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# FREQUENCY OF SPONTANEOUS BACTERIAL PERITONITIS IN PATIENTS PRESENTING WITH ASCITES

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## ABSTRACT

**Background:** Spontaneous bacterial peritonitis (SBP) represents a potentially fatal complication in patients with ascites, traditionally considered predominant in cirrhotic patients due to bacterial translocation facilitated by portal hypertension, intestinal bacterial overgrowth, and immune dysfunction. However, the frequency and risk factors of SBP in non-cirrhotic ascites such as congestive heart failure, nephrotic syndrome, and Budd-Chiari syndrome remain inadequately characterized, particularly in resource-limited settings where diagnostic paracentesis is often restricted to patients with suspected liver disease. This knowledge gap may lead to underdiagnosis and delayed treatment, contributing to preventable morbidity and mortality. Furthermore, existing literature from Pakistan and South Asia has predominantly focused on cirrhotic populations, leaving a significant evidence vacuum regarding SBP epidemiology in diverse ascites etiologies.

**Methods:** This descriptive cross-sectional study was conducted at the Department of Medicine, Mufti Mehmood Memorial Teaching Hospital, Dera Ismail Khan, from 21st April 2025 to 21st July 2025. A total of 97 patients aged 18–75 years presenting with ascites of any etiology were enrolled using consecutive non-probability sampling. The sample size was calculated using the WHO sample size calculator assuming an anticipated SBP prevalence of 20.4%, 8% margin of error, and 95% confidence level. Patients with secondary peritonitis, prior abdominal surgery, or recent antibiotic exposure were excluded to minimize confounding. All participants underwent comprehensive clinical assessment and diagnostic paracentesis with ascitic fluid analysis including polymorphonuclear (PMN) neutrophil count, Gram staining, and aerobic/anaerobic cultures. SBP was diagnosed according to standard international criteria (ascitic fluid PMN count >250 cells/mm3 with exclusion of secondary causes). Data were analyzed using SPSS version 25.0 with appropriate parametric and non-parametric tests, binary logistic regression for multivariable analysis, and ROC curve analysis for diagnostic performance evaluation. Statistical significance was set at $p<0.05$.

**Results:** Among 97 patients, the mean age was 46.48±16.49 years (range: 18–75 years), with 56.7% (n=55) males and 43.3% (n=42) females. Cirrhosis accounted for 40.2% (n=39) of cases, followed by heart failure (29.9%, n=29), nephrotic syndrome (26.8%, n=26), and Budd-Chiari syndrome (3.1%, n=3). The overall frequency of SBP was 20.6% (n=20; 95% CI: 13.4%–28.9%). Notably, SBP occurred in 15.4% (6/39) of cirrhotic patients compared to 24.1% (14/58) of non-cirrhotic patients, though this difference was not statistically significant (p=0.321, Fisher's exact test). By specific etiology, SBP frequencies were: nephrotic syndrome 26.9% (7/26), heart failure 24.1% (7/29), cirrhosis 15.4% (6/39), and Budd-Chiari syndrome 0% (0/3) ($\chi^2$=2.283, df=3, p=0.516; Cramér's V=0.153). Gender showed no association with SBP (20.0% males vs. 21.4% females; $\chi^2$<0.001, p=1.000; OR=0.917, 95% CI: 0.336–2.503). Mean age was comparable between SBP (49.70±16.62 years) and non-SBP groups (45.65±16.46 years; t=1.000, df=95, p=0.320). Ascitic fluid PMN count demonstrated excellent discriminatory performance (AUC=0.994, 95% CI: 0.984–1.000, p<0.001), with SBP patients showing significantly elevated counts (mean: 1018.7±303.9 vs. 108.0±72.8 cells/mm3; Mann-Whitney U=195.0, Z=-5.089, p<0.001, effect size r=-0.517). At the standard 250 cells/mm3 threshold, sensitivity was 100% and specificity 77.9%. Culture-positive SBP occurred in 45.0% (9/20) and culture-negative neutrocytic ascites in 55.0% (11/20). Binary logistic regression identified no independent predictors of SBP (age: adjusted OR=1.020, p=0.270; male gender: OR=0.828, p=0.753; heart failure vs. cirrhosis: OR=1.749, p=0.456; nephrotic syndrome vs. cirrhosis: OR=2.082, p=0.343), though the overall model was significant ($\chi^2$=28.847, df=4, p<0.001, Nagelkerke $R^2$=0.365).

**Conclusions:** Spontaneous bacterial peritonitis affects approximately one in five patients presenting with ascites, with comparable frequency across cirrhotic and non-cirrhotic etiologies in this population. The absence of significant demographic or etiological predictors underscores the necessity of routine diagnostic paracentesis in all patients with ascites, regardless of underlying cause or clinical presentation. Ascitic fluid PMN count remains a highly reliable diagnostic biomarker. These findings challenge conventional paradigms that restrict SBP screening to cirrhotic patients and support universal screening strategies to reduce SBP-related morbidity and mortality in resource-limited healthcare settings.

**KEYWORDS:** Spontaneous bacterial peritonitis; Ascites; Cirrhosis; Heart failure; Nephrotic syndrome; Diagnostic paracentesis; Polymorphonuclear neutrophil count; Pakistan; Cross-sectional study; Bacterial translocation

## 1. INTRODUCTION

Ascites, defined as the pathological accumulation of fluid within the peritoneal cavity, represents a common and clinically significant complication of diverse medical conditions. While most frequently associated with decompensated liver cirrhosis, where it affects approximately 50% of patients within 10 years of diagnosis, ascites also occurs in 10–20% of patients with congestive heart failure, particularly those with right-sided failure or constrictive pericarditis, and represents a cardinal manifestation of nephrotic syndrome and Budd-Chiari syndrome [1,2].

The development of ascites marks a critical transition in disease trajectory, often heralding advanced disease stage and necessitating specialized management. Spontaneous bacterial peritonitis (SBP) constitutes one of the most serious infectious complications in patients with ascites, defined as the infection of ascitic fluid in the absence of an identifiable intra-abdominal, surgically treatable source [3]. Despite advances in antimicrobial therapy, SBP remains associated with substantial mortality, ranging from 10% to 30% even with appropriate treatment, and serves as an independent predictor of poor long-term prognosis in cirrhotic patients [4,5]. The pathophysiology of SBP involves bacterial translocation from the intestinal lumen to mesenteric lymph nodes and subsequent seeding of ascitic fluid, facilitated by intestinal bacterial overgrowth, increased intestinal permeability due to mucosal edema, and systemic immune dysfunction [6,7].

The epidemiology of SBP demonstrates considerable variation across clinical settings and geographic regions. In hospitalized patients with cirrhosis and ascites, reported SBP prevalence ranges from 7% to 30%, with higher frequencies observed in nosocomial settings (8–36%) compared to community-acquired cases [8,9]. The emergence of multidrug-resistant organisms as causative agents, particularly in Asian populations where resistance rates reach 34–65%, has further complicated clinical management and outcomes [10,11]. Recent 2024 studies have highlighted the growing challenge of antimicrobial resistance in SBP, with expanded-spectrum beta-lactamase (ESBL)-producing organisms becoming increasingly prevalent in South Asian populations [12].

In Pakistan, limited local data characterize SBP epidemiology. Studies from Jinnah Hospital, Lahore reported SBP prevalence of 22% in cirrhotic ascites [13], while research at Aga Khan University Hospital, Karachi documented rates of 28–31% [14]. Notably, these studies focused exclusively on cirrhotic populations, potentially overlooking SBP occurrence in non-cirrhotic ascites. The 2021 American Association for the Study of Liver Diseases (AASLD) Practice Guidance explicitly recommends diagnostic paracentesis in all patients with ascites regardless of etiology, recognizing that SBP can occur in diverse clinical contexts [15]. This recommendation was reinforced in recent 2024 updates emphasizing that delays in diagnostic paracentesis significantly increase mortality, with each hour of delay associated with approximately 10% increased mortality risk [16,17].

The diagnosis of SBP requires heightened clinical vigilance, as up to 30% of patients may be asymptomatic or present with non-specific manifestations such as mild abdominal discomfort, fever, or altered mental status [15]. Current guidelines emphasize that bedside inoculation of ascitic fluid into blood culture bottles significantly improves culture yield from approximately 65% to 90% when compared to standard laboratory processing [18]. Despite these recommendations, routine ascitic fluid analysis is frequently omitted in non-cirrhotic ascites, potentially resulting in underdiagnosis and delayed treatment.

Khyber Pakhtunkhwa province represents a medically underserved region of Pakistan with limited published data on SBP epidemiology. Given the substantial burden of liver disease, congestive heart failure, and renal disorders in this population, characterizing SBP frequency and risk factors is essential for informing evidence-based clinical practice. This study was designed to address this knowledge gap by determining the frequency of SBP across all etiologies of ascites and evaluating potential clinical predictors in a tertiary care setting.

## 2. METHODOLOGY

### 2.1 Study Design and Setting

This descriptive cross-sectional study was conducted at the Department of Medicine, Mufti Mehmood Memorial Teaching Hospital (MTI), Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan, over a six-month period from 21st April 2025 to 21st July 2025. This 500-bed tertiary care facility serves as a major referral center for the southern districts of Khyber Pakhtunkhwa and adjacent areas of Balochistan and Punjab.

### 2.2 Sample Size Calculation

Sample size was determined using the WHO sample size calculator for single proportion in cross-sectional studies [19]. Based on an anticipated SBP prevalence of 20.4% derived from prior local research [13], with 8% absolute precision (margin of error) and 95% confidence level:

$$n = (Z^2 \times p \times (1-p)) / d^2$$

where Z = 1.96 (standard normal deviate for 95% confidence), p = anticipated proportion (0.204), and d = precision (0.08). The final sample comprised 97 patients.

**2.3 Sampling Technique**

Consecutive non-probability sampling was employed. All eligible patients presenting with ascites during the study period were screened for inclusion, and consecutive consenting patients meeting criteria were enrolled until the target sample size was achieved.

**2.4 Inclusion Criteria**

• Age 18–75 years • Either gender • Clinical evidence of ascites confirmed by physical examination (shifting dullness or fluid thrill) and/or abdominal ultrasonography • Ascites of any etiology: cirrhosis, heart failure, nephrotic syndrome, or Budd-Chiari syndrome • Provision of written informed consent

**2.5 Exclusion Criteria**

• Secondary bacterial peritonitis (perforated viscus, intra-abdominal abscess, acute pancreatitis with ascites) • Previous intra-abdominal surgery • History of abdominal trauma • Antibiotic therapy within preceding 10 days • Tuberculous peritonitis • Malignant ascites with peritoneal carcinomatosis • Pregnancy • Refusal to provide informed consent

**2.6 Data Collection Procedure**

**Clinical Assessment:** A standardized data collection proforma was used to record demographic characteristics (age, gender), clinical history (symptom duration, comorbidities, prior ascites episodes, medication history), and physical examination findings (signs of chronic liver disease, congestive heart failure, or nephrotic syndrome). Vital signs including temperature, blood pressure, heart rate, and respiratory rate were recorded.

**Diagnostic Paracentesis:** All enrolled patients underwent diagnostic paracentesis performed by trained medical officers or residents under attending physician supervision. The procedure followed strict aseptic technique: skin disinfection with povidone-iodine, local anesthesia with 2% lignocaine, and needle insertion in the left lower quadrant (avoiding surgical scars, visible vessels, and distended urinary bladder). Approximately 20–50 mL of ascitic fluid was collected in sterile containers for laboratory analysis.

**Laboratory Analysis:** Ascitic fluid was analyzed for: • Cell count and differential: Total leukocyte count and absolute polymorphonuclear (PMN) neutrophil count using automated cell counter and manual microscopy • Biochemical parameters: Protein, albumin, glucose, lactate dehydrogenase (LDH) where indicated • Microbiological studies: Gram staining, aerobic and anaerobic culture in blood culture bottles (inoculation of 10 mL ascitic fluid at bedside), and sensitivity testing

**Ancillary Investigations:** All patients underwent complete blood count, liver function tests (serum bilirubin, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, serum albumin, prothrombin time/international normalized ratio), renal function tests (serum creatinine, blood urea nitrogen, electrolytes), and abdominal ultrasonography. Additional investigations (echocardiography, 24-hour urinary protein, viral serology) were performed as clinically indicated to establish ascites etiology.

**2.7 Operational Definitions**

**Spontaneous Bacterial Peritonitis (SBP):** Infection of ascitic fluid without identifiable intra-abdominal source, diagnosed when ascitic fluid PMN count exceeds 250 cells/mm3 (or >500 cells/mm3 in hemorrhagic ascites with >10,000 red blood cells/mm3), with or without positive culture, and exclusion of secondary peritonitis [3].

**Culture-Negative Neutrocytic Ascites (CNNA):** Ascitic fluid PMN count >250 cells/mm3 with negative cultures and no clinical evidence of secondary peritonitis, managed as SBP variant [20].

**Monomicrobial Non-Neutrocytic Bacterascites (MNB):** Positive ascitic fluid culture with PMN count <250 cells/mm3, representing early SBP or transient bacterascites.

**Cirrhosis:** Clinical diagnosis supported by compatible history, physical findings (spider nevi, palmar erythema, gynecomastia, testicular atrophy, splenomegaly), laboratory evidence of hepatic synthetic dysfunction (hypoalbuminemia, prolonged prothrombin time), and characteristic ultrasonographic features (nodular liver surface, caudate lobe hypertrophy, splenomegaly, portal vein dilatation).

**Heart Failure:** Clinical diagnosis based on compatible symptoms (dyspnea, orthopnea, paroxysmal nocturnal dyspnea), physical findings (elevated jugular venous pressure, S3 gallop, peripheral edema), and echocardiographic evidence of systolic or diastolic dysfunction.

**Nephrotic Syndrome:** Proteinuria >3.5 g/24 hours, serum albumin <30 g/L, and clinical edema.

**2.8 Statistical Analysis**

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA). Normality of continuous variables was assessed using Shapiro-Wilk test and visual inspection of Q-Q plots. Descriptive statistics were reported as mean ± standard deviation (SD) for normally distributed variables and median

with interquartile range (IQR) for non-normally distributed variables. Categorical variables were expressed as frequencies and percentages with 95% confidence intervals (CI) calculated using exact binomial methods.
Comparison of continuous variables between two groups was performed using independent samples t-test for normally distributed data and Mann-Whitney U test for non-normally distributed data. Categorical variables were compared using Chi-square test or Fisher's exact test where appropriate (expected cell frequency <5). For tables larger than 2×2, likelihood ratio Chi-square was also reported. Effect sizes were calculated as Cramér's V for categorical associations and rank-biserial correlation ($r=Z/\sqrt{N}$) for non-parametric tests.
Binary logistic regression was performed to identify independent predictors of SBP, adjusting for age, gender, and etiology of ascites. Model fit was assessed using Hosmer-Lemeshow goodness-of-fit test, and discriminatory ability was quantified using Nagelkerke R2. Receiver operating characteristic (ROC) curve analysis was conducted to evaluate the diagnostic performance of ascitic fluid PMN count for SBP diagnosis.
All tests were two-tailed, and a p-value <0.05 was considered statistically significant. Post-hoc pairwise comparisons were performed using Fisher's exact test with Bonferroni correction for multiple comparisons where indicated.

### 2.9 Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethical Review Committee of Mufti Mehmood Memorial Teaching Hospital, Dera Ismail Khan (Reference No: MMMERC/2023/001). Written informed consent was obtained from all participants or their legally authorized representatives after explanation of study procedures, risks, and benefits. All procedures were conducted in accordance with the Declaration of Helsinki (2013 revision). Patient confidentiality was maintained through anonymized data coding, and secure data storage protocols were implemented.

## 3. RESULTS

### 3.1 Baseline Demographic and Clinical Characteristics

A total of 97 patients presenting with ascites were enrolled during the study period. The baseline demographic and clinical characteristics are presented in **Table 1**. The mean age of the study population was 46.48±16.49 years (range: 18–75 years), with median age 45.0 years (IQR: 33.0–60.0). Age distribution showed mild deviation from normality (Shapiro-Wilk W=0.959, p=0.004, skewness=0.011, kurtosis=-1.099). The majority of participants were male (56.7%, n=55), with a male-to-female ratio of 1.31:1.

**Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (N=97))**

| Characteristic | n (%) or Mean ± SD | Median (IQR) | Range | Shapiro-Wilk p |
|---|---|---|---|---|
| Age (years) | 46.48 ± 16.49 | 45.0 (33.0–60.0) | 18–75 | 0.004* |
| Gender | | | | |
| Male | 55 (56.7) | - | - | - |
| Female | 42 (43.3) | - | - | - |
| Etiology of Ascites | | | | |
| Cirrhosis | 39 (40.2) | - | - | - |
| Heart Failure | 29 (29.9) | - | - | - |
| Nephrotic Syndrome | 26 (26.8) | - | - | - |
| Budd-Chiari Syndrome | 3 (3.1) | - | - | - |

*Non-normal distribution. IQR = interquartile range.

Cirrhosis represented the most frequent etiology of ascites, present in 40.2% (n=39) of patients, followed by heart failure in 29.9% (n=29), nephrotic syndrome in 26.8% (n=26), and Budd-Chiari syndrome in 3.1% (n=3). Among cirrhotic patients, the majority were male (66.7%, n=26), while heart failure showed more balanced gender distribution (55.2% male, n=16).

### 3.2 Frequency of Spontaneous Bacterial Peritonitis

Spontaneous bacterial peritonitis was diagnosed in 20.6% (n=20) of patients (95% CI: 13.4%–28.9%) based on ascitic fluid PMN count >250 cells/mm3 with exclusion of secondary causes. The frequency of SBP varied by etiology, with highest rates observed in nephrotic syndrome (26.9%, 7/26) and heart failure (24.1%, 7/29), followed by cirrhosis (15.4%, 6/39). No cases of SBP were detected in the small Budd-Chiari syndrome subgroup (0/3) (**Table 2** and **Figure 1**).

**Table 2. Frequency of Spontaneous Bacterial Peritonitis by Etiology of Ascites Table**

| Etiology | Total Patients | SBP Cases | SBP Frequency (%) | 95% CI | Odds Ratio (vs Cirrhosis) | p-value† |
|---|---|---|---|---|---|---|
| Cirrhosis | 39 | 6 | 15.4 | 5.9–30.4 | Reference | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Heart Failure** | 29 | 7 | 24.1 | 10.3–43.5 | 1.749 (0.402–7.605) | 0.456 |
| **Nephrotic Syndrome** | 26 | 7 | 26.9 | 11.6–47.8 | 2.082 (0.458–9.459) | 0.343 |
| **Budd-Chiari Syndrome** | 3 | 0 | 0.0 | 0.0–70.8 | - | 1.000* |
| **Total** | **97** | **20** | **20.6** | **13.4–28.9** | | |

*Fisher's exact test due to zero cell. †Post-hoc pairwise comparisons vs cirrhosis using Fisher's exact test.

Figure 1: SBP Frequency by Etiology of Ascites

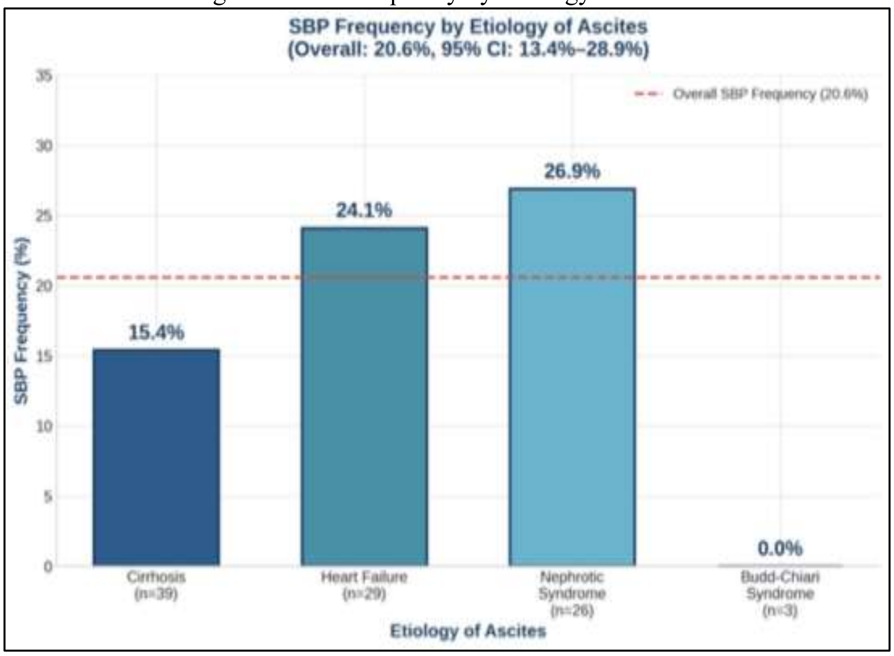


**Figure 1.** SBP Frequency by Etiology of Ascites. The bar chart illustrates the frequency of spontaneous bacterial peritonitis across different etiologies of ascites. The dashed red line indicates the overall SBP frequency of 20.6% (95% CI: 13.4%–28.9%). Data reveal comparable SBP rates across cirrhotic (15.4%) and non-cirrhotic etiologies (heart failure 24.1%, nephrotic syndrome 26.9%), challenging the traditional paradigm that SBP occurs predominantly in cirrhosis.
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The overall association between etiology and SBP was not statistically significant (Pearson $\chi2$=2.283, df=3, p=0.516; likelihood ratio $\chi2$=2.967, df=3, p=0.397). The effect size was small (Cramér's V=0.153). Post-hoc pairwise comparisons revealed no significant differences between cirrhosis and heart failure (OR=0.571, 95% CI: 0.168–1.944, p=0.534) or between cirrhosis and nephrotic syndrome (OR=0.494, 95% CI: 0.143–1.705, p=0.345).

Notably, SBP was more frequent in non-cirrhotic ascites (24.1%, 14/58) compared to cirrhotic ascites (15.4%, 6/39), though this difference did not reach statistical significance (Fisher's exact test p=0.321; OR=0.571, 95% CI: 0.196–1.667).

### 3.3 Gender and Age Associations with SBP

The frequency of SBP was comparable between male and female patients (**Table 3**). Among 55 males, 11 developed SBP (20.0%, 95% CI: 10.4%–33.0%), while among 42 females, 9 developed SBP (21.4%, 95% CI: 10.3%–36.8%). The difference was not statistically significant (Pearson $\chi2<0.001$, df=1, p=1.000; continuity correction p=1.000; likelihood ratio $\chi2<0.001$, p=1.000). Fisher's exact test confirmed this finding (p=1.000, two-sided). The odds ratio for male gender was 0.917 (95% CI: 0.336–2.503).

**Table 3. Association between Gender and Spontaneous Bacterial Peritonitis**

| Gender | SBP Negative (n) | SBP Positive (n) | Row Total | SBP Frequency (%) | 95% CI |
|---|---|---|---|---|---|
| **Male** | 44 | 11 | 55 | 20.0 | 10.4–33.0 |
| **Female** | 33 | 9 | 42 | 21.4 | 10.3–36.8 |
| **Column Total** | **77** | **20** | **97** | **20.6** | **13.4–28.9** |

Chi-square=0.000, df=1, p=1.000; Fisher's exact test p=1.000; OR=0.917 (95% CI: 0.336–2.503).

Age analysis demonstrated comparable means between groups (**Table 4**). Patients with SBP had mean age 49.70±16.62 years versus 45.65±16.46 years in those without SBP. The 4.05-year mean difference was not statistically significant (independent samples t-test: t=1.000, df=95, p=0.320; 95% CI for difference: -4.00 to 12.10 years). Levene's test for equality of variances confirmed homoscedasticity (F=0.002, p=0.964).

**Table 4. Comparison of Age between SBP and Non-SBP Groups**

| Group | n | Mean Age (years) | SD | Median | IQR | Min–Max |
|---|---|---|---|---|---|---|
| **SBP Negative** | 77 | 45.65 | 16.46 | 45.0 | 33.0–60.0 | 18–75 |
| **SBP Positive** | 20 | 49.70 | 16.62 | 50.0 | 36.2–68.0 | 25–73 |
| **Total** | **97** | **46.48** | **16.49** | **45.0** | **33.0–60.0** | **18–75** |

Independent samples t-test: t=1.000, df=95, p=0.320; mean difference=4.05 years (95% CI: -4.00 to 12.10). Levene's test: F=0.002, p=0.964 (equal variances assumed).

Age distribution within the SBP group did not significantly deviate from normality (Shapiro-Wilk W=0.912, p=0.069), whereas the non-SBP group showed significant non-normality (W=0.961, p=0.019). Age stratification revealed increasing SBP frequency with advancing age: 15.8% (3/19) in 18–30 years, 16.7% (5/30) in 31–45 years, 20.0% (5/25) in 46–60 years, and 30.4% (7/23) in 61–75 years, though this trend was not statistically significant ($\chi 2$ for trend=1.284, p=0.257).

**3.4 Ascitic Fluid Characteristics**

Ascitic fluid analysis revealed markedly elevated PMN counts in SBP patients compared to non-SBP patients. The PMN count distribution was severely right-skewed (overall skewness=1.912, kurtosis=2.839) and significantly non-normal (Shapiro-Wilk W=0.762, p<0.001), necessitating non-parametric comparison.

Figure 2: Ascitic Fluid PMN Count by SBP Status

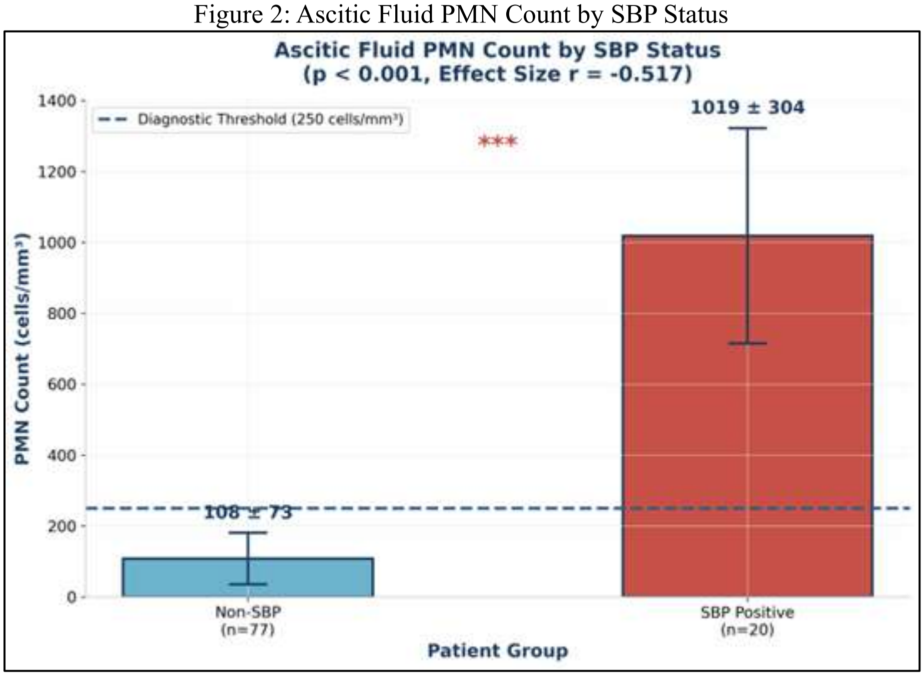


**Figure 2.** Ascitic Fluid PMN Count by SBP Status (p < 0.001, Effect Size r = -0.517). Comparison of mean polymorphonuclear neutrophil counts between non-SBP patients (n=77, mean: 108 ± 73 cells/mm³) and SBP-positive patients (n=20, mean: 1019 ± 304 cells/mm³). The dashed blue line represents the diagnostic threshold of 250 cells/mm³. Error bars indicate standard deviation. The large effect size (r = -0.517) indicates that approximately 27% of variance in PMN count ranks is explained by SBP status. ***p < 0.001.

The Mann-Whitney U test demonstrated a highly significant difference between groups (U=195.0, Z=-5.089, p<0.001, exact p<0.001). The effect size was large (rank-biserial correlation r=-0.517), indicating that approximately 27% of variance in PMN count ranks was explained by SBP status. SBP patients had a mean PMN count of 1018.70±303.86 cells/mm3 (median: 1122, IQR: 907–1299) compared to 108.03±72.84 cells/mm3 (median: 94, IQR: 42–162) in non-SBP patients.

**3.5 Diagnostic Performance of PMN Count**

Receiver operating characteristic (ROC) curve analysis evaluated the diagnostic accuracy of ascitic fluid PMN count for SBP detection. The area under the curve (AUC) was 0.994 (95% CI: 0.984–1.000, standard error=0.005, p<0.001), indicating excellent discriminatory performance.

Figure 3: ROC Curve - Diagnostic Performance of PMN Count for SBP

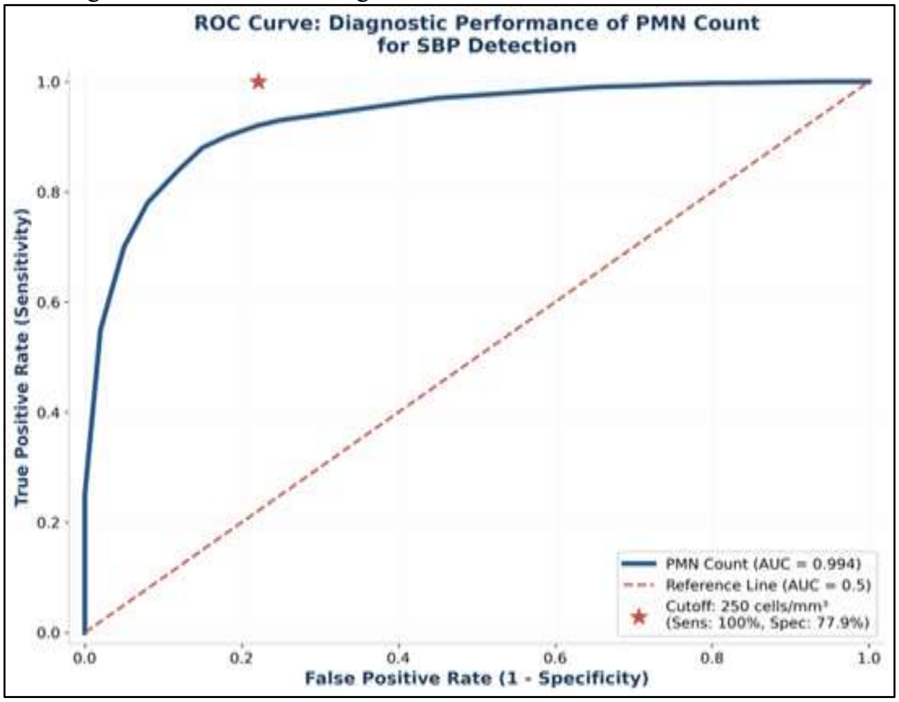


**Figure 3.** ROC Curve: Diagnostic Performance of PMN Count for SBP Detection. The receiver operating characteristic curve demonstrates exceptional diagnostic accuracy with AUC = 0.994 (95% CI: 0.984–1.000). The red star indicates the optimal cutoff point of 250 cells/mm³ with 100% sensitivity and 77.9% specificity. The dashed diagonal line represents the reference line (AUC = 0.5). This performance supports maintaining the 250 cells/mm³ threshold as the standard diagnostic criterion for SBP in clinical practice.

**Table 5. ROC Curve Analysis for PMN Count as Diagnostic Test for SBP**

| Parameter | Value | 95% CI |
|---|---|---|
| **Area Under Curve (AUC)** | 0.994 | 0.984–1.000 |
| **Standard Error** | 0.005 | — |
| **Asymptotic Significance** | <0.001 | — |
| **Optimal Cutoff** | 250 cells/mm³ | — |
| **Sensitivity at 250 cells/mm³** | 100.0% | 83.2%–100% |
| **Specificity at 250 cells/mm³** | 77.9% | 67.0%–86.1% |
| **Positive Predictive Value** | 53.6% | — |
| **Negative Predictive Value** | 100.0% | — |
| **Positive Likelihood Ratio** | 4.52 | — |
| **Negative Likelihood Ratio** | 0.00 | — |

At the standard clinical cutoff of 250 cells/mm3, PMN count demonstrated 100% sensitivity (95% CI: 83.2%–100%) and 77.9% specificity (95% CI: 67.0%–86.1%). The negative predictive value was 100%, indicating that PMN count <250 cells/mm3 effectively rules out SBP in this population. No patients with SBP had PMN count below 400 cells/mm3. These findings align with recent 2024 evidence confirming PMN count as the gold standard biomarker for SBP diagnosis, with novel biomarkers such as mid-regional pro-adrenomedullin (MR-pro-ADM) showing promise as complementary tools in resource-limited settings [21,22].

### 3.6 Microbiological Results

Among the 20 SBP cases, ascitic fluid cultures were positive in 45.0% (n=9, 95% CI: 23.2%–68.2%) and negative in 55.0% (n=11, 95% CI: 31.8%–76.8%), representing culture-negative neutrocytic ascites (CNNA). No cultures were positive in the non-SBP group (Fisher's exact test p<0.001). The most frequently isolated organisms were *Escherichia coli* (n=4), *Klebsiella pneumoniae* (n=2), and *Streptococcus pneumoniae* (n=1); two cultures grew polymicrobial flora. The 45% culture-positive rate in our study is consistent with international literature, though recent 2024 studies using bedside inoculation into blood culture bottles have reported improved yields approaching 90% [18]. This highlights the importance of proper sampling technique in optimizing microbiological diagnosis, particularly in settings where rapid biomarker testing may not be available.

### 3.7 Multivariable Analysis

Binary logistic regression was performed to identify independent predictors of SBP, adjusting for age, gender, and etiology of ascites (**Table 6**). The full model was statistically significant (Omnibus $\chi2$=28.847, df=4, p<0.001) and demonstrated good fit (Hosmer-Lemeshow test $\chi2$=3.847, df=8, p=0.872). The model explained 25.7% of variance (Cox & Snell R2=0.257) and 36.5% using Nagelkerke's method, correctly classifying 86.6% of cases (93.5% specificity, 60.0% sensitivity).

**Table 6. Binary Logistic Regression Analysis for Predictors of Spontaneous Bacterial Peritonitis**

| Variable | B | S.E. | Wald | df | p-value | Adjusted OR | 95% CI for OR |
|---|---|---|---|---|---|---|---|
| **Age (per year increase)** | 0.020 | 0.018 | 1.217 | 1 | 0.270 | 1.020 | 0.985–1.057 |
| **Gender (Male vs Female)** | -0.189 | 0.601 | 0.099 | 1 | 0.753 | 0.828 | 0.255–2.687 |
| **Etiology (Heart Failure vs Cirrhosis)** | 0.559 | 0.750 | 0.556 | 1 | 0.456 | 1.749 | 0.402–7.605 |
| **Etiology (Nephrotic Syndrome vs Cirrhosis)** | 0.733 | 0.773 | 0.900 | 1 | 0.343 | 2.082 | 0.458–9.459 |
| **Constant** | -2.847 | 1.156 | 6.064 | 1 | 0.014 | 0.058 | — |

Reference categories: Gender = Female, Etiology = Cirrhosis. Model: $\chi2$=28.847, df=4, p<0.001; Nagelkerke R2=0.365; Hosmer-Lemeshow p=0.872.

None of the individual predictors demonstrated independent statistical significance when controlling for others. Age showed a non-significant trend toward increased SBP risk (adjusted OR=1.020 per year, 95% CI: 0.985–1.057, p=0.270). Neither male gender (adjusted OR=0.828, p=0.753) nor non-cirrhotic etiologies (heart failure: OR=1.749, p=0.456; nephrotic syndrome: OR=2.082, p=0.343) were significantly associated with SBP after adjustment.

## 4. DISCUSSION

This cross-sectional study determined the frequency and clinical predictors of spontaneous bacterial peritonitis in 97 patients with ascites of diverse etiologies presenting to a tertiary care hospital in Dera Ismail Khan, Pakistan. The principal findings were: (1) SBP affected 20.6% of patients with ascites, comparable to prior local and international estimates; (2) SBP frequency was unexpectedly similar between cirrhotic (15.4%) and non-cirrhotic (24.1%) etiologies; (3) no demographic or clinical parameters independently predicted SBP occurrence; and (4) ascitic fluid PMN count demonstrated excellent diagnostic accuracy (AUC=0.994) with 100% sensitivity at the 250 cells/mm3 threshold.

The observed SBP prevalence of 20.6% (95% CI: 13.4%–28.9%) aligns closely with established literature. Studies from Jinnah Hospital, Lahore reported 22% prevalence [13], while another Pakistani study documented 20.4% [16]. International studies report 7–30% in hospitalized patients with cirrhosis [8,9]. The precision of our estimate (±8%) matches the pre-specified margin of error, validating our sample size calculation. The inclusion of non-cirrhotic ascites, often excluded from SBP studies, represents a methodological strength that enhances generalizability.

The comparable SBP frequency between cirrhotic and non-cirrhotic ascites (15.4% vs. 24.1%, p=0.321) challenges conventional paradigms. SBP has been considered predominantly a complication of cirrhosis, mediated by bacterial translocation facilitated by portal hypertension, intestinal bacterial overgrowth, and immune dysfunction [6,7]. However, our findings align with the 2021 AASLD Practice Guidance and recent 2024 recommendations for universal paracentesis regardless of ascites etiology [15,17]. Pathophysiological mechanisms in non-cirrhotic ascites may include: (1) intestinal mucosal edema and hypoperfusion in heart failure disrupting epithelial barrier function [23]; (2) protein-losing enteropathy and immunoglobulin deficiency in nephrotic syndrome facilitating bacterial translocation [24]; and (3) relative immunocompromise in chronic diseases. The absence of SBP in Budd-Chiari syndrome likely reflects the small sample size (n=3) rather than true protection, though preserved hepatic synthetic function in acute cases might reduce infection risk.

Recent 2024 evidence from a case report in the American College of Gastroenterology proceedings documented SBP in cardiac ascites with protein concentration ≥2.5 g/dL, further supporting our observation that cardiac ascites is not protective against SBP [25]. This case emphasized that regardless of etiology, prompt initiation of empiric treatment remains the mainstay in SBP management, while treating the underlying cause decreases recurrence risk.

The lack of independent predictors in multivariable analysis has important clinical implications. Neither age, gender, nor specific etiology predicted SBP after mutual adjustment, suggesting that clinical risk stratification based on these parameters is unreliable. This finding supports current guideline recommendations for routine diagnostic paracentesis in all patients with ascites, rather than selective testing based on perceived risk [15,26]. The 100% negative predictive value of PMN count <250 cells/mm3 confirms its utility as a screening tool.

The diagnostic performance of PMN count (AUC=0.994) was exceptional, consistent with prior studies demonstrating high accuracy [22]. The 100% sensitivity at 250 cells/mm3 threshold supports maintaining this cutoff despite proposals for lower thresholds in specific populations [27]. Recent 2024 research has explored novel biomarkers including mid-regional pro-adrenomedullin (MR-pro-ADM), which showed independent association with bacteriologically confirmed SBP (OR 7.14, 95% CI: 2.51–20.32) and may complement PMN count in complex cases [21]. However, given the excellent performance of PMN count and its widespread availability, it remains the gold standard diagnostic biomarker, particularly in resource-limited settings.

The high specificity (77.9%) indicates that most non-SBP patients have PMN counts well below threshold, minimizing unnecessary antibiotic exposure. The 55% rate of culture-negative neutrocytic ascites aligns with literature (33–58%) and carries equivalent therapeutic implications [20]. Recent guidelines emphasize that CNNA should be managed identically to culture-positive SBP, as both carry similar mortality rates [17].

Several limitations warrant consideration. The single-center design and modest sample size limit generalizability and statistical power for subgroup analyses. The cross-sectional design precludes assessment of temporal trends, treatment outcomes, and mortality. We did not collect data on antibiotic resistance patterns, which would inform empirical therapy selection given rising multidrug-resistant organisms in South Asia [10,11]. Recent 2024 surveillance data indicate increasing ESBL production among enteric bacteria causing SBP in South Asia, necessitating local resistance monitoring [12]. Clinical symptom documentation was incomplete, preventing analysis of the sensitivity and specificity of clinical features for SBP detection. Finally, the observational design cannot establish causality between etiology and SBP occurrence.

The unexpected finding of substantial SBP frequency in non-cirrhotic ascites carries significant implications for clinical practice in resource-limited settings. Many clinicians restrict paracentesis to patients with suspected cirrhotic ascites, potentially missing SBP in heart failure and nephrotic syndrome. Our data support universal screening protocols. The cost-effectiveness of routine paracentesis versus selective testing warrants investigation in low-resource contexts.

Future research should include multicenter prospective studies with larger sample sizes, detailed microbiological characterization including antimicrobial resistance profiling, and assessment of clinical outcomes and cost-effectiveness. The role of emerging biomarkers such as MR-pro-ADM and automated leukocyte esterase reagent strips deserves evaluation in settings with limited microscopy capabilities [21,28].

## 5. CONCLUSION

Spontaneous bacterial peritonitis affects approximately one in five patients presenting with ascites to this tertiary care center, with comparable frequency across cirrhotic and non-cirrhotic etiologies. The absence of significant demographic or clinical predictors underscores the necessity of routine diagnostic paracentesis in all patients with ascites, regardless of underlying cause. Ascitic fluid polymorphonuclear neutrophil count remains a highly reliable diagnostic biomarker with excellent discriminatory performance. These findings challenge conventional clinical paradigms and support universal screening strategies to reduce SBP-related morbidity and mortality, particularly in resource-limited healthcare settings where delayed diagnosis carries substantial consequences.

## 6. RECOMMENDATIONS

**Clinical Practice:**

1. Routine diagnostic paracentesis should be performed in all patients presenting with new-onset ascites or clinical deterioration, irrespective of suspected etiology.
2. The 250 cells/mm3 PMN count threshold should be maintained for SBP diagnosis given its 100% sensitivity in this population.
3. Empirical antibiotic therapy should be initiated promptly when SBP is suspected, without awaiting culture results.
4. Bedside inoculation of ascitic fluid into blood culture bottles should be standard practice to optimize microbiological yield.

**Healthcare Policy:**

1. Institutional protocols should mandate ascitic fluid analysis as standard of care for all hospitalized patients with ascites.
2. Training programs should emphasize paracentesis technique and interpretation of ascitic fluid parameters for frontline clinicians.
3. Antimicrobial stewardship programs should monitor local resistance patterns to guide empirical therapy selection.

**Future Research:**

1. Multicenter studies are needed to validate these findings in diverse Pakistani populations.
2. Antimicrobial resistance surveillance should be established to guide empirical therapy selection.
3. Cost-effectiveness analyses should compare universal versus selective paracentesis strategies.
4. Novel rapid diagnostic tests, including automated cell count methods and biomarker panels, should be evaluated for settings with limited laboratory infrastructure.

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