study between CT images, virtual and real conventional cystoscopy, and pathological results were carried out.

An excellent overview of the bladder masses was obtained in all the cases and the results of virtual cystoscopy and conventional cystoscopy were comparable with excellent sensitivity rates of VC in

detection, localization and morphology description of the bladder masses (greater in size than 5mm).

Our results corresponded to a great extent to those reported by many authors such as **Vining et al. (1996), Fenlon et al. (1997), Song et al. (2001), Bernhardt and Rapp-Bernhardt (2001),** and many others that stated that virtual CT cystoscopy is a useful technique in detection and localization of bladder masses greater than 5 mm, with high sensitivity, specificity and accuracy rates.

But recently high sensitivity rates for detection of bladder lesions less than 5 mm by VC, have been reported by many authors such as **Kim et al. (2002), Mang et al. (2003), and Heinz-Peer et al. (2003).** Unfortunately, in our study all the encountered masses were greater than 5 mm in size, therefore assessment of sensitivity of virtual CT cystoscopy for such small lesions was practically impossible.

In addition the results for virtual CT cystoscopy with air contrast and those for virtual CT cystoscopy with urografin contrast, were also comparable, and both methods reported adequate sensitivity and accuracy for bladder masses detection in our study. This coincides also with what was described by the authors who reported excellent results for both methods.

Generally speaking virtual cystoscopy has several advantages over conventional cystoscopy (specially after the technical advances of 3-D workstations that reduced markedly the postprocessing time): It is much less invasive, much less time consuming, requiring less equipment, with fewer patient preparation steps, allowing intraluminal viewing of the bladder from any angle ("fish eye" perspective of the bladder lumen) and bypassing any obstruction if present. On the other hand, it allows access to some areas which may be sometimes inaccessible by conventional cystoscopy (within bladder diverticulosis for example).

However, adequate preparation of the bladder is necessary for CT virtual cystoscopy performance: Beside the requirement of proper bladder distension, there must be an adequate difference between bladder wall and lumen by distending the bladder with air or contrast medium.

In addition, in case of bladder insufflations with air, scanning of the bladder in both supine and prone positions is preferred for optimal evaluation. Complementary analysis of both transverse and virtual CT images is always necessary for proper diagnosis.

CT virtual cystoscopy has still some limitations, in addition to the exposure to radiations and risk of allergic reactions to contrast media, the cost of such specialized workstations is an important limiting factor. On the other hand, it is unable to depict flat lesions or mucosal color changes; it also lacks the ability to provide tissue for histopathology; it is unable to identify the origin and nature of the bladder masses; it cannot evaluate deep space invasion in case of neoplasm, thus it is alone impractical in T-staging of bladder cancer. Therefore the complementary interpretation of VC and axial CT informations is essential, allowing us to obtain adequate results comparable, and even sometimes superior, to those of conventional cystoscopy.

Despite the great improvement recently in the virtual CT cystoscopy techniques, it cannot yet supplement real conventional cystoscopy that remains the basis for diagnosis and follow up of bladder lesions.

So far, virtual cystoscopy may be an alternative or a complementary examination, when conventional cystoscopy is difficult to perform or contraindicated in patients with cystitis, uretheritis, obstructive prostatic hypertrophy, stricture or rupture urethra, and for those who are at risk of complications (such as injury, perforation of the bladder or urethra, hemorrhage, and risks of anaesthesia).

It may serve as a follow up examination between conventional cystoscopies in bladder cancer patients who are under treatment.

As a minimally invasive procedure it is easily acceptable and could be performed on the patient's request, or if he refuses to undergo the classical conventional cystoscopy.

References

- **Althausen A.F., Prout G.R.Jr.and Daly J.J.** Noninvasive papillary carcinoma of the bladder associated with carcinoma in situ.J.Urol.116:575;1976.
- **American College of Radiology appropriateness criteria,** Urologic Imaging Radiologic investigation of patients with haematuria. Available at www.acr.org.Accessed December 1999.
- **Anderson J.E.:** The Urinary Bladder, in Williams Wilkins (eds), Grant's Atlas of Anatomy (8^{th} ed.); 3: 184-190. Waverly press, Baltimore, Maryand; 1983.
- **Anderstrome C., Johnson S. and Nilsscns S:**The significance of lamina propria invasion on on the prognosis of patients with bladder tumours.J.Urol.124:23;1989.
- **Babaian R.J., Johnson D.E., Liamas L. :** Metastases from Transitional Cell Carcinoma of Urinary Bladder . Urology ; 26 : 142-150;1990.
- **Bard R.H.:** The significance of a symptomatic microhaematuria in women and its economic implications: A ten –year study. Arch Intern Med.148:2629;1988.
- **Benson R.C.Jr., Sawnson S.K.and Farrow G.M.:** Relationship of leukoplakia to urothelial malignancy.J.Urol.131-507;1984.
- **Bernhardt T.M. and Rapp-Bernhardt U. :** virtual Cystoscopy of the bladder based on CT and MRI data . Abdom Imaging ; 26 : 325-332 ; 2001 .
- **Bernhardt T.M., Krause U.W. , Philipp C. :** Virtual cystoscopy with reduced tube current : an alternative to cystoscopy ? fortschr Rontgenstr ; 175 : 1106-1111 ; 2003 .

- **Bernstein J., Blandy J.P., Churg J., Epstein J.I., Ferluga D. :** Tumors of the Urinary Bladder and Miscellaneous Conditions , in Bernstein J and Churg J (eds), Urinary Tract Pathology ; 12: 141-152 , 21 :225 . Raven Press, NY ; 1992 .
- **Blinn J.F. :** Models of light reflection for computer Synthesized Pictures . SIGGRAPH ; 77 : 192-198 ; 1977 .
- **Bosoma M.K., Smith J. and Lobregt S. :** Iso-Surface Volume Rendering . Proceedings of SPIE Medical Imaging ; 3335 : 10-19 ; 1998 .
- **Bullock N.E. , Sibley G. and Whitaker R. :** Urothlial tumors . Essential Urology ; 16 : 214-226 ; 1990 .
- **Calhoum P.S. , Kuszyk B.S., Heath D.G., Carley J..C, Fishman E.K.:** Three-Dimensional volume rendering of spiral CT data : Theory and method RadioGraphics ; 19 : 745-764 ; 1999 .
- **Cheon J., Kim H., Yoon D.K. and Koh S.K.:** Malignant Inverted Papilloma of the bladde: The histopathological aspect of malignant potential of inverted papilloma.J.Korean Med. Sci. 10:103;1995.
- **Clark R.L. :** Bladder Cancer , in Putmann CE and Ravin CE (eds), Textbook of Diagnostic Imaging; 1244-1245. Saunders Company Ltd., Philadelphia , Montreal , Sydney , Tokyo ; 1994 .
- **Cotran R.S., Kumar V. and Collins T. : Lower urinary tract.** In: Robbin`s pathologic basis of disease sixth ed, deit by W.B.Saunders company, Philadelphia, London 22:997-1010;1999.
- **Cummings K.B.:** Diagnosis and staging of bladder cancer. Urol.Clin,North Am. Vol 19;3:455-456;1992.
- **Curley P. , Ralph D. , Scott D.J.A. :** Critical Limb Ischemia–a complicatin of cystoscopy . Br J Urol; 76 : 515 ; 1995 .

- **DeMeester L.J., Farrow G.M., and Utz D.C.:** Inverted papilloma of the urinary bladder. Cancer 36:505;1975.
- **Drollar M.J.:** Clinical presentation, investigation, and staging of bladder cancer. IN :Principles and Practice of Genitourinary Oncology. Edited by Raghavan D., Scher H.I. and lippincott-Raven publishers, Plliladelphia 23:249-259;1997.
- **El-Bolkainy M.N. , Ghoneim M. and Mochtar N.M. :** Pathology of Bladder Cancer associated with Shistosomiasis . Medical J.; 49 : 361-374 . Cairo Univ. ; 2001 .
- **El-Bolkainy M.N.:** The pathology of cancer of the Bilharzial Bladder, in El Sebai I and Hoogstraten B(eds.), Bladder Cancer General Review ; 1:83-120.Library of Congress Card, Florida;1983.
- **El-Bolkainy M.N.:** Topographic pathology of cancer. NCI J.,Cairo;1998.
- **Elsebai I.T.:** Carcinoma of urinary bladder in Egypt: Current Clinical Experience. In: Detection of Bladder Cancer Associated with Schistosomiasis edit by El-Bolkainy M,N. and CHU E.W. ELAHRAM Press.2:10-28;1981.
- **El Sebai I and Ibrahim AS :** Epidemiology of Bladder Cancer , in El Sebai I and Hoogstraten B (eds), Bladder Cancer General Review ; 1: 18-25 . Library of Congress Card, Florida ; 1983 .
- **Farrow G.M., Utz D.C and Rife C.C. :**Morphological and clinical observations of patients with early bladder cancer treated with total cystectomy.Cancer Res.36:2495;1976.
- **Fenlon H.M. , Bell T.V. , Ahari H.K. , Hussain S. :** Virtual Cystoscopy , early clinical experience . Radiology ; 205 : 272-275 ; 1997 .

- **Fettouh I.A.** :Bladder cancer in Egypt: changing cell type.J.Urol.151:474A;1994
- **Fielding J.R., Hoyte L., Okon S.A. :** Tumor detection by virtual cystoscopy with color mapping of bladder wall thickness . J Urol ; 167 : 559-562 ;2002 .
- **Flamm J. and Donna S.:**The significance of bladder quadrant biopsies in patient with primary superficial bladder cancer.Eur. Urol. 61:81;1989
- **Fleiter T.R., Merkle E.M., Aschoff A.J. :** Comparison of real time virtual and fiberoptic bronchoscopy in patients with brochial carcinoma : Opportunities and limitations . Am J Roentgenol ; 169 : 1591-1595 ; 1997 .
- **Fleiter T.R. , Merkle E.M. , Wisianowsky C. :** Virtual Cystoscopy , in Ragolla P , Sheltinga JT , Hamm B (eds) , Virtual Endoscopy and Related 3D Techniques . Springer-verlag, Berlin, NY ; 8 : 159-163 ; 2000 .
- **Fletcher J.G., Johnson C.D., MacCarty R.L., Welch T.J., Reed J.E., Hara A.K. :** CT Colonography :potential pitfalls and problem-solving techniques. Am J Roentgenol ; 172 : 1271-1278; 1999.
- **Fletcher J.G. and Luboldt W. :** CT colonography and MR colonograohy : current status , research directions and comparison . Eur Radiol ; 10 : 786-801 ; 2000 .
- **Foley J.O., Van Dam A., Feiner S.K. :** computer Graphics : principles and practice (2^{nd} ed) . Addison-wesley Publishing company Reading ; 2000 .
- **Fossa S.D.,Ous S. and Berner A.:** Clinical significanse of the "palpable mass" in patients with muscle infilterating bladder canaer

undergoing cystectomy after preoperative radiotherapy. Br J Urol. 67:54; 2003.

- **Frank R., Stenzl A., Frede T.H. :** Three-Dimensional computed tomography of the reconstructed lower urinary tract : Technique and finding . Eur Radiol ; 8: 657-663 ; 1998.
- **Freeman J.A., Esrig D.E., Stein J.P.** Radical cystectomy for high risk patients with superficial bladder cancer in the era of orthotopic urinary reconstruction. Cancer 76:833; 1995.
- **Gamarra M.C. and Zein T.** :Cytologic spectrum of bladder cancer. Urology 23:23; 2000.
- **Gordon D. and Reynolds R.A.:** Image space shading of 3-dimensional objects . computer vision graphics image processing ; 29:361-376; 2003.
- **Gordon N.S., Sinclair R.A. and Snow R.M. :** Pelvic lipomatosis with cystitis cystica , cystitis glandularis and adenocarcinoma of the bladder. J. Urology ; 60:229-236;1990 .
- **Gospodarowicz M.K., Reder W.D., Keen C.W.** Bladder cancer: long-term follow up results of patients treated with radical radiation. Clin Oncol. 3:155; 2001.
- **Gray H. :** The Urogenital Apparatus : Anatomy of the Urinary Bladder , in Warren HL(ed), Anatomy of the Human Body (20^{th} ed) ; 956-974. Bartleby Comp, NY ; 2000.
- **Gualdi G.F., Casciani E.,Rojas M., Polettini E. :**Virtual cystoscopy of bladder neoplasms:prelimnary experience.Radiol Med;97:506-509.Torino;1999.
- **Hayashi N., Tochigi H., Shiriashi T., Takeda K., Kawamura J.:** A new staging criterion for bladder carcinoma using gadolinium enhanced MRI with an endorectal surface coil :A comparison with

ultrasonography.Br J Urol;85:32-36:2000.

- **Heinz-Peer G., Mang T., Happel B., Latzke D. :** Virtual cystoscopy in detection of bladder lesions.Medical Imaging International; 6-9;2003.
- **Hopper K.D., Iyriboz A.T., Wise S.W., Newman J.O., Mauger D.I., Kasales C.J. :** Mucosal details at CT virtual reality:surface versus volume rendering.Radiology;214:517-522;2000.
- **Husband J.E., Olliff J.F.C., Williams M.P. :** Bladder cancer: staging with CT and MR imaging. Radiol. 173:435-440;2002.
- **Husband J.E. :**Staging bladder cancer. Clinical radiology;46:153-159;1992.
- **Husband J.E. :**Staging urinary bladder cancer. Clinical radiology;46:153-159;1995.
- **Husband J.E.:**Bladder Cancer Radiologic Investigation, in Raghavan D, Scher HI, Leibel SA and Lavge P(eds.), principles and practices of Genitourinary Oncology;261-268.Lippincott-Raven, Philadelphia,NY;1997.
- **Husband J.E. :** Bladder cancer.In:Imaging in Oncology. Edited by Husband J.E.S. and Reznek R.H. ISIS Medical Media, Oxford 14:215-238;1998.
- **Jung I., Messing E.M. and Frader Y.:** Diagnosis of bladder cancer .From: Current Clinical Urology:Current Diagnosis and Treatment Edited by:M.J. Droller Humana press Inc., Totowa, NJ 3:57-83;2001.
- **Kim B., Semelka R.C., Ascher S.M. :** Bladder tumor staging. Comparison of contrast enhanced CT, T1 and T2-weighted, dynamic gadolinium enhanced imaging. Radiology ;193.239-245;2003.

- **Klan R., Loy V. and Huland H. :** Residual tumor discovered in routine second transuretheral resection in patients with stage T1 transitional cell carcinoma of the bladder. J Urol, 146:316;2001.
- **Koshikawa L., Leyh H. and Scitenck U. :** Difficulties in evaluating urinary specimens after local mytomycin therapy of bladder cancer. Diagn. Cytopathol. 5:117;2002.
- **Koss L.G., Esperanza M.T. and Robbins M.A. :** Mapping cancerous and precancerous bladder changes:A study of the urothelium in ten surgically removed bladders.JAMA.227:281;1974.
- **Koss L.G. :** Tumors of the urinary bladder,in Harlan I and Firminger MD (eds.) Atlas of Tumour Pathology (fascicle 11).Washington,DC: Armed Forces Institute of Pathology,American Cancer Society,National Cancer Institute, National Institute of Health,U.S Public Health Service;1983.
- **Kraus W., Shild H.H. and Alken P. :** Urinary Bladder Computed Tomography .Urology; 226 -247.George Thieme Verlag, Stuttgart , NY ; 1992 .
- **Krueger W.A., and Bo W.J. :** Urinary Bladder, in Martin, Resnick and Roger (eds), Anatomical concepts of urogenital system : Gross and cross-sectional anatomy ; 1999
- **Ladetsky L., Mitty H. and Parsons R.B.:** Diagnostic Imaging of Urothelial Cancer .From: Current Clinical Urology: Current Diagnosis and Treatment Edited by: M.J. Droller Humana press Inc., Totowa, NJ 4:85-102 ;2001.
- **Lazarevic B. and Garret R. :**Inverted papilloma and papillary transitional cell carcinoma of urinary bladder.Cancer 42:1904;1978.

- **Lee J.K.T. :** Staging of pelvic neoplasm in contemporary imaging , in Henny , Goldberg , Higging and Ring (eds) . California Univ . USA ; 1998.
- **Lerner S.P., Skiner D.G., Lieskovski G. :**The rationale for en block pelvic lymph node dissection for bladder cancer patients with noda metastases:long term results.J.Urol.149:758;1995.
- **Levoy M. :** Display of Surfaces from Volume Data . IEEE computer Graphics and Application ; 8(3) : 29-37;1998.
- **Lipson S.A. and Hricack H. :** the urinary bladder and Female Urethra , in Higgins CB , Hricack H and Helms CA (eds) . Magnetic Resonance Imaging of the body ; 929-956 . Lippincott-Raven, Philadelphia , NY ; 1997.
- **Malmstron P.V. , Busch C. and Norlen B.J. :** Recurrence , progression and survival in bladder cancer . J UROL Nephrol ; 21: 185 ; 1987 .
- **Mang T., Happel B., Prokop M. :** Virtual multidetector row CT cystoscopy in the detection of urinary bladder lesion . Eur Radiol ; 13 (p) : B20 ; 2003 .
- **Mc Minn R.M. :** Urinary bladder and ureter in pelvis , in Mcminn RM (eds)) . Lasts anatomy : regional and Applied ; 381 . Churchill Livingstone , Edinburgh , London , Madrid , Melbourne , NY and Tokyo ; 1994 .
- **Merkle E.M., Wunderlich A., Aschoff A.J., Rilinger N., Gorich J., Bachor R. :** Virtual cystoscopy based on helical CT scan datasets : Perspectives and limitation . Br J Radiol ; 71 : 626-267 ; 1998 .
- **Messing E.M. and Catalona W.:**Urothelial tumours of urinary tract. In:Campbell's Urology 7th. Ed Walsh P.C., Retik A.B., Vaughan D.et

Wein A.J.edit by W.B.SAUNDERS Co. Philadelphia 77:2327-2410;1998.

- **Michael L , Cher C. and Peter R.C. :** anatomy of urinary bladder , in Raghavan D , Leibel SA , Scher HI , and Lange P (eds) . Principles and practice of the bladder in genitourinary oncology ; 158-193. Lippincott-Raven , Philadelphia , NY ; 1997 .
- **Murphy W.M. &Soloway M.S.:**Urothelial dysplasia J. Urol.127:849;1982.
- **Murphy W.M.** :Flow cytometry versus urinary cytology in the evaluation of patients with bladder cancer.J. Urol.136:815;2000.
- **Naidich D.P., Gruden J.F., McGuinness G. :** Volumetric CT of the airways . J Thoracic Imaging ; 12 : 11-28; 1997 .
- **Narumi Y., Kumatani T., Souvai Y.: The bladder and tumors;** Imaging with three-dimensional display of helical CT data . Am. J. Roentgenol ; 167 : 1134-1135 ; 1996 .
- **Nguyen P.L., Swanson P.E., Jaszez W. :**Expression of epidermal growth factor receptor in invasive transitional cell carcinoma of the urinary bladder.Am.J.Clin.Path.101:166;1994.
- **Olcott E.W., Nino Murcia M., Rhee J.S. :** Urinary bladder pseudolesion on contrast enhanced helical CT : Frequency and clinical implication . Am J Roentgenol ; 171: 1349-1354 ; 1998 .
- **Olumai A.F., Tsai Y.C., Nichols P.W. :**Allelic loss of chromosome 17p distinguishes high grade from low grade transitional cell carcinoma of the bladder.Cancer Res.50:7081;1990.
- **Paik D.S., Beaulieu C.F., Jeffrey R.B. :** Automated Flight path Planning for virtual endoscopy . Med. Phys. ; 25(5) : 629-637 ; 1998 .

- **Parker S.L., Tong T., Bolden S., Wingo P.A. :** cancer statistics . CA cancer J Clin ; 46: 5-27 ; 1996 .
- **Peterson R.O. :** Urologic Pathology (2nd ed.). Lippincott , Philadelphia ; 1992.
- **Peterson R.O. :**The urinary tract and male reproductive system.In:Pathology 2nd ed. Edited by Rubin E.&Farber J.L.J.B. Lippincott, Philadelphia 867-908;1994.
- **Peterson R.O.:** The urinary tract and male reproductive system.In: Essential Pathology 3rd ed.Edited by Rubin E.J.B,Lippincott,Philadelphia 17:487-506;2001.
- **Phong B.T. :** Illumination for Computer General Pictures . Communications of the ACM ; 18 (6) : d 1-317;1975 .
- **Putman C.E., Ravin C.E. and Louvric C.A. :** Textbook of diagnostic imaging ; 2011-2029 ; 1994 .
- **Rapp-Bernhardt U., Welte T., Doehring W., Kropf S. , Bernhardt T.M. :** Diagnostic potential of virtual bronchoscopy : Advantages in comparison with axial CT slices , MPR and MIP . Eur Radiol ; 10:981-988 ; 2000.
- **Riddle P.R., Chisholm G.D., Trott P.A.** :Flat carcinoma in situ of bladder. Br.J.Urol.47:829;1976.
- **Rodenwaldt I., Kopka L., Roedel R., Margas A., Grabber E. ;** 3-D virtual endoscopy of the upper airway : Optimization of the scan parameters in a cadaver phantom and clinical assessment . J Comput Assist Tomogr ; 21 : 405-411 ; 1997 .
- **Rogalla P. and Meiri N. :** Virual endoscpy of the trachea and bronchi , in Rogalla P , Scheltinga JT , and Hamm B (eds) , virtual endoscopy and related 3-D techniques ; 4: 45-76 ; 2000 .

- **Roy C., Tuchmann C. , Guth S. and Saussine C. :** Patholgie de la vessie : performances et limits des methods d'imagerie (pathology of the bladder : performances and limits of the imaging techniques) . J. Radiol ; 81:1099-1103 ; 2000.
- **Rubin G.D., Beaulieu C.F., Argiro V. : Perspective volume redering of CT and MR images :** applications for endoscopic imaging . Radiology ; 199: 321- 330 ; 1996
- **Ryan P.G., Thong H.N., William B.A. :** virtual endoscopy : Evaluationn of a new imaging technique . Laryngoscope ; 109: 1570-1579;1999 .
- **Ryan S. and McNicholas M. :** The bladder Anatomy for diagnostic imaging ; 6: 217-218 . Saunders Company Ltd, London , Philadelphia , Sydney , Tokyo , Tronto ; 1994 .
- **Scheltinga J. :** Technical Background , In :Virtual endoscopy and Related 3D Techniques.Rogalla P., Scheltinga J.,Humm B.et al.Edited by Springer-Verlag, Berlin Heidelberg 1-16;2001 .
- **Schlick C. :** A fast alternative to phong's Specular Model , in Heckbert P (ed) . Graphics Gems IV ; 385-387 . Academic Press , Boston ; 1994 .
- **Schneck C.D., Friedman A.C. and Peterson R.O. :** urinary bladder , in Friedman AC , Radecki PD , Lev-Toaff AS . hilpert PL (eds) , Clinical Pelvic Imaging ; 1:13-46. the C.V Mosby Company ,St Louis Baltimore, Philadelphia , Toronto ; 2000 .
- **Schreyer A.G., Fielding J.R., Warfield S.K. :** Virtual CT cystoscopy color mapping of bladder wall thickness . Invest. Radiol.; 35 : 331-334 ;2000.

- **Sedimon J.E. and Friedman A.C. :** Pelvis : Neoplastic and Nonneoplastic masses , in Friedman AC , Radecki PD , Lev-Toaff AS , Hilpert PL (eds) , clinial Pelvic Imaging ; 6:346-373 . the C.V Mosby Company , St Louis , Baltimore , Philadelphia , Toronto ; 1990 .
- **See W.A & Fuller J.R.:** Staging of advanced bladder cancer: current concept and pitfalls. Urol. Clin. North Am. 19:663; 2002.
- **Smith J.A., Jr. and Whitmore W.F. Jr. :**Regional lymph nodes metastases from bladder cancer.J Urol. 126-591;1981.
- **Smith H., Weaver G., Barenbruch O. :** Routine excretory urography in follow up of superficial transional cell carcinoma of the bladder . J Urology ;34: 193 -203 ;1990 .
- **Soloway M.S., Morrison D.A. and Shelton T.B.** : Modalities used in the diagnosis and evaluation of bladder cancer, AUA update series 4:1; 2002.
- **Song J.H., Francis I.R., Platt J.F. :** Bladder tumor detection at virtual cystoscopy Radiology ; 218:95-100;2001.
- **Spurck C.H., Ohneseit P.F., Gonzales-Zulueta M. :** Two molecular pathways to transitional cell carcinoma of the bladder. Cancer Res.54:784;1994.
- **Stenzl A., Frank R., Eder R. :** 3-dimensional computerized tomography and virtual reality endoscopy of reconstructed lower urinary tract . J Urol ; 159: 741-746 ; 1998.
- **Tanimoto A., Yuasa Y., Imai Y., Izutsu M., Hiramatsu K. Tachibana M. and Tazaki H. : Bladder tumor Staging :** comparison of convetional and gadolinium enhanced dynamic MR imaging and CT . Radiology ; 85: 741-747;1992.

- **Teeger S. and Sica G.T. :** MR imaging of the bladder diseases . MRI clinics of the Nourth America ; 4:565-581;1996 .
- **Tempany C.M. and Fielding J.R. :** Male pelvis , in Edelman RR, Zlatkim MB and Hessenlink JR (eds) , Clinical Magnetic Resonance Imaging ; 1393. Saunders Company Ltd , Philadelphia , Toronto , Sydney : 1996 .
- **Utz D.C.,Hanash K.A.and Parrow G.M. :** The plight of the patient with carcinomain situ of the bladder.J.Urol.103:160;1970.
- **Utz D.C.and Farrow G.M. :**Carcinoma in situ of the urinary tract. Urol.Clin.North Am. 11:735;1984.
- **Vander Werf-Messing R.H.P. :** Carcioma of the urinary bladder treated by interstitial radiotherapy. Urol.Clin.North Am. 11:659;1984.
- **Vicentee J., Lagura M.P., Duarte D. :** Carcinoma in situ as a prognostic factor for G3PT1, bladder tumors. Br J Urol. 68:380;2000.
- **Vinncombe S.J. and Husband J.E. :** the Bladder , in Butler P , Mitchell AWM and Ellis H (eds) , Applied Radiolgical Anatomy ; 14: 284-286 . Cambridge University Press , Cambridge UK ; 1999 .
- **Vining D.J. :** Virtual colonoscopy . Gastrointestinal Endoscopy Clin North Am; 7:285-291;1997 .
- **Vinind D.J., Zagoria R.J., Liu K., Stelts D. : CT cystoscopy :** An innovation in bladder imaging . Am J Roentgenol ; 166:409-410 ; 1996 .
- **Walsh J.W. :** Computed tomography of the pelvis , in Haga JR , Lanzieri CF , Sartoris DJ and Zerhoun EA (eds) , computed tomography and magnetic resonance imaging of the whole body (3rd ed) ; 1327-1349. Mosby , St Louis , Balimore , Berlin , Boston ; 1994 .

- **Wang D. and Vannier M.W. :** The effect of pitch multislice spiral /helical CT . Med Phys ; 26 :2648-2653 ;1999.
- **Wang D., Zhang W.S., Xiong M.H., Yu M., Xu J.K. :** Bladder tumours. Dynamic contrast enhanced axial imaging, multiplanner reformation, three dimentional reconstruction and virtual cystoscopy using helical CT. Chin Med. J; 17(1)62-66;Jan., 2004.
- **Wegner O.H. :** The Urinary Bladder . Whole Body Computed Tomography (2nd ed) ; 19:415-422. Blackwell scientific pub. , Boston , Oxford , London ; 2002.
- **Weinstein R.S., Alroy J., Farrow G.M. :**Blood group isoantigen deletion in carcinoma in situ of the urinary bladder.Cancer 43:661;1979.
- **Weldon T.E., and Soloway M.S. :**Susceptibility of urothelium to neoplastic cellular implantation.Urology 5:428;1975.
- **Zhang Z.F. and Steineck G. :** Epidemology and Etiology of Bladder cancer ,in Raghavan D , Scher HI , Leibel and Lange P (eds) , Principles and Practice of genitourinary oncology ; 215-222. Lippincott-Raven , Philadelphia , NY 1997 .

Arabic Summary

الملخص العربي

إن التقدم العلمي في الأجهزة الطبية و التقنية الحديثة بالإضافة إلى التطور السريع في أجهزة الكمبيوتر والبرامج الحديثة وإمكانية تطبيقها في المجال الطبي بالإضافة إلى انتشار استخدام الأشعة المقطعية الحلزونية أدى إلى إمكانية تصوير المثانة من الداخل باستخدام الأشعة المقطعية ثلاثية الأبعاد مما اتفق علميا على تسميته بالمنظار التقديري (التخيلي) للمثانة.

الهدف من هذه الدراسة هو تقييم دور المنظار التخيلي للمثانة مقارنة بالمنظار التقليدي (الحقيقي) في تشخيص ودراسة اورام المثانة. وقد اشتملت الدراسة على46 مريضا تتركز شكواهم في وجود أورام بالمثانة وقد ثبت بالتحليل الباثولوجي للعينات التي تم الحصول عليها باستخدام المنظار التقليدي (الحقيقي) إصابتهم جميعا بسرطان المثانة.

تمت الدراسة بوحدة الأشعة المقطعية بمستشفى الحسين الجامعي بجامعة الأزهر باستخدام جهاز الأشعة المقطعية الحلزونية حيث تم تصوير البطن والحوض لجميع الحالات، ثم نقلت الصور إلى جهاز كمبيوتر خاص مزود ببرنامج خاص بعمل المنظار التقديري للمثانة وفي جميع الحالات نجحت الدراسة قي الحصول على صور افتراضية تخيلية للمثانة من الداخل تضاهي ما أمكن الحصول عليه باستخدام المنظار التقليدي (الحقيقي).

وقد استغرقت الدراسة الفترة من مايو 2007 إلى ديسمبر 2007 وأثبتت ايجابية النتائج، وبالرغم من أن المنظار التقليدي (الحقيقي) يعتبر من أهم الفحوص التي تجري لتشخيص أورام المثانة حيث يتميز بإمكانية رؤية الورم بصورة مباشرة وكذلك رؤية التغيرات التي تحدث لجدار المثانة والحصول على عينة للتحليل الباثولوجي إلا أن المنظار التقديري يتميز بقدرته الفائقة على تصوير المثانة من جميع الزوايا والأبعاد، كذلك يمكنه فحص المثانة بعد

مرحلة الضيق أو الانسداد الناتج عن الأورام أو الأسباب الباثولوجية المختلفة والتي يعجز المنظار التقليدي (الحقيقي) عن المرور خلاله.

ومن أهم مزايا الفحص التقديري هو انه فحص آمن لذا فانه من الممكن استخدامه في الأطفال وفي الحالات التي يصعب أو يحظر فيها استخدام المنظار التقليدي (الحقيقي) كوجود التهابات أو ضيق أو لمتابعة حالات سرطان المثانة خاصة التي خضعت لتدخلات جراحية.

ليس من المتوقع أن يحل المنظار التقديري (التخيلي) للمثانة محل المنظار التقليدي (الحقيقي) الذي يعطي صورة حية ديناميكية للمثانة كذلك يتيح فرصة للحصول على عينة للتحليل الباثولوجي من الكتلة الموجودة، ولكن من المتوقع أن يكون هذا الفحص روتيني خاصة للمتابعة في حالات سرطان المثانة لما له من فوائد متعددة كذلك يعتبر إضافة جديدة لمزايا الأشعة المقطعية في دراسة وتقييم كتل المثانة.

منظار المثانة التخيلي عن طريق الأشعة المقطعية في تشخيص أورام المثانة البولية

رسالة

توطئة للحصول على درجة الماجستير في الأشعة التشخيصية

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