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Original Research Article

Diagnostic performance of routine urinalysis parameters in urinary tract infection

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ABSTRACT

Background: Urinary tract infection (UTI) is a common bacterial infection presenting from asymptomatic bacteriuria to severe disease. Early detection is essential, and urinalysis remains the most frequently used screening tool owing to its rapidity and low cost, although urine culture is the diagnostic gold standard. Dipstick tests such as leukocyte esterase (LE) and nitrite (NIT) are widely used, but their performance varies. This study assessed the diagnostic accuracy of LE, NIT, leukocyte count, and bacteriuria in predicting significant bacteriuria compared with urine culture.
Methods: This retrospective observational study included adult mid-stream urine samples processed in the Pathology and Microbiology Departments of FMMC Hospital, Mangalore (March, 2022). Of 3618 urinalysis samples, 306 had concurrent culture. Dipstick parameters (LE, NIT) and microscopic sediment findings (leukocyte count, bacteriuria) were recorded. Culture growth $\geq 10^5$ CFU/ml was taken as significant. Statistical analysis included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic accuracy, and kappa.
Results: Among 278 samples, females were slightly more represented. *E. coli* was the most common isolate (43.2%). Sixty-five percent showed $>10^5$ CFU/ml growth. NIT was positive in 16%, while LE 3+ was the most frequent dipstick result. High leukocyte count (≥20 WBC/hpf) occurred in 37% and bacteriuria in 29%. High leukocyte count showed 43.4% sensitivity and 75% specificity. Combining ≥20 WBC/hpf with bacteriuria improved specificity (91.7%) and PPV (81.8%).
Conclusions: Routine urinalysis is useful as an initial screening tool, but microscopic sediment analysis is superior to dipstick testing. However, urine culture remains essential for definitive diagnosis.

Keywords: Urinalysis, Urine culture, Bacteriuria, leukocyte esterase and nitrite

INTRODUCTION

Urinary tract infection (UTI) is a common bacterial infection encountered both in the community and healthcare settings. It encompasses a wide spectrum of clinical presentations, ranging from asymptomatic bacteriuria to severe infections complicated by bacteremia. In hospitalized patients, UTI is the second most common cause of bacteremia.[1,2] Although UTI symptoms are often mild, the condition may progress to serious complications, particularly among infants, pregnant women, and elderly. Early diagnosis and empirical antimicrobial therapy are therefore essential for optimal patient outcomes.

Urinalysis remains the most widely used initial diagnostic tool for UTI because it is rapid and cost-effective. Although urine culture is considered the gold standard for definitive diagnosis, it is time-consuming and may not be required in all cases of uncomplicated UTI.[1,3] Owing to these practical considerations, there is ongoing debate regarding the accuracy and utility of urinalysis compared with urine culture in different clinical settings.

LE and NIT are 2 commonly used dipstick parameters for rapid screening.[3,4] LE reflects pyuria, while NIT indicates presence of nitrate-reducing bacteria. However, diagnostic performance of these tests is variable and depends on bacterial load, organism type, and patient factors. Study aimed to evaluate diagnostic performance of urinalysis parameters-specifically LE, NIT, leukocyte count, and bacteriuria-against urine culture results in adult patients, and to determine their usefulness in predicting significant bacteriuria.

METHODS

Mid-stream clean catch urine was collected under aseptic conditions from both inpatients and outpatients of adult age group.

Study type

This was a retrospective observational study.

Study place

The study was conducted in departments of pathology and microbiology, Father Muller Medical College Hospital, Mangalore, a tertiary-care referral hospital, from March 1, to March 31, 2022.

Sampling technique

A consecutive sampling method was used. All eligible urine samples received by the laboratory during the study period were included without omission.

Inclusion criteria

Mid-stream clean-catch urine samples from adult patients (≥18 years) and samples for which both urinalysis and urine culture were performed were included in study.

Exclusion criteria

Samples showing polymicrobial growth in culture (≥3 organisms) and improperly collected/insufficient samples were excluded from study.

Procedure

Urinalysis

A total of 3618 urine samples were received during the study period for routine urinalysis. Of these, 306 underwent concurrent urine culture. Urinalysis included dipstick testing and microscopic sediment examination.

Dipstick analysis

Dipstick testing was performed using reagent strips capable of semiquantitative analysis of pH, specific gravity, NIT, LE, glucose, ketones, bilirubin, urobilinogen, protein and hemoglobin. Strip was immersed in urine for one-minute, excess urine was removed, and color changes were interpreted using the manufacturer's chart. In this study, LE and NIT were the tests of interest in the dipstick analysis and LE was graded as neg (LE-absent), 1+ (upto 25 µl), 2+(up to 100 µl) and 3+(up to 500 µl) and NIT was taken as positive (pos) and negative (neg).[5,6]

Microscopic sediment analysis was performed manually. Urine sample of 10-15 ml was centrifuged for about 5 minutes at 1500 rpm and supernantant was discarded, a single drop of urine sediment was transferred to a clean glass slide and a cover slip applied over it. A minimum of 20 random microscopic fields were examined under high power magnification (×400).[2,3] The parameters of interest in microscopic sediment evaluation were leucocyte count and bacteriuria. Leucocyte counts considered abnormal in men if it is >2 WBC/HPF and in females if it is >5 WBC/hpf. Leucocyte counts were categorised into 2 groups, low count (<20 WBCs/hpf) and high (≥20/hpf). Bacteriuria was reported as presence or absence bacteria in microscopic examination.

All samples received for urine culture were inoculated on 3 culture media including, Mac Conkeys agar, blood agar and UTI chrome agar and incubated at 37^0C. Two readings were taken each at 24 and 48 hours before testing for antibiotic sensitivity. Minimum bacterial count with 10^3 bacterial colony forming units (CFU) per ml were considered as culture positive growth and were separated into following colony count breakpoints for performance analysis as: 10^3-10^5 CFU/ml and >10^5 CFU/ml. Culture growth of >10^5CFU/ml was taken as the standard cut off value in diagnosing UTI. Bacterial identification in the growth media was done manually and the organism was reported. There were 28 samples with polymicrobial growth and were excluded from the study.[7,8]

Ethical approval

Ethical approval was obtained from the Father Muller institutional ethics committee, FMMC, Mangalore.

Statistical analysis

Data were analyzed using Jamovi statistical software (version jamovi 2.6.25). Sensitivity, specificity, PPV, NPV, diagnostic accuracy, and Kappa statistics were calculated for all urinalysis parameters in comparison with urine culture results.

RESULTS

Among 278 adult patients included in the study, 125 were males and 153 were females (Figure 1). Majority of patients (77 cases) belonged to 61-70 year age group (Figure 2).

The most common organism isolated was *E. coli* in 43.2% samples (Table 1) followed by *K. pneumoniae*. Out of the 278 culture positive samples, 65% showed bacterial growth of $>10^5$ CFU/ml and rest of samples showed growth between 10^3-10^5 CFU/hpf (35%). Urinalysis parameters including NIT, LE, leucocyte count and bacteriuria with respect to culture growth (Table 2).

NIT was positive only in 16% of samples whereas LE level was found to be 3+ in most of the samples (31%) (Figure 3). Leucocyte count of ≥20 WBC/hpf was observed in 37% samples and bacteriuria was identified in 29% of samples analysed. When these parameters were correlated with culture positive samples of $>10^5$ CFU/ml bacterial growth, both independently as well as in combination, the results were found to be statistically significant with regard to high leucocyte count and combination of high leucocyte count and presence of bacteriuria with $p<0.05$ (Figure 4). On comparison of the test group leucocyte count with the gold standard of culture, the test group has a sensitivity of 43.4% and specificity of 75%. The test has a PPV of 76.7% and NPV of 41.1%. The test and the gold standard agree on 151 out of 278 having a diagnostic accuracy of 54.31%. The Kappa value of 0.154 indicates poor agreement with a $p=0.003$. However, it was found that when high leucocyte count was combined with presence of bacteriuria, specificity and PPV of the tests improved to 91.7% and 81.8% respectively (Table 3).

Table 1: Organisms identified in culture.

Organisms	N	Valid percent
Acinetobacter	5	1.8
Candida albicans	17	6.1
Candida fermentati	5	1.8
Candida glabrata	3	1.1
Candida krusei	1	0.4
Candida parapsilosis	2	0.7
Candida tropicalis	2	0.7
Cogulase negative *Streptococci*	7	2.5
Escherichia coli	120	43.2
Enterococcus faecalis	24	8.6
Group B *Streptococci*	14	5
Klebsiella pneumoniae	42	15.1
Pseudomonas aeruginosa	25	9
Proteus mirabilis	1	0.4
Staphylococcus aureus	8	2.9
Serratia marcescens	1	0.4
Vancomycin resistant enterococcus	1	0.4
Total	278	100

Table 2: Distribution among various dipstick and sediment analysis parameters.

Test parameters	Results	Samples		Culture report	
		N	%	10^3-10^5 CFU/ml	$>10^5$ CFU/ml
NIT	Negative	234	84.2	79	155
	Positive	44	15.8	17	27
LE	Neg	58	20.9	17	41
	1+	84	30.2	35	49
	2+	50	18	19	31
	3+	86	30.9	25	61
Leucocyte count	<20 WBC/hpf	175	62.9	72	103
	≥20 WBC/hpf	103	37.1	24	79
Bacteuria	Absent	198	71.2	75	123
	Present	80	28.8	21	59

Table 3: Statistical analysis of various urinalysis parameters against urine culture with significant bacterial growth of $>10^5$ CFU/ml.

Parameters	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)	Kappa statistics	P value
NIT	14.80	82.30	61.40	33.80	38.13	-0.0210	0.6050
LE	33.50	74.00	70.90	37.00	47.48	0.0600	0.221

Continued.

Parameters	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)	Kappa statistics	P value
Leucocyte count	43.40	75.00	76.70	41.10	54.32	0.1540	0.003
Bacteuria	32.40	78.10	73.80	37.90	48.20	0.0840	0.071
NIT and LE	3.80	97.90	77.80	34.90	36.33	0.0120	0.505
NIT and bacteuria	5.50	96.90	76.90	35.10	37.05	0.0170	0.552
NIT and ≥20 leucocyte count	6.60	91.70	60.00	34.10	35.97	-0.0120	0.629
LE (3+) and bacteuria	12.60	90.60	71.90	35.40	39.57	0.0240	0.440
LE (3+) and ≥20 leukocyte count	15.90	92.70	80.60	36.80	42.45	0.0640	0.059
Bacteuria and ≥20 leukocyte count	19.80	91.70	81.80	37.60	44.60	0.0850	0.015

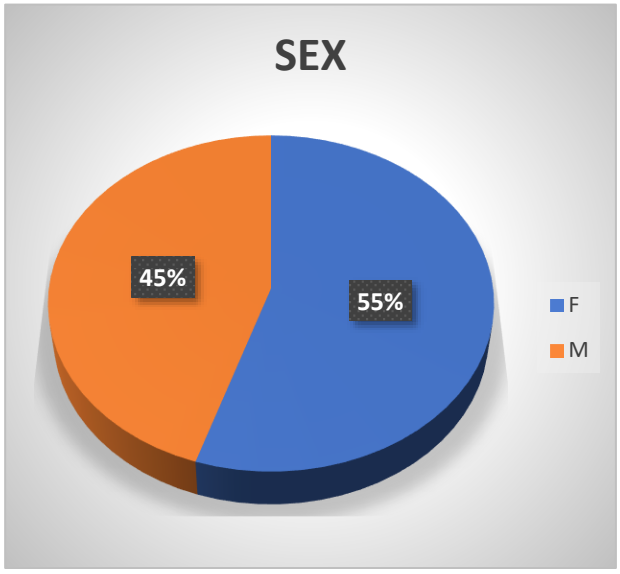

Figure 1: Gender distribution.

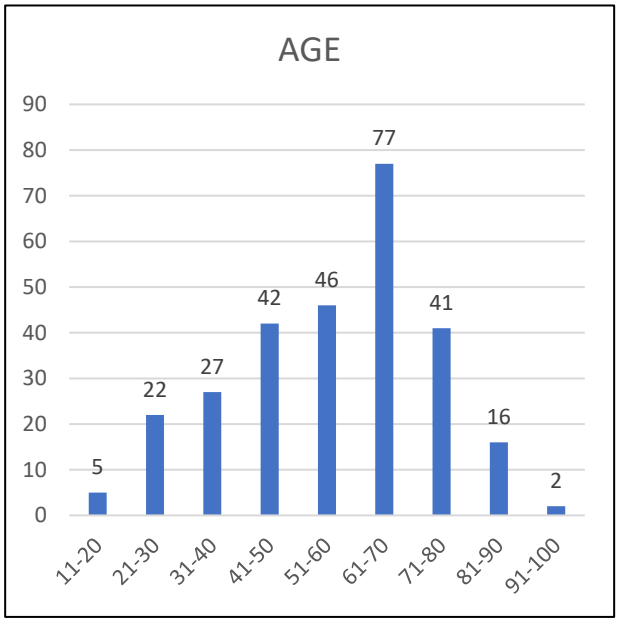

Figure 2: Age distribution of patients.

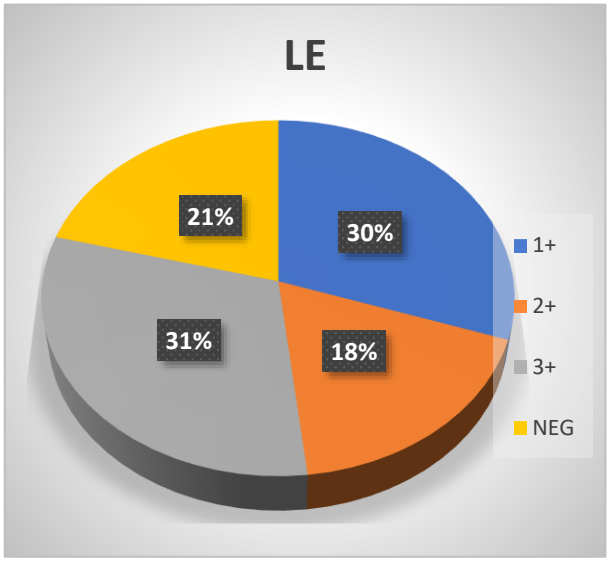

Figure 3: Distribution of samples among leucocyte esterase grades.

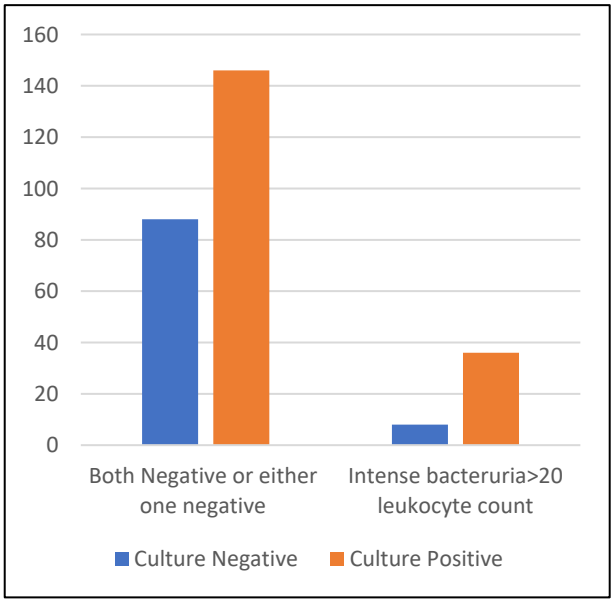

Figure 4: Samples with bacteruria and >20 WBC/hpf.

DISCUSSION

Urine analysis is typically a labor-intensive task that necessitates evaluation of large number of samples. In clinical practise, however, it is utilised as a fast diagnostic test for identifying UTI and guiding its empirical treatment using dipstick test strips. 55% of the participants in our study were female. Due to anatomical and physiological variables, there is a higher prevalence of UTI in female patients, according to the literature. *E. coli* was the most common bacterium isolated from the cultures of female patients (43.2%), followed by *K. pneumonia*. Numerous more studies demonstrate that *E. coli* is one of the most prevalent organisms causing UTIs in hospital settings.[9-11] Sixty-five percent of culture-positive samples had a considerable bacterial growth of $>10^5$ CFU/ml of urine, which is typically regarded as an indicative of UTI in culture.

High leucocyte counts (≥20 WBC/hpf) and the presence of bacteruria were the two routine urine analytical indicators with the highest predictive values for detecting UTI. This resembled the research undertaken by Nostrand et al and Semeniuk et al.[2,11] However, these studies demonstrated more sensitivity than our own. In a study conducted on pregnant women by Demelie et al the sensitivity and specificity of dipstick tests for LE were 50% and 89.1% for pregnant women with asymptomatic UTI and 71.4% and 86.7% for symptomatic UTI, respectively.[12] For NIT, the sensitivity and specificity were 35.7% and 98.0% for aymptomatic UTI and 57.1% and 96.7% for in addition, they also regarded a culture growth of $>10^5$ as the positive culture threshold for UTI.

The specificity of leucocyte esterase and NITs for dipstick analysis was 82,3% and 74 %, respectively. However, the test parameters were less sensitive than those of microscopic sediment analysis. According to research by dos Santhos et al the specificity and sensitivity of NIT positive were 99.5% and 38.9%, respectively.[1] The sensitivity and specificity of LE (3+) were 65.4% and 94.4%, respectively. Numerous gram-negative and gram-positive microorganisms are able to convert urinary nitrates into NITs, which are generally absent from urine. Dipstick analysis returns a positive result when these organisms are present in significant numbers (i.e., greater than 10,000/ml).[10,13] However, it is known that NIT dipstick reagent is sensitive to air exposure, resulting in erroneous results if the container is not immediately sealed following strip removal. LE is an indication of pyuria linked with UTI and is produced by neutrophils. In general, false positive results are observed in cases of contamination, while false negative results are observed in conditions such as glycosuria, ketonuria, increased specific gravity, and the use of certain oxidising medicines.[10,14,15]

The increased specificity of these routine urinalysis markers makes them effective for predicting cases of substantial culture growth. When combining and analysing two parameters, we found a specificity greater than ninety percent in every combination (Table 3). This was comparable to other previous literary studies. In our study, microscopic sediment analysis parameters were found to be superior than dipstick analysis parameters, despite the use of a combination of various parameters.

This study has few limitations. The one-month study period and single-center design restrict the generalizability of the findings. The number of samples with concurrent urine cultures was relatively small, reducing statistical strength. Clinical information such as symptoms, comorbidities, and prior antibiotic use was not included, limiting interpretation of urinalysis performance.

CONCLUSION

In conclusion, when UTI is suspected, a routine urinalysis is unquestionably useful as a primary test. Even though urine sediment analysis by microscopic sediment is a time-consuming process, it is preferable to dipstick analysis. Despite the fact that frequent urinalysis might aid in the diagnosis of UTI, it cannot serve as a substitute for culture; culture positive is the gold standard.

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