Clinical Insights and Outcomes in Community-Acquired Acute Bacterial Meningitis *versus* Postoperative Bacterial Meningitis

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ABSTRACT

Objective: To compare the demographics, clinical characteristics, and in-hospital mortality rates between community-acquired bacterial meningitis cases and postoperative bacterial meningitis.

Study Design: Analytical study.

Place and Duration of the Study: Department of Infectious Diseases and Clinical Microbiology, *Diskapi Yildirim Beyazit* Training and Research Hospital, Ankara, Turkiye, from 2016 to 2022.

Methodology: A total of 153 patients diagnosed with bacterial meningitis were included and categorised into two groups: 95 (62.1%) with community-acquired bacterial meningitis (CABM) and 58 (37.9%) with postoperative bacterial meningitis (POBM). Demographics, clinical features, laboratory, paraclinical findings, treatments, and outcomes of the cases were compared. Data were retrieved using a standard data collection form from the electronic medical records.

Results: A substantial portion (58.8%) of all patients had comorbidities. Fever was the common symptom in all groups. Headache, neck stiffness, nausea, and vomiting were more often observed in the CABM group ($p < 0.001$). Upon admission, the CABM exhibited higher levels of white blood cell count, C-reactive protein, and procalcitonin ($p = 0.017$, $p = 0.004$, $p = 0.007$, respectively). Overall 33.1% had positive cerebrospinal fluid cultures. The overall mortality rate was 26.8%. POBM was associated with longer hospital and intensive care unit (ICU) stays ($p < 0.001$). Shorter treatment durations, lower Glasgow coma scale scores (GCS), higher Charlson Comorbidity Index values, and elevated markers of inflammation were related to mortality.

Conclusion: This study illuminates the differences in clinical presentations and outcomes between community-acquired and postoperative bacterial meningitis. It also suggests that factors such as lower GCS scores, comorbidities, and elevated inflammation markers at the last follow-up may be associated with unfavourable clinical outcomes in bacterial meningitis.

Key Words: *Postoperative meningitis, Central nervous system infection, Cerebrospinal fluid, Antibiotics.*

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INTRODUCTION

Despite advances in medicine, antimicrobial agents, vaccine development, and critical care, bacterial meningitis remains a major global public health challenge with a significant risk of mortality and morbidity.[1,2] Bacterial meningitis is a medical emergency that often progresses rapidly and can lead to death in a substantial portion of patients, while survivors may face long-term neurological deficits.

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The worldwide mortality rate of bacterial meningitis is approximately 10%; nevertheless, this figure varies based on factors such as age, the specific causative organism, and geographical region.[3] Acute bacterial meningitis (ABM) could be acquired not only in the community but also may be associated with various invasive procedures[4] or head trauma.[5]

The clinical manifestations of ABM are multifaceted and largely depend on the pathogenesis of the infection, the virulence of the aetiological agent, and the route of ABM infection.[6] Common symptoms include fever, headache, changes in mental status, and neurological impairments. Common signs include fever, headache, meningismus, and altered mental status.[7,8] The severity of ABM varies and is influenced by the age of the patient, pre-existing medical conditions, or predisposing factors such as respiratory and systemic infections, head injuries, prior neurosurgical interventions, cancer,

alcohol abuse, and various states of immunodeficiency. These factors can exacerbate the patient's condition and complicate treatment. Prompt disease recognition and early and appropriate empirical antibiotic treatment initiation significantly reduce mortality and morbidity.[9,10]

This study focuses on these two groups by examining the distinct pathogenesis, microbial aetiology, and clinical presentations of these two forms of bacterial meningitis. The authors sought to elucidate differences in disease progression, treatment response, and outcome. Therefore, the aim of this study was to evaluate and compare clinical insights and patient outcomes between community-acquired bacterial meningitis (CABM) and postoperative bacterial meningitis (POBM).

METHODOLOGY

This study included individuals who were diagnosed with meningitis, aged 15 years and above and admitted at *Diskapi Yildirim Beyazit* Training and Research Hospital, Ankara, Turkiye, between January 2016 and December 2022. Individuals were excluded if they had either documented non-infectious causes for their neurological illness, or diagnosis of viral or aseptic meningitis, or identification of one of the causative agents of chronic meningitis, or were younger than 15 years old, or alternative source of infection external to CNS, and / or if accessible medical records were lacking. Cases were categorised as CABM and POBM. Demographic, clinical, and laboratory characteristics of the cases, their treatments, outcomes, and mortality rates were compared among the groups. CABM and POBM were defined according to the recommendations of the Centres for Disease Control and Prevention (Atlanta, GA).[11] Fever was defined as having a central body temperature exceeding 38.2°C at admission.

Patients' demographics, clinical profiles, medical history, laboratory data, and paraclinical information were meticulously recorded using a standardised data collection form, leveraging electronic medical records. The comorbidities were evaluated and classified using the Charlson Comorbidity Index (CCI).[12] All laboratory tests and radiological assessments, including brain computed tomography (CT), magnetic resonance imaging (MRI), and electroencephalography (EEG), were conducted at the discretion of the primary physician.

Antibiotic treatment was individually adjusted for each patient by the attending physician. Corticosteroid treatment was characterised by the utilisation of dexamethasone, at least 0.15mg/kg every 6 hours or a similar duration, initiated within the initial 24 hours following the diagnosis of bacterial meningitis and maintained for four days.

During this period, the microbiology department in the hospital identified bacterial strains utilising a combination of methods including traditional methods, automated microbial identification system, and matrix-assisted laser desorption / ionisation time-of-flight mass spectrometry. All patients were closely monitored throughout their hospital stay, from admission through recovery, discharge, or mortality. The primary endpoints were the time to clinical improvement and the time to discharge or death. The primary outcome was in-hospital mortality rates. The study was approved by the Clinical Research Ethics Committee of Ankara Etlik City Hospital, Ankara, Turkiye (Approval No: AESH-EK1-2023-060, Dated: 05.04.2023).

All data evaluation and statistical analysis were performed using the Statistical Package for the Social Sciences version 22 software for Windows. Graphs were created using the Microsoft Excel programme (2016). Results were presented as frequency (n) and percentages (%) for categorical variables. Continuous variables were presented as mean ± standard deviation or median (IQR). The normality assumption for continuous variables was verified using the Kolmogorov-Smirnov test. Categorical variables were analysed using the Chi-square or Fisher's exact test. For the comparison of independent continuous variables between CABM and POBM, the Student's t-test or Mann-Whitney U test was used depending on whether the statistical hypotheses were fulfilled or not. The survival between the two groups was compared by a Mantel-Cox (log-rank) test. A statistical significance threshold was set at a p-value of 0.05 for all tests.

RESULTS

Two hundered and eight hospitalised patients were identified with CNS infections between 1 January 2016 and 31 December 2022. From this group, 6 patients were excluded because they were under the age of 15 years. Additionally, 19 patients were excluded since they were diagnosed with non-CNS infections during follow-up. A total of 183 patients diagnosed with CNS infections were initially evaluated for eligibility in the study. Exclusions were made for specific conditions as four cases of viral meningitis, six cases each of tuberculosis meningitis and ventriculoperitoneal shunt infections, three cases of neurobrucellosis, two cases of aseptic meningitis, and nine cases diagnosed with brain abscess. Ultimately, 153 patients were included in the study.

According to the definitions, 95 (62.1%) were diagnosed with CABM and 58 (37.9%) with POBM. Of the 153 patients, 97 (63.4%) were males. The mean age was 51.5 ± 17.9 years. Comorbid diseases were present in 90 patients (58.8%), with hypertension (HT) being the most frequent (23.5%), followed by diabetes mellitus (16.3%), chronic obstructive pulmonary disease (COPD, 9.2%), and coronary artery disease (5.9%). The most common symptom was fever (83.0%), followed by confusion (81.0%), headache (46.4%), neck stiffness (42.5%), nausea (28.3%), and vomiting (24.3%). Signs of meningeal irritation (such as fever, headache, seizure, altered consciousness, focal neurological deficit, or neck stiffness) were more frequently observed upon presentation in patients within the CABM group, who presented more commonly with classic symptoms of meningitis ($p < 0.05$).

Table I: Comparison of demographic data, clinical characteristics, treatment, and outcome in patients diagnosed with community-acquired acute bacterial meningitis (COBM) and post-operative bacterial meningitis (POBM).

Variables	CABM	POBM	Total	p-value	OR (95% CI)
Demographics					
Patients N/(%) [a]	95 (62.1)	58 (37.9)	153 (100)		
Gender (Female)	33 (34.7)	23 (39.7)	56 (36.6)	0.540	1.24 (0.63 - 2.42)
Age (Mean ± SD)	50.9 ± 18.73	52.4 ± 16.6	51.5 ± 17.9	0.596	
Clinical characteristics					
GSC (Mean ± SD)	12.8 ± 2.01	13.1 ± 1.94	12.9 ± 2	0.372	
CCI (Min-Max) [a]	2.2 (0 - 10)	2.3 (0 - 9)	2.2 (0 - 10)	0.502	
Chronic disease N/(%) [a]	58 (61.1)	32 (55.2)	90 (58.8)	0.584	1.27 (0.66 - 2.47)
Hypertension N/(%) [a]	25 (26.3)	11 (19)	36 (23.5)	0.298	0.66 (0.30 - 1.46)
Diabetes mellitus N/(%) [a]	19 (20.2)	6 (10.3)	25 (16.4)	0.122	0.46 (0.17 - 1.22)
Immunosuppression N/(%) [a]	8 (8.4)	15 (26.3)	23 (15.1)	0.006	3.88 (1.53 - 9.88)
History of meningitis N/(%) [a]	10 (10.5)	2 (3.4)	12 (7.8)	0.134	3.29 (0.7 - 15.6)
Symptoms N/(%) [a]					
Fever	79 (83.2)	48 (82.8)	127 (83.0)	0.99	1.03 (0.43 - 2.45)
Headache	53 (55.8)	18 (31)	71 (46.4)	0.003	2.8 (1.41 - 5.58)
Nausea	38 (40)	5 (8.8)	43 (28.3)	<0.001	6.93 (2.54 - 18.95)
Vomiting	34 (35.8)	3 (5.3)	37 (24.3)	<0.001	10.03 (2.92 - 34.53)
Mental confusion	83 (87.4)	41 (70.7)	124 (81.0)	0.019	2.87 (1.25 - 6.57)
Seizure	17 (17.9)	3 (5.2)	20 (13.1)	0.044	4 (1.12 - 14.3)
Focal neurological deficit	0 (0)	1 (1.7)	1 (0.7)		
Neck stiffness	49 (53.3)	13 (24.1)	62 (42.5)	0.001	3.59 (1.7 - 7.58)
Rash	3 (3.2)	0 (0)	3 (2.0)		
Treatment N/(%) [a]					
Ampicillin	14 (14.7)	0 (0)	14 (9.2)	0.001	
Ceftriaxone + GPT	54 (56.8)	1 (1.7)	55 (35.9)	<0.001	
Meropenem + GPT	32 (33.7)	47 (81)	79 (51.6)		
Meropenem + Colistin + GPT	4 (4.2)	8 (13.8)	12 (7.8)		
Acyclovir	17 (17.9)	0 (0)	17 (11.1)	0.02	
Steroid treatment	23 (24.2)	20 (35.7)	43 (28.5)	0.185	0.58 (0.28 - 1.18)
Vancomycin N/(%) [a] (reference)	86 (90.5)	52 (89.7)	138 (90.2)	0.356	
Linezolid N/(%) [a]	4 (4.2)	5 (8.6)	9 (5.9)		3.02 (0.34 - 26.59)
Daptomycin N/(%) [a]	5 (5.3)	1 (1.7)	6 (3.9)		6.25 (0.50 - 77.49)
Disposition and outcome					
ICU admission N/(%) [a]	43 (45.3)	47 (81)	90 (58.8)	<0.001	0.19 (0.09 - 0.42)
ICU length of stay (Min-Max)	8 (0 - 180)	17.4 (0 - 75)	11.6 (0 - 180)	<0.001	
Total length of stay (Min-Max)	21.6 (2 - 180)	32.6 (7 - 85)	21.8 (2 - 180)	0.001	
Total duration of treatment (Min-Max)	13.8 (1 - 30)	14.8 (2 - 27)	14.2 (0 - 180)	0.144	
Mortality N/(%) [a]	21 (22.1)	20 (34.5)	41 (26.8)	0.136	0.54 (0.26 - 1.12)

Results were presented as mean ± standard deviation or count (n) and percentages (%); a p-value of ≤0.05 was considered statistically significant. According to distribution, Student's t-test or Mann-Whitney U test was performed. The Chi-square test (or Fisher's exact) was applied for categorical variables. CCI: Charlson comorbidity index, GSC: Glasgow coma scale, GPT: Gram-positive treatment (antimicrobial agents effective against gram-positive bacteria such as Vancomycin, Linezolid, and Daptomycin), ICU: Intensive care unit, [a]: column percentage, OR = Odds ratio, CI = Confidence interval, Min-Max = Minimum-Maximum.

Table II: The comparison of the laboratory, paraclinical, and radiological findings in patients diagnosed with community-acquired acute bacterial meningitis (CABM) *vs.* postoperative bacterial meningitis (POBM).

Variables	CABM	POBM	Total	p-value
Laboratory findings N/(%)[a]				
WBC (Day 0) (/uL, normal range: 4-10 ×10^3)	16829.1 ± 8277.77	13150.2 ± 5204.75	15434.4 ± 7465.9	0.017
CRP (Day 0) (Min-Max) (mg/L, normal range: 0-5)	149 (1 - 630)	77.7 (0.3 - 418)	121(0.3 - 630)	0.004
Procalcitonin (Day 0) (Min-Max)	9 (0 - 100)	1.9 (0.1 - 12)	6 (0 - 100)	0.007
WBC (Discharge/Ex) (/uL, normal range: 4-10 ×10^3)	8952.2 ± 5815.41	10253.2 ± 11801.26	9445.4 ± 8575.6	0.276
CRP (Discharge/Ex) (Min-Max) (mg/L, normal range: 0-5)	43.7 (0.8 - 506)	73.8 (0.6 - 448)	56 (0.6 - 506)	0.138
Procalcitonin (discharge/Ex) (Min-Max) (/uL)	13.6 (0 - 100)	1.4 (0.1 - 18.6)	10.3 (0 - 100)	0.06
Blood culture positive*	13 (14.1)	7 (12.3)	20 (13.4)	0.940
Paraclinical findings N/(%)[a]				
CSF glucose	45.6 ± 39.08	51.7 ± 34.49	50.8 ± 37.35	0.175
CSF/Blood glucose ratio	0.3 ± 0.37	0.4 ± 0.23	0.4 ± 0.33	0.38
CSF PMN ratio (%)	0.8 ± 0.15	0.8 ± 0.24	0.8 ± 0.19	0.114
Microorganism positivity* in gram stain	17 (19.5)	5 (8.6)	22 (15.2)	0.119
PMN positivity in gram* stain	75 (88.2)	48 (82.8)	123 (86)	0.495
CSF culture positive	30 (33.3)	18(32.7)	48 (33.1)	>0.99
Staphylococcus aureus	2 (6.6)	1 (5.6)	3 (6.3)	
Streptococcus pneumoniae	20 (66.7)	0 (0)	20 (41.7)	
Coagulase-negative *staphylococci*	5 (16.7)	8 (44.4)	13 (27.1)	
Enterococcus spp.	0 (0)	2 (11.1)	2 (4.2)	
Enterobacterecea spp.	0(0)	3(16.7)	3 (6.3)	
Acinetobacter baumanii	4(13.3)	5(27.8)	9(18.8)	
Other gram-positive micro-organisms	1 (3.3)	1 (5.6)	2 (4.2)	
Radiological findings N/(%)[a]				
Brain MR findings	35 (36.8)	6 (10.3)	41 (26.8)	0.001
Brain CT findings	5 (5.3)	1 (1.7)	6 (3.9)	0.408
Hydrocephalus	5(9.8)	7(28.0)	12(15.8)	0.052

Results were presented as mean ± standard deviation or count (n) and percentages (%); a p-value of ≤0.05 was considered statistically significant. According to distribution, Student's t-test or Mann-Whitney U test was performed. Chi-square test (or Fisher's exact) was applied for categorical variables. CSF: Cerebrospinal fluid, CT: Computer tomography, ICU: Intensive care unit, Min-Max = Minimum - Maximum, MR: Magnetic resonance, PMN: Polymorphonuclear Leucocytes, WBC: White blood cell. [a]: column percentage, Coagulase-negative staphylo-cocci, and Acinetobacter baumanii are not common causative agents in community-acquired meningitis and may yield false positives. However, in this case, they were acknowledged as causative agents and treated with appropriate therapy.

Table III: The comparison of demographics and clinical characteristics between the survivors (n = 112) and the non-survivors (n = 41) diagnosed with community-acquired acute bacterial meningitis and postoperative bacterial meningitis.

Variables	Survive	Non survive	p-value	OR (95% CI)
Demographics				
N/(%) [a]	112 (73.2)	41 (26.8)		
Gender (Female) N/(%) [a]	39 (34.8)	17 (41.5)	0.45	1.33 (0.64 - 2.76)
Age (Mean ± SD)	48.2 ± 16.9	60.4 ± 17.8	<0.001	
Clinical characteristics				
GCS	13.3 ± 1.6	11.7 ± 2.6	0.005	
CCI	1.84 (0 - 9)	3.32 (0 - 10)	<0.001	
Chronic disease N/(%) [a]	62 (55.4)	28 (68.3)	0.21	0.58 (0.27 - 1.23)
Immunosuppression N/(%) [a]	12 (10.7)	11 (27.5)	0.019	0.32 (0.13 - 0.79)
Diabetes mellitus N/(%) [a]	16 (14.4)	9 (22.0)	0.387	0.6 (0.24 - 1.49)
History of meningitis N/(%) [a]	10 (8.9)	2 (4.9)	0.516	0.52 (0.11 - 2.49)
Symptoms N/(%) [a]				
Fever	93 (83.0)	34 (82.9)	>0.99	1.01 (0.39 - 2.61)
Headache	61 (54.5)	10 (24.4)	0.001	0.27 (0.12 - 0.60)
Mental confusion	87 (77.2)	37(90.2)	0.079	2.66 (0.86 - 8.17)
Seizure	14 (12.5)	6 (14.6)	0.788	1.20 (0.43 - 3.37)
Laboratory findings N/(%) [a]				
Blood culture positive	12 (9)	11 (25)	0.005	0.24 (0.09 - 0.63)
CSF/Blood glucose ratio	0.4 ± 0.5	0.4 ± 0.3	0.785	
CSF PMN ratio	0.8 ± 0.2	0.8 ± 0.2	0.782	
WBC 0 (Day 0) (/uL, normal range: 4-10 $\times 10^3$)	14583 ± 7174.9	17760.3 ± 7834.8	0.019	
CRP (Day 0) (Min-Max) (mg/L, normal range: 0-5)	95.1 ± 105.2	193.8 ± 172.9	0.003	
Procalcitonin (Day 0) (Min-Max) (/uL)	1.6 ± 3.2	12.1 ± 24.8	0.019	
WBC (discharge/Ex) (/uL, normal range: 4-10 $\times 10^3$)	7014.7 ± 3781.7	16085.3 ± 13343	<0.001	
CRP (discharge/Ex) (mg/L, normal range: 0-5)	20.7 ± 37.2	169.8 ± 147.1	<0.001	
Procalcitonin (discharge/Ex) (/uL)	1.3 ± 4.7	19.6 ± 33.1	<0.001	
Treatment N/(%) [a]				
Ceftriaxone+GPT N/(%) [a]	39 (34.8)	16 (39.0)	0.494	0.94 (0.45 - 1.95)
Meropenem+ GPT N/(%) [a]	61 (54.5)	18 (43.9)	0.943	1.03 (0.49 - 2.14)
Meropenem+Colisin+ GPT N/(%) [a]	7 (6.3)	5 (12.2)	0.176	0.32 (0.06 - 1.66)
Steroid treatment N/(%) [a]	23 (20.7)	20 (50)	0.001	0.26 (0.12 - 0.57)
Vancomycin N/(%) [a] (reference)	102 (91.1)	36 (87.8)	0.508	
Linezolid N/(%) [a]	5 (4.5)	4 (9.8)		0.25 (0.02 - 3.1)
Daptomycin N/(%) [a]	5 (4.5)	1 (2.4)		0.44 (0.11 - 1.73)
Disposition and outcome				
Total follow-up day	24.8 ± 16.2	28.4 ± 31.9	0.475	
Total treatment day	15.2 ± 4.3	11.5 ± 7.9	0.007	
ICU admission	50 (44.6)	40 (97.6)	<0.001	
ICU day	7.6 ± 12.9	23 ± 31	<0.001	

Results were presented as mean ± standard deviation or count (n) and percentages (%); a p-value of ≤0.05 was considered statistically significant. According to distribution, Student's t-tests or Mann-Whitney U test was performed. The Chi-square test (or Fisher's exact) was applied for categorical variables. CCI: Charlson comorbidity index, CI=Confidence interval, CRP: C-reactive protein, CSF: Cerebrospinal fluid, GSC: Glasgow coma scale, GPT: Gram-positive treatment (antimicrobial agents effective against gram-positive bacteria), ICU: Intensive care unit, Min-Max = Minimum-Maximum, OR=Odds ratio, PMN: Polymorphonuclear Leucocytes, WBC: White blood cell. [a]: column percentage.

The antibiotic treatments administered to the patients are detailed in Table I. On average, all patients received antibiotics for 14.2 (0-180) days. During the follow-up, 55 (35.9%) patients received ceftriaxone, 96 (62.7%) meropenem, and 153 (100%) were treated with antibiotics effective against gram-positive bacteria; 14 (9.2%) received ampicillin, 17 (11.1%) were treated with acyclovir, and 43 (28.5%) were given steroids. The usage of ceftriaxone was more common in cases of CABM, whereas meropenem use was higher in the POBM group (p <0.001). The average hospital stay for the patients was 21.8 days (range 2-180) and patients diagnosed with POBM experienced significantly extended hospital stays.

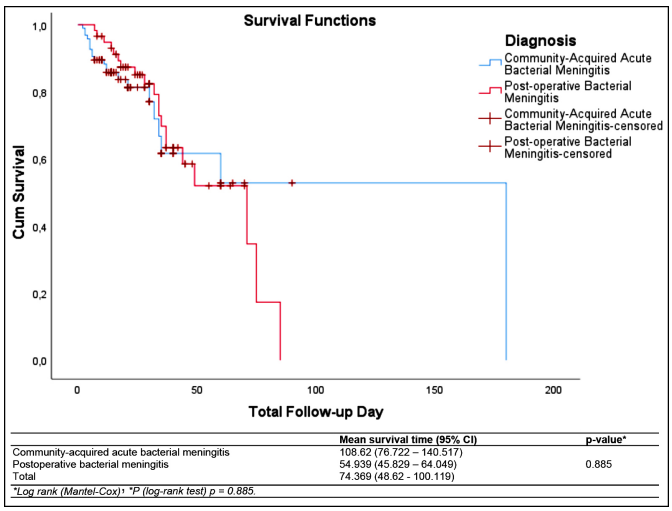
Table II summarises the laboratory parameters between CABM and POBM. Laboratory parameters, including WBC, CRP, and procalcitonin were assessed at admission and the last follow-up day, revealed higher values for the CABM group initially (p = 0.017, p = 0.004, and p = 0.007, respectively), with no significant differences in these parameters by the end of the follow-up. There were no significant differences between levels of CSF glucose and CSF/Blood glucose ratio in the two groups (p = 0.175 and p = 0.38). Micro- organisms were detected in 22 (15.2%) of all patient samples using Gram staining, and polymorphonuclear leucocytes (PMNs) were found in 123 (86.0%). Organisms were cultured from the CSF in 48 (33.1%) patients, *Streptococcus pneumoniae* was the most common pathogen, identified in 20 (41.7%) cases. However, it was not encountered in any cases of postoperative meningitis. Abnormal brain MRI findings were detected in 41 (26.8%) patients, with a higher incidence of abnormal MRI findings in CABM cases (p = 0.001). However, only 6 (3.9%) patients showed abnormal CT scan results among all the participants.

During the follow-up period, 90 (58.8%) patients were transferred from the ward to the ICU. The median stay in ICU was 11.6 days (range 0-180). The rates of ICU admission and stay were higher in POBM patients (p <0.001). The median duration of ICU stay for POBM patients was 17.4 days (range 0-75), compared to the CABM group which was 8 days (range 0-180). The mortality rate among ICU-admitted patients was found to be 44.4%.

Table III summarises the patients' demographics, clinical findings, laboratory parameters, treatment, and outcome of survival *versus* non-survival groups. The average age of survivors was 48.2 ± 16.9 years. Non-survivors were older

and had a lower GCS, and higher CCI score compared to the survivors. The non-survivors group exhibited elevated levels of WBC, CRP, and procalcitonin ($p \leq 0.05$) both at the time of admission and discharge/death. Notably, the use of steroids was higher among survivors compared to non-survivors ($p = 0.001$). The analysis suggests that inadequate antibiotic therapy may be linked to higher mortality ($p = 0.007$) observed by lower antibiotic treatment duration in non-survivors (mean 11.5 days) than in survivors (mean 15.2 days).

According to the Kaplan-Meier analysis used to compare the mean survival times of patients diagnosed with CABM and POBM, the survival curves showed no statistically significant difference between the two groups ($p = 0.885$, Figure 1).



	Mean survival time (95% CI)	p-value*
Community-acquired acute bacterial meningitis	108.62 (76.722 – 140.517)	
Postoperative bacterial meningitis	54.939 (45.829 – 64.049)	0.885
Total	74.369 (48.62 - 100.119)	

*Log rank (Mantel-Cox)¹ *P (log-rank test) p = 0.885.

Figure 1: Kaplan-Meier survival curves of patients diagnosed with community-acquired acute bacterial meningitis *vs.* postoperative bacterial meningitis.

DISCUSSION

This study, which lasted over six years at a tertiary research and training hospital, provided significant insights into the clinical profile and outcomes of CABM and POBM patients. This study brings light to the considerable differences in demographics and clinical manifestations, including symptomatology, laboratory findings, and outcomes between CABM and POBM as well as in patients who survived *vs.* those who did not. Previous studies have assessed patients' demographic characteristics, and clinical and laboratory findings with POBM or CABM. However, research comparing these patients is quite limited in the literature.[8,13-16] Understanding the differences based on bacterial meningitis type and identifying patients at high mortality risk can aid in developing an early diagnosis, appropriate antibiotic therapy, and follow-up strategies.

Inconsistent with the study of Sonneville *et al.*,[17] older age and immunosuppression are non-modifiable factors associated with worse functional outcomes. The most common comorbidities in the study were hypertension and diabetes, similar across groups and were not higher among the non- survivors. However, immunosuppression was more often observed in the POBM group, and the higher CCI may be linked to the increased mortality observed. Contrarily, in studies discussed, diabetes was the most common comorbidity.[14,17]

It has been observed that patients with CABM presented more often with classic symptoms such as fever, headache, neck stiffness, nausea, and vomiting, underscoring the importance of recognising these symptoms for early diagnosis and treatment. Symptoms suggestive of increased intracranial pressure, such as headache, nausea, vomiting, and neck stiffness, were observed more often in the CABM group.[8,14-16] Patients with POBM may not exhibit symptoms resulting from meningeal irritation and increased intracranial pressure, indicating that the diagnosis in this patient group could be overlooked. This underscores the need for increased vigilance in patients the authors suspect and those with risk factors, as exemplified by a case where delayed diagnosis led to significant complications.

Early diagnosis and optimal antibiotic treatment are crucial for survival in ABM.[18] In patients who start antibiotic treatment before diagnosis, the identification of ABM is complicated due to the negative CSF cultures and changes in the usual CSF profile for pyogenic meningitis. In the study, although the authors could not ascertain whether these patients had received antibiotics, lumbar punctures were performed on all, yet only 33.1% showed CSF culture growth. Studies on CNS infections conducted in the outhers' region have identified pathogen growth rates in CSF cultures between 17-38.6%, while this rate has been observed to rise to 55% in studies on POBM.[16] Prior antibiotics use or suboptimal conditions during sample collection might have contributed to a lower culture positivity rate. The rates of growth in blood and CSF cultures were similar between the two groups, but a higher rate of bacterial growth was detected in non-survival patients.

It is commonly noted that ABM is generally associated with a lower CSF glucose level, reflecting a distinctive marker that helps differentiate it from other types of meningitis. In this study, consistent with the literature, a lower CSF glucose ratio was found and detected in both the bacterial meningitis groups.[19,20] Furthermore, while the initial values of WBC, CRP, and procalcitonin were higher in CABM, no significant difference was found in the values checked on the last day of follow-up. In the study conducted by Kumari *et al.*,[21] which compared POBM and spontaneous meningitis, similar CSF glucose, protein, and cell counts were observed while serum WBC levels were found to be higher in cases of POBM. Additionally, Casado *et al.*, suggested that CRP, procalcitonin levels, and leucocyte counts are elevated in patients with CABM.[19] The authors suggest that in patients with POBM, laboratory findings may become less distinct. This should be taken into consideration in cases where the diagnosis is uncertain.

The choice of antibiotic therapy is made based on the patients' age and the region they live in, considering demographic /

epidemiologic factors and differentiated based on antimicrobial susceptibility testing. Initiating the antimicrobial therapy early correlates with better outcomes, in line with published research on bacterial meningitis.[17,22] However, the use of empiric antibiotics in patients with unconfirmed diagnoses can hinder accurate diagnosis, delay appropriate treatment, and potentially lead to poor outcomes. Therefore, careful consideration and evaluation are necessary in such cases. Upon examining the treatments received by patients, it was found that the CABM group most frequently received ceftriaxone and gram-positive effective treatment. In contrast, the postoperative meningitis group predominantly chose meropenem and gram-positive effective therapy. No effect was observed on mortality based on the choice of therapy.

A notable finding from this study was the in-hospital mortality rate of 26.8%. Similar to prior research, in-hospital mortality and extended hospital stays were significant issues arising from bacterial meningitis.[15]

Hospital mortality rates of ABM patients admitted to ICU have been reported at varying levels in different studies, with some identifying rates as high as 44%. In ABM caused by resistant micro-organisms, mortality tends to be higher.[23] In this study, the mortality rate among ICU-admitted patients was found to be 44.4%, which is consistent with the results from the largest prospective international multicentre cohort study in ICUs.[17] This study reported that around half of the patients experienced poor functional outcomes in three months. Moreover, it was emphasised that delayed ICU admission for patients needing care for ABM was an independent marker of poor prognosis. This underlines the severe nature of ABM and the critical need for timely and effective management.

The observation that POBM patients not only had a longer median ICU stay but also experienced a higher rate of ICU admissions compared to other groups, highlights the substantial intensive care requirements of this subgroup. This aligns with previous research indicating the complexity and severe prognosis of POBM.[13,16]

The high CCI score and immunosuppressive conditions were noted to be higher in non-survivors. The surviving patients had lower levels of CRP and procalcitonin on admission and the last follow-up day. In the literature, studies indicate that elevated levels of CRP and procalcitonin are consistent with unfavourable outcomes.[13,24] CRP and procalcitonin could be beneficial for evaluating early treatment response.

The effectiveness of adjuvant dexamethasone in the treatment of ABM is a matter of debate in various studies. The Cochrane meta-analysis revealed that corticosteroids reduced the overall incidence of hearing loss and neurological after effects, though they did not decrease mortality rates. Furthermore, it indicated that corticosteroids were advantageous in research conducted in high-income countries with advanced medical care, yet no benefits were noted in studies from low-income countries.[25] In this study, the use of steroids, which was higher among non-survivors, presents an interesting aspect of these findings. While the role of steroids in ABM infections is debated, this study's data does not suggest a possible association with improved outcomes, a point that might warrant further investigation.

The main strength of this study is that being a hospital with a high volume allowed the authors to conduct a comprehensive analysis of a large number of patients diagnosed with ABM, but there are some limitations. Despite the large patient sample size, all were from a single centre and belonged to the same ethnic group. The absence of a healthy control group is a significant limitation that could have enhanced the study's internal validity. Additionally, the absence of a standard treatment protocol and missing information, such as the duration from the patient's arrival to the initiation of antibiotic therapy diminishes the scope of the study and the short duration of follow-up. Despite these limitations, the study provides a realistic insight into the current clinical situation. The findings also point to potential areas for future research, particularly in optimising treatment protocols and exploring the role of adjunct therapies.

CONCLUSION

Factors such as insufficient antibiotic therapy, a lower GCS, a higher CCI score, and elevated CRP and procalcitonin levels at the last follow-up may link to unfavourable clinical outcomes.

ETHICAL APPROVAL:
The study received approval from the Clinical Research Ethics Committee of Ankara Etlik City Hospital (Approval No: AESH-EK1-2023-060, Date: 05.04.2023).

PATIENTS' CONSENT:
The study was conducted using medical records from patients who provided informed consent.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
HNKP: Conception, design, data collection and analysis, and primary drafting of the manuscript.
DB, BRA: Conceptualisation, writing of the manuscript, investigation, and data curation.
MH: Data interpretation and assistance in drafting of the initial manuscript.
IS, AHS: Patient care, supervision, and critical revision of the manuscript.
All authors reviewed and approved the final version of the manuscript to be published.

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