RESEARCH ARTICLE / ARAŞTIRMA

DOI: 10.4274/mjima.galenos.2024.23063.4
Mediterr J Infect Microb Antimicrob 2024;13:23063.4
Erişim: http://dx.doi.org/10.4274/mjima.galenos.2024.23063.4

Clinical Profile, Bacteriological Profile, and Outcomes of Patients with Spontaneous Bacterial Peritonitis with Preexisting Chronic Liver Disease

Önceden Kronik Karaciğer Hastalığı Olan Spontan Bakteriyel Peritonitli Hastaların Klinik Profili, Bakteriyolojik Profili ve Sonlanımları

Juhi R[1], Dilip Kumar S[1], Karthikayan R K[2], Clement Jenil Dhas[1], Yoganathan Chidambaram[1], Sujith Kumar S[1]

[1]PSG Institute of Medical Sciences and Research, Department of General Medicine, Tamil Nadu, India
[2]PSG Institute of Medical Sciences and Research, Department of Gastroenterology, Tamil Nadu, India

Abstract

Introduction: Spontaneous bacterial peritonitis (SBP) is a critical complication in patients with chronic liver disease (CLD). Understanding the clinical features and bacterial profile of SBP is essential for its effective management. To study the clinical and bacteriological profile and the factors influencing the outcome of SBP in patients with CLD.

Materials and Methods: We retrospectively analyzed the medical records of 113 patients diagnosed with SBP between January 2018 and December 2022 at a tertiary care hospital. We assessed the clinical features, laboratory parameters, causes of cirrhosis, and bacterial profiles. Statistical analyses were performed to identify associations between these parameters and the clinical outcomes. A p value of <0.05 was considered statistically significant.

Results: The mean age of the patients was 54.04 years. The common clinical features were abdominal distension (80.5%) and abdominal pain (54%). Abnormalities were observed in the parameters of the renal function tests (elevated creatinine, bicarbonate, sodium, and potassium levels) and liver function tests (elevated SGPT, alkaline phosphatase, gamma-glutamyl transferase, and globulin levels). Bacterial cultures of the ascitic fluid and blood predominantly grew *Escherichia coli* and *Klebsiella pneumoniae* species. Jaundice (p=0.001) and altered mental status (p=0.000) significantly influenced the clinical outcomes. Total leukocyte count (p=0.001) and bicarbonate levels (p=0.008) were significantly associated with the clinical outcomes. Non-alcoholic fatty liver disease and cryptogenic cirrhosis were significantly associated with the clinical outcomes. Child-Pugh scores, duration of hospital stay, and higher Model for End-Stage Liver Disease scores and INR were associated with negative outcomes (p<0.05).

Conclusion: This study provides valuable insights regarding the regional differences in clinical features and bacterial profile of SBP in patients with CLD. Understanding these factors can aid in the management and prognosis of SBP.

Keywords: Bacterial infection, chronic liver disease, clinical profile, *E. coli*

Öz

Giriş: Spontan bakteriyel peritonit (SBP), kronik karaciğer hastalığı (KAH) olan hastalarda kritik bir komplikasyondur. Spontan bakteriyel peritonitin klinik özelliklerini ve bakteriyel profilini anlamak, SBP'nin etkili yönetimi için esastır. Kronik karaciğer hastalığı olan hastaların klinik ve bakteriyolojik profilini ve SBP'nin sonlanımını etkileyen faktörleri incelemek.

Gereç ve Yöntem: Ocak 2018 ile Aralık 2022 tarihleri arasında üçüncü basamak bir hastanede SBP tanısı alan 113 hastanın tıbbi kayıtları retrospektif olarak analiz edildi. Hastaların klinik özellikleri, laboratuvar parametreleri, sirozun nedenleri ve bakteri profilleri değerlendirildi.

Cite this article as: R J, Kumar S D, R K K, Jenil Dhas C, Chidambaram Y, Kumar S S. Clinical Profile, Bacteriological Profile, and Outcomes of Patients with Spontaneous Bacterial Peritonitis with Preexisting Chronic Liver Disease. Mediterr J Infect Microb Antimicrob 2024;13:23063.4.

Address for Correspondence/Yazışma Adresi: Dilip Kumar S MD, PSG Institute of Medical Sciences and Research, Department of General Medicine, Tamil Nadu, India
Phone: +91 9480249835 **E-mail:** dilforfriends7@gmail.com **ORCID ID:** orcid.org/0000-0002-4000-1150
Received/Geliş Tarihi: 25.10.2023 **Accepted/Kabul Tarihi:** 29.02.2024

Published: 19.03.2024

Mediterr J Infect Microb Antimicrob
2024;13:23063.4

Öz

Bu parametreler ile klinik sonlanım arasındaki ilişkileri belirlemek için istatistiksel analizler yapıldı. P<0,05'lik istatistiksel olarak anlamlı kabul edildi.

Bulgular: Hastaların ortalama yaşı 54,04 idi. Ortak klinik özellikler karın şişliği (%80,5) ve karın ağrısı (%54) idi. Böbrek fonksiyon testleri (yüksek kreatinin, bikarbonat, sodyum ve potasyum düzeyleri) ve karaciğer fonksiyon testleri (yüksek SGPT, alkalin fosfataz, gama-glutamil transferaz ve globulin düzeyleri) parametrelerinde anormallikler gözlendi. Asit sıvısı ve kanın bakteriyel kültürlerinde ağırlıklı olarak *Escherichia coli* ve *Klebsiella pneumoniae* türleri üredi. Sarılık (p=0,001) ve zihinsel durum değişikliği (p=0,000) klinik sonuçları önemli ölçüde etkiledi. Toplam lökosit sayısı (p=0,001) ve bikarbonat düzeyleri (p=0,008) klinik sonlanımla anlamlı düzeyde ilişkiliydi. Alkolsüz yağlı karaciğer hastalığı ve kriptojenik siroz klinik sonlanımla anlamlı derecede ilişkiliydi. Child-Pugh skorları, hastanede kalış süresi ve daha yüksek Son Dönem Karaciğer Hastalığı Modeli skorları ve INR, olumsuz sonlanımla ilişkilendirildi (p<0,05).

Sonuç: Bu çalışma, KAH'lı hastalarda SBP'nin klinik özelliklerine ve bakteriyel profilindeki bölgesel farklılıklara ilişkin değerli bilgiler sunmaktadır. Bu faktörleri anlamak SBP'nin yönetimine ve prognozuna yardımcı olabilir.

Anahtar Kelimeler: Bakteriyel enfeksiyon, kronik karaciğer hastalığı, klinik profil, *E. coli*

Introduction

Chronic liver disease (CLD) is the 11th leading cause of death worldwide. It accounts for approximately 2 million deaths annually, and is predominantly seem among men. Often arising from various etiologies such as alcohol consumption, acute hepatitis, and nonalcoholic fatty liver disease (NAFLD), CLD poses a significant global health challenge[1,2]. A steady rise in CLD-related mortality has been reported in India as a result of increasing alcohol consumption and obesity rates[1]. Additionally, the adoption of a Western diet and sedentary lifestyle habits has increased the prevalence of alcoholic liver disease and NAFLD[3].

Spontaneous bacterial peritonitis (SBP) is a severe complication of CLD. It is a bacterial infection of the ascitic fluid without a treatable intra-abdominal source of infection[4,5]. Signs of liver decompensation, such as progression of ascites, hepatic encephalopathy, gastrointestinal bleeding, and renal failure, can occur during or after an episode of SBP[6]. The global prevalence of SBP is reportedly 17.12% in patients with cirrhosis, and the prevalence of community-acquired SBP and healthcare-associated SBP is 6.05% and 11.11%, respectively[7]. In Punjab, India, the prevalence is reportedly 20.4%[8].

Overall, the SBP outcomes in patients with CLD are unfavorable. The worldwide SBP-related mortality rate in patients with cirrhosis is >30.61%, with an inhospital mortality of approximately 20%[6,7].

Gram-negative enteric bacteria are predominantly isolated from ascitic fluid culture, indicating that SBP may arise in patients with cirrhosis due to intestinal bacterial translocation. Diminishing immunity and structural abnormalities in the intestinal wall due to portal hypertension could also lead to increased intestinal permeability and susceptibility to infection[7].

Depending on the bacteriological diagnosis, patients with SBP are treated with third-generation cephalosporins and other antibiotics. Administration of carbapenem is suggested in the presence of multidrug-resistant bacteria in the ascitic fluid or sepsis. Furthermore, intravenous albumin can be administered to reduce the risk of complications such as acute kidney injury and hepatorenal syndrome[6]. Thus, patients with SBP should be continuously monitored for common bacterial pathogens and their antibiogram to help guide the treatment. Understanding the features, bacterial profiles, and other factors influencing clinical outcomes in patients with SBP is crucial for the timely and effective management of the condition. In India, there is a lack of updated studies that enlist these factors. Therefore, herein, we retrospectively analyzed a comprehensive dataset of patient records to provide an overview regarding SBP in patients with CLD. We aimed to identify the clinical presentation, laboratory parameters, and bacterial profile of SBP and determine their implications on the clinical outcomes of patients with preexisting CLD.

Materials and Methods

A retrospective observational study was conducted at a tertiary care hospital to determine the clinical features and bacterial profile of SBP in patients with preexisting CLD.

The case records of patients aged >18 years with a confirmed diagnosis of SBP who were admitted between January 2018 and December 2022 were retrieved from the hospital's electronic database and included in the study. Patients who presented with fever, ascites, and abdominal pain and/or demonstrated an elevated total white blood cell (WBC) count with >250 polymorphonuclear neutrophils in the ascitic fluid were considered to have confirmed SBP.

The study was approved by the Institutional Human Ethics Committee PSG Institute of Medical Sciences and Research (no: PSG/IHEC/2023/124; date: 04.04.2023). The need for a written consent was waived off because this was retrospective study that used anonymized data. During the study period, 128 patients

were admitted for SBP. Patients with incomplete records and those without any records were excluded from the study. Thus, the data of 113 patients were included in the final analysis.

The following data were collected and analyzed: demographics, clinical features of SBP, causes of cirrhosis, laboratory parameters [complete blood count, renal and liver function tests, and international normalized ratio (INR)], upper gastrointestinal (UGI) endoscopy findings, antibiotic regimen, duration of hospital stay, and clinical outcomes [death, discharge, and discharged against medical advice (DAMA)].

The Child-Pugh scores that determine the prognosis and mortality in patients with cirrhosis was obtained. The score is based on hepatic function parameters such as serum albumin level, serum bilirubin level, ascites, encephalopathy, and prothrombin time/INR[9]. Based on the scores, the patients were classified as follows: good hepatic function, 5-6 points; moderate hepatic dysfunction, 7-9 points; and advanced hepatic dysfunction, 10-15 points[9]. The Model for End-Stage Liver Disease (MELD) score was also obtained. The MELD score is based on liver function parameters such as serum bilirubin and creatinine levels and INR, and higher MELD scores imply more severe hepatic dysfunction[10].

The antibiotic sensitivity pattern was assessed using the growth profile of both the ascitic fluid and blood cultures.

Statistical Analysis

All data were analyzed using R version 4.3.0 (A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria (https://www.R-project.org/). Continuous data are presented as means ± standard deviations, and categorical data are presented as frequencies and percentages. The chi-square test was used to analyze the association of clinical outcomes with the clinical features and Kruskal-Wallis test for laboratory parameters, renal and liver function parameters, causes of cirrhosis, duration of hospital stay, Child-Pugh score, MELD score, and other parameters. A p value less than 0.05 was considered statistically significant.

Results

During the study period, 113 patient were considered eligible for analyses. The mean age of the study patients was 54.04±11.891 years. The predominant clinical features observed in patients with SBP were abdominal distension (n=91, 80.5%), abdominal pain (n=61, 54%), swelling of the lower limbs (n=52, 46%), jaundice (n=41, 36.3%), altered mental status (n=31, 27.4%), and fever (n=26, 23%). The less common features observed in these patients were vomiting, diarrhea, cough, hematemesis, and melena (Table S1). Approximately 88% (n=100) of the patients were not administered antibiotics in the past three months, and 8.8% (n=10) of the patients had a prior history of SBP. Approximately 49.6% (n=56) of the patients were discharged, 15.9% (n=18) were DAMA, and 34.5% (n=39) died. All the patients who were DAMA were in a moribund state.

Laboratory Parameters

In most of the patients, the total WBC count was abnormal (n=60, 53.1%) and the hemoglobin and platelet levels were within the standard normal range (hemoglobin: males, 14-16.5 gm/dL and females, 12-16 gm/dL; platelets, 150,000-400,000) (Table S2).

Renal function tests demonstrated abnormal levels of creatinine, bicarbonate, sodium, and potassium in 19.5% (n=22), 24.8% (n=28), 27.4% (n=31), and 66.4% (n=75) of the patients, respectively.

Liver function demonstrated abnormal levels of alanine transaminase (SGPT), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), and serum globulin in 61.1%, (n=69), 54.9% (n=62), 68.1% (n=77), and 51.3% (n=58) of the patients, respectively (Table S3).

UGI endoscopy demonstrated the presence of portal hypertensive gastropathy, esophageal varices, and fundal varices in 41.6% (n=47), 91.2% (n=103), and 6.2% (n=7) of the patients, respectively.

Bacterial Culture Report

Table 1 presents the distribution and antibiotic sensitivity pattern of bacteria based on the report of ascitic fluid and blood cultures. The ascitic fluid culture reports demonstrated that 72.6% (n=82) of the samples were sterile, and among the positive culture results, 8.8% (n=10) were *Escherichia coli (E. coli),* and 3.5% (n=4) were *Klebsiella pneumoniae (K. pneumoniae).* The other bacteria detected were *Enterococcus, Klebsiella oxytoca* (carbapenem-resistant), *Staphylococcus aureus, Candida* species, *Sphingomonas paucimobilis,* and *Pseudomonas fluorescens.* Similarly, 70.8% (n=80) of the blood culture samples were sterile. Furthermore, among the positive blood culture results, 6.2% (n=7) were *E. coli* and 4.4% (n=5) were *K. pneumoniae.* Methicillin-resistant *Staphylococcus aureus* (MRSA), methicillin-resistant coagulase-negative *Staphylococci* (MRCoNS), ampicillin-C- and carbapenem-resistant *E. coli,* extended spectrum ß-lactamase (ESBL)-producing *E. coli,* ESBL-producing *K. pneumoniae*, and methicillin-sensitive *Staphylococcus aureus* (MSSA) was detected in one patient each. Among the patients with positive culture reports, 16 were discharged after recovery, 21 died, and ten were DAMA (Table S4).

Association of Clinical Outcomes with Clinical Features

The presence or absence of jaundice significantly influenced the clinical outcomes of the patients (x^2=13.309, p=0.001).

Table 1. Distribution and antibiotic sensitivity pattern of bacteria obtained from ascitic fluid and blood cultures

	Organism	Count	Percent (%)
Ascitic fluid	*E. coli*	10	8.8
	E. coli - Amp C + carbapenemase-resistant	1	0.9
	E. coli - (extended spectrum ß-lactamases, ESBL)	2	1.8
	Enterococcus	1	0.9
	Klebsiella oxytoca-carbapenem-resistant	1	0.9
	Klebsiella pneumoniae	4	3.5
	Klebsiella pneumoniae-carbapenem-resistant	4	3.5
	Klebsiella pneumoniae (ESBL-producing)	1	0.9
	Klebsiella pneumoniae/Stenotrophomonas	2	1.8
	Pseudomonas fluorescens and *Enterococcus faecium*	1	0.9
	Sphingomonas paucimobilis	1	0.9
	Staphylococcus aureus-methicillin sensitive (MSSA)	2	1.8
	Sterile	82	72.6
	Stenotrophomonas and *Candida*	1	0.9
Blood	*Acinetobacter baumannii* and *Klebsiella pneumoniae*	1	0.9
	Acinetobacter lwoffii	1	0.9
	Candida	1	0.9
	E. coli	7	6.2
	E. coli and *Klebsiella pneumoniae*	1	0.9
	E. coli - Amp C + carbapenemase-resistance	1	0.9
	E. coli and *Streptococcus pyogenes*	1	0.9
	Enterococcus	1	0.9
	Klebsiella pneumoniae	5	4.4
	Klebsiella pneumoniae (ESBL and carbapenemase resistant)	4	3.5
	Pseudomonas aeruginosa	1	0.9
	Pseudomonas stutzeri	1	0.9
	Staphylococcus aureus (MSSA)	1	0.9
	Staphylococcus haemolyticus	1	0.9
	Staphylococcus, methicillin-resistant coagulase-negative staphylococci (MRCoNS)	2	1.8
	Methicillin-resistant *Staphylococcus aureus*	2	1.8
	Sterile	80	70.8
	Stenotrophomonas	2	1.8

ESBL: Extended spectrum ß-lactamase, MSSA: Methicillin-sensitive *Staphylococcus aureus,* MRCoNS*:* Methicillin-resistant coagulase-negative *Staphylococci*

Altered mental status significantly influenced the outcomes of the patients (x^2=17.053, p=0.00). There was no statistically significant association between the other clinical features and clinical outcomes (Table 2).

Association of Clinical Outcomes with Laboratory Parameters

There was a significant association between the clinical outcomes and the total WBC count (p=0.002). However, the platelet count and hemoglobin level were not significantly associated with the clinical outcomes. A lower leukocyte count was noticed among patients who were discharged than among those who died or were DAMA. Among the renal function parameters, the creatinine and bicarbonate levels were significantly associated with clinical outcomes (p=0.000). Higher creatinine and lower bicarbonate levels were seen among patients who died than among those who were discharged or DAMA. Among the liver function parameters, the direct bilirubin level was significantly associated with clinical outcomes (p=0.026) (Table 3).

Association of Clinical Outcomes with the Causes of Liver Cirrhosis

The different causes of cirrhosis identified were alcohol, hepatitis-B and hepatitis-C infection, NAFLD, autoimmune diseases, extrahepatic portal vein obstruction, primary sclerosing cholangitis, primary biliary cirrhosis, Wilson's disease, hepatocellular carcinoma, Budd-Chiari syndrome, cholangiocarcinoma, noncirrhotic portal fibrosis, sarcoidosis, and cryptogenic origin. Among these causes, NAFLD (x^2=8.517, p=0.014) and cirrhosis of cryptogenic origin (x^2=7.798, p=0.020) were significantly associated with the clinical outcomes (Table S5).

Patients with class B and C Child-Pugh had significantly different clinical outcomes (x^2=9.312, p=0.010).

Association of Clinical Outcomes with the Duration of Hospital Stay

The duration of stay significantly influenced the clinical outcomes (H=7.302, p=0.008). Upon further pairwise comparison, and Bonferroni post-hoc tests the duration of stay between the DAMA and discharge groups (p=0.019) and between the death and discharge groups were statistically significantly different (p=0.043). However, the duration of stay between the DAMA and death groups was not significantly different (Table 4).

Association of Clinical Outcomes with the MELD Score and INR

Both the MELD score (H=18.443, p<0.001) and INR (H=13.050, p=0.001) were significantly influenced the outcomes. Pairwise comparisons and Bonferroni post-hoc tests revealed highly

Table 2. Association of clinical features with the clinical outcomes of patients with SBP

		Outcome			p value
		DAMA	Death	Discharge	
Fever	No	14	33	40	0.322
	Yes	4	6	16	
Abdomen distension	No	4	7	11	0.930
	Yes	14	32	45	
Jaundice	No	14	16	42	**0.001***
	Yes	4	23	14	
Hematemesis	No	15	38	51	0.175
	Yes	3	1	5	
Malena	No	18	36	48	0.178
	Yes	0	3	8	
Abdominal pain	No	6	18	28	0.467
	Yes	12	21	28	
Vomiting	No	15	34	51	0.637
	Yes	3	5	5	
Diarrhea	No	15	37	54	0.126
	Yes	3	2	2	
Cough	No	15	37	51	0.362
	Yes	3	2	5	
Swelling of the lower limbs	No	9	19	33	0.577
	Yes	9	20	23	
Altered mental status	No	12	20	50	**0.000***
	Yes	6	19	6	

*Indicates significance at p<0.05.

DAMA: Discharged against medical advice, SBP: Spontaneous bacterial peritonitis

significant differences in both the MELD score and INR (p<0.001) between patients who were discharged and those who died (Tables S6a and S6b). These differences were insignificant between the DAMA and discharged groups and between the DAMA and death groups.

Association of Clinical Outcomes with Ascitic Fluid Culture Growth

There was no significant association between ascitic fluid culture growth and clinical outcomes (p=0.620) (Table 5).

Association of Clinical Outcomes with the Absolute Neutrophil Count

There was no significant association between absolute neutrophil count and clinical outcomes (p=0.475) (Table S7).

Discussion

Multidrug-resistant bacteria pose a challenge to the treatment of SBP in patients with CLD. Hence, it is necessary to understand the clinical and laboratory features as well as bacteriological profile of SBP and identify the factors that influence the outcomes to determine suitable treatment strategies which reduce mortality rates.

In our study, we found that SBP in patients with CLD predominantly manifested as abdominal distension, abdominal pain, and swelling of the lower limbs. However, symptoms such as jaundice and altered mental status were not uncommon. This finding was in accordance with a those of previous studies that reported abdominal pain and altered mental status are the most common presentations of SBP. However, they also reported that most of the patients are asymptomatic[4,11,12]. We did not encounter any asymptomatic patients in our present study. In the present study, the presence or absence of jaundice and altered mental status significantly influenced the clinical outcomes. Previous studies have indicated that jaundice is an independent predictor of SBP[13], and altered sensorium is a common presentation of SBP[8,11]. Together, they indicate the presence of hepatic encephalopathy or sepsis which are grave complications in patients with cirrhosis[14].

Abnormalities in various laboratory parameters were frequently observed in our study, especially those of renal and liver function.

Table 3. Association of laboratory parameters with the clinical outcomes of patients with SBP

	Outcome							
	DAMA		Death		Discharge		Kruskal-Wallis's	p value
	Mean	SD	Mean	SD	Mean	SD		
Total leukocyte count	13,106	8,166	15,846	13,575	9,498	7,101	12.141	**0.002***
Hemoglobin	9.0	2.0	9.0	1.7	8.9	2.1	0.049	0.976
Platelet count	98,722	71,323	109,051	93,035	115,828	90,217	0.493	0.781
Creatinine	1.94	1.28	2.34	1.96	1.56	1.71	15.265	**0.000***
Bicarbonate	29.3	51.1	16.8	4.7	20.5	4.0	18.028	**0.000***
Sodium	132	8	131	6	132	5	1.560	0.458
Potassium	4.22	1.29	4.39	0.97	3.93	0.62	5.489	0.064
Direct bilirubin	6.2	5.4	6.4	6.3	4.0	4.6	7.319	**0.026***
Indirect	1.8	1.1	2.3	1.7	1.5	1.2	5.773	0.056
SGOT	114	152	229	436	71	78	4.117	0.128
SGPT	70	152	110	254	46	82	1.445	0.485
ALP	173	170	129	65	134	62	0.857	0.652
GGT	41.1	37.3	46.1	66.5	46.3	40.2	1.413	0.493
Albumin	2.2	0.5	2.3	0.6	2.4	0.5	2.337	0.311
Globulin	3.5	0.9	5.1	10.2	3.8	1.0	3.322	0.190

*Indicates significance at p<0.05.

DAMA: Discharged against medical advice, SD: Standard deviation, ALP: Alkaline phosphatase, GGT: Gamma-glutamyl transferase, SBP: Spontaneous bacterial peritonitis

Table 4. Association of clinical outcomes with the duration of hospital stay in patients with SBP patients

Summary statistics		Duration of hospital, days				
		No. of patients	Mean	Maximum	Minimum	SD
Outcome	DAMA	18	6	27	1	7
	Death	39	7	24	1	6
	Discharge	56	9	26	1	6
Pairwise comparisons of outcome						
Sample 1-Sample 2		Test statistic	SE	Std. test statistic	p value	Adjusted sig.[a]
DAMA-Death		-6.949	9.310	-0.746	0.455	1.000
DAMA-Discharge		-20.720	8.853	-2.341	**0.019***	0.058
Death-Discharge		-13.772	6.814	-2.021	**0.043***	0.130

[a]Significance values have been adjusted by the Bonferroni correction for multiple tests.

*Indicates significance at p<0.05.

DAMA: Discharged against medical advice, SD: Standard deviation, SE: Standard error, Std: Standard

Table 5. Association of clinical outcomes with the ascitic fluid test culture growth in patients with SBP

		Ascetic fluid total count				
		Count	Mean	Maximum	Minimum	SD
Outcome	DAMA	18	4,074	29,000	370	6,647
	Death	39	8,895	56,810	100	13,221
	Discharge	56	6,747	89,220	180	13,401

DAMA: Discharged against medical advice, SD: Standard deviation, SBP: Spontaneous bacterial peritonitis

In our study, abnormal levels of creatinine, bicarbonate, sodium, and potassium were observed, and the abnormal creatinine and bicarbonate levels significantly influenced the clinical outcomes. Renal dysfunction, including renal failure, is a common complication of SBP[11]. Abnormal serum bicarbonate levels reportedly predict negative clinical outcomes and indicate

a higher incidence of complications, including SBP[15]. In the present study, patients presented with abnormal levels of SGPT, ALP, GGT, and globulin. However, none of these parameters influenced the clinical outcomes. Liver function tests sometimes do not correlate with liver disease and are not considered a standard diagnostic test for CLD[16].

In the current study, the bacterial profile of the patients, regardless of ascitic or blood samples, revealed a higher prevalence of *E. coli* and *K. pneumoniae*. This finding is consistent with those of previous studies wherein Gram-negative bacteria were the main causative agents of SBP[4,5,8,17]. Additionally, we detected atypical causative agents, including MSSA, ESBL-producing *E. coli* and *K. pneumoniae*, MRSA, and MRCoNS, which highlights the need for considering regional variations and antibiotic resistance patterns during the treatment of SBP.

In the present study, the causes of cirrhosis, especially NAFLD and cryptogenic cirrhosis, a Child-Pugh severity class of B or C, and the duration of hospital stay were also found to influence the clinical outcomes of patients with SBP and preexisting CLD. The association between Child-Pugh class C and severe liver function damage has been previously demonstrated, and these patients reportedly develop SBP[11,18]. In the current study, a higher MELD score and INR were also associated with negative outcomes. This finding is consistent with those of previous studies wherein higher MELD scores and INR were independent predictors of SBP in patients with cirrhosis[13,19,20].

Our study findings warrant further studies on the regional differences in bacteriological profile and clinical manifestations of SBP in patients and to determine methods for early diagnosis and appropriate treatment strategies.

Study Limitations

The retrospective nature of the study could have introduced a selection bias. Additionally, it was a single-center study. A multi-centric approach is required to collect robust data regarding clinical features and the related outcomes. Although our study focused on bacterial identification, the antibiotic resistance patterns in these patients were not explored. This is critical for the determination of appropriate treatment strategies. A study which includes patients with CLD and without SBP as controls could prove beneficial in comparing the outcomes and influencing factors.

Conclusion

Our study provides valuable insights into the clinical features, laboratory parameters, and bacterial profile of SBP in patients with CLD. Additionally, we determined the factors influencing clinical outcomes, such as causes of cirrhosis (NAFLD and cryptogenic cirrhosis), Child-Pugh class B or C, and duration of hospital stay. These findings contribute to the growing body of knowledge on SBP and highlight the importance of a multidisciplinary approach for its management.

Ethics

Ethics Committee Approval: The study was approved by the Institutional Human Ethics Committee PSG Institute of Medical Sciences and Research (no: PSG/IHEC/2023/124; date: 04.04.2023).

Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: J.R., D.K.S., K.R.K., C.J.D., Y.C., S.K.S., Concept: Y.C., S.K.S., Design: Y.C., S.K.S., Data Collection or Processing: D.K.S., K.R.K., C.J.D., Analysis or Interpretation: K.R.K., C.J.D., Literature Search: J.R., D.K.S., Writing: J.R., D.K.S., Y.C.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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Table S1. Clinical features of patients with spontaneous bacterial peritonitis

Clinical features		Frequency	Percentage (%)
Fever	No	87	77.0
	Yes	26	23.0
Abdomen distension	No	22	19.5
	Yes	91	80.5
Jaundice	No	72	63.7
	Yes	41	36.3
Hematemesis	No	104	92.0
	Yes	9	8.0
Melena	No	102	90.3
	Yes	11	9.7
Abdomen pain	No	52	46.0
	Yes	61	54.0
Vomiting	No	100	88.5
	Yes	13	11.5
Diarrhoea	No	106	93.8
	Yes	7	6.2
Cough	No	103	91.2
	Yes	10	8.8
Swelling of lower limbs	No	61	54.0
	Yes	52	46.0
Altered mental status	No	82	72.6
	Yes	31	27.4

Table S2. Distribution of blood count in patients with SBP

		Count	Percentage (%)
Total leukocyte count	Normal	53	46.9
	Abnormal	60	53.1
Haemoglobin	Normal	111	98.2
	Abnormal	2	1.8
Platelet	Normal	91	80.5
	Abnormal	22	19.5

SBP: Spontaneous bacterial peritonitis

Table S3. Distribution of liver function parameters in patients with SBP

		Count	Percentage (%)
Direct bilirubin	Normal	72	63.7
	Abnormal	41	36.3
Indirect bilirubin	Normal	83	73.5
	Abnormal	30	26.5
SGOT (aspartate amino-transferase)	Normal	91	80.5
	Abnormal	22	19.5
SGPT (alanine transaminase)	Normal	44	38.9
	Abnormal	69	61.1
ALP	Normal	51	45.1
	Abnormal	62	54.9
GGT	Normal	36	31.9
	Abnormal	77	68.1
Albumin	Normal	112	99.1
	Abnormal	1	0.9
Globulin	Normal	55	48.7
	Abnormal	58	51.3

SBP: Spontaneous bacterial peritonitis, ALP: Alkaline phosphatase, GGT: Gamma-glutamyl transferase

Table S4. Outcomes based on bacterial ascitic fluid and blood culture positivity

		Discharge	Death	AMA
Culture positive (blood or ascitic fluid or both)	Yes (%)	16 (14.16)	21 (18.6)	10 (8.85)
	No (%)	40 (35.4)	18 (15.93)	8 (7.08)

Table S5. Association of clinical outcomes with causes of liver cirrhosis in SBP patients

		Outcome			Test statistic	p value
		AMA	Death	Discharge		
Alcohol	No	10	22	29	0.219	0.896
	Yes	8	17	27		
Hep-B	No	17	37	51	0.580	0.748
	Yes	1	2	5		
Hep-C	No	17	38	53	0.489	0.783
	Yes	1	1	3		
Non-alcoholic fatty liver disease	No	18	30	52	8.517	0.014
	Yes	0	9	4		
Autoimmune	No	17	36	52	0.086	0.958
	Yes	1	3	4		
Extrahepatic portal vein obstruction	No	18	39	54	2.072	0.355
	Yes	0	0	2		
Primary sclerosing cholangitis	No	18	39	55	1.027	0.598
	Yes	0	0	1		
Primary biliary cirrhosis	No	18	39	54	2.072	0.355
	Yes	0	0	2		
Wilson's	No	18	35	54	3.244	0.198
	Yes	0	4	2		
HCC	No	18	33	53	5.006	0.082
	Yes	0	6	3		
Buddchiari	No	18	38	56	1.914	0.384
	Yes	0	1	0		
Cholangiocarcinoma	No	17	39	56	5.325	0.070
	Yes	1	0	0		
NCPF	No	17	39	55	2.187	0.337
	Yes	1	0	1		
Sarcoidosis	No	18	39	55	1.027	0.598
	Yes	0	0	1		
Cryptogenic	No	13	38	49	7.798	0.020
	Yes	5	1	7		

SBP: Spontaneous bacterial peritonitis

Table S6a. Association of clinical outcomes with MELD scores in SBP patients

Summary statistics		MELD score				
		Count	Mean	Minimum	Maximum	SD
Outcome	AMA	18	26	14	37	6
	Death	39	29	12	40	7
	Discharge	56	22	8	37	7

Test summary			
Total N	Test statistic	Degree of freedom	Asymptotic sig. (2-sided test)
113	18.443[a]	2	**<0.001***

[a]The test statistic is adjusted for ties.

Pairwise comparisons of outcome					
Sample 1-Sample 2	Test statistic	SE	Std. test statistic	p value	Adj. sig.[a]
Discharge-AMA	16.088	8.870	1.814	0.070	0.209
Discharge-Death	29.129	6.828	4.266	**<0.001***	0.000
AMA-Death	-13.041	9.328	-1.398	0.162	0.486

[a]Significance values have been adjusted by the Bonferroni correction for multiple tests.

*Indicates significance at p<0.05.

MELD: The Model for End-Stage Liver Disease, SBP: Spontaneous bacterial peritonitis, INR: International normalized ratio, SD: Standard deviation, SE: Standard error, Std: Standard

Table S6b. Association of clinical outcomes with INR scores in SBP patients

Summary statistics		INR				
		Count	Mean	Maximum	Minimum	SD
Outcome	AMA	18	1.99	3.66	1.20	0.71
	Death	39	3.05	16.00	1.12	2.66
	Discharge	56	1.78	3.32	1.01	0.54

Test Summary			
Total N	Test statistic	Degree of freedom	Asymptotic Sig. (2-sided test)
112	13.050[a]	2	**0.001***

[a]The test statistic is adjusted for ties.

Pairwise comparisons of outcome					
Sample 1-Sample 2	Test statistic	SE	Std. test statistic	p value	Adj. Sig.[a]
Discharge-AMA	8.565	8.798	0.974	0.330	0.991
Discharge-Death	24.627	6.824	3.609	**<0.001***	0.001
AMA-Death	-16.061	9.291	-1.729	0.084	0.252

[a]Significance values have been adjusted by the Bonferroni correction for multiple tests.

*Indicates significance at p<0.05.

SBP: Spontaneous bacterial peritonitis, SD: Standard deviation, SE: Standard error, Std: Standard

Table S7. Association of absolute neutrophil count with clinical outcomes in patients with SBP

Summary statistics		Absolute neutrophil count				
		Count	Mean	Maximum	Minimum	SD
Outcome	AMA	18	0.74	0.90	0.35	0.16
	Death	39	0.78	0.99	0.36	0.13
	Discharge	56	0.71	0.98	0.18	0.20

Test summary			
Total N	Test statistic	Degree of freedom	Asymptotic sig. (2-sided test)
113	1.491[a]	2	0.475

[a]The test statistic is adjusted for ties.

SBP: Spontaneous bacterial peritonitis, SD: Standard deviation