Section: General Medicine

Original Research Article

MICROBIOLOGICAL AND ANTIBIOTIC RESISTANCE PATTERN IN ADULTS PRESENTING WITH ACUTE PYELONEPHRITIS – A RETROSPECTIVE OBSERVATIONAL SINGLE CENTER STUDY

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ABSTRACT

Background: Due to the extensive usage of antibiotics, multidrug-resistant bacteria are becoming more prevalent. In this study, the microbiological profile and pattern of antibiotic resistance in adult patients with acute pyelonephritis were assessed. **Materials and Methods:** The case records of the patients admitted with evidence of urinary tract infection were examined retrospectively as part of this cross-sectional study, which was carried out in a tertiary care hospital in Chennai between January and December 2023. The study included 76 individuals who were 20 years of age or older. A positive urine dipstick for leukocyte esterase or nitrite, or more than 10 white blood cells per high-power field on microscopy, was used to identify acute pyelonephritis. Extended-spectrum beta-lactamase (ESBL) production was assessed using the VITEK-2 ESBL test, and bacterial isolates from blood and urine cultures were identified by biochemical profiling using the VITEK-2 system. **Result:** The ratio of males to females was 1:0.9. The average age was 58.7 ± 16.8 years; the majority of patients (25%) were in the 51–60 age range, followed by those over 60 (19%). The most frequent symptom was fever (53.9%), which was followed by vomiting (27.6%). The most common isolate was Escherichia coli (63.2%), which was followed by Klebsiella spp. (26.3%) and Pseudomonas spp. (10.5%). Overall resistance rates to trimethoprim-sulfamethoxazole (TMP/SMX), quinolones, and piperacillin-tazobactam (TZP) were 32.9%, 19.7%, and 18.4%, respectively. Among E. coli isolates, resistance was highest to TZP (20.8%) and ceftriaxone (20.8%), followed by quinolones and carbapenems (18.8% each). Klebsiella spp. showed the highest resistance to TMP/SMX (25%), followed by quinolones (15%) and TZP (15%). Pseudomonas spp. demonstrated the highest resistance to quinolones (37.5%). **Conclusion:** E. coli was the most common pathogen causing acute pyelonephritis, with notable resistance to TZP and ceftriaxone. To direct empirical antibiotic therapy and improve patient outcomes, it is essential to evaluate local patterns of antimicrobial resistance.

INTRODUCTION

The most severe type of urinary tract infection (UTI), acute pyelonephritis (APN), is characterized by infection of the pelvis and renal parenchyma. Upper UTI symptoms, including fever, flank pain, and pyuria, are usually how it presents.[1,2] However, these symptoms can often be nonspecific or ambiguous; in some cases, fever may be the only presenting feature.[3,4] In such situations, objective confirmation of pyuria becomes crucial for diagnosis.[5-7] Nevertheless, the absence of pyuria has been observed in certain patients diagnosed with APN, a finding that is frequently encountered in clinical practice.[8]

A broad spectrum of organisms can cause APN, with Gram-negative bacilli—particularly Escherichia coli—being the predominant pathogens, responsible for approximately 75–90% of cases.[9] Although most patients respond well to antimicrobial therapy, the increasing prevalence of antimicrobial resistance among common uropathogens, especially E. coli and Enterobacter species, poses a growing therapeutic

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challenge.[10] These organisms need special attention because they limit treatment options and complicate clinical care by conferring resistance to the majority of broad-spectrum β-lactam antibiotics, such as cephalosporins, monobactams, penicillins, and aztreonam.[11]

Recurrent APN occurs in approximately 10% of patients and is of particular concern due to its negative impact on quality of life, increased healthcare costs, and contribution to antimicrobial resistance.[12] Several risk factors for recurrence have been identified, including neurogenic bladder, prior UTI history, and fluoroquinolone nonsusceptibility during the index infection.[13]

A major threat to human health and an obstruction to the United Nations' "Sustainable Development Goals (SDGs)", "AMR (Antimicrobial Resistance)" has become a worldwide health emergency.[14] Clinical outcomes significantly worsen as infections develop resistance, which raises mortality, prolongs hospital stays, and drives up healthcare expenses.[15] Particularly concerning are multidrug-resistant Gram-negative bacteria, which include carbapenem-resistant Enterobacteriaceae and carbapenem-resistant Acinetobacter baumannii, which the "Centers for Disease Control and Prevention (CDC)" chose as "urgent threat" pathogens in 2019, requiring strict infection control protocols and increased surveillance.[16]

The most common cause of community-acquired UTIs globally remains E. coli, and the frequency of infection is rising as diabetes mellitus and antibiotic use become more common.[17] A serious threat to public health is the rise of multidrug-resistant (MDR) E. coli bacteria, especially those that produce ESBL.[18] There is currently no clinical information on the prognosis of critically ill people with E. coli infections that produce ESBL. Therefore, this study aims to assess the microbiological profile and antibiotic resistance patterns among adult patients presenting with acute pyelonephritis, with a focus on ESBL-producing organisms.

MATERIALS AND METHODS

From January 2023 to December 2023, all patients with acute pyelonephritis (APN) admitted to the general medicine department of Southern Railway Headquarters Hospital in Chennai, South India, were the subject of a retrospective, hospital-based cross-sectional study.

Case records of eligible patients were retrieved and analyzed retrospectively.

Inclusion criteria comprised patients aged over 20 years with a confirmed diagnosis of APN. Exclusion criteria included pregnant women, renal transplant recipients, patients with a previous history of pyelonephritis, and incomplete medical records.

Data was gathered from medical records using a pre-made, organized proforma. Demographic factors (age, sex, and "body mass index [BMI]"), a thorough medical history, physical examination results, underlying comorbidities, abnormalities of the urinary system, and the presence of urinary catheters or percutaneous nephrostomy were all included in the information. Complete blood count, C-reactive protein (CRP), blood culture results, urine routine and culture results, antibiotic susceptibility patterns, and the presence of organisms that produce extended-spectrum β-lactamases (ESBLs) were among the laboratory data documented. Additional metrics were recorded, including in-hospital mortality, length of hospital stay, and "ICU (Intensive Care Unit)" stay.

Microbiological analysis: The VITEK-2 automated system was employed for biochemical profiling in order to identify bacterial isolates from blood and urine cultures. The VITEK-2 ESBL test, which was carried out in the hospital microbiology lab, was used to measure ESBL production. The "Centers for Disease Control and Prevention (CDC)"/ "Infectious Diseases Society of America (IDSA)" criteria were used to establish the diagnosis of acute pyelonephritis (APN). At least one clinical symptom, such as fever (>38°C), urgency, frequency, dysuria, suprapubic discomfort, or costovertebral angle tenderness, along with one or more of the following, was required to be diagnosed as APN: The presence of more than 10 white blood cells per high-power field on microscopy, or a positive urine dipstick for leukocyte esterase or nitrite. A quantitative urine culture in a patient with symptoms that demonstrates bacterial growth of $>10^5$ CFU/mL or 10^3–10^4 CFU/mL. Included in the supporting evidence were: harmful organisms' growth in blood cultures. Ultrasonography, "CT (Computed Tomography)", "MRI (Magnetic Resonance Imaging)", or nuclear scan results (e.g., gallium or technetium) that point to a renal infection.

Statistical Analysis: A Microsoft Excel spreadsheet was employed to enter the acquired data, and Epi Info version 7.2 software was employed for analysis. Frequencies and percentages were utilized to represent categorical variables, whereas range, mean, and standard deviation (SD) were used to characterize continuous variables. The relationship between dependent and independent variables was evaluated using bivariate analysis. The Student's t-test was employed for continuous data and the Chi-square test for categorical variables. Statistical significance was a p-value of 0.05 or less.

The Institutional Ethics Committee granted ethical permission prior to data collection, and the study was carried out in compliance with the Declaration of Helsinki's principles.

RESULTS

In all, 76 patients were involved in the research. The study population's mean age was 58.7 ± 16.8 years, and [Table 1] indicates that the largest percentage (32.9%) was in their fifth decade of life. The male-to-female ratio was 1:0.9, with 40 (52.6%) of the

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participants being men and 36 (47.2%) being women [Figure 1].

The most common presenting symptom was fever (53.9%), followed by vomiting (27.6%), abdominal pain (19.7%), burning micturition (15.8%), and reduced urine output (9.2%) as summarised in Table 2. Among comorbid conditions, diabetes mellitus was the most prevalent, seen in 52.6% of cases, followed by hypertension (39.5%), CAD (18.4%), CKD (15.8%), and CLD (5.3%) as detailed in [Table 2].

The most frequent complication observed was acute renal failure (61.8%), followed by hepatic dysfunction (27.6%), altered sensorium (19.7%), septic shock (13.2%), and MODS (7.9%). The average length of antibiotic treatment was 6.6 ± 0.9 days, the average length of hospitalization was 8.8 ± 2.6 days, and the average length of time spent in the ICU was 4.3 ± 0.5 days [Table 3]. According to radiological results, 86.8% of patients had bulky kidneys, whereas 84.2% had perinephric fat stranding, 25% had hydroureteronephrosis, 18.4% had renal calculi, 15.8% had emphysematous pyelonephritis, and 5.3% had renal abscess [Table 2].

Microbiological examination revealed that, as illustrated in [Figure 2], Escherichia coli was the most common bacterium recovered in 63.2% of cases, followed by Klebsiella spp. (26.3%) and Pseudomonas spp. (10.5%). Piperacillin–tazobactam (TZP) was the most frequently prescribed antibiotic (48.7%), followed by ceftriaxone (22.4%) and Amoxicillin/clavulanic acid (10.5%), as shown in [Table 4]. Regarding antibiotic resistance patterns, the highest overall resistance was observed for trimethoprim–sulfamethoxazole (TMP/SMX) (32.9%), followed by quinolones (19.7%), and piperacillin–tazobactam (TZP) (18.4%), as shown in Figure 3. Carbapenem resistance was noted in 15.8% of isolates. Organism-by-organism analysis revealed that E. Coli isolates had the greatest resistance to ceftriaxone (20.8%) and TZP (20.8%), followed by quinolones (18.8%) and carbapenems (18.8%). For Klebsiella spp., resistance was highest to TMP/SMX (25%), followed by quinolones (15%) and TZP (15%). For Pseudomonas spp., quinolone resistance was most common, observed in 37.5% of isolates as shown in [Figure 4].

Table 1: Age Distribution [N=76]

Age Group (in years)	Numbers	Percentage (%)
20-30	4	5.3
31-40	10	13.2
41-50	18	23.7
51-60	25	32.9
>60	19	25

Table 2: Clinical characteristics

Characteristics	Numbers(n)	(%)
Symptoms		
Fever	41	53.9
Abdominal pain	15	19.7
Vomiting	21	27.6
Burning micturition	12	15.8
Reduce urine output	7	9.2
Co-morbidity		
DM	40	52.6
HTN	30	39.5
CAD	14	18.4
CKD	12	15.8
CLD	4	5.3
Complication		
Altered sensorium	15	19.7
Renal failure	47	61.8
Hepatic failure	21	27.6
Septic shock	10	13.2
MODS	6	7.9
Radiological findings		
Bulky kidney	66	86.8
Perinephric fat stranding	64	84.2
Hydroureteronephrosis	19	25.0
Renal calculi	14	18.4
Emphysematous pyelonephritis	12	15.8
Abscess	4	5.3

Table 3: Duration of hospital, ICU stay, and Antibiotic therapy

Stay (in days)	Mean ± SD
Hospital stay	8.8 ± 2.6
ICU stay	4.3 ± 0.5
Duration of antibiotic therapy	6.6 ± 0.9

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Table 4: Prescribed antibiotics among study participants [N=76]

Prescribed antibiotics	Numbers (%)
Piperacillin/tazobactam (TZP)	37 (48.7%)
Ceftriaxone	14 (18.4%)
Amoxicillin/clavulanic acid	8 (10.5%)
Others	17 (22.4%)

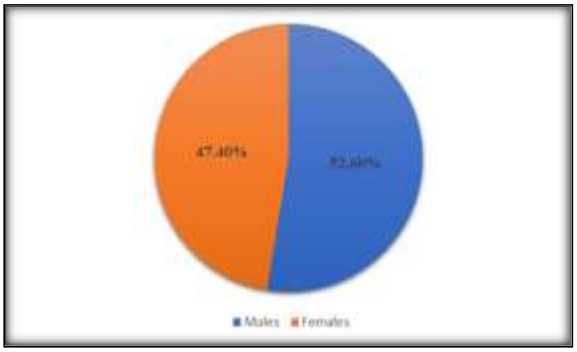

Figure 1: Gender Distribution

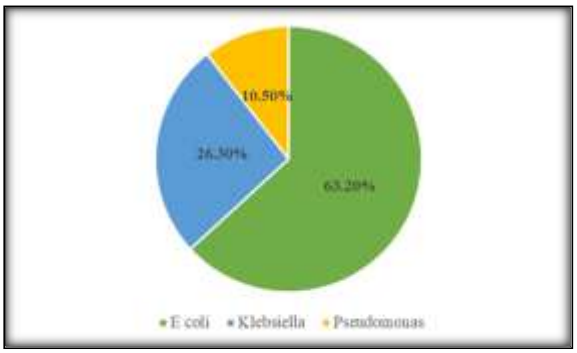

Figure 2: Causative organism distribution

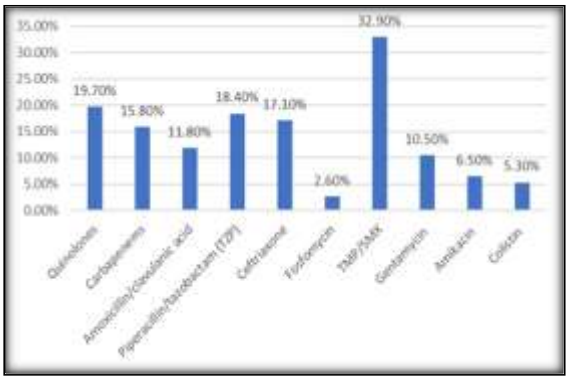

Figure 3: Antibiotic resistance profile

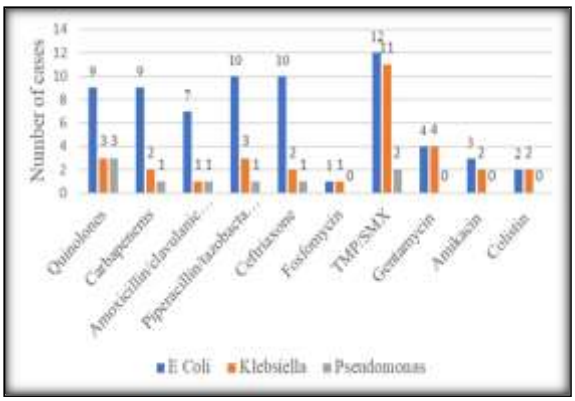

Figure 4: Causative organism Vs resistance to antibiotics

DISCUSSION

The study's mean age was 58.7±16.8 years, and the largest group of participants (25%), followed by those 60 years and older (19%), were in the 51–60 years age range. Subramani J et al,[18] and Hase A N et al,[19] found mean ages of 50 and 50.33 ± 13.9 years, respectively, which are in line with these findings. The male-to-female ratio in our study was 1:0.9, which is comparable to the observations made by Subramani J et al,[18] Umesha L et al,[21] and Hase A.N. et al.[19] Similarly, in the study conducted by Hyma T et al,[20] among 40 patients, 26 (65%) were males and 14 (35%) were females, yielding a male-to-female ratio of 1.85:1.

Regarding clinical presentation, fever (53.9%) was the most common symptom observed, followed by vomiting (27.6%). These results correspond with Subramani J et al,[18] who found fever and vomiting in 54% and 28% of their patients. Among comorbidities, diabetes mellitus (DM) was the most frequent (52.6%), followed by hypertension (39.5%). Similar trends were observed in studies by Subramani J et al,[18] Hase A.N. et al,[19] and Hyma T et al.[20] Epidemiological studies by Buonaiuto V.A et al,[22] Janifer J et al,[23] Boyko E.J et al,[24] and Somani B.K et al,[25] have demonstrated that the risk of urinary tract infection (UTI) is nearly twice as high in diabetic patients compared to non-diabetics. This increased susceptibility is attributed to immunosuppression, the enhanced bacterial growth associated with hyperglycemia, and urological complications such as cystopathy.

We found that the average length of hospital stay in our study was 8.8 days, with an average length of stay in the ICU of 4.3 days and an average length of antibiotic therapy of 6.6 days. These values closely correlate with those reported by Subramani J et al,[18] where the mean ICU stay and antibiotic duration were 4.2 days and 6.5 days, respectively. In line with the findings of Subramani J et al,[18] (renal failure 62%, hepatic failure 28%), the most frequent consequence in our study was renal failure (61.8%), followed by hepatic dysfunction (27.6%).

On microbiological analysis, Escherichia coli (63.2%) and Klebsiella spp. (26.3%) were the most frequent causal organisms. These results are consistent with research by Hyma T et al. [20] (E. coli 64%, Klebsiella 24%) and Hase A.N. et al,[19] (E. coli 53%, Klebsiella 24.4%).

Radiological evaluation in the present study revealed that a bulky kidney (86.8%) was the most common imaging finding, followed by perinephric fat stranding (84.2%), hydroureteronephrosis in 25%, renal calculi in 18.4%, emphysematous

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pyelonephritis in 15.8%, and renal abscess in 5.3%. These results are in accordance with those of Hase A.N. et al,[19] who noted that 77 patients (86.5%) had large kidneys, 75 (84.3%) had perinephric fat stranding, and 23 (25.7%) had hydroureteronephrosis. In their study, 52% of patients had calculous disease, 39% had bladder outlet obstruction such as prostatomegaly or urethral stricture, and 8.6% had papillary necrosis. Additionally, emphysematous pyelonephritis (EPN) was identified in 14 patients (15.7%), while renal abscess occurred in 5.6% of cases.

Regarding antibiotic usage, piperacillin–tazobactam (TZP) was the most frequently prescribed agent in the present study (48.7%), followed by ceftriaxone (22.4%). Analysis of antimicrobial resistance patterns revealed that trimethoprim–sulfamethoxazole (TMP/SMX) exhibited the highest resistance rate (32.9%), followed by quinolones (19.7%) and piperacillin–tazobactam (18.4%). Carbapenem resistance was observed in 15.8% of isolates.

When stratified by organism, Escherichia coli isolates demonstrated the highest resistance to TZP (20.8%) and ceftriaxone (20.8%), followed by quinolones (18.8%) and carbapenems (18.8%). Klebsiella spp. showed the highest resistance to TMP/SMX (25%), followed by quinolones (15%) and TZP (15%). Pseudomonas spp. exhibited the highest resistance to quinolones (37.5%). These results are somewhat consistent with those of Hase A.N. et al,[19] who found that 4% of isolates had pan-resistance and 12.2% had carbapenem resistance. In their study, E. coli showed high-grade resistance to co-trimoxazole (50%), quinolones (92.3%), and cephalosporins (53.8%), while retaining susceptibility to nitrofurantoin (61.5%), aminoglycosides (84.6%), aminopenicillins (92.3%), β-lactam/β-lactamase inhibitor combinations (88.5%), carbapenems (92.3%), and colistin/polymyxin B (96.3%).

The relatively lower resistance rates observed in the present study compared with previous reports may reflect institutional variations in antibiotic prescribing patterns, differences in local microbial ecology, and antimicrobial stewardship practices. However, the observed resistance to commonly used antibiotics such as TMP/SMX, quinolones, and third-generation cephalosporins remains clinically significant, emphasizing the need for judicious empirical therapy guided by local antibiograms and continuous surveillance of antimicrobial resistance trends.

CONCLUSION

The present study demonstrates that acute pyelonephritis (APN) requiring hospitalization is more common among older adults and males, particularly those with diabetes mellitus. Escherichia coli was shown to be the primary source of infection, and it showed notable resistance to prevalent antibiotics like ceftriaxone and piperacillin–tazobactam (TZP). The highest resistance was observed for trimethoprim–sulfamethoxazole (TMP/SMX), followed by quinolones and TZP. To direct empirical treatment and enhance clinical results, it is essential to continuously monitor local trends of antibiotic resistance. Formulation of institution-specific antibiotic guidelines based on local microbiological data is strongly recommended. In order to avoid renal problems and lower the related morbidity and mortality, early identification and timely beginning of adequate antimicrobial therapy are still crucial.

Limitations: This research possesses multiple limitations. The study's restricted sample size and single-center methodology may have limited how far the findings can be applied. Secondly, due to its retrospective character, it depended on the precision and comprehensiveness of medical records, and certain clinical or laboratory information may have been absent. Third, molecular characterization of the bacterial isolates and genotypic analysis of antimicrobial resistance were not performed, which could have provided deeper insights into resistance mechanisms. Fourth, treatment outcomes beyond the hospital stay were not evaluated, so long-term renal sequelae and recurrence rates could not be assessed. It is advisable to conduct multicentric prospective research with larger sample sizes and molecular analyses to corroborate and enhance these findings.

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