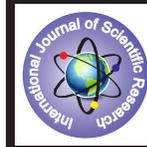


A Retrospective Analysis of the Accuracy & Role of Ultrasound And MDCT in the Evaluation of Traumatic & Non- Traumatic Bladder Pathologies



Medical Science

KEYWORDS : Urinary Bladder, bladder rupture, bladder tumor

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ABSTRACT

Objective:

To evaluate the role of ultrasound and MDCT in traumatic and non traumatic bladder pathologies

Materials & Methods:

This was a retrospective study conducted over a period of one and half years from March 2014 to October 2015. Out of the 65 patients initially sent for KUB assessment by ultrasound, 50 patients were identified to have urinary bladder related pathology either on ultrasound or on further examination by MDCT. Final diagnosis was by surgery/histopathology as applicable. Statistical analysis included percentage frequency, sensitivity and specificity.

Results:

Among the 50 patients included in the study males comprised 74% and females 26%. Ultrasound and MDCT had a combined sensitivity and specificity of 95.8% and 88.2% respectively in accurately identifying various bladder pathologies.

Conclusion

It is of utmost importance to differentiate between extraperitoneal and intraperitoneal bladder rupture as the treatment for both is different. Accurate and early diagnosis by imaging helps reduce time for management and as well as avoid unnecessary surgery.

Introduction

Urinary bladder pathologies may present as a focal lesion or diffuse wall thickening. Focal masses may be secondary to inflammatory, infectious or even congenital causes. Histopathological evaluation is often necessary as clinical and imaging findings often overlap. In certain conditions such as bladder endometriosis, inflammatory pseudotumors and ureteroceles, imaging features are characteristic and are hence are often first identified by radiologists. Causes of diffuse bladder wall thickening include: infections (bacteria, schistosomiasis, tuberculosis etc), inflammatory causes (eosinophilic cystitis, cystitis cystica) or secondary to chemotherapy or irradiation. Although imaging patterns of these conditions are less characteristic, radiological evaluation is still useful. In this study we review a diverse group of pathologies affecting the bladder including inflammatory, infectious and neoplastic conditions presenting as focal bladder lesions or as diffuse wall thickening.

Materials and Methods

This was a retrospective study conducted over a period of one and half years from March 2014 to October 2015. at the Dept. of Radiology, Father Muller Medical College, Mangalore, India. Father Muller Institutional Ethics Committee approval was obtained prior to the study and patient consents were obtained for use of their radiology images. Out of 65 patients initially sent for KUB assessment by ultrasound, 50 patients were identified to have urinary bladder related pathology either on ultrasound or on further examination by MDCT. Final diagnosis was by histopathology. Statistical analysis included percentage frequency, sensitivity and specificity.

All patients were initially evaluated on ultrasound (Philips IU-22) by an experienced sonologist using standardized examination techniques, terms and definitions. Prior to examination, patients were asked to distend their urinary bladder by drinking 4 to 6 glasses of water. Trans-abdominal Sonography (TAS) was done using a curvilinear probe of 3-5 Mhz. All lesions were evaluated further by colour doppler to assess the vascularity.

In those patients who underwent further evaluation by MDCT

(GE BRIGHT SPEED 16 SLICE scanner), initial plain abdominal CT images were acquired by at 120 kV and 200 mAs to determine baseline HU value and to look for any calcifications. Post contrast images were obtained after administration of 90 ml of non- iodinated contrast (350 mg % w/v) injected at the rate of 3 ml/ second with the help of a Mallinckrodt pressure injector. Arterial, porto-venous and delayed phase images were acquired at 18-22 sec, 60-65 sec and 5 min. respectively. 3D reconstruction using thin sections (1mm) were performed in coronal and sagittal planes for better depiction of the pathology and its extent and involvement of adjacent structures.

Results

Of the initial 65 patients sent for ultrasound KUB (Kidney Ureter Bladder) evaluation, 50 patients were identified to have bladder related pathologies and included in the study. Of these 37 were males (74%) and 13 were females (26%). Final diagnosis was based on surgery/ histopathology. Among the various pathologies which were initially diagnosed by imaging were: Trauma related injuries- 5(10%) [Extraperitoneal bladder rupture- 4, Intraperitoneal bladder rupture- 1], BPH related secondary obstruction- 16(32%), Calculus-7(14%), Ureteroceles- 5(10%), **Bladder carcinomas- 4 (8%), Bladder clot- 2(4%), Cervical carcinoma with bladder invasion- 4(8%), Stricture- 1(2%), Endometriosis- 1(2%), Uterine Leiomyoma- 1(2%), Schistosomiasis- 1(2%), Tuberculosis-3(6%).** Among these there were two false negative and two false positive cases. The two false negatives were a case of bladder growth which failed to show vascularity (probably due to poor gain settings) and was wrongly diagnosed as a clot, and the other was a case of carcinoma of cervix post chemo and radio-therapy sent for evaluation with possible obstructive changes in the collecting system and was wrongly diagnosed as a case of stricture when in fact it was carcinoma recurrence with bladder invasion. The two false positive cases involved a case of uterine endometriosis involving the posterior bladder wall and wrongly diagnosed as a uterine leiomyoma, and the other was a case of a bladder clot in a 62 year old male who presented with hematuria and wrongly diagnosed on imaging to have a bladder carcinoma. As per our study, ultrasound in

combination with contrast MDCT had a sensitivity and specificity of 95.8% and 88.2% respectively in identifying various bladder pathologies. The two limitations noted in our study was the retrospective analysis which can lead to observer bias and the small sample size of our patients.

Table 1

Bladder Pathologies Diagnosed on Imaging (USG & MDCT)	Frequency (n)	Percentage (%)
Trauma	5	10%
Extraperitoneal Rupture (n=4)		
Intraperitoneal Rupture (n=1)		
Benign Prostatic Hyperplasia (BPH)	16	32%
Calculus	7	14%
Ureterocele	5	10%
Carcinoma	4	8%
Clot	2	4%
Cervical Carcinoma with bladder invasion	4	8%
stricture	1	2%
Endometriosis	1	2%
Uterine Leiomyoma	1	2%
Urachal cyst	1	2%
Tuberculosis	3	6%
Total	50	100%

Table 2.

Final Diagnosis of Bladder Pathologies Based on Surgery/Histopathology	Frequency (n)	Percentage (%)
Trauma	5	10%
Extraperitoneal Rupture (n=4)		
Intraperitoneal Rupture (n=1)		
Benign Prostatic Hyperplasia (BPH)	16	32%
Calculus	7	14%
Ureterocele	5	10%
Carcinoma	5	10%
Clot	1	2%
Cervical Carcinoma with bladder invasion	5	10%
Endometriosis	2	4%
Urachal cyst	1	2%
Tuberculosis	3	6%
Total	50	100%

Table 3. Sensitivity & Specificity

	n		n
True positive (a)	46	False positive (c)	2
False negative (b)	2	True negative (d)	15

- ☞ Sensitivity= 95.83%
- ☞ Specificity= 88.24%
- ☞ Positive predictive value= 95.83%
- ☞ Negative predictive value= 88.24%

Discussion

Radiologists play a crucial role in the evaluation of genitourinary pathology. In pathologies involving the urinary bladder, especially in trauma and certain non-traumatic conditions an early and accurate diagnosis is of utmost importance as it may not only save the patient's life but also avoid unnecessary surgeries. The purpose of our study was to highlight and describe the must know pathologies of urinary bladder on imaging that may be encountered by radiologists on a day to day basis with a brief review of literature.

Bladder Trauma

Injury to the urinary bladder may result from either blunt or penetrating trauma. The risk for bladder injury is proportional to the degree of bladder distension at the time of impact. Urinary bladder trauma is often associated with other injuries and has a high mortality rate of up to 44%. Therefore an early and accurate diagnosis is imperative. [1-3] Based on CT cystography bladder injuries maybe classified into 5 types: Type 1- Bladder Contusion; Type 2- Intraperitoneal Rupture (10-20%); Type 3- Interstitial Bladder Injury; Type 4- Extraperitoneal Rupture (80-90%); and Type 5- Combined Bladder Injury (5-12%). [4]

On CT cystography bladder contusions usually appear normal. Intraperitoneal bladder rupture shows intraperitoneal contrast material around bowel loops, between mesenteric folds and in the paracolic gutters. Interstitial bladder injury is rare and demonstrates as an intramural or partial thickness laceration with intact serosa. Extraperitoneal bladder rupture is usually caused by bladder rupture and on CT cystography the extravasated contrast is confined to the perivesical space in simple rupture giving a classical 'flame shaped' appearance, whereas in the complex subtype the contrast extends beyond the perivesical space and may extend into different fascial planes. In the combined type of rupture CT cystography demonstrates patterns of both extra and intra- peritoneal bladder rupture. [4,5]



Extraperitoneal bladder rupture (1a&b) in a 24 year old male patient with post contrast CT axial and coronal reformatted images showing perivesical extravasation of contrast material and the classical 'flame shaped' appearance (arrow).
Intraperitoneal bladder rupture (1c&d) in a 54 year old male patient with coronal and sagittal reformatted images showing a rent in the dome of the bladder and extraluminal location of the Foley's catheter and accumulation of contrast in the peritoneum.

Vesical Calculus

Similar to renal calculi bladder calculi comprises of calcium oxalate and calcium phosphate. Calculi maybe laminated, faceted, speculated or seedlike in appearance.[6] Urinary bladder stones are usually secondary to lower urinary tract obstruction. Vesical diverticula can cause urinary stasis leading to stone formation. Rarer causes include trauma, catheterisation, neurogenic bladder, foreign body etc. Giant Vesical calculi are rare. Patients with giant bladder calculus present with recurrent urinary tract infection, azotaemia and retention of urine. On radiographs they maybe single or multiple and appear as radio-opaque structures. On ultrasound they're usually mobile, echogenic and show distal shadowing. [7,8]

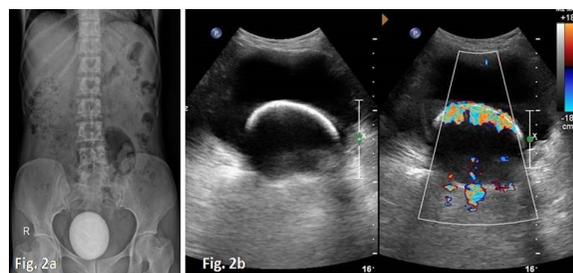


Figure 2. Abdominal radiograph (2a) and Ultrasound (2b) images of a 53 year old female patient with a large Vesical calculus. On abdominal radiograph the large calculus appears laminated and disc shaped, and on ultrasound it appears as a curvilinear echogenic structure with twinkling artifact on colour doppler

Bladder Tuberculosis

Genitourinary Tuberculosis (TB) always involves the upper tracts with the bladder being secondarily involved. TB of the urinary bladder occurs from direct infection with Mycobacterium tuberculosis or rarely from Bacillus Calmette- Guerin (BCG) therapy for urothelial carcinoma. Clinical symptoms include dysuria, urgency, frequency and hematuria. Patients who have refractory cystitis with sterile pyuria or originating from TB endemic zones, genitourinary TB must be considered as a differential diagnosis. On ultrasound in the acute phase, findings include diffuse wall thickening with trabeculation and irregular

mucosal masses. [9] On urography, bladder mucosa appears irregular with or without stricture and thickening of the ureter leading to obstruction and vesicoureteric reflux. In the chronic phase there is fibrosis of the bladder leading to a thickened and contracted bladder with markedly reduced volume. Bladder wall calcification is often rare and maybe seen only during the healing stage. [10]

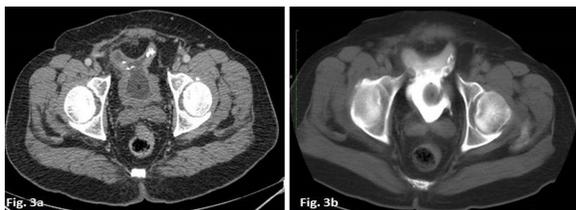


Figure 3. Venous (3a) and delayed phase (3b) axial CT sections of a 61 year old male patient showing a contracted bladder with calcification and diminished volume. The patient had multiple enlarged mesenteric and retroperitoneal lymph nodes, in addition to findings in bilateral kidneys and ureters. This was a proven case of **Genitourinary TB**.

Endometriosis

Although the urinary tract is an uncommon site for endometriosis, when it is involved the urinary bladder is the most common site affected. Endometriosis of urinary bladder may occur spontaneously by direct implantation or after surgery of the pelvis. Cyclical hematuria is highly suggestive of urinary bladder endometriosis. On imaging, these lesions present as non specific filling defects usually located posterior, with variable protrusion into the bladder lumen and inseparable from uterus. [11,12] Trans-abdominal (TAS) and Transvaginal Sonography (TVS) is the initial modality of choice for evaluation of suspected bladder endometriosis. On ultrasound these lesions present as localized wall thickening which leads to the differential diagnosis of endometriosis, leiomyoma and bladder carcinoma. MRI is more superior compared to other modalities and the typical imaging patterns include hyperintensity on fat suppressed and non fat suppressed T1 and T2 weighted images. [13]

Bladder Schistosomiasis

Urinary bladder schistosomiasis is a major health condition in developing parts of the world. The infection is usually caused by *Shistosoma haematobium* species. The larvae are released from snails into water and enter human skin on exposure to contaminated water. These larvae then travel to the lungs and liver of the human host and later on maturation deposit eggs in the bladder wall vessel inciting a granulomatous response resulting in polypoidal masses. During this time eggs are excreted in urine. [14] The eggs can incite a chronic inflammatory response and fibrosis which can later lead to squamous cell carcinoma. 10-12 weeks post infection hematuria is the first clinical sign. Dysuria and hematuria are seen in both early and late stages of the disease. Proteinuria often with values in the nephritic range can present as a late manifestation. [15, 16] On imaging, bladder calcifications are seen initially at the base, leading to a linear pattern running parallel to the upper border of the pubic bone, eventually encircling the entire bladder. [44] The classical imaging pattern of a calcified bladder resembling a fetal head in the pelvis is highly characteristic of chronic urinary tract schistosomiasis. Other patterns of calcifications that have been described include- fine granular, fine linear and thick irregular calcification. [18-20] Chronica irritation of the bladder may later on lead to cystitis cystica or cystitis glandularis. [21,22]

Bladder Carcinoma

The most common bladder carcinoma is the urothelial (transitional cell) carcinoma. Significant overlap exists in the clinical details and imaging findings of various bladder tumor subtypes and therefore they all eventually require biopsy for diagnosis. Ultrasound is often the initially modality used, and the tumor appears as a papillary hypoechoic mass or focal area of wall thickening. On Doppler, vascularity within the lesion aids in dif-

ferentiating the tumor from a blood clot. On CT these lesions appear as an intraluminal papillary or nodular mass or as an area of focal wall thickening. Calcifications may be seen in 5% of cases. The lesions show early enhancement on contrast administration. [23, 24]

As disease progresses, diffuse wall thickening maybe seen. Hydroureteronephrosis may be due to ureteral involvement. MRI has certain advantages over CT, such as its ability to delineate the various wall layers. [25] On T1WI urine appears dark while the bladder wall and the mass are of intermediate signal intensity. T1 weighted sequences are optimal for detection of extravescical infiltration, nodes and bone metastases. T2 weighted sequences are useful for evaluation of tumor depth and differentiating tumor from fibrosis. Post gadolinium administration, bladder tumor enhances avidly and earlier compared to other tissues. MR is also superior for detection of bone marrow involvement. [26,27]

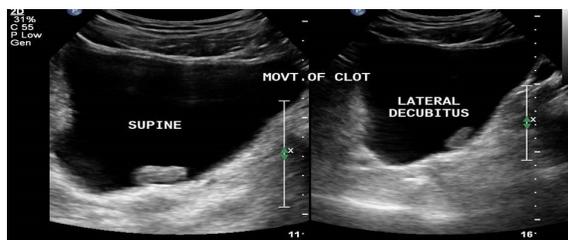


Figure 4. Ultrasound axial sections of the bladder showing a mobile clot within the bladder lumen.



Figure 5. A rare case of histopath proven **Transitional Cell Carcinoma (arrow)** of urinary bladder in a 16 year old female patient.

External Masses Presenting as Bladder Filling Defects

Along with the above mentioned pathologies several other entities can protrude into the bladder lumen and mimic as a mass. These include masses of prostatic, uterine, cervical and ovarian origin; ureteroceles; urachal cysts, paraganglionic tissue, vascular malformation etc.

Benign Prostatic Hyperplasia may protrude into the bladder base simulating a bladder mass and hence need to be differentiated. On ultrasound and CT, site and origin of the mass is more diagnostic than the imaging appearance. Benign prostatic hyperplasia on MRI consist of rounded nodules of varying sizes that show hyperintensity on T2WI and variable amount of hypointensity due to fibrosis. [28]

Ureteroceles can also present with bladder filling defects. They result from a congenital obstruction of the ureteric meatus leading to saccular dilatation of intramural segment of the ureter. Females are more prone to ureteroceles when compared to males with a 4-7:1 ratio. 10% of ureteroceles are bilateral. On ultrasound they classically present as a fluid filled intraluminal lesion arising from the bladder wall. An associated ureteral jet can

confirm the diagnosis. On urography a radiolucent rim maybe seen around the urteroceles referred to as the 'cobra sign'. CT/MR urography allows a more detailed study, and ureteroceles present as filling defects. [29]

Conclusion

On imaging bladder pathologies may present as a focal mass or as diffuse wall thickening requiring further evaluation. Although neoplasms involving the urinary bladder are common, several non neoplastic and inflammatory conditions can have similar imaging patterns and mimic malignancy. Some of these conditions such as schistosomiasis, endometriosis, ureteroceles, BPH have classical imaging patterns and should be identified and diagnosed by the radiologist to prevent unwarranted radical surgery. Diffuse bladder wall thickening has an extensive list of differential diagnosis requiring a clinico-radiologic and pathological correlation. Regarding bladder traumatic injuries, radiologists play a crucial role in differentiating between extraperitoneal bladder rupture from intraperitoneal rupture, as the treatment for the former is conservative, while that for the latter is surgical. Hence it is of utmost importance to know the imaging patterns of various conditions affecting the urinary bladder.

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