



COMPARATIVE EVALUATION OF DIPSTICK TESTS AND URINE MICROSCOPY AGAINST CULTURE IN CHILDHOOD URINARY TRACT INFECTION: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Urinary tract infections (UTIs) are among the most common bacterial infections in children. Because they are often not diagnosed early, UTIs can lead to complications such as renal scarring and chronic kidney disease. For diagnosis urine culture is the gold standard test, rapid screening tools are there for early diagnosis and management.

Methods: This prospective observational study was conducted in a tertiary care hospital between January 2021 and June 2022. This study included 217 children who met inclusion criteria and they are suspected of having a UTI. All patients had urine dipstick testing for nitrites and leukocyte esterase (LE), along with urine culture and microscopy.

Results: Urine culture was positive in 17.5% of the UTI cases, *Escherichia coli* and *Acinetobacter baumannii* are the most common organisms detected. Microscopy suggested highest sensitivity at 93.5% and a negative predictive value of 98.3%, which indicates strong rule-out potential. LE showed moderate sensitivity at 80.6% but lower specificity at 61.3%. Nitrite testing had excellent specificity at 94.6% and a positive predictive value of 74.2%. LE and nitrite testing both combined, improved specificity to 97.9% and PPV to 86.4%.

Conclusion: Most reliable screening test for ruling out pediatric UTI was found to be Urine microscopy, while nitrite testing had good rule-in accuracy. Combination of dipstick results improves specificity for diagnosis. Hence in settings with limited resources they are useful due to a quickness and cost-effective alternative to culture.

KEYWORDS: Routine Urine Microscopy, Urinary Tract Infection, Leukocyte Esterase Test, Nitrite Test, Dipstick Test.

Introduction

Urinary tract infections (UTIs) are the common bacterial infection in children and imposes health burden. Pediatric

Urinary tract infections are usually presented with fever and other systemic symptoms like abdominal pain, shivering, vomiting etc. If they remain undiagnosed or partially treated, may lead to long-term renal damage like scarring,

high blood pressure, and, in severe cases, chronic renal failure. These potential consequences urge the need for early diagnosis and proper management of UTIs in children to avoid future kidney damage[1,2].

Epidemiological data indicate that UTIs occur in all pediatric age groups, with variable frequency and risk in different age and gender groups. According to studies, the estimated lifetime incidence before 14 years is about 1-3% in boys and 3-10% in girls, with the increased risk in early childhood. Uncircumcised Male children are more prone to infections in their first year of life. After infancy, the risk significantly increases in females as compared to males, with a male-to-female ratio of around 1:10. Different Studies indicate that newborns presented with fever have a UTI incidence of up to 20% in males and about 5% in females, likely due to differences in anatomy and physiological structure. After the neonatal period, UTI occurrences show two main peaks: 1st during infancy and another between ages 2-4 years, coinciding with toilet training, which is linked to behavioral and hygiene-related risks[3,4,5].

The Chances of developing a UTI in children depends on factors like personal and environmental factors etc. Female children with urinary tract issues like obstructive uropathy or vesicoureteric reflux, as well as those who associated bowel dysfunction or constipation, are at increased risk. prolonged urinary catheter use and other medical interventions also increase the risk, particularly in children with immune-compromised conditions or those on long-term immunosuppressive medications. Pathogens like E coli causes 70-90% of pediatric UTIs worldwide. Other casutive organisms include K.pneumoniae, E. faecalis, P. aeruginosa, etc. These infective pathogens have different mechanisms to improves their ability to stick to and invade the urinary tract, such as adhesins, fimbriae, and toxins,. The infection mainly travels from the area around the urethral opening to the bladder and then to kidneys, making anatomy and hygiene crucial factors in disease progress[6,7].

The signs and symptoms of a UTI in children may vary widely and often do not leads to a proper diagnosis. In newborns and infants, symptoms such as fever, irritability, poor feeding, vomiting, jaundice, or improper weight gain can also indicates other illnesses. Older ones usually presents with specific urinary issues, including pain or burning during micturation, urgency, frequency to the bathroom, discomfort or dull pain in the lower abdomen, back pain, or hematuria. A grade high fever associated with pain in the back typically indicates an upper urinary tract infection, indicates possible pyelonephritis rather than a lower infection[8,9].

Due to the variable signs and symptoms of a UTI, laboratory tests are crutial for diagnosis. The gold standard for diagnosis is always urine culture, which detects the growth of a organism in significant amounts ($\geq 10^5$ CFU/mL). However, urine culture has practical challenges: it takes 24-48 hours for results, contamination can occur during collection, and

antibiotic usage may affect the culture results[10]. These issues can affect or delays the targeted treatment, making early diagnostis very important in clinical settings.

Urine dipstick tests and microscopy are the most feasible and cost effective early diagnostic tests for UTIs. The dipstick can detect leukocyte esterase (LE), which indicates white blood cell activity, and nitrite, which is produced by bacteria that reduce nitrate. LE is very sensitive but not very specific. On the other hand, nitrite has high specificity but lower sensitivity, especially in infants. Combining both tests simultaneously increases diagnostic accuracy, although sensitivity and specificity rates may vary in different studies and populations[11,12].

Urine microscopy always a key diagnostic tool as it allows identification of pyuria, bacteriuria, red blood cells, and casts. Urine microscopy is more sensitive than dipstick testing but requires trained personnel and proper lab settings, which may lack in resource-limited areas. While both dipstick tests and microscopy are commonly used, their accuracy compared to culture depends on the patient's age, the collection technique used, and the facility setting. This variability makes early clinical decisions highlighting the need to validate these tests, especially where culture resources are limited or not feasible[13].

Present study focused on evaluate the accuracy of urine dipstick tests (for leukocyte esterase and nitrite) and urine microscopy against urine culture in suspected UTI in children. This study conducted to know how reliable these diagnostic tools are and provide evidence-based guidance for pediatric clinical practice.

Materials and Methods

Study Design and Setting

This prospective observational study was carried out in the Department of Pediatrics at the tertiary care hospital between January 2021 and June 2022. The primary objective was to evaluate the diagnostic performance of urine dipstick testing (leukocyte esterase and nitrite) and urine microscopy in comparison with urine culture, which served as the reference standard, for diagnosing urinary tract infection (UTI) in children.

Participants

Children aged 3 months to 12 years presenting with clinical features suggestive of UTI were enrolled. Clinical suspicion was based on age-appropriate symptoms: infants and younger children with fever without an identifiable source, vomiting, abdominal discomfort, or poor weight gain; and older children with urinary symptoms such as dysuria, urgency, frequency, suprapubic pain, or flank pain.

Inclusion Criteria

All children aged 3 months to 12 years with clinical suspicion of UTI were included.

Exclusion Criteria

Children were excluded if they had received antibiotics prior to enrollment, were younger than 3 months or older than 12 years, had congenital or acquired immunodeficiency, had a history of urinary catheterization, were receiving long-term corticosteroid or immunosuppressive therapy, or if informed consent was not obtained from parents or guardians.

Clinical Evaluation

Clinical evaluation was carried out for all participants who were included. It was composed a detailed medical history of illness that documented the onset, duration, progression, and details of symptoms, as well as previous medical, drug, family, and socioeconomic or any other history. The physical examination included documentation of vital parameters like pulse, respiratory rate, temperature, and blood pressure. Other signs like pallor, cyanosis, icterus, lymphadenopathy, and edema were also noted. The systemic examination included evaluating the respiratory system, abdomen, cardiovascular system, and neurological system.

Laboratory and Radiological Investigations

Baseline investigations such as complete blood count, renal and liver function tests, and random blood glucose were included. An per-abdominal ultrasonography was done for all cases to detect structural problems. A retrograde micturating cystourethrogram was oconducted in children with recurrent infections or abnormal ultrasound to diagnose vesicoureteric reflux or obstructive uropathy.

Urine Sample Collection

Under all aseptic conditions Urine was collected using appropriate methods:

1. For toilet-trained children, a clean-catch midstream urine sample was taken after cleaning the perineum with sterile water.
2. For children under 5 years, sterile catheterization was done using a Foley's catheter.
3. Three separate urine samples collected from each child, which were tested .

Urine Microscopy

Collected urine samples were centrifuged as per guidelines, and the sediment was examined under a microscope at high power i.e.400.if sample has having more than 5 WBCs per high-power field in centrifuged urine or more than 10 WBCs/mm³ in un-centrifuged urine sample then it was labelled as Pyuria. The presence of visible bacteria was noted as bacteriuria. All analyses were done by trained lab technician.

Dipstick Analysis

Urine dipsticks which are commercially available were used to detect leukocyte esterase and nitrite. Positive results

for LE were indicated by a change in colour according to calibration provided by manufacturer, while nitrite positivity was indicated by a pink color. To ensure accuracy all results were interpreted visually within two minutes by Trained staff.

Urine Culture

The Urine culture and antibiotic sensitivity testing were done following standard microbiological guidelines. The growth of a single organism at a concentration of $\geq 10^5$ colony-forming units (CFU)/mL was considered significant bacteriuria. Mixed growths were considered as contamination, and repeat samples were collected when feasible.

Treatment

Empirical antibiotic therapy was started as per guidelines,after urine collection. Antibiotic regimens were adjusted based on culture and sensitivity results and other factors if any, to provide targeted therapy.

Statistical Analysis

Data was analyzed using SPSS version 25. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and 95% confidence intervals were calculated for dipstick and microscopy results. to assess diagnostic accuracy Receiver operating characteristic curves were plotted.

Ethical Considerations

Study protocol was approved by the Institutional Ethics Committee at Government Medical College, Aurangabad,Maharashtra (letter No. Pharm/IEC-GMCA/70/2020, dated 12/11/2020). Written informed consent was obtained from parents or legal guardians before participation.

Results

As shown in Table no.1 total 217 urinary tract infection suspected children were included in the present study. The mean age of the cases of UTI was found 5.4 years, of which 102 (47.0%) children were between 5 and 12 years . distribution of Infants (3 months to 1 year), toddlers (1 to 3 years), and preschoolers (3 to 5 years) was 24(11.1%),51(23.5%), and 40(18.4%),respectively. Female ses had more in number i.e. 119(54.8%),as compared to males which was at 98(45.2%). inbetween male patients, 66 of 98 (67.0%) were uncircumcised, while 32 of 98 (33.0%) were circumcised. Total 130 of 217 (59.9%) children came from rural areas, while 87 (40.1%) lived in urban regions. Using the Modified Kuppaswamy Scale , the socioeconomic breakup showed that 125(57.6%) children were in class III,followed by class IV 55(25.3%), class II 29(13.4%), and class V 8(3.7%); none were in class I.

Table 1: Baseline demographic characteristics of study participants

Characteristic	Category	Frequency	Percentage (%)
Age group	3 months – 1 year	24	11.1
	1 – 3 years	51	23.5
	3 – 5 years	40	18.4
	5 – 12 years	102	47.0
Gender	Male	98	45.2
	Female	119	54.8
Male subgroup	Uncircumcised	66	67.0*
	Circumcised	32	33.0*
Residence	Rural	130	59.9
	Urban	87	40.1
Socioeconomic class (MKS)	Class I	0	0.0
	Class II	29	13.4
	Class III	125	57.6
	Class IV	55	25.3
	Class V	8	3.7

Table 2: Clinical Features of Patients (N = 217)

Clinical feature	Frequency	Percentage (%)
Fever	201	92.6
Abdominal pain	79	36.4
Dysuria	65	30.0
Vomiting	57	26.3
Decreased urine output	24	11.1
Increased frequency	11	5.1
Constipation	12	5.5
Past history of UTI	7	3.2

Table 3: Urine Culture Findings

Urine culture result	Frequency	Percentage (%)
Sterile	179	82.5
Positive cultures	38	17.5
E. coli	10	4.6
Acinetobacter baumannii	10	4.6
Klebsiella pneumoniae	6	2.8
Enterococcus	5	2.3
Candida species	2	0.9
Proteus	2	0.9
Pseudomonas	2	0.9

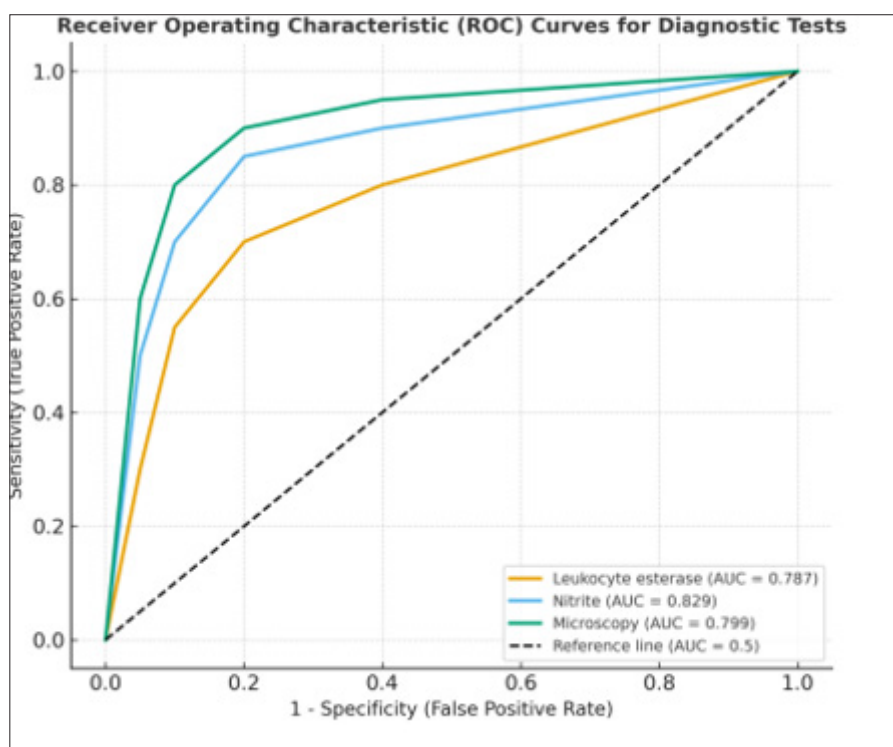


Figure 1.ROC curves showing the diagnostic performance of leukocyte esterase, nitrite, and urine microscopy in detecting urinary tract infection (UTI) among children

Table 4: Summary of Diagnostic Performance

Test	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)
Leukocyte esterase	80.6% (68.2% - 89.1%)	61.2% (53.8% - 68.2%)	30.5% (22.5% - 39.8%)	93.8% (87.9% - 97.0%)	1.9 (1.5 - 2.5)	0.31 (0.18 - 0.52)
Nitrite	74.2% (61.5% - 83.9%)	94.6% (90.2% - 97.1%)	74.2% (61.5% - 83.9%)	94.6% (90.2% - 97.1%)	20.4 (11.2 - 37.1)	0.21 (0.12 - 0.36)
Leukocyte esterase + nitrite	61.2% (48.2% - 72.9%)	97.9% (94.6% - 99.2%)	86.3% (72.6% - 93.8%)	92.3% (87.5% - 95.4%)	29.0 (11.4 - 73.7)	0.39 (0.29 - 0.54)
Urine microscopy	93.5% (84.4% - 97.5%)	80.9% (74.5% - 86.0%)	50.9% (40.3% - 61.4%)	98.3% (95.0% - 99.5%)	12.6 (8.5 - 18.7)	0.15 (0.06 - 0.35)

Table 2, summarizes clinical features observed in UTI patients. Most common symptom in UTI patients was Fever, which was noted in 201 (92.6%) children. Second most common symptom was abdominal pain, occurred in 79 cases (36.4%), followed by dysuria in 65 (30.0%) and vomiting in 57 (26.3%). Other symptoms like decreased urine output, constipation, and increased urinary frequency observed in 24 (11.1%), 12 (5.5%), 11 (5.1%) children, respectively. A past history of urinary tract infection was recorded in 7 children (3.2%).

In 38 (17.5%) of 217 children of UTI, urine culture showed positive growth and in 179 (82.5%) cases sterile results. The main isolates were E coli (10, 4.6%) and A baumannii (10, 4.6%). K pneumoniae appeared in 6 children (2.8%) and Enterococcus in 5 (2.3%). Other isolates included Candida,

Proteus, and Pseudomonas species, each found in 2 cases (0.9%). Detailed culture results are presented in Table 3.

Table 4 and figure 1 summarize the diagnostic performance of leukocyte esterase (LE), nitrite, combined LE plus nitrite, and urine microscopy in detecting urinary tract infection (UTI) in children, using urine culture as the standard. Among the tests evaluated, urine microscopy had the highest sensitivity at 93.5% and a negative predictive value of 98.3%. This indicates that it is very reliable for ruling out UTI. Its specificity was 80.9% and its positive predictive value was 50.9%, which are moderate but sufficient for clinical screening. The nitrite test showed excellent specificity at 94.6% and a high positive predictive value of 74.2%. This confirms effectiveness of nitrite test as a rule-in test for bacteriuria, especially for nitrate-reducing

organisms like *Escherichia coli*. Leukocyte esterase (LE) test had shown sensitivity at 80.6% but specificity was lower at 61.2%. When both these test results were combined, specificity improved to 97.9%, and PPV increased to 86.3%. But, sensitivity dropped to only 61.2%. This combination produced the highest positive likelihood ratio of 29.0.

Discussion

In present study, 217 children with age in between 3 months to 12 years had suspected urinary tract infection (UTI) were included. Urine cultures were positive for organism in about 17.5% of the cases. *E coli* and *A baumannii* were the most commonly isolated organisms in culture. Most common symptom in UTI patients was Fever, which was noted in 201 (92.6%) children. Second most common symptom was abdominal pain, occurred in 79 cases (36.4%), followed by dysuria in 65 (30.0%) and vomiting in 57 (26.3%). Among the tests evaluated, urine microscopy had the highest sensitivity at 93.5% and a negative predictive value of 98.3%. This indicates that it is very reliable for ruling out UTI. Its specificity was 80.9% and its positive predictive value was 50.9%, which are moderate but sufficient for clinical screening. The nitrite test showed excellent specificity at 94.6% and a high positive predictive value of 74.2%. This confirms effectiveness of nitrite test as a rule-in test for bacteriuria, especially for nitrate-reducing organisms like *Escherichia coli*. Leukocyte esterase (LE) test had shown sensitivity at 80.6% but specificity was lower at 61.2%. When both these test results were combined, specificity improved to 97.9%, and PPV increased to 86.3%. But, sensitivity dropped to only 61.2%. This combination produced the highest positive likelihood ratio of 29.0.

In present study, LE had a sensitivity of 80.6%. similarly Gorelick et al.[11] and Huicho et al.[14], also reported similar diagnostic accuracy for this test. But, our sensitivity results were lower than those reported by study conducted by Bafna et al.[16], likely due to factors like patient demographics, the prevalence of infection, and urine collection methods. The specificity of LE in our study was 61.3%, which was lower than study done by Al Musawi et al.[17], suggesting high chance of false positives, may be due to contamination or transient pyuria. Our results were also comparable to those of Williams et al.[15], who evaluated clean-catch urine samples in clinical conditions. Overall, these findings confirm that LE is a useful and sensitive screening tool for UTI in children. It also lacks specificity to be used as a only confirmatory test.

Similarly, our study documented excellent specificity of nitrite testing at 94.6%, confirming its role in identifying bacteriuria from nitrate-reducing Gram-ve bacteria like *E coli*. This results aligns with the meta-analysis by Gorelick et al. [11], who found the good capability of the nitrite test in diagnosing UTI. Similarly, studies by Al Musawi et al.[17] and Ojha et al.[18] demonstrated similar findings, indicating the reliability of nitrite in detection of the infection

when positive. Sensitivity of nitrite testing in our study was 74.2%, which was higher than observed in older studies by Fernandes et al.[19] and Goldsmith et al.[20]. This likely due to improved sample handling, processing. The nitrite test also has its limitations. Frequent urination in infants and infections by nitrate-reducing organisms may lower sensitivity of test. Hence, while nitrite testing is a strong rule-in tool for pediatric UTI diagnosis.

Urine microscopy in our study shown good diagnostic performance, with having a sensitivity of 93.5%. These results align with findings of the studies by Gorelick[11], Devillé et al.[12] and Huicho et al.[14], who also reported that microscopy, is one of the most reliable rapid diagnostic tool for pediatric UTI. Similarly, Williams and Craig found that microscopy has effective balance of accuracy and accessibility in clinical settings[15]. In our study negative predictive value was high at 98.3%, suggestive of a negative microscopy result can reliably rule out infection and reduce unnecessary antibiotic use. Variable accuracy across different studies is likely due to technical variations, like urine was centrifuged or not, differences in defining significant pyuria, operator expertise, and variations in prevalence of the disease. Devillé et al.[12] and Mori et al.[22] noted that such methodological inconsistencies can impact diagnostic precision of microscopy, highlighting the importance of standardized microscopy protocols.

Likelihood ratio in this study observed the clinical value of combining dipstick tests. The positive likelihood ratio for both LE and nitrite together was 29. This suggests that children with both positive tests are about 29 times more likely to have a culture-confirmed UTI than those with negative results. This observation was in line with the findings of meta-analyses by Whiting et al. and Mori et al.[21,22], which observed that combining dipstick test significantly boosts diagnostic accuracy in pediatric UTI. The negative likelihood ratios in our analysis further indicates the complementary strengths of the tests. Microscopy also had a negative likelihood ratio of 0.15, indicating good rule-out capability, while the combined dipstick's ratio of 0.39 confirms its role as a rapid rule-in tool. Similar conclusion drawn by Whiting et al.[21] and Mori et al.[23], who stated that combining dipstick parameters enhances clinical decision-making.

Confirmation of these results were done by ROC analysis, showing an area under the curve of 0.829 for nitrite, 0.799 for microscopy, and 0.787 for LE. These values suggests good discriminative power and match results reported in earlier reviews done by Dadzie et al.[24] and Marques et al.[25]. This confirms that dipstick tests and microscopy remain reliable, rapid diagnostic methods when used alongside culture.

Conclusion

We conclude that, urine microscopy has the best ability to rule out infection, while nitrite dipstick is the most effective

for ruling in infection. The combination of LE and nitrite achieves excellent specificity and positive predictive value. Integrating these rapid tools into pediatric practice, while confirming with culture, can optimize management, reduce unnecessary antibiotic use, and improve outcomes for children with suspected UTI.

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Conflict of Interest

Authors declares that they have no conflict of interest.

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