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BACTERIAL SPECTRUM AND ANTIBIOTIC SENSITIVITY IN SPONTANEOUS BACTERIAL PERITONITIS ASSOCIATED WITH LIVER CIRRHOSIS

Original Research

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ABSTRACT

Background: Spontaneous bacterial peritonitis (SBP) is a life-threatening complication of liver cirrhosis, often leading to severe morbidity and mortality. The increasing prevalence of multidrug-resistant (MDR) organisms has complicated empirical treatment protocols, particularly in regions with limited microbiological surveillance. This study aims to address the local gap in data on bacterial spectrum and antimicrobial sensitivity in cirrhotic patients with SBP.

Objective: To determine the bacterial spectrum and antibiotic sensitivity patterns in spontaneous bacterial peritonitis among patients with liver cirrhosis.

Methods: A cross-sectional study was conducted over six months at the Department of Medicine, Khyber Teaching Hospital, Peshawar. A total of 139 patients aged 30–65 years, diagnosed with SBP secondary to liver cirrhosis, were included through non-probability consecutive sampling. Ascitic fluid was analyzed for culture and sensitivity against commonly used antibiotics. Data on demographics and resistance patterns were recorded and analyzed using SPSS v27. Chi-square tests were applied post-stratification to examine associations.

Results: *Escherichia coli* was the most frequently isolated organism (64.0%), followed by *Klebsiella* spp. (40.3%) and *Staphylococcus* spp. (27.3%). High resistance rates were observed for ciprofloxacin and ceftriaxone among *E. coli* isolates (43.9% and 35.9%, respectively). *Klebsiella* showed equal resistance and sensitivity to ceftriaxone and piperacillin (50%), while *Staphylococcus* spp. remained fully sensitive to vancomycin but demonstrated significant resistance to clindamycin (52.6%) and cefazolin (57.9%).

Conclusion: The predominance of resistant *E. coli* and rising MDR patterns underline the need for continuous microbiological surveillance and revised empirical treatment guidelines. Local resistance profiles should guide antibiotic choices in SBP management to improve outcomes.

Keywords: Anti-Bacterial Agents, Ascitic Fluid, Bacterial Infections, Drug Resistance, Escherichia coli, Klebsiella, Liver Cirrhosis, Microbial Sensitivity Tests, Spontaneous Bacterial Peritonitis, Staphylococcus.

INTRODUCTION

Liver cirrhosis represents the final common pathway of chronic liver injury, characterized by progressive hepatic fibrosis, regenerative nodules, and eventual liver dysfunction (1). As cirrhosis advances, patients frequently develop serious complications including ascites, hepatic encephalopathy, variceal hemorrhage, and bacterial infections, which collectively contribute to high morbidity and mortality rates (2). Approximately 30% of these patients progress to extrahepatic organ failure or acute-on-chronic liver failure (ACLF), with a 90-day mortality rate reaching up to 50% in ACLF cases, largely due to the absence of targeted therapeutic interventions (3). Among the various triggers of acute decompensation, spontaneous bacterial peritonitis (SBP) emerges as one of the most common and life-threatening infections in cirrhotic patients. Defined as an infection of previously sterile ascitic fluid without an evident intra-abdominal source, SBP necessitates prompt diagnosis and treatment to avert systemic complications such as sepsis, renal dysfunction, and hepatic encephalopathy (4,5). Despite the clinical significance of SBP, its presentation may be subtle or asymptomatic, posing challenges in early detection. Although routine diagnostic paracentesis is recommended in hospitalized patients with cirrhosis and ascites, studies have revealed a low prevalence of asymptomatic SBP, reinforcing the importance of clinical vigilance in symptomatic individuals (6,7). The microbiological profile of SBP has evolved over recent decades, with increasing reports of multidrug-resistant (MDR) organisms complicating its management.

Pathogens commonly implicated include *Escherichia coli*, *Klebsiella* species, and *Staphylococcus* species, each exhibiting variable resistance patterns based on geographic location and antimicrobial usage trends (8,9). Recent findings demonstrate worrying resistance trends: *E. coli* showed resistance rates of 35.9% to ceftriaxone and 43.9% to ciprofloxacin; *Klebsiella* showed 50% resistance to both ceftriaxone and piperacillin; while *Staphylococcus* species demonstrated full sensitivity to vancomycin but substantial resistance to clindamycin and cefazolin (10-12). These patterns underscore the clinical urgency of routinely updating empirical treatment guidelines in line with local microbial sensitivity profiles. In regions where data on SBP microbiology and antimicrobial resistance are scarce, especially in low-resource healthcare settings, there remains a significant gap in evidence-based guidance for frontline clinicians. Understanding the current bacterial spectrum and corresponding antibiotic susceptibility is therefore essential to ensure effective empiric therapy, minimize resistance development, and improve patient outcomes. Given the evolving landscape of SBP pathogens and antibiotic response, this study aims to determine the bacterial spectrum and antibiotic sensitivity patterns in patients with spontaneous bacterial peritonitis associated with liver cirrhosis at a tertiary care hospital, thereby providing essential local data to support clinical decision-making and antimicrobial stewardship.

METHODS

This cross-sectional study was conducted in the Department of Medicine at Khyber Teaching Hospital, Peshawar, over a minimum duration of six months following the approval of the research synopsis by the College of Physicians and Surgeons Pakistan (CPSP). Ethical clearance was obtained from the hospital's Institutional Review Board (IRB), and permission was also granted by the CPSP Research and Training Monitoring Cell. All enrolled participants provided written informed consent after receiving a clear explanation of the study's purpose, procedures, potential benefits, and assurance of confidentiality and voluntary participation. The study population comprised male and female patients aged between 30 and 65 years who were diagnosed with spontaneous bacterial peritonitis (SBP) secondary to liver cirrhosis, according to predefined operational criteria. A total sample size of 139 patients was calculated using the WHO sample size calculator, assuming a ciprofloxacin sensitivity of 10% for SBP in cirrhotic patients, a margin of error of 5%, and a confidence level of 95% (8). Participants were recruited through non-probability consecutive sampling. Patients were excluded if they had surgical, tuberculous, or fungal peritonitis; renal impairment; or were pregnant.

Eligible patients were evaluated after securing informed consent. Demographic and clinical details such as age, gender, education status, occupation, body mass index (BMI), socioeconomic status, and place of residence were recorded on a pre-structured data collection proforma. Ascitic fluid samples were collected and analyzed for bacterial culture and sensitivity patterns, with the identification of pathogens including *Escherichia coli*, *Klebsiella* spp., and *Staphylococcus* spp. Antibiotic susceptibility testing was performed for key antimicrobials including ceftriaxone, piperacillin, ciprofloxacin, vancomycin, clindamycin, and cefazolin. All clinical assessments,

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sample collections, and interpretations were carried out under the supervision of a consultant with at least five years of post-fellowship experience in internal medicine or gastroenterology (13,14). Data were entered and analyzed using IBM SPSS Statistics version 27. The Shapiro-Wilk test was applied to assess the normality of numerical data. Continuous variables such as age and BMI were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR) where appropriate. Categorical variables including gender, bacterial species, antibiotic resistance patterns, and sociodemographic factors were presented as frequencies and percentages. Stratification was conducted based on age, gender, BMI, occupation, education level, socioeconomic status, and residence to assess potential effect modifiers. Post-stratification comparisons were performed using Chi-square or Fisher's exact tests, as applicable, with a significance level set at $p < 0.05$. Final results were summarized in tables for clarity and comprehensiveness.

RESULTS

A total of 139 patients with spontaneous bacterial peritonitis associated with liver cirrhosis were enrolled. The mean age was 48.6 ± 9.3 years, with a male predominance (63.3%). The mean BMI was 24.5 ± 3.7 kg/m². Most participants belonged to the lower (48.9%) or middle (39.6%) socioeconomic strata. Nearly 57% were unemployed, and a majority (53.2%) resided in rural areas. Regarding microbial distribution, *Escherichia coli* was the most commonly isolated organism, followed by *Klebsiella* species and *Staphylococcus* species. Antibiotic sensitivity testing showed that among *E. coli* isolates, resistance was highest to ciprofloxacin (43.9%, n=61), followed by ceftriaxone (35.9%, n=50), while piperacillin had relatively better sensitivity (71.8%). Conversely, *Klebsiella* species demonstrated equal resistance and sensitivity (50%) to both ceftriaxone and piperacillin. Interestingly, resistance to ciprofloxacin in *Klebsiella* was notably low (7.1%, n=4), with a high sensitivity rate of 92.9% (n=52). In the case of *Staphylococcus* species, vancomycin retained complete sensitivity (100%, n=38), making it the most effective agent in this group. However, resistance to clindamycin (52.6%, n=20) and cefazolin (57.9%, n=22) was considerably high, limiting their utility. These findings underscore varying resistance patterns among common SBP pathogens, which necessitate careful selection of empirical antibiotics tailored to local microbiological data. The results are summarized in the attached tables, while two colored bar charts visually represent the antibiotic sensitivity patterns of *E. coli* and *Klebsiella* species.

Table 1: Demographics

Variable		n (%) or Mean ± SD
Age (Mean ± SD)		48.6 ± 9.3
Gender	Male	88 (63.3%)
	Female	51 (36.7%)
BMI (Mean ± SD)		24.5 ± 3.7
Socioeconomic Status	Lower	68 (48.9%)
	Middle	55 (39.6%)
	Upper	16 (11.5%)
Occupation Status	Employed	60 (43.2%)
	Unemployed	79 (56.8%)
Residence	Rural	74 (53.2%)
	Urban	65 (46.8%)

Table 2: E. coli Antibiotic Sensitivity

Antibiotic	Resistant n (%)	Sensitive n (%)
Ceftriaxone	50	89
Piperacillin	39	100
Ciprofloxacin	61	78

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Table 3: Klebsiella Antibiotic Sensitivity

Antibiotic	Resistant n (%)	Sensitive n (%)
Ceftriaxone	28	28
Piperacillin	28	28
Ciprofloxacin	4	52

Table 4: Staphylococcus spp. Antibiotic Sensitivity

Antibiotic	Resistant n (%)	Sensitive n (%)
Vancomycin	0	38
Clindamycin	20	18
Cifazolin	22	16

Table 5: Bacterial Isolate Frequency

Bacterial Species	Number of Isolates (n)	Percentage (%)
Escherichia coli	89	64.0%
Klebsiella spp.	56	40.3%
Staphylococcus spp.	38	27.3%

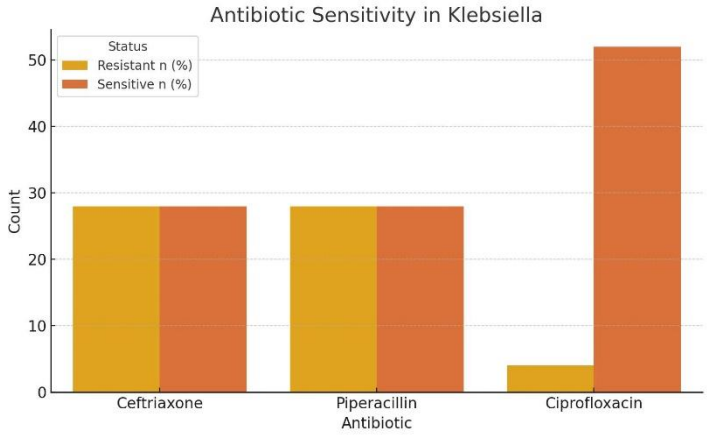

Figure 1 Antibiotic Sensitivity in Klebsiella

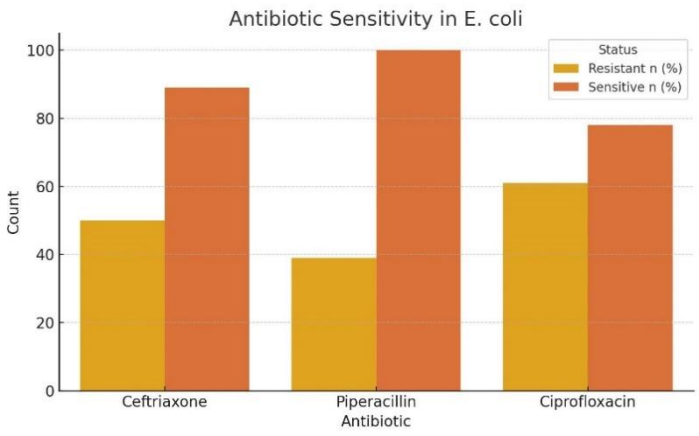

Figure 2 Antibiotic Sensitivity in E. coil

DISCUSSION

The findings of this study affirm the significant role of Gram-negative and Gram-positive bacteria in spontaneous bacterial peritonitis (SBP) among cirrhotic patients, with *Escherichia coli* being the predominant organism, followed by *Klebsiella* spp. and *Staphylococcus* spp. This pattern aligns with earlier research, which consistently identifies *E. coli* as the leading causative agent of SBP, representing 25–60% of isolates across various populations (15-17). The study demonstrated high levels of resistance in *E. coli* isolates to ciprofloxacin (43.9%) and ceftriaxone (35.9%), echoing concerns highlighted by recent literature regarding the declining efficacy of first-line empirical antibiotics (18). Similar resistance patterns have been documented across multiple settings, where quinolones and third-generation cephalosporins have shown reduced sensitivity due to the emergence of extended-spectrum beta-lactamase (ESBL)-producing organisms (19). *Klebsiella* species in this study demonstrated a mixed resistance profile, with equal resistance and sensitivity to ceftriaxone and piperacillin (50%). Notably, ciprofloxacin resistance in *Klebsiella* was low, which is not consistent with most global data that typically report high fluoroquinolone resistance in this pathogen (20). This deviation may reflect regional antibiotic usage patterns or a smaller isolate sample and warrants closer local surveillance.

Among Gram-positive organisms, *Staphylococcus* spp. showed complete sensitivity to vancomycin, aligning with standard recommendations for treating suspected MRSA in nosocomial SBP cases (21). However, significant resistance was noted to clindamycin

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(52.6%) and cefazolin (57.9%), highlighting the limitation of these agents as empirical choices. The presence of multidrug-resistant (MDR) organisms continues to challenge SBP management globally. This study supports findings from multiple contemporary analyses, which estimate MDR prevalence in SBP isolates to range from 40% to 50% (22-24). These trends mandate periodic reevaluation of hospital antibiograms to inform empirical therapy protocols. A notable strength of this study lies in its prospective design and standardized data collection, including stratified analysis and confirmation of SBP diagnosis using clear operational definitions. Moreover, the findings provide updated regional data, an essential component in antimicrobial stewardship and in refining hospital-specific treatment algorithms.

However, the study also bears limitations. The sample was derived from a single tertiary care center, potentially limiting generalizability. The absence of clinical outcome data such as mortality, treatment failure, or recurrence restricted the ability to correlate microbial resistance with prognosis. Additionally, molecular testing for ESBL or carbapenemase production was not performed, which would have provided deeper insight into resistance mechanisms. Future studies should focus on multicentric sampling with larger cohorts and incorporate molecular diagnostics for resistance genes. Research exploring predictive factors for MDR infection, including prior antibiotic exposure and hospitalization history, would further improve empiric therapy decisions. Given the global trend toward increased resistance, investigation into non-antibiotic prophylaxis options such as immunomodulators or gut microbiota modulation may also be valuable (24,25). In conclusion, the study confirms the predominance of *E. coli* and *Klebsiella* as causative organisms of SBP, with an alarming rate of resistance to commonly used antibiotics such as ceftriaxone and ciprofloxacin. The findings reinforce the need for region-specific treatment guidelines and underscore the critical importance of routine microbiological surveillance in guiding empirical antibiotic therapy.

CONCLUSION

This study highlights *Escherichia coli* as the predominant pathogen in spontaneous bacterial peritonitis among cirrhotic patients, with notable resistance to first-line antibiotics such as ceftriaxone and ciprofloxacin. The rising trend of multidrug-resistant organisms reinforces the urgent need for region-specific antimicrobial policies and routine local surveillance. These findings offer valuable data to inform empirical treatment strategies and improve patient outcomes in similar clinical settings.

AUTHOR CONTRIBUTION

Author	Contribution
Sohrab Khan	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Inam Ullah Khan*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Zahid Ullah	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Essa Hassan	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Saif Ullah	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Aitizaz	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Muhammad Aman Khan	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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