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Evaluation of Routine Urine Analysis in Diagnosing Urinary Tract Infection among Pediatric Population: A Validation Study

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ABSTRACT

Background: Urinary tract infection (UTI) stands out as one of the most common bacterial infections affecting children below the age of five. A valid diagnostic test for UTI is of utmost importance for avoiding bacterial resistance.
Objectives: To assess the diagnostic efficacy of routine urine examinations in detecting urinary tract infections in pediatric patients, employing urine culture as the reference standard
Material and Methods: This diagnostic study was conducted at leady reading hospital, Peshawar. The study employed a non-probability consecutive sampling technique and included 130 children between the ages of 1 and 5 years, regardless of gender, who exhibited symptoms suggestive of urinary tract infections. Exclusion criteria comprised children who had taken antibiotics within the past 48 hours, those with congenital renal anomalies such as renal or renal tumors, renal tract obstruction, and acute renal failure. All participants underwent urine regular examination and urine culture. Sensitivities, specificities, and accuracy were calculated, and the data was further stratified based on gender and age.
Results: The mean age of the participants was 2.646±1.32 years. The males were predominant (n-86, 66.2%). The urine examination demonstrated a specificity of 90.91% and a sensitivity of 58.06% in detecting urinary tract infections. A statistically significant difference was observed when comparing the diagnosis of Urinary tract infections using urine culture and urine examination.
Conclusion: While urine examinations exhibit satisfactory specificity, their sensitivity is insufficient to be utilized as a reliable diagnostic test for detecting urinary tract infections in children. Clinicians are advised to depend on urine culture for accurate diagnosis in such cases.
Keywords: Diagnostic accuracy, Pediatrics, Urine Microbiology, Urinalysis, Urinary tract infection.

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INTRODUCTION

Urinary tract infection (UTI) stands out as one of the most common bacterial infections affecting children below the age of five.[1] UTI covers both pyelonephritis; an infection in the upper urinary tract; and cystitis, which involves infection in the lower urinary tract. Distinguishing between these two types of infection is challenging in clinical practice.[2]

Urinary tract infections are highly prevalent among children, with estimates ranging from 70-90%.[3, 4] This poses a significant concern for parents and clinicians due to the importance of timely diagnosis and treatment to prevent complications.[5] Nonetheless, the present diagnostic techniques, including urinalysis and urine culture, are associated with high costs, lengthy processing times, and frequently produce a substantial number of negative outcomes.[6] In order to enhance the efficiency of urine sample management and decrease the occurrence of culture-negative samples, it is imperative to develop quicker screening methods.[7]

The diagnosis of UTI typically involves the evaluation of, signs, symptoms and the routine urine examination. Early detection and prompt treatment are crucial for effective management of Urinary tract infections. Despite being regarded as the gold standard for UTI diagnosis and offering detailed information about bacterial infections, this semi-quantitative culture of a urine specimen can be expensive and time-consuming, requiring a minimum of 24 hours for analysis. Moreover, a significant percentage of culture results (about 80%) yield negative outcomes.[8] Consequently, there is an urgent need for faster screening methods to streamline urine sample processing, thereby reducing the number of cases with negative culture results.[9]

When there is suspicion of UTI in children, it is advisable to perform both urinalysis and urine culture[10] Nevertheless, it is crucial to acknowledge that these methods possess inherent limitations, and their diagnostic accuracy may exhibit variability. According to a study conducted by Ali MA et al.[11], the diagnostic accuracy of urine regular examination for diagnosis of UTI in pediatrics, with urine culture as the gold standard, was reported as follows: sensitivity of 80.95%, specificity of 62.42%, positive predictive value of 35.98%, negative predictive value of 92.63%, and an accuracy rate of 66.26%. The study also revealed a UTI prevalence of 20.9% based on confirmed diagnoses.

The rationale for this study was to detect urinary tract infections at an early stage by utilizing urine routine examination (URE). This diagnostic test is convenient to conduct and cost-effective, enabling the timely administration of antibiotics to reduce complications associated with delayed UTI detection. If URE proves

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to be effective, it could serve as a valuable tool for early treatment and prevention of complications. Therefore, our study aims to assess the diagnostic accuracy of URE in detecting urinary tract infections in children compared to the gold standard of urine culture.

MATERIAL AND METHODS

This Cross Sectional Validation Study was carried out at department of pediatrics, Leady reading hospital, Peshawar from April 10th, 2021 to October 10th, 2022. The study involved 130 children and employed a non-probability consecutive sampling technique. Prior to commencement, the study received approval from the hospital's ethical committee (95/LRH/MTI dated:25/3/2023), and written informed consent was obtained from the parents/guardians of the participants for their participation in the study.

The required sample size of 103 participants was determined using Epitool software (https://epitools.ausvet.com.au/samplesize), considering a sensitivity of 80.95%, specificity of 62.42%, disease prevalence of 20.9%, and a precision level of 15% for both sensitivity and specificity.[11] The study included children aged 1 to 5 years, of both genders, presenting with symptoms such as abdominal pain in suprapubic region burning micturition, frequent urination (10-15 times per day), and a fever of more than 101°F. The study excluded children who had consumed antibiotics in last two days, with congenital renal anomalies including renal tract obstruction, renal neoplasm, and acute renal failure.

In the study, essential demographic data, such as age and gender, were documented. Urine samples were collected by experienced nurses having experience of more than 03 years by either the midstream clean catch method or supra pubic aspiration. Sterile containers were utilized to collect the urine samples, which were then swiftly transported to the hospital laboratory within an hour. The samples underwent examination and incubation in the laboratory. Following a 24-hour incubation period, laboratory assistants scrutinized the medium for the emergence of pink, glistening colonies, serving as an indication of the presence of gram-negative bacteria.

The operational definitions of Positive urinary tract infection was on URE as the presence of pyuria, which was white blood cell count of =5 WBCs/HPF or =10 WBS/mm^3. On the other hand, a positive UTI based on urine culture was defined as the presence of growth of bacteria (including Pseudomonas species, E. coli, and Klebsiella species) more 105 colony-forming units per milli-litter. This presence of pink, glistening colonies on the culture medium served as an indication of a positive UTI.

All data analysis was conducted using SPSS 22. The computation of qualitative variables, such as the presence of UTI on URE and urine culture, as well as gender, was performed in terms of frequency and percentages. Numeric data, such as the age of the participants, were calculated as mean and standard deviation (SD). To determine the fundamental parameters for calculating diagnostic values (e.g., false positive, false negative, true positive, and true negative), a cross-tabulation of URE and urine culture was performed. The recorded values were entered into the MEDCALC package to compute diagnostic parameters. Stratification was performed by dividing participants into groups based on gender and age groups with significance level at p = 0.05.

RESULTS

The mean age of the subjects was 2.645±1.31 years. The males (n=86, 66.21%) were more than females (n=44, 33.81%).

The urine examination exhibited a specificity of 90.91% and a sensitivity of 58.06%. A statistically significant distinction was observed between urine culture and URE in terms of detecting UTI (p=0.001). (Fig. 01)

Table 01 presents the cross-tabulation results, indicating the true negative (specificity), true positive (sensitivity), false negative, and false positive values for the entire study population, as well as for different gender and age groups.

In terms of sensitivity, URE demonstrated the highest values among females (94.3%) and males (89.1%), while the overall sensitivity was recorded as 58.06%. Regarding specificity, the highest value was observed for the overall study (90.9%), followed by males (72.7%), and the lowest was seen in females (22.2%). (Table-02)

In the age group 4-5 years, the sensitivity was found to be higher at 93.8% compared to the sensitivity of 89.6% in the age group 1-3 years. Conversely, the specificity was higher in the age group 1-3 years at 60.7% compared to the specificity of 33.3% in the age group 4-5 years. (Table-03)

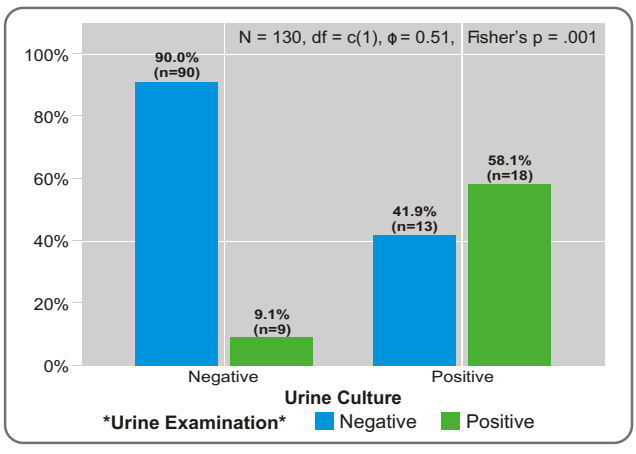


Fig 01. Comparison of urine examination with the gold standard

Table 01. Comparison of URE and urine culture

Variable	URE	Urine's Culture	
		Positive Results	Negative Results
Whole Sample	Positive results	18 (T.P)	9 (F.P)
	Negative results	13 (F.N)	90 (T.N)
Males	Negative results	57(T.P)	6(F.P)
	Positive results	7(F.N)	16(T.N)
Females	Negative results	33(T.P)	7(F.P)
	Positive results	2(FN)	2(T.N)
1 to 3 Years	Negative results	60(T.P)	11(F.P)
	Positive results	7(FN)	17(T.N)
4 to 5 Years	Negative results	30(T.P)	2(F.P)
	Positive results	2(F.N)	1(T.N)

*T.P, True positive; F.P, False positive; F.N, False negative; T.N, True negative

Table 02. Urine examination of overall and both genders

Diagnostic Values	Overall*	Males*	Females*
Specificity (%)	90.9(83.4 - 95.8)	72.7(49.8-89.3)	22.2(2.8 - 60)
Sensitivity(%)	58.1(39.1 -75.4)	89.1(78.8-95.5)	94.3(80.8 - 99.3)
Diagnostic Accuracy (%)	83.1(75.51 - 89.08)	84.9(75.54 -91.70)	79.5(64.7 - 90.2)
Positive Likelihood Ratio (PLR)	6.4(3.2 - 12.7)	3.3(1.6-6.5)	1.2(0.8 - 1.)
Negative Likelihood Ratio(NLR)	0.5(0.3 - 0.7)	0.15(0.1-0.3)	0.3(0.04 - 1.6)
Positive Predictive Value (%)	66.7(50.05 - 80)	90.5(82.7 -95)	82.5(76.7 - 87.09)
Negative Predictive Value (%)	87.4(82 - 91.3)	69.6(52.05-83)	50(14 - 86.03)

*value (95%CI)

Table 03. Urine examination in various age groups

Diagnostic Parameters	1 to 3 Years*	4 to 5 Years*
Sensitivity (%)	89.5(79.7-95.7)	93.7(79.2-99.2)
Specificity (%)	60.7(40.6-78.5)	33.3(0.8-90.6)
Positive Likelihood Ratio	2.3(1.4-3.6)	1.4(0.6-3.1)
Negative Likelihood Ratio	0.2(0.08-0.4)	0.2(0.02-1.5)
Positive Predictive Value(%)	84.5(77.4-89.7)	93.7(87.02-97.1)
Negative Predictive Value(%)	70.8(53.1-83.9)	33.3(5.8-80.1)
D.Accuracy(%)	81.05(71.7-88.4)	88.57(73.3-96.8)

*value (95%CI)

DISCUSSION

The outcomes of our research shed light on the effectiveness of urine routine examination, showcasing a sensitivity of 58.06% and a specificity of 90.91% in comparison to the established gold standard, urine culture. This implies that the urine routine examination is adept at correctly identifying true positive cases with a sensitivity rate of 58.06%, while maintaining a high degree of accuracy in determining true negative cases with a specificity rate of 90.91%.

Among children aged five and below, UTI stands out as one of the most common types of infections. Timely diagnosis and treatment play a critical role in mitigating the risk of renal scarring. Consequently, there is a pressing need for efficient and affordable alternatives to culture for the analysis of UTI.[12]

Our study findings revealed that urine dipstick exhibited a sensitivity of 58%, specificity of 90.9%, and diagnostic accuracy of 83% in detecting UTI among

children when compared to urine culture as the gold standard. Interestingly, these results align with the findings reported by Ali et al.[11], who documented a sensitivity of 80.9%, specificity of 62.4%, and accuracy rate of 66.3% for urine routine examination in detecting UTI among pediatric populations against urine culture. The consistency between our study and previous research provides additional support for the reliability and validity of our findings.

In a study conducted in 2010, it was observed that urine dipsticks exhibited a moderate sensitivity of 75% but a relatively low specificity of 66% when predicting urinary tract infections (UTIs). These findings suggest that while urine dipsticks can identify a significant proportion of UTI cases, they also tend to generate a considerable number of false-positive results.[13] False-positive results can results in undue antibiotics prescription and emergence of resistant species.[13] However, it is worth noting that in 2007, the American Academy of Pediatrics discouraged the use of dipsticks for UTI detection due to their low diagnostic accuracy. This recommendation highlights the importance of considering alternative diagnostic methods that offer higher precision and reliability in accurately identifying UTIs.[14]

In a study conducted by Smith et al.[14], researchers investigated the performance of a predictive method in determining culture results, specifically focusing on identifying the absence of reportable pathogens. The study found that the method demonstrated a sensitivity of 83%, indicating its ability to correctly identify cases without reportable pathogens in the majority of instances. Additionally, the method exhibited a specificity of 76%, suggesting its effectiveness in correctly identifying cases with reportable pathogens. These findings align with the results of the current study, strengthening the evidence supporting the accuracy and reliability of the predictive method in assessing the presence or absence of pathogens in culture results.

Another study focused on children ranging from 3 weeks to 21 years of age and investigated the use of paper-based testing for suspected urinary tract infections (UTIs). The study reported a sensitivity of 92%, indicating the test's ability to accurately identify true positive cases, and a specificity of 62%, suggesting its capability to correctly identify true negative cases. The positive predictive value (PPV) was reported as 22%, indicating the probability that a positive test result corresponds to an actual UTI, while the negative predictive value (NPV) was 99%, indicating the probability that a negative test result accurately rules out a UTI.[15]

Others found that negative dipstick analysis and microscopy results effectively rule out UTIs in children, eliminating the need for confirmatory culture. Positive results on both tests suggest further investigation with a urine culture. Implementing these tests can cut clinic costs by avoiding unnecessary cultures for negatives and reduce inappropriate antibiotic use while waiting for culture results.[16]

This study, with only 130 children in a single center and a narrow age range (1-5 years), has limitations. It may not fully represent a broader population of children with urinary tract infections, and findings may not apply to diverse healthcare settings or older age groups. Future research with larger samples, multi-center designs, and a wider age range is needed to establish accurate diagnostic capabilities of urine examination for detecting UTIs in children.

CONCLUSION

Urine examinations demonstrate satisfactory specificity but limited sensitivity as a diagnostic test for detecting urinary tract infections (UTIs) in children. Therefore, clinicians should rely on urine culture for accurate diagnosis of UTIs in this population.

Ethical Consideration

This study was approved by the ethical review board of Lady Reading Hospital, Peshawar, Pakistan.

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Conflict of Interest

Authors declared no conflict of interest

REFERENCES

1. White B. Diagnosis and treatment of urinary tract infections in children. Am Fam Physician. 2011; 83(4):409-15.
2. Kuppermann N, Dayan PS, Levine DA, Vitale M, Tzimenatos L, Tunik MG, et al. A clinical prediction rule to identify febrile infants 60 days and younger at low risk for serious bacterial infections. J Am Med Assoc Pediatr. 2019;173(4):342-51. DOI: https://doi.org/10.1001/jamapediatrics.2018.5501
3. Waterfield T, Foster S, Platt R, Barrett MJ, Durnin S, Maney J-A, et al. Diagnostic test accuracy of dipstick urinalysis for diagnosing urinary tract infection in febrile infants attending the emergency department. Arch Dis Child. 2022;107(12):1095-9. DOI: https://doi.org/10.1136/archdischild-2022-324300
4. Veauthier B, Miller MV. Urinary tract infections in young children and infants: common questions and answers. Am Fam Physician. 2020 Sep 1;102(5): 278-85.
5. Leung AK, Wong AH, Leung AA, Hon KL. Urinary tract infection in children. Recent Adv Inflamm Allergy Drug Discov 2019;13(1):2-18. DOI: https://doi.org/10.2174/1872213X13666181228154940
6. Chen J, Ahmad R, Li W, Swain M, Li Q. Biomechanics of oral mucosa. J R Soc Interface. 2015;12(109):20150325. DOI: https://doi.org/10.1098/rsif.2015.0325.

7. Salahuddin A, Ahmad S, Jan AZ, Zahid B, Khan A, Khan H, et al. Diagnostic accuracy of urine routine examination for diagnosis of urinary tract infection in different pediatric age groups taking culture as gold standard: a single center study from Peshawar. J Rehman Med Inst. 2021;7(4):15-7.
8. Limpuangthip N, Somkotra T, Arksornnukit M. Modified retention and stability criteria for complete denture wearers: A risk assessment tool for impaired masticatory ability and oral health-related quality of life. J Prosthet Dent. 2018;120(1):43-9. DOI: https://doi.org/10.1016/j.prosdent.2017.09.010
9. Seals JR, Kuebker WA, Stewart KL. Immediate complete dentures. Dent Clin North Am. 1996;40(1):151-67.
10. Rahn AO, Ivanhoe JR, Plummer KD. Textbook of complete dentures/by Arthur O. Rahn, John R. Ivanhoe, Kevin D. Plummer. Shelton, Conn. People's Medical Publishing House; London: McGraw-Hill; 2009.
11. Bandari B, Sindgikar SP, Kumar SS, Vijaya MS, Shankar R. Renal scarring following urinary tract infections in children. Sudan J Paediatr. 2019;19(1): 25-30.
12. Zhao J, Wang X. Dental prostheses. Advanced ceramics for dentistry: Elsevier; 2014. p. 23-49.
13. Saquib Ahmed Shaikh LK, Mathur G. Relationship between occlusal plane and three levels of ala tragus line in dentulous and partially dentulous patients in different age groups: A pilot study. J Clin Diagnos Res. 2015;9(2):ZC39-ZC43. DOI: https://doi.org/10.7860/JCDR/2015/11820.5575.
14. Driscoll CF, Freilich MA, Guckes AD, Knoernschild KL, Mcgarry TJ, Goldstein G, et al. The Glossary of Prosthodontic Terms. J Prosthet Dent. 2017;117:c1-e105.
15. Pediatrics AAo. Practice parameter: the diagnosis, treatment, and evaluation of the initial urinary tract infection in febrile infants and young children. Pediatr. 1999;103:843-52.
16. Diviney J, Jaswon MS. Urine collection methods and dipstick testing in non-toilet-trained children. Pediatric Nephrology. 2021 Jul;36:1697-708. DOI: https://doi.org/ 10.1007/s00467-020-04742-w

DATA SHARING STATEMENT: The data that support the findings of this study are available on request from the corresponding author. The data is not publicly available due to privacy or ethical restrictions.

AUTHORS' CONTRIBUTION

The following authors fullfill authorship criteria as per ICMJE guidelines;

Tasmia:	Substantial contribution to conception and design, drafting the manuscript, final approval, agreed to be accountable for all the work.
Muhammad A:	Substantial contribution to conception and design, data acquisition, drafting the manuscript, final approval, agreed to be accountable for all the work.
Beland B:	Analysis and interpretation of data, drafting the manuscript, final approval, agreed to be accountable for all the work.
Zarin A:	Analysis and interpretation of data, critical revision,final approval, agreed to be accountable for all the work.

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