

Diagnosis of Urinary Tract Infection: Medical Imaging or Laboratory Based

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Abstract

Urinary tract infection (UTI) affects women more than males mainly due to smaller urethra and feminine genital anatomy. Symptoms of UTI includes painful micturition, flank pain, fever etc while its signs are pyuria, bacteriuria and tenderness in flank. In order to rule out UTI, laboratory tests are primarily performed, most important are urine routine examination, urine culture and sensitivity test. Radiological evaluation of urinary system is also done to determine the underlying causes of infection and the extent of damage caused to the renal system by the infection.

Key words: Drainage, UTI, Micturition, Pyelonephritis.

Introduction

Urinary tract infection (UTI) is a diverse condition ranging from mild cystitis to severe urosepsis leading to organ failure and death. The probability of UTI is high in females as compared to males because of the smaller urethral size. UTI is classified into 2 types i.e. lower UTI or cystitis and upper UTI or Pyelonephritis. The symptoms of former are fever and painful micturition while for later it is fever, flank tenderness and pain.¹

UTI can be complicated or uncomplicated. Most common bacteria causing UTI include *Escherichia Coli*; transmitted from anus to the urethra.² Other agents include: *Pseudomonas aeruginosa*, *Mycobacterium tuberculosis*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Enterococcus faecium*,³ fungi and viruses.⁴ Risk factors of UTI include: female gender, family history, unhygienic sanitary condition, diabetes mellitus,

uncircumcised and large prostate. Urinary catheters can also cause UTI.⁵

Pyelonephritis is a more complicated condition than cystitis. It can be caused from urinary tract obstruction especially at pelvi-ureteric junction, untreated cystitis and renal abscess.¹

Untreated pyelonephritis can cause severe damage to the kidney resulting in emphysematous pyelonephritis. Treatment of upper and lower UTI includes administration of broad spectrum antibiotics and analgesics/ antipyretics. Oral or intravenous (IV) surgical intervention is required if there is urinary tract obstruction, abscess or emphysema.⁶

Medical imaging (MI) is a very basic diagnostic procedure in which visual representation of body's internal structure is produced utilizing X-rays, along with ultrasonic frequencies, radiofrequencies and γ -radiations.⁷⁻⁹ Radio frequencies are utilized in magnetic resonance imaging.¹⁰ γ -radiations are utilized in nuclear medicine primarily to access the function of an organ.¹¹

UTI, particularly pyelonephritis, is mostly caused by an obstruction to the flow of the urine due to either calculus, tumor, stenosis or abscess/ cystitis. In order to detect these abnormalities, imaging studies are required.¹² Imaging is performed for abnormalities requiring surgical intervention. For diagnosing acute papillary necrosis in children and in cases with rapidly deteriorating renal functions along with pyuria and bacteriuria.¹³

Commonly adopted methods for the diagnosis of Urinary Tract Infection (UTI) along with their pros and cons are compiled and a brief review is presented in this paper.

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NF has done the conceptualization of project and data collection. MS did the literature search. QA has done the statistical analysis. Drafting, revision and writing of the manuscript were done by NF and MS. MJA and AS were the internal peer reviewers.

Table 1: Laboratory Methods for Detection of UTI.

	<i>Laboratory Methods</i>		<i>Procedure</i>	<i>Advantages</i>	<i>Disadvantages</i>
Non-culture methods	Bacteriuria Detection by Urine Microscopy	Gram Staining of Un-centrifuged Bacteria	Specimen is placed on the slide and is allowed to dry. Dried specimen is gram stained and is checked microscopically.	Simplest method. Provides immediate information about the type of infecting pathogen.	Insensitive test. Provides positive results only if the bacterial concentration in the sample is more than 10 ⁵ cfu/ml. Recommended not to be used in outpatient settings.
		Gram Staining of Centrifuged Bacteria	Specimen is mixed and is placed in slide cytospin centrifuge, gram stained and then analyzed under microscope.	Pathogens and cells can be separated and identified on the basis of their structures. Sensitive test.	Less specific.
	Bacteriuria Detection by Nitrite Test		Biochemical reaction of converting nitrate in to nitrite by certain species of bacteria is detected chemically.	Very useful in detecting <i>Enterobacteriaceae</i> .	Cannot identify pathogens associated with urinary tract.
	Pyuria Detection by Urine Microscopy		Can be performed on either centrifuged or un-centrifuged gram stained urine sample. Leucocytes are counted through hemocytometer.	Leucocytes can be observed directly.	Leucocyte count decreases rapidly if the urine is not fresh or is not preserved properly.
	Pyuria Detection by Leucocyte Esterase Test		Human leucocyte produce about ten proteins which react with ester substrate to produce alcohol, acid and colour change proportional to the amount of esterase in the specimen.	Can yield positive test result even if the sample is not preserved properly.	Can yield false positive result when the urine sample gets contaminated with vaginal fluid. Low sensitivity. Low specificity. Low positive predictive value with higher negative predictive value.
	Simultaneous Detection of Bacteriuria and Pyuria		It involves tests for both nitrate conversion and leucocyte esterase.	Both tests used together give better results than if they are used alone. Very useful commercially. Higher specificity.	Difficult to diagnose smaller number of bacteria. Less sensitive. Abnormal urine colour which could be due to the use of certain drugs can affect the tests result.
Culture methods	Routine Bacterial Urine Culture: Important in patients with recurrent UTI, who are not responding to the treatment or who have complicated UTI.		Midstream clean catch urine is collected. Bacteria are allowed to grow at 37°C for 48 hours. Sample is then examined under microscope.	The causative organism is identified. Antimicrobial sensitivity test can be performed on it.	Time consuming

Diagnosis of UTI is primarily laboratory based as shown in Table.¹⁴

Medical imaging is generally performed after clinical evaluation and laboratory findings. It is always indicated if renal calculi, cystitis, tumor, emphysematous pyelonephritis or abscess are suspected.^{15,16} The urine route examination (RE), ultrasound of urinary system and , plain

radiography are followed by a computed tomography (CT) scan.

The most common findings in patients with UTI or pyelonephritis are hydronephrosis, renal calculus, pyonephrosis, renal abscess, renal cystitis, changes in renal parenchyma, change/reduction in kidney size, renal scars, emphysematous pyelonephritis and changes in renal function.¹⁷

The commonly performed imaging studies in case of UTI include plain radiography, intra venous urography, ultrasonography and computed tomography. Rarely Tc99m DTPA scan is performed to evaluate renal function which might have been severely affected by the infection.¹⁸

The advantages of plain radiography are that radio-opaque renal calculus or renal cystitis/ abscess can be ruled out. It can help in measuring the size of kidneys and can locate the position of calculus or presence of air in the urinary tract. Its disadvantage is radiation hazard.

The advantages of intravenous radiography are that the contrast media lines the renal tract and shows clearer image, it shows all the phases of excretion and post-voidal urine in the bladder and identifies any radio-lucent obstruction. Its disadvantages are radiation hazards, contrast reactions and contrast induced nephropathy.

The advantages of ultrasonography are that it has non ionizing radiation, therefore there are no radiation hazards. It can help in measuring the size of kidneys and extent of renal damage, it can detect renal calculus and its size, hydronephrosis and its extent, any dilatation of pelvicalyceal system, or renal cystitis, abscess, calculus and residual post-voidal urine in bladder or any changes in renal parenchyma. Its disadvantages are that sometimes it is difficult to position the patient, it is real time and operator dependent, full bladder is necessary for its evaluation and has a very low contrast resolution.

Computed tomography has advantages that size of kidneys, extent of renal damage, renal calculus and its size, hydronephrosis and its extent, renal cystitis and abscess, calculus and residual post-voidal urine in the bladder, renal parenchymal changes and renal tumor (benign or metastatic) can be assessed. It can help in differentiating between acute and chronic UTI. The disadvantages are that it has ionizing radiations, very high radiation dose is required and contrast hazards can occur if contrast is used.

In plain radiography, anteroposterior view of abdomen is taken either in supine or prone position.¹⁹ During intravenous urography, low osmolar iodinated contrast media is injected intravenously according to the patient's weight. Series of x-rays are taken after specific time intervals to trace excretion phases. It is used to assess any obstruction in the renal tract, either radiolucent or radio-opaque.²⁰

Ultrasound of kidney, ureter and urinary bladder (KUB) is sometimes indicated as the first line diagnostic procedure in UTI after laboratory assessment. In ultrasonography, a curvilinear probe is placed on patient's abdomen, flank and suprapubic region where the transmitter transducer sends ultrasound frequencies of 3.5 – 5 MHz and images of kidneys and bladder are taken.²¹

In computed tomography, the patient lies on the couch and the couch is moved through the rotating gantry. Gantry is fixed with x-ray source and image receptor. The axial cut images of the patient's abdomen are obtained which traces the whole urinary tract system.²²

UTI can cause severe damage to the renal system. Dysuria can result from UTI either pyelonephritis or cystitis. Imaging techniques help finding the underlying cause of UTI and proceed toward better medical and surgical intervention.

UTI can result in acute renal failure and chronic kidney disease, therefore any renal scarring or damage to the renal parenchyma can be assessed using imaging techniques. The stages of chronic kidney disease are evaluated on the basis of ultrasonography and not on the basis of CT as CT urogram can result in contrast induced nephropathy. Emphysematous pyelonephritis is caused by gas producing bacteria or fungi and often requires urgent medical or surgical intervention. It is practically impossible to assess gas in renal tract through lab based studies. For its diagnosis plain radiography is performed but reconstructed CT images shows better visualization of air in urinary tract. Pus in urinary tract system or hydronephrosis proximal to the obstruction requires drainage of pus either percutaneously or by retrograde method. Ultrasound in such cases can estimate the extent of hydronephrosis and pyonephrosis. Imaging in the patients with UTI should be performed along with laboratory tests.

Conclusion

Several Laboratory methods are employed for the detection of UTI. A dipstick test is used for the simultaneous detection of bacteriuria and pyuria, if positive for nitrites with weakly positive for leukocytes (Pus cells), it suggests possible infection, but if it is positive for nitrites and strongly positive for leukocytes, it points towards UTI. When nitrites are found positive, a mid-stream urine sample should be sent for culture and sensitivity.

Radiological imaging in UTI can be used to detect underlying cause especially in patients having recurrent UTI and those with renal damage and deteriorating renal functions. Whenever radiological studies are performed, other than ultrasound, radiation exposure should be kept in mind.

Conflict of interest: None declared.

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