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Developing An Algorithm For Empirical Antibiotic Therapy Using Urinary Pus Cells And Hematological Markers In Urinary Tract Infections.

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Abstract
Urinary tract infections (UTIs) are among the most prevalent bacterial infections globally, affecting individuals of all age groups and posing a significant public health challenge. While Escherichia coli is the leading causative agent, accounting for approximately 80% of infections, other pathogens such as Klebsiella spp., Staphylococcus aureus, and Proteus species also contribute to the disease burden. Clinical manifestations include dysuria, urinary frequency, urgency, and systemic symptoms like fever and flank pain in severe cases. Risk factors include anatomical anomalies, poor hygiene, urinary retention, diabetes, and immunosuppression. This study investigates the clinical features, common pathogens, and potential biomarkers for diagnosing and predicting the severity of UTIs. Biomarkers such as white blood cell count, hemoglobin levels, and urinary pus cell counts emerged as significant indicators for early diagnosis and pathogen identification. The findings highlight the importance of timely diagnosis and appropriate management to mitigate complications such as recurrent infections and the growing threat of antibiotic resistance. Future research should focus on elucidating the molecular mechanisms of UTI pathogenesis and developing advanced strategies for prevention and treatment.

Keywords: *Urinary tract infection*, Escherichia coli, *Biomarkers*, *UTI pathogens*, *antibiotic resistance*, *diagnosis*, *recurrent infections*

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I. Introduction

Urinary tract infections (UTIs) are one of the most prevalent bacterial infections globally, affecting individuals of all age groups and causing significant morbidity and economic burden. Women are particularly susceptible due to anatomical factors, although UTIs also affect men, the elderly, and individuals with specific risk factors such as diabetes, urinary tract obstructions, or immunosuppression [1-2]. These infections are characterized by symptoms such as dysuria, urinary frequency, urgency, and, in severe cases, systemic manifestations like fever and flank pain. Timely and accurate management is essential to prevent complications such as ascending infections, recurrent UTIs, and long-term renal damage.

The majority of UTIs are caused by *Escherichia coli*, which accounts for approximately 75–80% of cases. However, other pathogens, including *Klebsiella spp.*, *Proteus* species, and *Staphylococcus aureus*, have been implicated in varying proportions, particularly in patients with recurrent or healthcare-associated infections [3,4]. Identifying the causative organism is critical for initiating targeted antibiotic therapy, but the conventional reliance on urine culture—a gold standard diagnostic method—poses a challenge due to the time required for results, often 48–72 hours [5]. This delay can lead to inappropriate empirical treatment, contributing to therapeutic failure, prolonged illness, and the emergence of antimicrobial resistance.

Recent studies suggest that readily available laboratory markers such as urinary pus cell counts, hemoglobin levels, and white blood cell counts can provide valuable insights into the severity and etiology of UTIs before culture results are available [6-7]. Elevated pus cell counts, for example, are a hallmark of infection, while hematological changes can indicate systemic inflammation or the type of pathogen involved. Correlating these markers with pathogen-specific trends could enable clinicians to predict the likely causative organism and start tailored empirical antibiotic therapy earlier.

This study aims to develop a diagnostic algorithm leveraging urinary pus cell counts and hematological markers to guide empirical antibiotic therapy for UTIs. Such an algorithm would not only expedite appropriate treatment but also reduce the misuse of broad-spectrum antibiotics, addressing the critical issue of antibiotic resistance. By integrating clinical and laboratory data, this approach seeks to bridge the gap between the onset of symptoms and culture confirmation, optimizing patient outcomes and resource utilization in healthcare settings.

II. Material And Methods

Study Design

This is a retrospective, observational study conducted to analyzehematological and urinary parameters in patients with culture-positive urinary tract infections (UTIs). The study includes data collected from medical records of patients of all age groups admitted to [Hospital Name] over a specified period (e.g., January 2020 to December 2023).

Study Population

Patients of all age groups with culture-positive urinary tract infections were included in the study. Only patients with a positive urine culture, indicating a UTI, were considered. Patients without culture results, incomplete records, or those with missing hematological and urine microscopy data were excluded from the analysis.

Data Collection

Data were collected from the electronic health records and laboratory databases for each patient meeting the inclusion criteria. The following variables were retrieved for each patient:

1. Hemoglobin Level: Measured in grams per deciliter (g/dL) as part of the complete blood count (CBC) during the UTI diagnosis.
2. Total Leukocyte Count (TLC): Measured in cells per microliter (cells/µL), collected from the CBC to assess systemic inflammation.
3. Platelet Count: Measured in platelets per microliter (platelets/µL), obtained from the CBC.
4. Pus Cells in Urine: Reported as the number of pus cells per high-power field (HPF) under urine microscopy to evaluate local infection response.

Laboratory Analysis

- Urine Culture: Standard microbiological techniques were used to culture urine samples. A positive result was defined as bacterial growth ≥10^5 colony-forming units (CFU) per milliliter.
- Complete Blood Count (CBC): Hematological parameters, including hemoglobin level, total leukocyte count, and platelet count, were measured using an automated hematologyanalyzer.
- Urine Microscopy: Pus cells in urine were evaluated by examining centrifuged urine samples under a high-power field using a light microscope.

Statistical Analysis

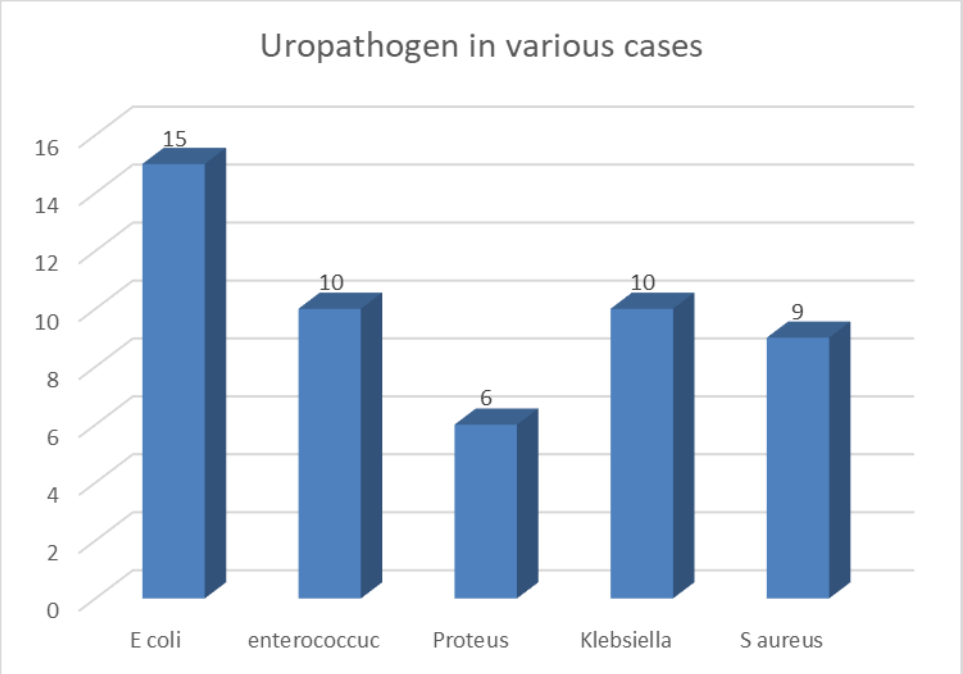
- Descriptive statistics were used to summarize patient demographics and laboratory parameters.
- Mean and standard deviation (SD) or median and interquartile range (IQR) were calculated for continuous variables.
- Subgroup analyses were conducted based on age groups, gender, and severity of UTI to identify any significant associations with the laboratory parameters.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee, and a waiver for informed consent was obtained due to the retrospective nature of the study.

III. Result

In the present study, a total of 50 culture-positive urinary tract infection (UTI) cases were analyzed. The majority of cases (30%) were positive for Escherichia coli (15 cases), followed by Enterococcus and Klebsiella, each accounting for 20% (10 cases each). The least frequent uropathogen was Proteus, with six cases (12%).



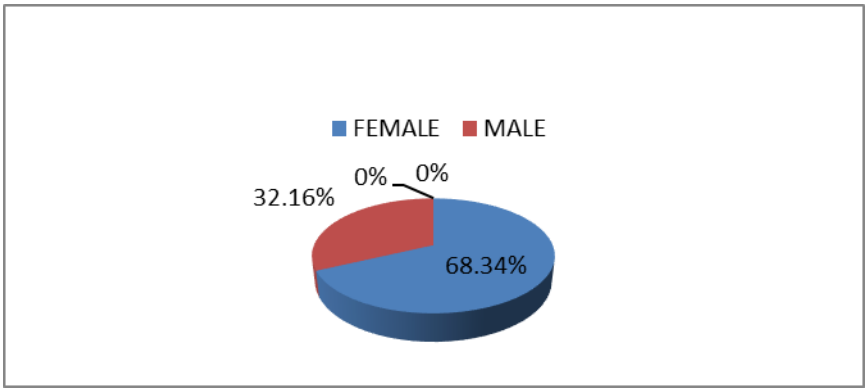
Graph showing various pathogen in study

Age distribution

The mean age of the patients was 36.7 years, with a standard deviation (SD) of 16.2 years.

Gender Distribution

Out of the 50 cases, 16 (32.16%) were male, and 34 (68.34%) were female, as illustrated in the accompanying pie chart.



Pie chart showing number of male and female cases or Urinary tract infection in present study.

Common Symptoms

The study identified four predominant symptoms among patients: high-grade fever (14 cases), dysuria (13 cases), lower abdominal pain (13 cases), and fever with chills (10 cases). Among the 15 *E. coli*-positive cases, the most common symptom was high fever, seen in 7 cases (46.66%). For *Enterococcus*, high fever was also predominant in 4 out of 10 cases (40%). Dysuria was the leading symptom in *Klebsiella*-positive cases, occurring in 5 out of 10 cases (50%). Among the six cases of *Proteus* infection, lower abdominal pain was reported in 5 cases (83.33%). Lastly, for *Staphylococcus aureus*, dysuria and fever with chills were the most common symptoms, each occurring in 3 out of 9 cases (33%).

Hematological and Microscopic Features

The average hemoglobin level among the participants was 11.05 g/dL (SD: 1.46), while the mean total leukocyte count (TLC) was 9,540/mm³ (SD: 5,027.31). The average platelet count was 3.20 lakh/mm³ (SD: 0.09), and the mean pus cell count per high-power field (HPF) was 9.44 cells (SD: 6.54).

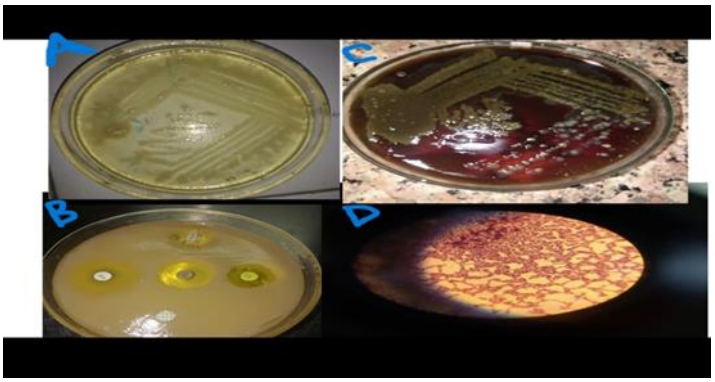


Fig A: Growth of Staphylococcus aureus on nutrient agar.
Fig B: Antibiotic sensitivity pattern on MHA agar.
Fig C: Growth of Klebsiella pneumoniae on blood agar.
Fig D: Microscopic image of E.coli .

The hematological and urinary microscopic parameters for each uropathogen are summarized in Table 1.

Table no 1 Shows haematological and urinary microscopic features in cases with urinary tract infection as per the various pathogents. The Hemoglobin percentage in e coli cases were 11.11gm% with Standard deviation of 1.81 gm%, Enterococci cases shows haemoglobin percentage of 10.99gm% with standard deviation of 1.82%, Klebsiella positive cases shows haemoglobin level 10.65gm% with standard deviation of 1.15gm%, Proteus positive cases shows haemoglobin percentage 11.83% with standard deviation of 0.81 gm%, lastly S aureus cases shows 10.94 gm% with standard deviation of o.66%. . The difference in the values of all parameters in respect of three groups was not statistically significant ($p>0.05$) .

The platelet count in the case of E.coli the value was 3.18 lakh per mm3 with the standard deviation of 0.82 lakh per mm3 , for Enterococci the value was 3.22 lakh per mm3 with the standard deviation of 0.77 lakh per mm3, in the case of Klebsiella the value was 2.68 lakh per mm3 with the standard deviation of 0.01 lakh per mm3, for Proteus the value 3.09 lakh per mm3 with standard deviation of 0.53 lakh per mm3 , and lastly for S.aureus the vale was 3.71 lakh per mm3 with the standard deviation of 0.40 lakh per mm3 .

The pus cell count for E.coli the value was 17.2 per HPF with the standard deviation of 5.2 per HPF ,in the case of Enterococci the value was 4.5 per HPF with the standar deviation of 1.08 per HPF ,for Klebsiella the value was 7.1 per HPF with the standard deviation of 1.44 per HPF , in the case of Proteus 8.66 per HPF with the standard deviation of 1.96 per mm3 , and lastly for S.aureus the value was 6.06 per HPF with the standard deviation of 5.07 per HPF .

This study provides valuable insights into the clinical presentations, gender distribution, and hematological profiles of UTI cases caused by various uropathogens.

Statistical Analysis

The statistical analysis revealed no significant differences in hematological parameters across the groups ($p > 0.05$). However, urine microscopy findings showed a statistically significant difference in the presence of pus cells between samples with *E. coli*uropathogens and those with other uropathogens. Independent t-test analysis demonstrated a p-value < 0.001, indicating a robust association between *E. coli* infections and higher pus cell counts in urine microscopy compared to infections caused by other uropathogens.

But there was no significant difference between e coli and other uropathogen in terms of haemoglobilnevenm and total leukocyte count with p vale 0.49 and 0.09 respectively.

Table no 1 Shows haemoglobin , total leukocyte count, platelets and pus cell per high power field in various uropathogens.

	Hemoglobin	TLC in per mm3	Platelets in lakh per mm3	Pus cell per high power field	Most common symptom
E coli	11.11±1.81	8000±4391	3.18±0.82	17.2±5.7	High fever
Enterococci	10.99±1.82	10600.1±6292	3.22±0.77	4.5±1.08	High fever
Klebsiella	10.65±1.15	11400±5501	2.68±0.01	7.1±1.44	Dysuria
Proteus	11.83±0.81	10333.33±5163	3.09±0.53	8.66±1.96	Lower abdominal pain
S aureus	10.94±0.66	8333.33±3674.	3.71±0.40	6.06±5.07	Dysuria/ Fever with chills

IV. Discussion

This study highlights a significant correlation between urinary pus cell counts, and specific uropathogens in patients with urinary tract infections (UTIs). Establishing these associations offers a potential diagnostic approach for predicting the likely uropathogen before culture results are available, facilitating timely and targeted antibiotic treatment. This strategy could reduce reliance on broad-spectrum antibiotics, minimize unnecessary exposure, and contribute to the prevention of antibiotic resistance.Also we can create an algorithmic approach to identify the specific uropathogen based of common symptoms which were variable in different uropathogens.

Biomarkers as Predictive Tools

Analyzing biomarkers such as hemoglobin, total leukocyte count (TLC), and pus cell count provides critical insights into diagnosing and assessing the severity of UTIs. Our findings revealed that a pus cell count exceeding 10–13 per high-power field (HPF) was predominantly associated with *Escherichia coli* infections, while counts below 10 were linked to other pathogens such as *Klebsiella*, *Staphylococcus aureus*, *Enterococci*, and *Proteus* species. These results are consistent with the findings of M.J. Haja Abdul Nazeer et al. [8]and similar studies by Anjila Dongolet al. [9] and Dhakal et al. [10], which indicated that 5–10 pus cells per HPF serve as a marker for UTIs .

Furthermore, the TLC count in UTI patients ranged from 11,000 to 25,000/mm³ in 30–33 out of 50 cases, irrespective of the pathogen, aligning with the immune response observed in UTIs. Platelet counts, however, remained within a normal range of 2.5–3 lakh/mm³, showing no direct association with infection severity.

Hemoglobin and Anemia as Risk Factors

A significant finding was the variation in hemoglobin levels between genders among UTI patients. Females exhibited hemoglobin levels between 7–11 g/dL, with 35% identified as anemic (hemoglobin<10 g/dL). In contrast, males showed levels ranging from 9.5–12.5 g/dL. These results align with earlier studies in Erbil (2013) and Mexico (2009), which demonstrated a strong association between anemia and UTIs .Anemia, often linked to iron deficiency, is a well-established risk factor for infections, including UTIs, due to its role in compromising immune function. Studies by G.S. Tansarliet al.[13] and the National Center for Health Statistics (2004)[14] corroborate these findings, emphasizing iron's critical role in both human immunity and microbial growth .

Gender Distribution and Pathogen Prevalence

UTIs were more prevalent among females (68%) in our study, a trend consistent with previous findings by Hooker et al.[15] and other research that emphasizes the anatomical and hormonal predisposition of women to UTIs . *Escherichia coli* was the most frequently isolated pathogen (30%), followed by *Klebsiella* (20%) and *Staphylococcus aureus* (18%), reflecting global patterns reported in studies such as those by Kristiansen et al. [16], where *E. coli* accounted for 81.5% of UTIs .

Clinical Implications and Future Directions

The study proposes a diagnostic model utilizing hemoglobin levels, TLC, and pus cell count as predictive biomarkers. Integrating this model into mobile or web-based platforms could enable healthcare providers to predict the causative uropathogen and guide empirical antibiotic therapy more effectively. Such a tool could improve the timeliness of treatment while reducing reliance on broad-spectrum antibiotics, addressing the critical challenge of antibiotic resistance. However, validation in diverse clinical settings is essential for broader implementation.

Further research should focus on larger sample sizes, advanced statistical modeling, and machine learning techniques to enhance predictive accuracy. Exploring the integration of additional biomarkers and patient-specific data could further refine this diagnostic approach .

Limitation

The study's primary limitation is the relatively small sample size of 50 patients, which restricts the generalizability of the findings and the robustness of the proposed algorithm. A larger, more diverse sample is essential to validate these correlations and improve the predictive accuracy of the model.

V. Conclusion

This study aimed to explore early detection of UTIs using easily detectable biomarkers such as hemoglobin (Hb), total leukocyte count (TLC), and pus cell count. The findings indicated a decrease in Hb, an increase in TLC, and varying pus cell counts in urine, all of which can be utilized for early UTI detection. By

establishing ranges for these biomarkers, it is possible to detect UTIs at an early stage, which is both budget-friendly and beneficial for patients. Notably, this is the first study focused on uropathogen-specific biomarkers, offering a promising strategy to reduce the overuse of broad-spectrum antibiotics, thereby helping prevent the development of multidrug-resistant pathogens.

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