Original Research Paper

Volume - 7 | Issue - 7 | July - 2017 | ISSN - 2249-555X | IF : 4.894 | IC Value : 79.96

Radiology

A PROSPECTIVE STUDY OF THE IMAGING OF URINARY BLADDER NEOPLASM BY ULTRASOUND AND COMPUTED TOMOGRAPHY.

Dr. Pranita Vishwas .G — MBBS, DNB Radiodiagnosis, Assistant Professor, Wayanad Institute of Medical Sciences WIMS, Wayanad, Kerala

Dr. Megharanjini — MBBS, DNB Radiodiagnosis, Senior Resident, Karnataka Institute of Medical sciences - KIMS, Hubballi, Karnataka.

ABSTRACT

AIMS AND OBJECTIVES

- To demonstrate the radiological features of Urinary bladder carcinoma by US and CT.
- To compare US and CT in identifying, characterizing and staging of Urinary bladder carcinoma.

Materials and methods: Age, gender of patient, presenting complaints were analysed

Number , morphology , depth of wall invasion , calcifications , location, size, shape, margins , perivesicle fat extension and invasion into adjacent organ , extension of the mass to the lateral pelvic wall and distant metastasis was valuated by USG.

Urinary bladder mass was examined for morphology, enhancement , wall invasion , calcifications, number, location, size, shape, margins , perivesicle fat stranding and adjacent organ invasion , extension of the mass to the lateral pelvic wall and distant metastasis were studied by CT.

For staging of Urinary bladder tumour the TNM staging were used. Regional lymph nodes were considered to be enlarged if they were at least 15mm in the short axis.

Staging of Urinary bladder tumours by US and CT were compared with histopathological findings. Strength of agreement between US, CT and histopathological findings were analysed.

CONCLUSION :

- Urinary Bladder carcinoma is more common in males with a peak incidence during fifth decade. Characteristic and commonest presenting feature is gross hematuria.
  Most common location for a urinary bladder neoplasm is the trigone of the bladder and most common morphology is a polypoidal lesion irrespective of the histopathological diagnosis.
- On ultrasound most of the Urinary bladder tumours appear isoechoic to hypoechoeic and on non enhanced CT majority of them are isodense and show homogenous enhancement.
- Both US and CT have limitation in differentiating Stage TI from T2a and T2b.
- CT is superior to US in detecting perivesicle extension , lymphnodes, involvement of the adjacent viscera and distant metastasis.
- US should be the initial modality in investigating patients who present with clinical symptoms suggestive of Urinary bladder neoplasms.
- CT should be done for staging the tumour and in lesions with indeterminate sonographic findings.

KEYWORDS : .

INTRODUCTION

Urothelial cancers account for 5.6% of male and 1.8% of female cancers in India with actual crude rate (ACR) incidence of males about 1 in 174 men and 1 in 561 women.{1}

Bladder cancer is fourth most common cancer in men and tenth most common cancer in women. Both the sexes are equally affected when tumour occurs secondary to analgesic abuse or with Balkans nephropathy.{3, 10}

The age at diagnosis is generally older than 40 years; the median age is in mid-60s .

Established risk factor for bladder cancer is cigarette smoking but chemical carcinogens (such as aniline, benzidine, aromatic amines, and azo dyes) also are thought to predispose to development of transistional cell carcinoma, these substances are metabolized and excreted into the urine as carcinogens that act upon the urothelium.

Analgesic abuse and urine stasis from structural abnormalities, such as horseshoe kidneys, neurogenic bladder also are associated with an increased incidence of these tumors {2,23}.

Squamous cell carcinoma is associated with Schistosoma haematobium infection, recurrent urinary tract infection and bladder calculus {2,4,24}.

Adenocarcinoma of nonurachal origin generally is thought to arise from metaplasia of chronically irritated transitional epithelium. Adenocarcinomas may be of urachal origin or of nonurachal origin , with the urachal type typically occurring in the dome of the bladder in the embryonal remnant of the urachus .

Other important risk factors associated with the patient's medical history include prior radiation therapy to pelvis and treatment for malignancy with certain chemotherapy agents, in particular cyclophosphamide.

Heredity may play a role in some cases of bladder cancer, as the risk of developing the disease increases almost twofold when a first-degree relative carries the diagnosis of urothelial tumor (transistional cell carcinoma, TCC){2,27-30}.

More than 95% of bladder tumors arise from the uroepithelium (epithelial tumors), including TCC (over 90%), squamous cell carcinomas (6% to 8%), and adenocarcinomas (2%) .

Rarer epithelial tumors include small cell/neuroendocrine carcinoma (1%, with or without associated paraneoplastic syndrome), carcinoid tumors, and melanoma .

TCC exhibit a spectrum of neoplasia ranging from a benign papilloma through carcinoma in situ to invasive carcinoma . Most TCC are low-grade papillary tumors, tend to be multifocal and recur but have a relatively good prognosis. High-grade invasive tumors are less common and have poorer prognosis.

Epithelial tumors having a mixed histology, such as TCC and squamous or TCC and adenocarcinoma are treated as urothelial carcinomas (TCC) .{11}.

Mesenchymal bladder tumors can be benign (leiomyoma, paraganglioma, fibroma, plasmacytoma, hemangioma, solitary fibrous tumor, neurofibroma, and lipoma) or malignant (rhabdomyosarcoma, leiomyosarcoma, lymphoma, and osteosarcoma).

Patient symptoms are all nonspecific. Most common presenting symptom is gross hematuria, although microscopic hematuria may be detected at urinalysis. Patients may experience voiding symptoms such as frequency, dysuria, and pelvic pain and pressure {10}.

Less commonly, patients may present with urinary tract infection, or for a more advanced lesion, urinary obstruction, pelvic pain and pressure, or a palpable pelvic mass. Very rarely, patients present with symptoms of advanced disease such as weight loss and abdominal or bone pain from distant metastases

This study was undertaken to describe the features of urinary bladder neoplasm on US and CT and to compare ultrasonography and computed tomography in identifying, characterizing and staging Urinary bladder carcinoma.

AIMS AND OBJECTIVES

- **To demonstrate the radiological features of Urinary bladder carcinoma by US and CT.**
- **To compare US and CT in identifying, characterizing and staging of Urinary bladder carcinoma.**

REVIEW OF LITERATURE

The basis of ultrasound-the piezoelectric effect dates back to1880.The Curie brothers, Pierre and Jacques Curie first demonstrated the piezo-electric effect in 1880 {32}.

Paul Langevin in England developed a method of detecting submerged submarines. His work laid the foundation for SONAR (Sound Navigation and Ranging) and later for ultrasonic imaging {32}.

The first step towards making an anatomical image with ultrasound was made by Karll Dussick and Fred Dussick in 1947 {33}.

The development of the first CT scanner by Sir Godfrey N. Hounsfield, a research scientist at EMI Limited in England, is one of the great advances in the field of radiology {34}.

The first clinical body scanner was developed at Georgetown University in 1974 and was called the Automated Computerized Transverse Axial (ACTA) Scanner {35}.

In 1975, Alfridi RJ et al studied computed tomography of the thorax and abdomen {36}.

Historically, the staging of TCC has been clinicopathological. In 1922, Broders created a landmark by formulating a grading system based on the percentage of undifferentiated urothelial cells, which was predictive of both behavior of the bladder urothelium over time and prognosis.

In 1931, Aschner classified neoplasms of the bladder as papillary versus a solid configuration and in relation to the presence or absence of invasion where he found that disease severity increased with solid tumors.

In 1944, Jewett and Strong analyzed the relation of depth of penetration (stage) to the incidence of local extension and metastases.

In 1948, McDonald and Thompson discovered the concept of vascular and lymphatic invasion and showed that there was a direct relation to prognosis.

In 1952, Jewett-Marshall-Strong redefined the staging based on bimanual palpation and biopsy into Stage 0, A and B1 (superficial disease) and B2 (deep muscle invasion) and C.

Continuing his studies, in 1956 Marshall established the impact of gradation of tumor.

Till 1967, the Jewett-Marshall-Strong classification was in vogue. Later Jewett and his group under the aegis of the American Joint Committee System formed the AJCC task force recognized a need to broaden the staging to accommodate additional tumor characteristics and a common taxonomy formulating the TNM staging in 1983.

The TNM classification is currently the standard staging procedure for bladder cancer and is based on clinico-pathological findings.

IMAGING FEATURES OF URINARY BLADDER NEOPLASMS

Plain radiography

Plain radiography typically has little value in the detection of TCC (transitional cell carcinoma); calcifications occur in approximately 7% of TCC lesions. These tumors may obstruct the collecting system and can mimic urinary calculi. Therefore, plain radiography is of little value {41}.

Intravenous urography

Many patients who have bladder cancer present with hematuria and traditionally would undergo excretory urography, which used to be the most common imaging test for the evaluation of hematuria.

A bladder tumor may be recognized as a pedunculated, radiolucent filling defect projecting into the lumen or a focal irregularity of the bladder wall. In a study by Hillman and colleagues, only 60% of known bladder tumors could be detected on intravenous urography (IVU).

In the early stages, these neoplasms are seen on IVU as subtle filling defects or focal mural thickening. TCC tends to appear as fixed, smooth, or irregular, single, or multiple filling defects within the renal collecting systems. A papillary lesion may absorb contrast into its interstitium, resulting in a stipple sign (26).

This radiologic sign is not specific for TCC and can be produced by other pathologic processes, such as fungal lesions and blood clots .

An obstructed infundibulum occurs in 26% of cases . This can produce a phantom calyx that may fill either early, late, or not at all because of the presence of a TCC. Signs of ureteric TCC include the presence of a nonfunctioning kidney (46%), fixed wall thickening that can be either eccentric or circumferential, filling defects, hydronephrosis (36%) with or without hydroureter, and irregular ureteric narrowing with proximal shouldering (goblet sign) {2,41,44,45} .

Bladder neoplasms most commonly appear as polypoidal filling defects.

Cystoscopy and biopsy remain the standard of reference in confirming the diagnosis of bladder cancer. Once the diagnosis of bladder cancer is made, CT or MR is performed for staging and treatment planning, and routine IVU generally is not indicated {2}.

Retrograde pyelography

In the era before Multidetector CT Urography (MDCTU) was developed, opacification of the urinary tract was frequently very poor with IVU in patients with diminished renal function retrograde pyelography was then the only available method of visualizing the pelvicaliceal system and ureters.

Limitations of retrograde ureterography - only demonstrate the lumen of the ureter and do not allow direct visualization of extrinsic abnormalities that involve the ureter {41}.

Ultrasonography

US methods of bladder evaluation include transabdominal (suprapubic), transrectal, transvaginal, and intravesical US. Most tumors appear as a papillary, hypoechoic mass or area of focal wall thickening . Doppler imaging will show flow within the mass, aiding in differentiation of tumor from blood clot {10}.

It is important to evaluate the bladder when it is fully distended. Sonographic detection of bladder tumors depends on the size and location of the neoplasm. Bladder tumors less than 0.5 cm in size and tumors located in the bladder neck or dome areas are difficult to detect. On the other hand, diagnostic accuracy may approach 95% for tumors more than 0.5 cm in size situated on the posterior or lateral walls of the bladder {2}.

Bladder TCCs occur most frequently at the trigone and along the lateral and posterior walls of the bladder. Sonographic detection of bladder TCC is excellent, with sensitivities of greater than or equal to 95% being reported {41}.

Limitations of USG

Bladder visualization may be limited by patient body habitus, overlying bowel gas, or poor bladder distention. Accuracy in the detection of lymph node metastases remains very low. Fibrosis or

calcifications may create increased echogenicity {42}. The extent of invasion of the bladder wall and extra vesicular extension cannot be assessed accurately by trans abdominal ultrasound. Edema, intra vesicular clot, and tumor calcification can cause over staging of tumors.

CT IMAGING OF URINARY BLADDER NEOPLASMS

CT is the imaging modality of choice for the workup of patients presenting with hematuria. It also is indicated in patients with high-grade bladder cancer raising suspicion for muscle invasion.

In the presence of urothelial tumor, the detailed evaluation of the entire urinary system provided by CTU (CT Urography) is essential, as patients with urothelial tumor (TCC) may have multifocal disease.

CTU can detect direct perirenal, periureteral, and extravesical tumor spread, as well as lymphadenopathy and distant metastases. CTU also allows more detailed evaluation of the renal parenchyma and perirenal tissues and permits better evaluation of obstructed collecting systems than does excretory urography.

Therefore detecting and evaluating urinary tract neoplasms and the work-up for hematuria, CTU is the imaging modality of choice for patients who can tolerate iodinated intravenous contrast.

The advantages of CTU are made possible by multidetector helical CT with volumetric acquisition, which provides fast acquisition of high-resolution images and allows multiplanar reconstruction {2}.

Thin-section precontrast, postcontrast, and delayed excretory phase images are obtained.

Precontrast images covering the area from the top of the kidneys to the bottom of bladder provide a baseline attenuation measurement for evaluating the degree and pattern of enhancement for any incidentally identified lesions of the urinary tract .

Postcontrast images are performed during the renal parenchymal phase (approximately 90 seconds after initiation of the intravenous contrast injection), and they cover the entire abdomen and pelvis. These images are helpful in the identification of enhancing urothelial lesions, incidental renal cortical masses, and other abdominal/pelvic abnormalities such as hepatic metastases and lymphadenopathy.

The excretory phase images achieved with a scan delay of 10 minutes or more , give information both in confirming enhancing lesions as true lesions and not pseudolesions related to focal opacified urine arising from a ureteral jet within the bladder lumen and in demonstrating discrete filling defects caused by tumor not evident on earlier scans.

If the urinary tract is not well distended and opacified with contrast throughout its entire course, then additional delayed images may be acquired targeting the nonopacified portion up to two times. Putting the patient in the prone position, applying abdominal compression, or both, may help distend the urinary collecting system. In the setting of frank hydronephrosis, the patient may be allowed to return to the CT department 30 or 60 minutes later for delayed imaging. The excretory phase images are reconstructed further into thin overlapping sections, which then are transferred to a workstation for three dimensional post-processing. Any abnormality visualized on the post processed images, however, needs to be confirmed on the axial source images.

Virtual cystoscopy, obtained by manipulating CTU data acquired through the contrast-filled bladder during the excretory phase, allows navigation within a three-dimensional model and shows promise for detecting bladder mucosal lesions .

At CT or CT urography, urothelial carcinoma appears as an intraluminal papillary or nodular mass or focal wall thickening. Lesions may be missed without adequate bladder distention, especially small, flat tumors. CT demonstrates tumoral calcification in approximately 5% of cases.

With progression of disease, wall thickening may become diffuse. The presence of ureteral obstruction strongly suggests the presence of muscle invasion. Other causes of wall thickening (eg, biopsy, inflammation, hypertrophy from chronic outlet obstruction, radiation fibrosis, chemotherapy) may complicate the CT diagnosis.

Once the tumor has extended into the perivesical fat, increased attenuation or infiltration is noted in the fat.

After transurethral bladder tumor resection, focal wall thickening and perivesical fat stranding may mimic tumor and deep invasion, resulting in overstaging. Optimally, CT should be delayed for at least 7 days to improve specificity. Accuracy for staging of primary tumor with CT has ranged from 40% to 85% . Sensitivity and specificity for detecting perivesical invasion with multidetector CT are improved over those of conventional CT, at 92% and 98% respectively, with an accuracy of 96%, if performed more than 7 days after biopsy.

The lymph node staging accuracy of CT ranges from 50% to 97% . As with other tumors, however, CT allows visualization of lymph node size or enhancement abnormalities only. Pelvic lymphadenopathy is defined as pelvic lymph nodes larger than 15 mm in the short axis . Microscopic metastases are easily missed in small or normal-sized nodes. Differentiating between enlarged metastatic nodes and benign reactive nodes remains problematic.

CT virtual cystoscopy is a newer technique that shows promise for detecting bladder tumors greater than 5 mm in diameter in patients who are unable to tolerate conventional cystoscopy. Because this technique is limited to evaluating the epithelial surface of the bladder, it is inappropriate for staging bladder tumors. However, the clinical utility of virtual cystoscopy remains indeterminate, and further studies are necessary {2,42,43}.

MAGNETIC RESONANCE IMAGING OF BLADDER NEOPLASMS

MR imaging has many advantages over other modalities for detecting and staging bladder neoplasms because of its intrinsic high soft tissue contrast, direct multiplanar imaging capabilities, and the availability of a non-nephrotoxic, renally excreted contrast agent.

Due to these advantages, MR imaging has the potential to become the modality of choice in staging all pelvic malignancies.

Currently MR imaging of bladder masses includes the following sequences:

T1 weighted spin echo images of the entire pelvis, which are helpful in identifying extravesical infiltration, pelvic adenopathy and osseous lesions

T2 weighted fast spin echo images of the bladder with small field of view and high matrix for high-resolution images in at least two different planes, which can offer a submillimeter resolution and are useful in evaluating the tumor depth and detecting invasion of surrounding organs

Dynamic contrast-enhanced T1 weighted images for evaluating the enhancement pattern of a bladder lesion.

For dynamic contrast-enhanced images, three dimensional fast-spoiled gradient echo sequences with fat suppression may be performed before and after contrast administration during the arterial and later phases for evaluation of the presence and pattern of enhancement in a bladder mass, and perivesical soft tissue enhancement.

Both overdistention and underdistention of the bladder may affect diagnostic accuracy. It has been suggested by some that the patient void approximately 2 hours before the MR examination to achieve optimal bladder filling.

Detection of bladder tumors by MRI has a positive predictive value of >90% .

On T1 weighted images, the bladder tumor typically has a low-to-intermediate signal intensity that is similar to that of the bladder wall, higher than the dark urine and lower than the bright perivesical fat.
On T2 weighted images, the tumor tends to have intermediate signal intensity that is mildly brighter than the dark bladder wall muscle and lower than the high-signal urine.

An intact, low-signal intensity muscle layer at the base of the tumor is indicative of nonmuscle invasive bladder tumor of stage Ta or T1.

With fast dynamic contrast-enhanced imaging, bladder cancer enhances more avidly and earlier than other tissues such as normal bladder and post biopsy changes. This may enable differentiation of tumor from fibrosis or edema, although this is still difficult soon after transurethral resection.

MR imaging has a reported staging accuracy of 72%–96% for the primary tumor. But inflammation can mimic perivesical fat invasion and result in overstaging.

Metastatic lymph nodes have no specific appearance on T1- or T2-weighted images but enhance early, simultaneously with the bladder cancer. Improved MR detection of pathologic lymph nodes (sensitivity, 96%; specificity, 95%; and negative predictive value, 98%) has been achieved with an intravenous suspension of ultrasmall iron particles, ferumoxtran-10. Ferumoxtran is taken up by macrophages in lymph nodes and causes loss of signal in normal nodes on T2*- weighted images.

Distant metastases may be evaluated with either MR imaging or CT, with MR imaging superior to CT for detection of bone marrow involvement {10}.

MR imaging remains the most sensitive and specific modality for the detection of bone metastases because the bone marrow and cellular signal intensity abnormalities, rather than bone metabolism, are directly visualized {2,42,43}.

NUCLEAR SCINTIGRAPHY

Role of scintigraphy in evaluation of bladder cancer has been limited to staging for bone metastases. Initial metastases replace normal marrow, resulting in increased bone metabolism and osteolysis. Bone scintigraphy may show foci of either increased or decreased activity and reveal lesions that are undetectable with CT. However, scintigraphy remains limited to the detection of bone destruction. MR imaging remains the most sensitive and specific modality for the detection of bone metastases because the bone marrow and cellular signal intensity abnormalities, rather than bone metabolism, are directly visualized {44,42}.

Evaluation of bladder cancer by fluorine 18 fluorodeoxyglucose (FDG) positron emission tomography (PET) is limited by the renal excretion of the radioisotope into the collecting system and bladder.

Currently, the role of PET or PET-CT is in the detection of metastases. Preliminary work has been performed with tracers not excreted in the urine, such as 11C methionine and 11C choline which may be useful for detecting the primary bladder tumor {42,50}.

STAGING OF URINARY BLADDER CANCER

The main staging system of bladder cancer, which has been revised, is one developed jointly by the International Union Against Cancer (UICC) and the American Joint Committee on Cancer (AJCC) (Sobin and Wittekind, 1997)

1997 AJCC-UICC, TNM Staging

Ta Papillary, epithelium confined
Tis Flat carcinoma in situ
T1 Lamina propria invasion

- T2a Superficial muscularis propria invasion
- T2b Deep muscularis propria invasion
- T3a Microscopic extension into perivesical fat
- T3b Macroscopic extension into perivesical fat
- T4a Cancer invading pelvic viscera (e.g., prostatic stroma, vaginal wall, rectum, uterus)
- T4b Extension to pelvic sidewalls, abdominal walls, or bony pelvis
- N0 No histologic pelvic node metastases
- N1 Single positive node ≤2 cm in diameter, below common iliacs
- N2 Single positive node 2-5 cm in greatest diameter or multiple positive nodes
- N3 Positive nodes >5 cm in diameter

Nx Nodal status unknown

- M0 No distant metastases
- M1 Distant metastases documented

Mx Distant metastases status uncertain

TREATMENT OF URINARY BLADDER CANCER

Nonmuscle invasive tumors (also referred to as superficial tumors) include noninvasive carcinomas (Ta), carcinoma in situ (Tis), and tumors invading the lamina propria (T1), standard treatment is transurethral resection with fulguration, which can be repeated when necessary. Depending on the depth of invasion and histologic grade, intravesical medication such as BCG may be used to reduce the chances of recurrence or prevent progression to a higher grade or stage.

For stage T2 and T3 disease, and selected T4a disease without nodal metastasis, radical cystectomy is considered standard treatment.

There is evidence that neoadjuvant therapy before cystectomy may improve survival of patients with muscle-invasive bladder cancer.

Stage T4 bladder carcinoma - Radical cystectomy with or without preoperative irradiation or chemotherapy may be considered in these patients if no nodal disease is identified on imaging. If enlarged lymph nodes are documented by imaging, a biopsy may be needed for a definitive confirmation before chemotherapy or radiation therapy is initiated.

Findings suspicious for distant metastases on imaging also typically need to be confirmed by biopsy. If confirmed, these patients generally are treated with systemic chemotherapy {2,40,41}.

DIFFERENTIAL DIAGNOSIS

Conditions that can mimic neoplasm, include cystitis, wall thickening secondary to bladder outlet obstruction, blood clot, postoperative change, prostate carcinoma, lymphoma, neurofibromatosis and endometriosis

MATERIALS AND METHODS

Fifty three patients who were found to have a mass in the urinary bladder on ultrasound, subsequently confirmed on CT and with positive surgical and histopathological diagnosis of Urinary bladder neoplasm were included in our study.

Exclusion criteria

Patients with history of allergy to contrast medium, patients with serum creatinine value more than 1.8 mg/dl, post operative cases of Urinary bladder neplasms were excluded from our study. Follow-up for recurrence after the surgery was not evaluated.

Basic clinical criteria to proceed for the study

Detailed clinical history, history of reaction to the contrast medium, history of allergy, asthma was taken from all the patients and all the patients were clinically examined. Random blood sugar, serum creatinine and blood urea values were obtained from all patients before enrolling them into the study. Chest X-ray PA view was obtained in all patients. Informed written consent was taken from both the patient and patient attendants.

Procedure for Ultrasonography

Patients were evaluated by AGILENT SONOS 5500 TECHNOLOGIES equipment in Department of Radiodiagnosis , Sri Satya Sai Institute of Higher Medical Sciences , Whitefield and on GE LOGIQ 400 PRO SERIES equipment Sri Satya Sai Institute of Higher Medical Sciences, Prashanthigram respectively, using 2- 5 MHz curvilinear transducer in Department of imaging sciences. The Abdomen and Pelvis was scanned with the patient with an adequately filled bladder.

Procedure for Computed Tomography

CT was performed using Siemens Somatom Volume Zoom scanner in department of Radio diagnosis, Sri Satya Sai Institute of Higher Medical Sciences, Whitefield and Siemens Somatom Plus 4 scanner in Depatment of imaging sciences, Prashanthigram respectively. For CT, the patients were requested to come fasting. First, a non-contrast CT of the abdomen and pelvis with 3mm contiguous slices was obtained from domes of diaphragm.

Non ionic contrast media was injected into a peripheral vein in the upper limb at the rate of 3ml per second using a pressure injector and 3mm contiguous slices were obtained, with reconstruction interval of 3-5mm at the pitch of 6-8. Post contrast images were acquired after an interval of 90 seconds. A delayed phase (10 minutes or more after

injection of contrast) was also obtained.

OBSERVATIONS & RESULT

Table 1 : Correlation of ultrasound findings with pathology (an observation)

USG findings	True Positive	False Positive	False Negative	True Negative	Total
Bladder wall invasion	27	7	6	13	53
Lymph node detection	2	3	5	43	53
Tumour extention into adjacent viscera prostate , seminal vesicle , rectum, uterus	2	0	1	50	53
Tumour extention into lateral pelvic wall	0	0	0	53	53
Distatnt Metastasis	0	0	1	52	53

Table 2 : Correlation of ultrasound with pathology(an evaluation)

USG findings	Sensitivity	Specificity	PPV	NPV	Accuracy	P value
1.Bladder wall invasion	81.82	65.00	79.41	68.42	75.47	0.001**
2.Lymph node detection	33.33	93.48	40.00	91.49	86.54	0.124
3.Tumour extention into adjacent viscera prostate , seminal vesicle , rectum, uterus	66.67	100.00	100.00	98.04	98.11	0.002**
4.Tumour extention into lateral pelvic wall	-	100.00	-	-	-	-
5.Distatnt Metastasis	0.00	100.00	50.00	98.11	98.11	-

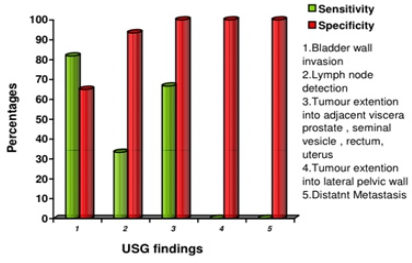


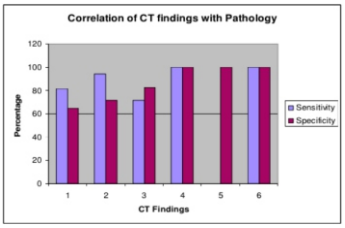
Table 3 – Correlation of CT findings with pathology (an observation)

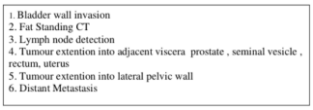
CT findings	True Positive	False Positive	False Negative	True Negative	Total
Bladder wall invasion	27	7	6	13	53
Perivesicle Fat Standing	17	10	1	25	53
Lymph node detection	5	8	2	38	53
Tumour extention into adjacent viscera prostate , seminal vesicle , rectum, uterus	3	0	0	50	53
Tumour extention into lateral pelvic wall	0	0	0	53	53
Distant Metastasis	1	0	0	52	53

Table 4: Correlation of CT and pathology (an evaluation)

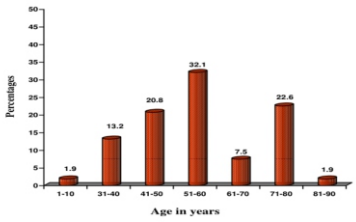
CT findings	Sensitivity	Specificity	PPV	NPV	Accuracy	P value
1. Bladder wall invasion	81.82	65.00	79.41	68.42	75.47	0.001**
2. Fat Standing CT	94.44	71.43	62.96	96.15	79.25	<0.001**
3. Lymph node detection	71.43	82.61	38.46	95.00	81.13	0.007**
4. Tumour extention into adjacent viscera prostate , seminal vesicle , rectum, uterus	100.00	100.00	100.00	100.00	100.00	<0.001**
5.Tumour extention into lateral pelvic wall	-	100.0	-	-	-	-
6.Distant Metastasis	100.00	100.00	100.00	100.00	100.00	0.019*

Bar graph showing Correlation of CT findings with pathology.

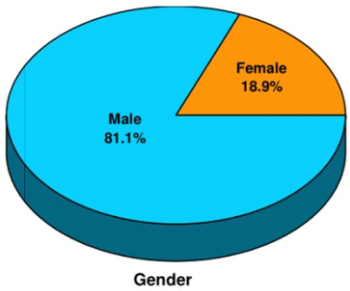




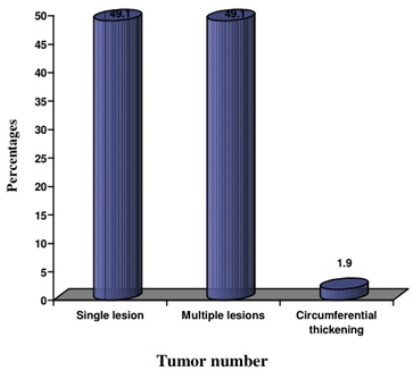
Bar graph showing age distribution of patients studied



Pie chart showing gender distribution of patients studied



Bar graph showing number of tumors in patients studied.



Bar graph showing distribution of tumour morphology.

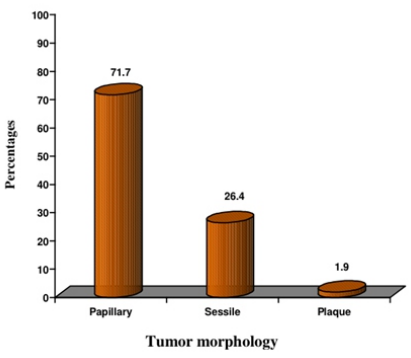
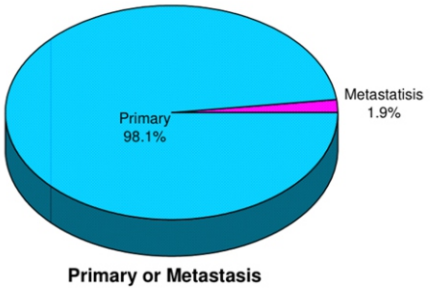
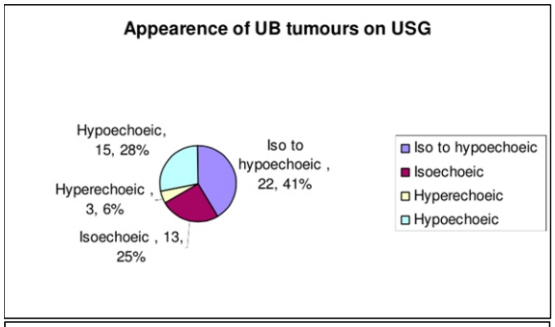


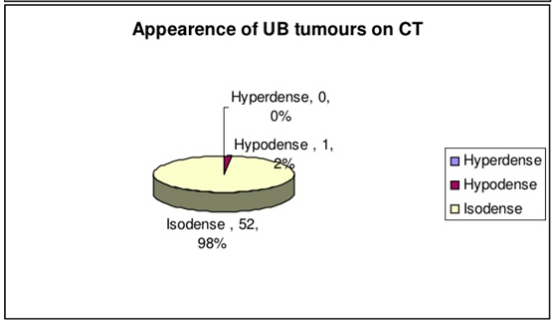
Table : Showing tumor type at pathology

Tumour type	Number	%	95%CI
1.Urothelial tumour	47	88.7	77.42-94.71
2.Squamous cell tumour	2	3.8	1.04-12.75
3.Adenocarcinoma	2	3.8	1.04-12.75
4.Rhabdomyoscarcoma	1	1.9	0.3-9.94
5.Mixed - Adenosquamous	1	1.9	0.3-9.94

Pie chart showing distribution between primary and metastatic lesion







OBSERVATIONS AND ANALYSIS

Among 53 patients in our study group the **age** of the patients ranged from 6 – 83 years. Majority of the patients were in the 5th- 6th decade (32.1%) at the time of presentation. There were 43 males (81.1%) and 10 of them females (18.9%) in the study group . The Male to female ratio was 4.3 : 1

Histopathological diagnosis of the urinary bladder tumour in our study was as follows , urothelial tumour (TCC) was present in 47(88.7%) patients, squamous cell tumour in 2 (3.8%) patients , adenocarcinoma in 2 (3.8%) patients , rhabdomyoscarcoma in 1 (1.9%) patient and mixed - adenosquamous in 1 (1.9% %) patient.

Of the 53 patients who were known cases of the urinary bladder tumour primary tumour of the bladder was found in 52 (98.1%) and metastatic tumour was found in 1(1.9 %) patient.

Clinical symptoms in our study group in the descending order were gross hematuria in 42 patients (79. 2 %), incidentally detected microscopic hematuria in 5 (9.4 %) patients , urinary tract infection in 3 patients **(** 5.7 %) and increased frequency of micturation in 3 patients (5.7%).

Morphology of the tumour as was similar for both USG and CT which was : 38 (71.7%) patients with papillary masses (polypoidal), 14 (26.4%) sessile tumours and 1(1. 9%) patient with plaque like growth.

Tumour location : at the base (Trigone) of bladder in 17 (32.1%) patients, lateral wall (right or left) in 9 (17%) patients, anterior wall in 2 (3.8 %) patients, posterior wall in 1 patient (1.9 %), multifocal in 23 (43. 4 %) patients and dome of the bladder in 1 (1.9 %) patient. Which was similar to both USG and CT.

Tumour sizes ranged from 1cm to 9.6 cms, there was no difference of more than 1-3 mm in the size of the tumours as compared with USG , CT and Gross pathological readings .

Number of Lesions Single lesion was found in 26 (49.1 %) patients and multiple lesions was found in 26 patients (49.1%) and Circumferential thickening of bladder wall was found in 1 patient (1.9%) both on USG and CT .

Calcification was detected in 10 out of 11 cases by USG and 11 (100%) cases by CT.

Sonographically Urinary bladder tumurs appeared Isoechoeic to hypoechoeic in 22 (41%) patients , isoechoic in 13 (25%) patients , hypoechoic in 15 (28%) patients and were hyperechoic in 3 (6%) patients.

No cases showed totally anechoic pattern or with posterior acoustic enhancement.

Tumour assessment and Staging by Ultrasound

Tumour wall invasion was detected in 27(sensitivity 81.1 % specificity of 65 %) cases correctly and missed in 6 cases . Pelvic Lymph node enlargement was detected in 2 (sensitivity of 33. 33 % and specificity of 93.48) patients and was missed in 5 paients . Tumour extention into adjacent viscera such as the prostate , seminal vesicle , rectum, uterus was detected in 2 (sensitivity of 66.67 % and specificity of 100% and accuracy of 100%) cases and missed in 1 case on ultrasound. There was no urinary bladder tumour that was noted to extend into lateral pelvic wall in our study. Distant Metastasis was not detected in any of the cases by USG.

Tumour assessment and Staging by CT

On Non enhanced CT scan Urinary bladder tumours appeared isodense to adjacent pelvic muscle 52 (98%) cases, hypodense in1(2%) patient.

Calcification was detected in 11 cases out of the 11 (100%) cases which had calcification on histopathological studies.

Majority of the cases showed homogenous enhancement with post contrast studies. Tumour wall invasion was correctly diagnosed in 27 (81.82 % sensitivity , specificity of 65 % and an accuracy of 75.47%)

Perivesicle fat stranding secondary to tumour invasion was correctly diagnosed in 17 (94.44 % sensitivity , specificity of 71.43 % and accuracy of 79.25%) patients . Pelvic lymph node enlargement was detected in 5 (71.43 sensitivity , specificity of 82.61% and accuracy of 81.13%) patients and was missed in 2 patients.

Tumour extension into adjacent viscera such as the prostate , seminal vesicle , rectum, uterus was detected in 3 (100 % sensitivity , specificity of 100% and accuracy of 100%) cases. There was no urinary bladder tumour that was noted to extend into lateral pelvic wall in our study. Distant metastasis to the vertebra was detected in 1 patient (sensitivity of 100 % , specificity of 100% and accuracy of 100%)

DISCUSSION

Among 53 patients in our study, age of the patients ranged from 6 – 83 years. Majority of the patients were in the 5th-6th decade (32.1%) at the time of presentation.

There were 43 males (81.1%) and 10 of them females (18.9%) in the study group . The Male to female ratio was 4.3 : 1

Out of the 53 patients in our study the Urothelial tumour was present in 47(88.7 %) patients, Squamous cell tumour in 2 (3.8 %) patients , Adenocarcinoma in 2 (3.8 %) patients , Rhabdomyoscarcoma in 1 (1.9 %) patient and Mixed - Adenosquamous in 1 (1.9 %) patient. Our study is comparable with the study done by Dibb MJ e al which showed that the commonest tumour of the bladder was the urothelial tumour followed by adenocarcinoma and subsequently followed by sarcoma . Of 109 patients reviewed by them , 104 had transitional cell carcinoma, 3 adenocarcinoma, 1 carcinosarcoma, 1 prostatic carcinoma**.**

Of the 53 patients who were known cases of the urinary bladder tumour primary tumour of the bladder was found in 52 (98.1%) and metastatic tumour was found in 1(1.9 %) patient.

The clinical symptoms in our study group in the descending order were

gross hematuria in 42 patients (79.2 %), incidentally detected microscopic hematuria in 5 (9.4 %) patients , urinary tract infection in 3 patients (5.7 %) and increased frequency of micturation in 3 patients (5.7%)

In our study we came across 38 (71.7%) patients with papillary masses (polypoidal), 14 (26.4%) Sessile tumours and 1 (1. 9%) patient with plaque like growth. Our Study is comparable to the study by Dibb MJ et al where their study showed 67 (51.5%) tumors were polypoidal, 47 (36.2%) were sessile and 16 (12.3%) plaque-like. Thus concluding that the polypoidal mass was the commonest appearance of the urinary bladder tumour irrespective of the histopathological diagnosis.

The location of the tumour : at the base (Trigone) of bladder in 17 (32.1%) patients, lateral wall (right or left) in 9 (17%) patients, anterior wall in 2 (3.8 %) patients, posterior wall in 1 patient (1.9 %), multifocal in 23 (43. 4 %) patients and dome of the bladder in 1 (1.9 %) patient. Thus in our study we found that the commonest location for a single Urinary bladder tumour was found to be the trigone of the bladder followed by the lateral wall, anterior wall and lowest frequency of tumour occurring in the posterior wall and dome of bladder. In the study conducted by Dibb MJ et al , the tumor involved the trigone was 63 (48.5%), lateral wall 32

(24.6%), posterior wall 17 (13.1%), anterior wall 5 (3.8%) or was multifocal 13 (10%). Therefore concluding that the trigone of the bladder is the commonest site for the occurrence of bladder carcinoma.

Contrary to the study conducted by Dibb MJ et al {53} we in our study found that multifocal lesions which occurred in more than one wall was the most common feature, and the frequency of the tumours occurring in the anterior wall was higher than those occurring in the posterior wall.

Tumor sizes ranged from 1cm to 9.6 cms , there was no difference of more than 1-3 mm in the size of the tumors as compared with USG , CT and gross pathological readings.

Single lesion was found in 26 (49.1 %) patients and multiple lesions was found in 26 patients (49.1%) and Circumferential thickening of bladder wall was found in 1 patient (1.9%). In the study by Dibb MJ et al, a total of 130 tumors (including 13 multifocal tumors) were detected with 30 (27.5%) patients having more than one tumor in the bladder. Thus in comparison we found that the patients with single and multiple lesions were equal in our study group.

In our study calcification was detected in 11 (20.7 %) cases as compared to the study done by Dibbs MJ et al which found the presence of calcification in 54 (41.5%) tumors. In our study we found that the percentage of tumoral calcification was not as high as that found by Dibb MJ et al {53}.

Sonographically Urinary bladder tumours appeared Isoechoeic to hypoechoeic in 22 (41%) patients , isoechoic in 13 (25%) patients , hypoechoic in 15 (28%) patients and were hyperechoic in 3 (6%) patients. No cases showed totally anechoic pattern or with posterior acoustic enhancement.

Tumour assessment and Staging by Ultrasound

Tumour wall invasion was detected in 27(sensitivity 81.82% specificity of 65 %) cases correctly and missed in 6 cases . Tumour extension into adjacent viscera such as the prostate , seminal vesicle , rectum, uterus was detected in 2 (sensitivity of 66.67 % and specificity of 100% and accuracy of 100%) cases and missed in 1 case on ultrasound. Pelvic lymph node enlargement was detected in 2 (sensitivity of 33.33 % and specificity of 93.48%) patients and was missed in 5 patients There was no urinary bladder tumour that was noted to extend into lateral pelvic wall in our study . Distant Metastasis was not detected in any of the cases by USG.

Tumour assessment and Staging by CT

On Non enhanced CT scan Urinary bladder tumours appeared isodense to adjacent pelvic muscle 52 (98%) cases, hypodense in 1 (2%) patient.

Calcification was detected in 11 cases out of the 11 (100%) cases which had calcification histopathological studies. Majority of the cases showed homogenous enhancement with post contrast studies. Tumor wall invasion was correctly diagnosed in 27(81.82% sensitivity, specificity of 65 % and an accuracy of 75.47%)

Perivesicle fat stranding secondary to tumor invasion was correctly diagnosed in 17 (94.44% sensitivity, specificity of 71.43 % and accuracy of 79.25%) patients. Our study is comparable by the study conducted by Janet E. S. Husband et al which showed similar findings such as accuracy of 80% , sensitivity of 94% and specificity, 62% in the detection of perivesicle fat stranding due to tumour invasion . Pelvic lymph node enlargement was detected in 5 (71.43 % sensitivity, specificity of 82.61% and accuracy of 81.13%) patients and was missed in 2 patients. Our study is comparable to the study done by Carlisle L. Morgan M et al where overall accuracy of pelvic lymph node evaluation by CT was 79 % in 34 patients.

Tumour extention into adjacent viscera such as the prostate , seminal vesicle , rectum, uterus was detected in 3 (100 % sensitivity , specificity of 100% and accuracy of 100%) cases. There was no urinary bladder tumour that was noted to extend into lateral pelvic wall in our study . Distant metastasis to the vertebra was detected in 1 patient (sensitivity of 100 % , specificity of 100% and accuracy of 100%) .

LIMITATIONS OF OUR STUDY

1. Patients whose creatinine values were high and who were contraindicated for a Contrast enhanced CT were not included in the study.
2. Cases with histopathological diagnosis of Urinary bladder tumour were included in our study.
3. Follow-up for recurrence of tumour after surgery were not evaluated.
4. No case of Urinary bladder tumour of less than 1cm in size was present in our study.

SUMMARY

Fifty three patients suspected of having urinary bladder tumours were studied prospectively. For all the cases US and CT was done. The cases who were operated and were histologically proved as Urinary bladder tumour were studied.

The following conclusions were made from our study.

Urinary bladder carcinoma are more common in males and in fifth decade of life. The commonest symptom being that of gross hematuria. The most common imaging appearance of Urinary bladder tumour is a solid polypoidal mass.

Both US and CT are effective in picking up lesions in clinically symptomatic patients. Most of them are isoechoic to hypoechoeic on US and isodense on CT with homogenous enhancement on contrast study.

US is as effective as CT in demonstrating the morphology and location of neoplasm. Both US and CT have limitation in differentiating T1 , T2a and T2b. CT is better in demonstrating perivesicle fat stranding (T3a and T3b) , lymph node enlargement (N), adjacent organ invasion (T4a) and (T4b) and metastases (M1) as compared to US. Therefor CT is superior to US in staging the tumour.

On the basis of this study it is suggested that sonography should be the initial modality of imaging whenever Urinary bladder carcinoma is suspected as it is cost effective, it is as accurate as CT in detecting bladder masses in clinically symptomatic patients.

It is further suggested that CT is more helpful in cases with indeterminate sonographic findings, poor sonographic visualization due to obesity , excessive bowel gas shadows, extra abdominal metastases and tumor staging

CONCLUSION

- Urinary Bladder carcinoma is more common in males.
- An increasing frequency for the occurrence of peaking during the fifth decade.
- Characteristic and commonest presenting feature is gross hematuria.
- Most common location for a urinary bladder neoplasm is the trigone of the bladder.
- Most of the Urinary bladder neoplasms are polypoidal in shape

irrespective of the histopathological diagnosis.

- On ultrasound most of the Urinary bladder tumours appear isoechoic to hypoechoeic and on non enhanced CT majority of them are isodense.
- On contrast enhanced CT the Urinary bladder neoplasms enhance homogenously.
- Both US and CT have limitation in differentiating Stage TI from T2a and T2b.
- CT is superior to US in detecting perivesicle extension , lymphnodes, involvement of the adjacent viscera and distant metastasis.
- US should be the initial modality in investigating patients who present with clinical symptoms suggestive of Urinary bladder neoplasms.
- CT should be done for staging the tumour and in lesions with indeterminate sonographic findings.

References:

1. KavaranaNM,KamatMR,KurkureAP,etal.Nationalcancer registry project. ICMR: 2000 published in 2003.
2. JingboZhang,MDa,*,ScottGerst,MDb,RobertA.Lefkowitz, Ariadne Bach, MDb Imaging of Bladder Cancer Radiol Clin N Am 45 (2007) 183–205
3. HowardHPollack-TumoursoftheurotheliumSeminarsin Roengenology Vol.XXX, No.2 ,April 1995 : 149 – 167
4. Amling CL.Department of Urology, Naval Medical Center, San Diego, California, USA. : Diagnosis and management of superficial bladder cancer. Curr Probl Cancer. 2001 Jul-Aug;25(4):219-78.
5. Murphy WM, Grignon DJ, Perlman EJ. Tumors of the kidney, bladder, and related urinary structures. Washington, DC: American Registry of Pathology; 2004. p. 394.
6. Mostofi FK, Davis CJ, Sesterhenn IA. Pathology of tumors of the urinary tract. In: Skinner DG, Lieskovsky G, editors. Diagnosis and management of genitourinary cancer. Philadelphia: WB Saunders; 1988. p. 83–117.
7. Wilson TG, Pritchett TR, Lieskovsky G, et al. Primary adenocarcinoma of bladder. Urology 1991;38(3):223–6.
8. Kakizoe T, Matsumoto K, Andoh M, et al. Adenocarcinoma of urachus. Report of 7 cases and review of literature. Urology 1983;21(4):360–6.
9. Kantor AF, Hartge P, Hoover RN, et al. Urinary tract infection and risk of bladder cancer. Am J Epidemiol 1984;119(4):510–5.
10. Wong-You-Cheong JJ, Woodward PJ, Manning MA, et al. From the Archives of the AFIP: neoplasms of the urinary bladder: radiologic- pathologic correlation. Radiographics 2006;26(2):553– 80.
11. Reuter VE. Pathology of bladder cancer: assessment of prognostic variables and response to therapy. Semin Oncol 1990;17(5):524–32.
12. J. N. Kulkarni, G. K. Bakshi Staging of transitional cell carcinoma: Has anything changed? Indian Journal of Urology ; January-March 2008
13. Vineis P, Simonato L. Proportion of lung and bladder cancers in males resulting from occupation: a systematic approach. Arch Environ Health 1991;46(1):6–15.
14. Markowitz SB, Levin K. Continued epidemic of bladder cancer in workers exposed to orthotoluidine in a chemical factory. J Occup Environ Med 2004;46(2):154–60.
15. Popp W, Schmieding W, Speck M, et al. Incidence of bladder cancer in a cohort of workers exposed to 4-chloro-o-toluidine while synthesising chlordimeform. Br J Ind Med 1992; 49(8):529–31.
16. Schulte PA, Ringen K, Hemstreet GP, et al. Risk assessment of a cohort exposed to aromatic amines. Initial results. J Occup Med 1985; 27(2):115–21.
17. Schulte PA, Ringen K, Hemstreet GP, et al. Risk factors for bladder cancer in a cohort exposed to aromatic amines. Cancer 1986;58(9):2156–62.
18. Steenland K, Palu S. Cohort mortality study of 57,000 painters and other union members: a 15-year update. Occup Environ Med 1999; 56(5):315–21.
19. Marrett LD, Hartge P, Meigs JW. Bladder cancer and occupational exposure to leather. Br J Ind Med 1986;43(2):96– 100.
20. Gaertner RR, Theriault GP. Risk of bladder cancer in foundry workers: a meta-analysis. Occup Environ Med 2002;59(10):655– 63.
21. Theriault G, Tremblay C, Cordier S, et al. Bladder cancer in the aluminum industry. Lancet 1984;1(8383):947–50.
22. Boffetta P, Silverman DT. A meta-analysis of bladder cancer and diesel exhaust exposure. Epidemiology 2001;12(1):125–30.
23. Browne RF, Meehan CP, Colville J, et al. Transitional cell carcinoma of the upper urinary tract: spectrum of imaging findings. Radiographics 2005;25(6):1609–27.
24. Bedwani R, Renganathan E, El Kwhsky F, et al. Schistosomiasis and the risk of bladder cancer in Alexandria, Egypt. Br J Cancer 1998;77(7): 1186–9.
25. Kaldor JM, Day NE, Kittelmann B, et al. Bladder tumours following chemotherapy and radiotherapy for ovarian cancer: a case–control study. Int J Cancer 1995;63(1):1–6.
26. Travis LB, Curtis RE, Glimelius B, et al. Bladder and kidney cancer following cyclophosphamide therapy for non-Hodgkin's lymphoma. J Natl Cancer Inst 1995;87(7):524–30.
27. Kiemeney LA, Schoenberg M. Familial transitional cell carcinoma. J Urol 1996;156(3): 867–72.
28. Kramer AA, Graham S, Burnett WS, et al. Familial aggregation of bladder cancer stratified by smoking status. Epidemiology 1991;2(2):145–8.
29. Aben KK, Witjes JA, Schoenberg MP, et al. Familial aggregation of urothelial cell carcinoma. Int J Cancer 2002;98(2):274–8.
30. Czene K, Lichtenstein P, Hemminki K. Environmental and heritable causes of cancer among 9.6 million individuals in the Swedish Family Cancer Database. Int J Cancer 2002;99(2): 260– 6.
31. Motzer RJ, Bander NH, Nanus DM. Renal cell carcinoma. N Engl J Med 1996;335(12): 865–75
32. Curry III, TS, Dowdwey JE, Marry RC, Christensen's Physics of diagnostic radiology, 4th edition. Philadelphia: Lea and Febiger, 1990:323-371.
33. Meire H, Farrant P. A historical overview. In: Meire H., Farrant P. editors. Basic Ultrasound: A historical overview. John Wiley and Sons Publications, 1995:1-7.
34. Hounsefield GN: Computerized transverse axial scanning (tomography).PartI: Description of the system. BJ Radiology 1973; 46: 1016.
35. Schellinger D, Dichiro G, Axelbaum SP, et al: Early clinical experience with the ACTA scanner. Radiology 1975; 114: 257.
36. Alfidi RJ, Hagga J, Meaney TF, et al : Computed Tomography of the thorax and abdomen. A preliminary report. Radiology 1975; 117:257
37. Macvicar AD. Bladder cancer staging. BJU Int 2006;86:111-22.
38 T.W. Sadler: Urogenital system. In Langman's Medical Embryology textbook. Lipincott Williams and Wilkins;10 edition: 2006; 229-235.
39. Text book of Urology : Campbell-Walsh Urology, 9th ed. 2007 Saunders
40. Text book of Anatomy : Grays anatomy
41. Owen J. O'Connor, MD, MRCSIa,b, Sean E. McSweeney, MB, MRCSI, FFR(RCSI) Michael M. Maher, MD, FRCSI, FFR(RCSI), FRCR, Imaging of Hematuria , Radiol Clin N Am 46 (2008) 113– 132
42 Jason T. Wong, MD , Neil F. Wasserman, MD , Adrian M. Padurean, MD Bladder Squamous Cell Carcinoma RadioGraphics 2004; 24:855–860 .Published online 10.1148/rg.243035153
43. Kawashima A, Glockner JF, King BF Jr. CT urography and MR urography. Radiol Clin North Am 2003;41:945–61.
44. McLean GK, Pollack HM, Banner MP. The "stipple sign"— urographic harbinger of transitional cell neoplasms. Urol Radiol 1979;1(2): 77–9.
45. Brennan RE, Pollack HM. Nonvisualized ("phantom") renal calyx: causes and radiological approach to diagnosis. Urol Radiol 1979; 1(1):17–23.
46. Noroozian M, Cohan RH, Caoili EM, et al. Multislice CT urography: state of the art. Br J Radiol 2004;77:S74–86.
47. Caoili EM, Inampudi P, Cohan RH, et al. Optimization of multi- detector row CT urography: effect of compression, saline administration, and prolongation of acquisition delay. Radiology 2005;235:116–23.
48. Chai RY, Jhaveri K, Saini S, et al. Comprehensive evaluation of patients with haematuria on multi-slice computed tomography scanner: protocol design and preliminary observations. Australas Radiol 2001;45:536–8.
49. Chow LC, Kwan SW, Olcott EW, et al. Splitbolus MDCT urography with synchronous nephrographic and excretory phase enhancement. AJR Am J Roentgenol 2007;189:314–22.
50. Schoder H, Larson SM. Positron emission tomography for prostate, bladder, and renal cancer. Semin Nucl Med 2004;34(4):274–92. 100
51. Janet E. S. Husband, FRCP, FRCR #{149} Julie F. C. Olliff, MRCP, FRCR #{149}Michael P. Williams, MA, FRCR Christine W. Heron, MRCP, FRCR2 #{149}Graham R. Chennyman, FRC. Bladder Cancer: Staging with CT and MR Imaging' Radiology 1989; 173:435-440
52. Carlisle L. Morgan, M.PhiL., Ph.D., M.D., Ronald F. Calkins, M.D., and Eduardo J. Cavalcanti, M.D. Computed Tomography in the Evaluation, Staging, and Therapy of Carcinoma of the Bladder and Prostate'
53. Dibb MJ, Noble DJ, Peh WC, Lam CH, Yip KH, Li JH, Tam PC. Department of Diagnostic Radiology, The University of Hong Kong, Hong Kong, China. Ultrasonographic analysis of bladder tumors. Clin Imaging. 2001 Nov-Dec;25(6):416-20