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A cross-sectional descriptive study of culture and urine dipstick methods for evaluation of urinary tract infection in children as a rapid screening tool

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Abstract

Background: This study was designed to analyze the efficacy of a urine dipstick to detect urinary tract infection (UTI) in children and to correlate it with the urine culture.

Methods: A prospective laboratory descriptive study was conducted at the Department of Pediatrics at Government General Hospital, Kadapa, from February 2022 to September 2023. Urine samples from 250 children of 2 and 12 years of age with UTI symptoms were analyzed using urine dipstick and other clinical/laboratory variables.

Results: The urine culture was positive in 38.4% (n=96) of the children and negative in 61.6% (n=154) of the children using the dipstick. Urinary tract infection was more common among female than male children. It was common in children aged 6 to 10 years, accounting for 41.42%. The most prevalent organism isolated was Escherichia coli (24.8%), followed by Klebsiella (8.8%) and other Gram-negative bacilli (5.6%). Urine microscopy for pus cells revealed that 158 (63.2%) samples had no pus cells, 49 (19.6%) had up to 5 pus cells, 35 (14%) had 5-10 pus cells, and 8 (3.2%) had >10 pus cells. Pyuria was found in 56 of the 96 children in the culture-positive group, leukocyte esterase was positive in 123 cases, leukocyte esterase was negative in 88 cases, and the nitrite test was positive in 9 cases. However, the combined dipstick was positive in 121 (48.4%) of all cases. Among the culture-positive group, the combined dipstick was positive in 39 cases and negative in 3 cases. Among the culture-negative cases, the combined dipstick was positive in 28 cases and negative in 126 cases. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of leucocyte esterase and nitrite were 65%, 80%, 69%, and 78% for diagnosing UTI in our study, respectively. The sensitivity, specificity, PPV, and NPV of the combined dipstick compared with urine culture were 95.5%, 80%, 74.9%, and 95.9%, respectively.

Conclusion: The combined dipstick + nitrite and leukocyte esterase show higher sensitivity and specificity, making it superior to leukocyte esterase or nitrite alone in diagnosing UTI. When compared to the urine culture, the combined dipstick has higher sensitivity, specificity, and positive and negative predictive values. Therefore, the combined dipstick can be used consistently as a quick screening tool for UTIs when culture facilities are not available.

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Highlights

What is current knowledge?

Although various studies have been conducted to evaluate the performance characteristics of rapid diagnostic tests for the accurate diagnosis of UTI, there was a lack of sufficient studies and a scarcity of data on these in India.

What is new here?

Urine dipstick has high sensitivity and can be used as a bedside tool to diagnose UTIs in children.

Introduction

Urinary tract infection (UTI) is the most prevalent bacterial infection in the human population and one of the most frequently occurring nosocomial infections. Urinary tract infections refer to the presence of microbial pathogens within the urinary tract, and the site of infection usually classifies as the bladder (cystitis) or kidney (pyelonephritis) (1). It is estimated that approximately 7 million visits to OP clinics, 1 million visits to the emergency department, and 100 000 hospitalizations annually are due to UTIs (2). Urinary tract infection is more prevalent in women as their urethra is shorter, making it easy for bacteria to spread further. Occasionally, bacteria can also spread from another part of the body through the bloodstream to the urinary tract.

Urinary tract infections can be divided into 3 categories: acute pyelonephritis (kidney infection), acute cystitis (bladder infection), and asymptomatic bacteriuria. If left untreated, UTI is highly frequent in children and can have serious effects on renal function, leading to chronic kidney disease (CKD) and hypertension (3). The clinical diagnosis of a UTI is based on symptoms and the presence of bacteria in the urine. Urine cultures are expensive, and the findings take 24-48 hours after the symptoms are presented.

Urinary tract infections are caused by an imbalance between bacterial virulence and host defense. These parameters differ depending on the type of UTI. P-fimbriated Escherichia coli virulence factors have been examined (4). Reagent strips have been developed to test for infection indicators. Leukocyte esterase and nitrite have been integrated on a single dipstick to test urine samples for UTIs (5). These are less expensive, take less time, and are beneficial in small laboratories without a culture facility.

The basic dipstick approach is the quickest screening procedure that could be useful in the early diagnosis of UTIs in apparently healthy or asymptomatic people with the goal of preventing and delaying the development of chronic renal failure (6). Furthermore, the use of a quick urine dipstick has been demonstrated to be beneficial in selecting the appropriate cases for sending urine cultures, thereby minimizing unnecessary spending.

There have been few studies in this area, particularly in pediatric populations with large samples. Therefore, the aim of this study was to determine the efficacy of urine dipstick in screening UTI in children and to compare the results with the urine culture.

Methods

Study type and setting:

This was a prospective laboratory descriptive study carried out at the Department of Pediatrics, Government General Hospital, Kadapa.

Duration:

February 2022 to September 2023

Study sample:

The research sample consisted of 250 children with suspected UTIs who were present in the Outpatient department or wards.

Inclusion criteria:

Children aged 2 to 12 years with symptoms suggestive of UTI or feverish children with undetected focus were eligible.

Exclusion criteria:

Children under the age of 2 years, with pre-existing renal/other systemic illnesses, or on steroid medication were excluded.

Data collection:

After we received informed parental consent, a clinical history was taken, an examination was performed, comorbidities were documented, and basic tests such as the complete blood count and urine analysis were performed. A renal function test was also carried out. All the children underwent an abdominal and pelvic ultrasound.

Urine collection:

Urine samples were collected in 2 containers under stringent aseptic conditions for urine analysis and urine culture. Urine samples for complete urine examination and culture were immediately forwarded to the clinical pathology and microbiology laboratories.

Urine microscopy was performed immediately upon collection. Bacteria, red blood cells (RBCs), white blood cells (WBCs), hyaline, cellular, epithelial cells, and granular fatty casts were identified. Direct microscopy revealed microscopic hematuria, WBCs, and bacteria.

Urine dipstick test:

A dipstick was dipped in urine for 60 seconds to detect the presence of nitrite in urine. Nitrite was deemed positive if the dipstick changed from colorless to pink within 60 seconds. The results were scored as 0, 1+, 2+, 3+, and 4+, depending on the strength of the color shift. Others were considered positive, with the exception of no change in color. If the color of the leukocyte esterase changed from white to purple within 2 minutes, it was regarded as positive. The intensity of the color change was scored as 0, 1+, 2+, 3+, and 4+. Other than the lack of color change, the results were considered positive.

Significant bacteriuria:

A colony count of more than 105 of a single pathogen or > 104 CFU/mL in the patients with urethral catheterization was considered severe bacteriuria. Small numbers were deemed substantial if the patient was symptomatic.

Urine dipstick and microscopy results were compared to the urine culture. Four measures (leukocyte esterase, pyuria, nitrites, and hematuria) were compared to the urine culture.

Statistical analysis:

Continuous data were reported as mean, standard deviation (SD), and median. Categorical metrics were reported as numbers and percentages. By comparing the test findings to the culture norms, the sensitivity, specificity, negative predictive (NPV), and positive predictive values (PPV) for all lab variables were calculated. A further set of values was evaluated to determine the greatest sensitivity and specificity. After computing the sensitivity and specificity, the likelihood ratio was computed. A likelihood ratio of greater than 1 indicates that the test is effective, whereas a ratio of less than 1 indicates that the test is ineffective. The chi-square test was performed to determine the significance of research parameters on a categorical scale between the two groups. P-values less than 0.05 were considered statistically significant.

Results

The distribution of culture-positive cases according to demographics is described in Table 1. In this study, 96 of the 250 urine samples tested positive for culture. Out of 250 cases, 90 (36%) were between the ages of 3 and 5, 140 were 6-10 years, and 20 (8%) were more than 10 years. The mean age was 6.2 ± 2.5 years. Out of the 250, 96 (38.4%) were culture-positive. Among the 250 cases, 117 (46.8%) were male and 133 (53.2%) were female.

Table 1. Distribution of culture-positive cases according to age and sex

	Total cases	Culture positive, n%	Culture negative, n%	P-value
AGE				
3- 5 Y	90	30 (33.33%)	60 (38.96%)	0.462
6-10 Y	140	58(41.42%)	82 (53.24%)	
>10	20	8 (40%)	12 (7.8%)	
SEX				
Male	117	32 (27.4%)	85 (55.19%)	0.0007*
Female	133	64 (48.12%)	69 (44.81%)	
Total	250	96	154	

Chi-square test, *significant at P <0.05

Symptoms:

Dysuria was the most common symptom in 230 cases (92%), followed by increased frequency of micturition in 219 cases (87.6%), persistent vomiting in 163 cases (65.2%), abdominal pain in 139 cases (55.6%), fever in 113 cases (45.2%), hematuria in 35 cases (14%), pyuria in 27 cases (10.8%), and constipation in 26 cases (10.4%).

Fever of less than 1 week was present in 70 children (28%), fever of 1 week was present in 36 children (14.4%), and fever of more than 1 week was present in 7 children (2.8%).

Pallor was observed in 4% of the patients, while face puffiness was observed in 4.4%. Pedal edema was observed in 2% of the patients. Abdominal examination was normal in 44.4%, and suprapubic discomfort was seen in 54%. Lumbar tenderness was observed in 1.2% of the children, while periumbilical tenderness was found in 1. A genitourinary examination of 27 male children revealed phimosis. No female children had vulval synechia. Comorbidities were present in 10 children. Three of the 250 children had nephrotic syndrome, 2 had a neurogenic bladder, 2 had posterior urethral valve, 1 had vesicourethral reflux, 1 had hydroureteronephrosis, and 1 had ureteropelvic junction (UPJ) blockage. Five children had a history of urinary tract abnormalities.

Microscopy revealed that 158 (63.2%) instances had no pus cells, 49 (19.6%) had up to 5 pus cells, 35 (14%) had 5-10 pus cells, and 8 (3.2%) had more than 10 pus cells.

Sensitivity, specificity, PPV, and NPV of pyuria: Sensitivity, specificity, positive and negative predictive values of pyuria compared to urine culture were 65%, 80%, 69%, and 78%, respectively (p<0.001).

Pyuria in culture-positive cases:

Pyuria was present in 56 children in the culture-positive group and 40 children in the negative group.

Pyuria vs. culture negative: Pyuria was positive in 29 children and negative in 125 (P=0.001).

Leukocyte esterase:

Among the 250 cases, Leukocyte esterase was negative in 127 and positive in 123. Out of these leukocyte esterase-positive cases, 20 had a 1+ color change, 62 had a 2+ color change, 29 had a 3+ color change, and 16 had a 4+ color change.

Sensitivity, specificity, PPV, and NPV of leukocyte esterase: Sensitivity, specificity, positive predictive value, and negative predictive value of leukocyte esterase compared to urine culture were 89%, 78%, 72%, and 91.5%, respectively (P<0.001).

Leukocyte esterase in culture-positive children:

Among the culture- positive cases, leukocyte esterase was positive in 88 cases and negative in 8 cases.

Leukocyte esterase in culture-negative children:

Among the culture-negative cases, leukocyte esterase was positivein 28 cases and negative in 126 cases.

The P-value calculated by the chi-square test was <0.001 and was statistically significant. The positive likelihood ratio was 4.23, and the negative likelihood ratio was 0.1257.

Nitrite test:

Among total cases, nitrite was negative in 157 and positive in 93 cases. Out of these nitrite-positive cases, in 27 cases, 1+ color change was noted; in 40 cases, 2+ color change was noted; in 18 cases, 3+ color change was noted; and in 8 cases, 4+ color change was noted.

Urine culture vs. nitrate:

All the true positive cases had Gram-negative organisms in the culture. Sensitivity, specificity, PPV, and NPV of nitrite compared with urine culture were 91.5%, 91%, 86%, and 89.2%, respectively.

Among the culture-positive cases, the nitrite test was positive in 81 cases and negative in 15 cases.

Nitrite test in culture-positive cases:

Among the culture-negative cases, the nitrite test was positive in 9 cases and negative in 145 children (P<0.001).

Dipstick: Among all the cases, combined dipstick was positive in 121 (48.4%) cases and negative in 129 (51.6%) cases (Table 2).

Table 2. Distribution of DIP-positive cases according to culture positivity

	Total	Culture +ve	Culture -ve	P-value
DIP + ve	121	93	28	< 0.00001
DIP - ve	129	3	126	
Total	250	96	154	

The sensitivity, specificity, PPV, and NPV of the combined dipstick compared with urine culture were 95.5%, 80%, 74.9%, and 95.9%, respectively. In the culture-positive group, combined dipstick was positive in 39 cases and negative in 3 children. Among the culture- negative cases, the combined dipstick was positive in 28 and negative in 126 children.

Urine culture:

Urine culture was positive in 38.4% (n=96) of the children and negative in 61.6% (n=154) of the children. All the organisms were Gram-negative, including *Klebsiella sp., Proteus, Pseudomonas*, etc. (Table 3).

Table 3. Urine culture and spectrum of bacteria

Urine culture	No. of cases	Percentage
No growth	145	58%
E. coli	62	24.8%
Klebsiella sp.	22	8.8%
Proteus	14	5.6%
Other Gram-negative bacilli	4	1.6
Pseudomonas	3	1.2%
Total	250	100%

Out of the 96 culture-positive cases, 80(32%) had a colony count of $>10^5$ and were considered significant bacteriuria. Twelve cases who were catheterized had a colony count of $>10^4$ and were considered significant. They constituted 4.8% of the total children population. Eight children had scanty growth in culture and were not considered as significant bacteriuria. Only 92 were considered culture-positive.

Renal Function Test:

Six children showed increased renal parameters. Two of the 6 children had posterior urethral valves, and 3 had hydroureteronephrosis. One of these 3 cases of hydroureteronephrosis had primary vesicoureteral reflux, 1 had prenatal hydroureteronephrosis, and 1 had UPJ blockage. Three children had a neurogenic bladder. The mean urea value measured was 35.8± 10.9. The mean creatinine value was 0.8±0.32.

Hematuria:

Hematuria was found in 35 children (14%). Sensitivity, specificity, PPV, and NPV were 30.5%, 90%, 70%, and 62.2%, respectively. It was observed that all of the children with hematuria had cystitis on ultrasonography.

The ultrasound of the abdomen and pelvis:

The most prevalent ultrasound finding was cystitis in 38 instances (15.2%), followed by hydroureteronephrosis in 6 cases (2.4%). Out of the 6 cases of hydroureteronephrosis, 2 were known cases of posterior urethral valve obstruction, 1 was a case of UPJ obstruction, 1 was a known case of primary vesicourethral reflux, 1 was a case of antenatal hydroureteronephrosis, and 3 had neurogenic bladders detected by thickened bladder >2 mm and the post-void residue of urine >20 mL (Table 4).

Table 4. Ultrasonography of the abdomen and pelvis

USG Abdomen and Pelvis	No. of Cases	Percentage
Normal	200	80%
Ascites	3	1.2
Cystitis	38	15.2
Hydroureteronephrosis	6	2.4
Neurogenic bladder	3	1.2
Total	250	100.0

Discussion

In all the 250 patients studied, 38.4% had a culture-positive UTI. Urinary tract infection was more common in female children (n=64, 48.12%) than in male children. It was also more common in children aged 6 to 10 years, accounting for 58 (41.42%) of all cases (3).

Urinary tract infections are common bacterial illnesses in children, affecting approximately 17% of boys and 84% of girls before the age of 7 years. They afflict both boys and girls equally during the first year of birth; however, after that age, the majority of cases occur in girls (7).

In our investigation, the most prevalent organism recovered was E. coli (24.8%), followed by Klebsiella (8.8%) and other Gram-negative bacilli (5.6%). Fever was present in less than half of the cases in our research. Only a few children had a fever for more than 1 week.

In our study, abdominal examination was normal in fewer than half of the infants, while suprapubic soreness was found in more than half of the children.

The sensitivity (the ability of the parameter to correctly diagnose UTI), specificity (the ability of the parameter to correctly rule out UTI), PPV (the test when tested positive, the likely chances that the patient has UTI), and NPV (the test when tested negative) were calculated in our study for 4 parameters: pyuria, leucocyte esterase, nitrite, and combined dipstick.

Pyuria: Our findings suggest that urine microscopy has a low sensitivity, higher specificity, and a PPV for detecting UTI.

The sensitivity, specificity, PPV, and NPV values of leucocyte esterase and nitrite were 65%, 80%, 69%, and 78% for diagnosing UTI in our study. The sensitivity, specificity, and PPV values of leucocyte esterase and nitrite were 63.5%, 82%, and 87% for diagnosing UTI in Gorelick Shaw et al.'s study (8). The sensitivity, specificity, PPV, and NPV values of leucocyte esterase and nitrite were 63.5%, 25%, 70%, and 20% for diagnosing UTI in Mod hk et al.'s study (9). Moreover, the sensitivity, specificity, PPV, and NPV values of leucocyte esterase and nitrite were 90.3%, 91.3%, 58.6%, and 98.6% for diagnosing UTI in Eric et al.'s study (10).

Combined leukocyte esterase and nitrite (dipstick):

When compared to prior research on the utility of combined dipstick in detecting UTI, our study revealed very good sensitivity, fairly acceptable specificity, good NPV, and relatively good PPV.

The sensitivity, specificity, PPV, and NPV of the combined dipstick compared with urine culture were 95.5%, 80%, 74.9%, and 95.9% in our study.

The sensitivity, specificity, and PPV values of the dipstick method were 73%, 99%, and 61% for diagnosing UTI in Shaw et al.'s study (9). The sensitivity, specificity, PPV, and NPV values of the dipstick method were 68%, 25%, 71.4%, and 22% for diagnosing UTI in Mod hk et al.'s study (9). The sensitivity, specificity, PPV, and NPV values of the dipstick method were 90.8%, 93.8%, 66.8%, and 98.7% for diagnosing UTI in Eric et al.'s study (10). The sensitivity, specificity, PPV, and NPV values of the dipstick method were 62.2%, 82.8%, 45.9%, and 90.3% for diagnosing UTI in Bagga R & Girotra study (11).

Sensitivity is nearly identical for leukocyte esterase, nitrite, and combination dipstick but lower for microscopic analysis. While the specificity of microscopic examination, leukocyte esterase, and combination dipstick is almost identical, it is high for nitrite alone.

In our study, the most prevalent ultrasound finding was cystitis, followed by hydroureteronephrosis, ascites, and neurogenic bladder. Patients with acute pyelonephritis had a fever. In older children, flank discomfort was present, whereas in younger children, stomach pain was seen.

According to Mod et al.'s study, one-third of cases exhibited some abnormality, with cystitis being the most common finding, which was consistent with our findings. Hydronephrosis was the next most prevalent finding, affecting one-fifth of the population. Our study for hydronephrosis did not include children under the age of 2, so the number is not large. As a result, anomaly detection may be biased. In the reference study, just a few people had calculus and medical renal illness. The current investigation did not yield similar results.

Acute cystitis in children causes pain during urination, increased frequency and urge to urinate, and sometimes, pain in the lower area of the stomach.

A single episode of febrile UTI is frequently caused by a virulent E. coli strain, but recurring infections and asymptomatic bacteriuria are frequently caused by urinary tract malformations or bladder abnormalities.

The sensitivity, PPV, and NPV of urine microscopic examination were all quite low. As a result, this method cannot be relied on to screen for UTI. Because leukocyte esterase has a high sensitivity and moderate specificity, it is an excellent screening test for UTIs. Since nitrite has high sensitivity and specificity, it can be used to properly diagnose UTIs. When compared to urine culture, combined dipstick has higher sensitivity, specificity, and positive and negative predictive values. Leukocyte esterase has strong sensitivity, nitrite has good specificity, and combined dipstick has good sensitivity and specificity and can be used reliably for detecting UTI while waiting for urine culture results.

Conclusion

In urban and rural areas where culture facilities are unavailable, a combined dipstick can be utilized as a reliable and fast screening technique for UTIs. While urine culture tests are awaited, treatment can be started safely based on the dipstick results. Even at facilities where a microscope is available, in the event of a delay in examination following sample collection, a dipstick can be used with confidence since leucocyte esterase can be found even in lysed cells, whereas microscopy cannot observe lysed pus cells. When compared to urine culture, the combined dipstick has higher sensitivity, specificity, and positive and negative predictive values.

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Ethical statement

The study followed the guidelines of the Declaration of Helsinki.

Conflicts of interest

None.

Author contributions

Concept development-A; data collection-B; data analysis-C; research supervision-J; data validation-K; manuscript writing-M; review & editing-N; approval of the final version-O.
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