Original article:

Analysis of Neurological Complications in Bacterial Meningitis Patients at a Tertiary Care Hospital

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Abstract

Background: Bacterial meningitis is a serious neurological emergency associated with substantial morbidity, mortality, and long-term disability. Despite advances in antimicrobial therapy and intensive care, neurological complications such as seizures, altered mental status, cranial nerve palsy, hearing impairment, hydrocephalus, cerebral edema, and focal neurological deficits remain common. Early recognition of these complications and their associated risk factors is essential for improving patient outcomes.

Aim: To analyze neurological complications in bacterial meningitis patients at a tertiary care hospital.

Materials and Methods: This hospital-based observational study included 95 patients diagnosed with bacterial meningitis. Demographic characteristics, clinical presentation, neurological examination findings, Glasgow coma scale score, laboratory parameters, cerebrospinal fluid findings, blood culture results, neuroimaging findings, treatment requirements, and outcomes were recorded using a structured proforma. Neurological complications were assessed during hospitalization. Patients were categorized according to the presence or absence of neurological complications, and the two groups were compared.

Results: The mean age of the patients was 34.82 ± 18.64 years, and 58 (61.05%) were males. Neurological complications occurred in 38 (40.00%) patients. Seizures were the most common complication, observed in 21 (22.11%) patients, followed by altered mental status in 18 (18.95%), cranial nerve palsy in 11 (11.58%), hearing impairment in 9 (9.47%), and hemiparesis or focal neurological deficit in 8 (8.42%). Age above 40 years, Glasgow Coma Scale score below 8, positive blood culture, delayed presentation of more than five days, and seizures at admission were significantly associated with neurological complications. Complete recovery was lower among patients with complications than among those without complications (47.37% versus 82.46%, $p<0.001$).

Conclusion: Neurological complications were common in bacterial meningitis and were associated with poorer recovery, greater neurological disability, increased intensive care requirements, and higher mortality. Early diagnosis, prompt antimicrobial treatment, careful neurological monitoring, and timely critical care support are essential for reducing adverse outcomes.

Key words: Bacterial Meningitis; Neurological Complications; Seizures; Glasgow Coma Scale; Clinical Outcome.

INTRODUCTION

Bacterial meningitis is an acute infection of the leptomeninges and cerebrospinal fluid and remains a neurological emergency despite advances in therapy, vaccination, critical care, and diagnostics. The disease may progress rapidly from nonspecific symptoms to severe neurological dysfunction, permanent disability, or death. It affects individuals of all ages, although the causative organisms, manifestations and outcomes vary with age,

immune status, vaccination history, geographical setting, and illnesses. *Streptococcus pneumoniae* and *Neisseria meningitidis* are important causes, while *Haemophilus influenzae*, group B streptococci, gram-negative bacilli, and *Listeria monocytogenes* occur in particular clinical groups. Early suspicion is essential because presentation may be incomplete or atypical among infants, older adults, immunocompromised patients, and those who received antibiotics before admission.[1] The pathogenesis begins with mucosal colonization, bloodstream invasion, evasion of host immune mechanisms, and penetration of the blood–brain barrier. After bacteria enter the subarachnoid space, multiplication and the host inflammatory response produce meningeal inflammation, endothelial injury, altered cerebral blood flow, increased blood–brain barrier permeability, and cerebral edema. These processes may raise intracranial pressure, reduce cerebral perfusion, and cause neuronal injury. The responsible organism can influence severity and complication patterns; for example, *Listeria monocytogenes* is particularly relevant among older or immunocompromised adults and requires different antimicrobial coverage.[2] Clinical manifestations commonly include fever, headache, vomiting, neck stiffness, photophobia, irritability, altered sensorium, and meningeal signs. However, the complete classical picture is not present in every patient. Neurological abnormalities at admission, including reduced consciousness, focal weakness, cranial nerve dysfunction, and seizures, may indicate advanced inflammation or intracranial involvement. Seizures can occur before admission or during hospitalization and may be related to cortical irritation, cerebral edema, infarction, metabolic disturbances, or structural complications. Their occurrence requires prompt assessment because they may interfere with neurological evaluation and identify patients requiring intensive monitoring.[3] Neurological complications are among the most serious consequences of bacterial meningitis. Acute complications include seizures, cerebral edema, hydrocephalus, ventriculitis, cerebral infarction, venous thrombosis, subdural effusion, subdural empyema, brain abscess, cranial nerve palsies, hearing impairment, and focal neurological deficits. Computed tomography and magnetic resonance imaging are valuable when patients have persistent altered consciousness, new focal deficits, recurrent seizures, raised intracranial pressure, or an unsatisfactory response to treatment. Neuroimaging can identify abnormalities requiring modified therapy, neurosurgical consultation, or prolonged follow-up.[4] The consequences may continue after the acute infection has resolved. Survivors can experience hearing loss, epilepsy, motor impairment, cognitive dysfunction, behavioral changes, memory difficulties, impaired attention, and reduced ability to perform daily activities. Some deficits are obvious at discharge, whereas subtle neuropsychological problems may appear only during later follow-up. Outcome assessment should therefore extend beyond survival and include neurological, audiological, cognitive, and functional evaluation. Long-term observation is particularly important after pneumococcal meningitis and in patients with severe impairment of consciousness or other neurological complications.[5] Children are especially vulnerable because bacterial injury occurs during critical periods of brain development. Neurological and developmental consequences may affect language, learning, vision, hearing, motor performance, and psychosocial functioning. These impairments can influence educational achievement and independence. Neurological and developmental assessment is important after pediatric meningitis, even when apparent recovery has occurred. Early

recognition permits referral for audiological care, rehabilitation, physiotherapy, occupational therapy, speech therapy, and educational support.[6]

MATERIALS & METHODS

This hospital-based observational study was conducted to analyze neurological complications in bacterial meningitis patients at a tertiary care hospital. The study included patients diagnosed with bacterial meningitis based on clinical presentation, cerebrospinal fluid (CSF) analysis, microbiological findings, and neuroimaging investigations wherever indicated. The study was designed to assess the spectrum, frequency, and determinants of neurological complications occurring in patients with bacterial meningitis and their clinical outcomes. A total of 95 patients diagnosed with bacterial meningitis were enrolled in the study. Patients of either sex who fulfilled the diagnostic criteria for bacterial meningitis and provided informed consent for participation were included. The diagnosis was established on the basis of characteristic clinical features such as fever, headache, neck stiffness, altered sensorium, seizures, and signs of meningeal irritation, supported by laboratory and cerebrospinal fluid findings suggestive of bacterial infection. Patients with viral, fungal, tuberculous, or non-infectious meningitis, those with pre-existing neurological disorders that could confound outcome assessment, and patients with incomplete clinical records were excluded from the study.

Methodology

Detailed demographic, clinical, laboratory, and radiological data were collected using a structured proforma. Information regarding age, sex, residence, comorbid illnesses, immunization status where applicable, history of prior antibiotic therapy, duration of symptoms before admission, and presenting complaints was documented. Clinical examination included assessment of vital signs, level of consciousness, neurological status, meningeal signs, cranial nerve involvement, focal neurological deficits, and evidence of raised intracranial pressure. The Glasgow Coma Scale (GCS) score at admission was recorded for all patients to assess the severity of neurological impairment.

Diagnostic Evaluation

All patients underwent routine hematological and biochemical investigations, including complete blood count, erythrocyte sedimentation rate, C-reactive protein, blood glucose, serum electrolytes, renal function tests, and liver function tests. Cerebrospinal fluid analysis was performed following lumbar puncture and included measurement of opening pressure, cell count, differential leukocyte count, protein concentration, glucose levels, Gram staining, bacterial culture, and antibiotic sensitivity testing whenever feasible. Blood cultures were obtained before initiation of antimicrobial therapy whenever possible. Neuroimaging studies such as computed tomography (CT) scan or magnetic resonance imaging (MRI) of the brain were performed in selected patients based on clinical indications, including altered consciousness, focal neurological deficits, recurrent seizures, or suspected intracranial complications.

Assessment of Neurological Complications

Patients were systematically evaluated for the occurrence of neurological complications during hospitalization. The complications assessed included seizures, altered mental status, cranial nerve palsies, hearing impairment, hydrocephalus, cerebral edema, cerebral infarction, brain abscess, subdural effusion, subdural empyema, ventriculitis, focal neurological deficits, hemiparesis, cognitive dysfunction, movement disorders, and persistent neurological sequelae. Neurological examinations

were performed by experienced clinicians, and findings were corroborated with imaging studies and specialist consultations whenever necessary. The timing, severity, and progression of each neurological complication were documented in detail.

Clinical Outcome Assessment

Clinical outcomes were evaluated based on neurological status at discharge. Patients were categorized as having complete recovery, recovery with neurological sequelae, or mortality. Neurological sequelae assessed included persistent motor deficits, cranial nerve dysfunction, hearing loss, cognitive impairment, recurrent seizures, and other residual neurological abnormalities. The requirement for intensive care support, mechanical ventilation, duration of hospital stay, and need for neurosurgical interventions were also recorded as indicators of disease severity and outcome.

Statistical Analysis

The collected data were entered into a computerized database and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation or median with interquartile range as appropriate, while categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the Chi-square test or Fisher's exact test for categorical variables and Student's t-test or Mann–Whitney U test for continuous variables. A p-value of less than 0.05 was considered statistically significant. The findings were presented using tables, charts, and descriptive summaries to illustrate the frequency and pattern of neurological complications associated with bacterial meningitis.

RESULTS

The mean age of the patients was 34.82 ± 18.64 years, indicating that bacterial meningitis affected a wide age range of patients. Neurological complications were observed in 38 patients, accounting for 40.00% of the total study population.

Table 1 shows the demographic profile of the study participants. The highest number of patients belonged to the 19–40 years age group, comprising 39 patients or 41.05% of the study population. This was followed by the 41–60 years age group with 23 patients or 24.21%, while 21 patients or 22.11% were aged 18 years or below. Patients above 60 years formed the smallest group, with 12 patients or 12.63%. Male patients were more commonly affected than female patients, with 58 males representing 61.05% and 37 females representing 38.95%. With respect to residence, 56 patients or 58.95% were from rural areas, whereas 39 patients or 41.05% belonged to urban areas.

Table 2 describes the clinical presentation of patients at the time of admission. Fever was the most common presenting symptom, observed in 89 patients or 93.68%, followed by headache in 78 patients or 82.11%. Neck stiffness was present in 72 patients or 75.79%, reflecting the classical meningeal involvement seen in bacterial meningitis. Vomiting was reported in 49 patients or 51.58%, while altered sensorium was present in 41 patients or 43.16%, suggesting significant central nervous system involvement in a considerable proportion of patients. Seizures were seen at admission in 27 patients or 28.42%. Photophobia was observed in 18 patients or 18.95%, focal neurological deficit in 16 patients or 16.84%, and cranial nerve involvement in 12 patients or 12.63%.

Table 3 presents the pattern of neurological complications observed during hospitalization. Overall, 38 patients or 40.00% developed at least one neurological complication. Seizures were the most frequent complication, occurring in 21 patients or 22.11%, followed by altered mental

status in 18 patients or 18.95%. Cranial nerve palsy was observed in 11 patients or 11.58%, while hearing impairment was noted in 9 patients or 9.47%. Hemiparesis or focal neurological deficit occurred in 8 patients or 8.42%. Radiological or clinically significant complications such as cerebral edema were found in 7 patients or 7.37%, hydrocephalus in 5 patients or 5.26%, cerebral infarction in 4 patients or 4.21%, and brain abscess in 3 patients or 3.16%. Subdural effusion and ventriculitis were each observed in 2 patients or 2.11%.

Table 4 shows the factors associated with the development of neurological complications. Age above 40 years was significantly associated with neurological complications, as 20 patients or 52.63% in the complication group were above 40 years compared with 15 patients or 26.32% in the non-complication group, with a p-value of 0.009. Male gender was more common in both groups, but the difference was not statistically significant, with 25 males or 65.79% in the complication group and 33 males or 57.89% in the non-complication group, p=0.442. A Glasgow Coma Scale score below 8 at admission showed a highly significant association with neurological complications, being present in 17 patients or 44.74% with complications compared with 8 patients or 14.04% without complications, p<0.001. Positive blood culture was also significantly associated with complications, reported in 15 patients or 39.47% in the complication group and 10 patients or 17.54% in the non-complication group, p=0.017. Delayed presentation of more than 5 days was significantly higher among patients with complications, seen in 19 patients or 50.00%, compared with 14 patients or 24.56% without complications, p=0.011. Seizures at admission were strongly associated with neurological complications, occurring in 18 patients or 47.37% in the complication group compared with 9 patients or 15.79% in the non-complication group, p<0.001.

Table 1. Demographic Characteristics of Study Participants (N = 95)

Variable	Frequency (n)	Percentage (%)
Age Group (Years)		
≤18	21	22.11
19–40	39	41.05
41–60	23	24.21
>60	12	12.63
Gender		
Male	58	61.05
Female	37	38.95
Residence		
Rural	56	58.95
Urban	39	41.05

Table 2. Clinical Presentation at Admission (N = 95)

Clinical Feature	Frequency (n)	Percentage (%)
Fever	89	93.68
Headache	78	82.11
Neck stiffness	72	75.79
Altered sensorium	41	43.16
Vomiting	49	51.58
Seizures	27	28.42
Photophobia	18	18.95
Focal neurological deficit	16	16.84
Cranial nerve involvement	12	12.63

Table 3. Neurological Complications Observed in Patients with Bacterial Meningitis (N = 95)

Neurological Complication	Frequency (n)	Percentage (%)
Seizures	21	22.11
Altered mental status	18	18.95
Cranial nerve palsy	11	11.58
Hearing impairment	9	9.47
Hemiparesis/Focal deficit	8	8.42
Cerebral edema	7	7.37
Hydrocephalus	5	5.26
Cerebral infarction	4	4.21
Brain abscess	3	3.16
Subdural effusion	2	2.11
Ventriculitis	2	2.11
Any neurological complication*	38	40.00

*Patients could develop more than one complication.

Table 4. Factors Associated with Neurological Complications

Variable	Neurological Complications Present (n=38)	Neurological Complications Absent (n=57)	p-value
Age >40 years	20 (52.63%)	15 (26.32%)	0.009
Male gender	25 (65.79%)	33 (57.89%)	0.442
GCS <8 at admission	17 (44.74%)	8 (14.04%)	<0.001
Positive blood culture	15 (39.47%)	10 (17.54%)	0.017
Delayed presentation (>5 days)	19 (50.00%)	14 (24.56%)	0.011
Seizures at admission	18 (47.37%)	9 (15.79%)	<0.001

Table 5. Clinical Outcomes According to Presence of Neurological Complications

Outcome	Neurological Complications Present (n=38)	Neurological Complications Absent (n=57)	p-value
Complete recovery	18 (47.37%)	47 (82.46%)	<0.001
Recovery with neurological sequelae	13 (34.21%)	7 (12.28%)	0.009
Mortality	7 (18.42%)	3 (5.26%)	0.041
ICU admission	21 (55.26%)	12 (21.05%)	<0.001
Mechanical ventilation	14 (36.84%)	6 (10.53%)	0.002

Table 5 compares the clinical outcomes between patients with and without neurological complications. Complete recovery was significantly lower among patients with neurological complications, seen in only 18 patients or 47.37%, compared with 47 patients or 82.46% among those without complications, p<0.001. Recovery with neurological sequelae was significantly higher in the complication group, observed in 13 patients or 34.21%, compared with 7 patients or 12.28% in the non-complication group, p=0.009. Mortality was also higher among patients with neurological complications, with 7 deaths or 18.42%, compared with 3 deaths or 5.26% among patients without complications, p=0.041. ICU admission was required in 21 patients or 55.26% with neurological complications, compared with 12 patients or 21.05% without complications, p<0.001. Similarly, mechanical ventilation was needed in 14 patients or 36.84% in the complication group and 6 patients or 10.53% in the non-complication group, p=0.002.

DISCUSSION

The demographic findings indicate that bacterial meningitis affected patients across a broad age range, with a mean age of 34.82 ± 18.64 years. The largest proportion was aged 19–40 years (41.05%), followed by those aged 41–60 years (24.21%), ≤18 years (22.11%), and >60 years (12.63%). Males constituted 61.05% of the study population. A similar male predominance was reported by Tsai et al. (2006), who evaluated 62 young adults aged 17–40 years with bacterial meningitis and found that 48 patients (77.42%) were male and 14 (22.58%) were female. Their exclusively young-adult cohort differs from the wider age distribution in the present study, but both studies demonstrate greater involvement of males. The lower male proportion in the present study may be related to the inclusion of pediatric, middle-aged, and elderly patients. Rural residents accounted for 58.95% of the present population, which may reflect the referral pattern and catchment area of the tertiary care hospital; however, the Taiwanese study did not provide a rural–urban comparison.[7] The clinical presentation in the present study was predominantly characterized by fever (93.68%), headache (82.11%), neck stiffness (75.79%), vomiting (51.58%), and altered sensorium (43.16%). Seizures were present at admission in 28.42%, while focal neurological deficits and cranial nerve involvement were observed in 16.84% and 12.63%, respectively. Van de Beek et al. (2004), in a prospective study of 696 episodes of adult community-acquired bacterial meningitis, reported headache in 87%, neck stiffness in 83%, fever in 77%, and altered mental status in 69% of episodes.

Focal neurological deficits occurred in 33%, and 14% of patients were comatose at admission. The classic triad of fever, neck stiffness, and altered mental status was present in only 44%, although 95% had at least two of the four features of fever, headache, neck stiffness, and altered mental status. Compared with their study, the present study had a higher frequency of fever but lower frequencies of altered sensorium and focal deficits. These variations may be explained by differences in age composition, disease severity at referral, previous antimicrobial exposure, and criteria used to define altered mental status.[8] Neurological complications developed in 38 patients, representing 40.00% of the present study population. Seizures were the most frequent complication at 22.11%, followed by altered mental status at 18.95%, cranial nerve palsy at 11.58%, hearing impairment at 9.47%, hemiparesis or focal deficit at 8.42%, cerebral edema at 7.37%, hydrocephalus at 5.26%, cerebral infarction at 4.21%, brain abscess at 3.16%, and subdural effusion and ventriculitis at 2.11% each. Kastenbauer et al. (2003) studied 87 adults with pneumococcal meningitis and reported meningitis-associated intracranial complications in 74.70% of patients. Diffuse brain edema occurred in 28.70%, hydrocephalus in 16.10%, arterial cerebrovascular complications in 21.80%, and hearing loss in 19.50% of all patients and 25.80% of survivors. These complication rates were higher than the respective rates in the present study. This difference is likely related to their inclusion of pneumococcal meningitis alone, which is commonly associated with more severe neurological injury, whereas the present study included bacterial meningitis caused by different organisms. Selective use of neuroimaging in the present study may also have resulted in fewer radiological complications being detected.[9] Age above 40 years and severe impairment of consciousness were important factors associated with neurological complications in the present study. Among patients with complications, 52.63% were older than 40 years, compared with 26.32% of patients without complications, and this association was statistically significant ($p=0.009$). A GCS score below 8 was present in 44.74% of patients with complications and only 14.04% of those without complications ($p<0.001$). Male gender was not significantly associated with complications (65.79% versus 57.89%, $p=0.442$), indicating that the observed male predominance in the overall population did not independently correspond to a greater complication rate. Dzupova et al. (2009) similarly identified coma as an independent predictor of an unfavorable outcome in adults with bacterial meningitis. In their cohort, 55 patients (20%) died and 63 (23%) had neurological sequelae at six-month follow-up. Other independent predictors included internal comorbidity, hypotension, treatment initiated more than 48 hours after symptom onset, elevated CSF protein, a low CSF-to-blood glucose ratio, and non-meningococcal etiology. The agreement regarding impaired consciousness supports the importance of admission GCS as a practical indicator of severe neurological involvement.[10] Positive blood culture, delayed presentation, and seizures at admission were also significantly associated with neurological complications. Positive blood cultures were found in 39.47% of patients with complications compared with 17.54% without complications ($p=0.017$). Presentation more than five days after symptom onset occurred in 50.00% of the complication group and 24.56% of the non-complication group ($p=0.011$). Seizures at admission were documented in 47.37% of patients who subsequently developed complications, compared with 15.79% of those who did not ($p<0.001$). Lepur et al. (2007) evaluated 286 patients and found an unfavorable

outcome in 125 patients (43.70%). Appropriate antibiotic therapy was initiated significantly later among patients with unfavorable outcomes when measured from the onset of symptoms (p=0.018) and, particularly, from the onset of consciousness disturbance (p<0.001). Early adequate treatment was independently associated with a favorable outcome, with an odds ratio of 11.19, while advanced age, lower GCS, and seizures were associated with poor outcome; seizures had an odds ratio of 3.65. Although their study did not directly compare culture-positive with culture-negative patients, its analysis of culture-positive cases supports the importance of rapidly recognizing severe disease and beginning appropriate treatment.[11] Clinical outcome was substantially worse among patients who developed neurological complications. Complete recovery occurred in 47.37% of patients with complications compared with 82.46% without complications (p<0.001). Neurological sequelae remained in 34.21% of the complication group and 12.28% of the non-complication group (p=0.009), while mortality was 18.42% and 5.26%, respectively (p=0.041). Considering the entire population, 65 of 95 patients (68.42%) recovered completely, 20 (21.05%) survived with neurological sequelae, and 10 (10.53%) died. Aronin et al. (1998) evaluated 269 adults with community-acquired bacterial meningitis and reported an in-hospital mortality rate of 27%. Neurological deficits developed in 56 patients (21%), and deficits persisted at discharge in 9%. The overall frequency of neurological sequelae in the present study was therefore similar to the 21% frequency of neurological deficits reported by Aronin et al., although persistent deficits and mortality were lower in the present study. Aronin et al. also found that hypotension, altered mental status, and seizures independently predicted adverse outcome, further supporting the relationship between early neurological severity and subsequent morbidity or death.[12] The increased requirement for critical care among patients with neurological complications further demonstrates the severity of their illness. ICU admission was necessary in 55.26% of patients with complications compared with 21.05% without complications (p<0.001), while mechanical ventilation was required in 36.84% and 10.53%, respectively (p=0.002). Overall, 33 of 95 patients (34.74%) required ICU care and 20 (21.05%) required mechanical ventilation. Flores-Cordero et al. (2003) studied 64 episodes of community-acquired bacterial meningitis in 62 adults admitted to an ICU. Altered mental status was present in 95.30%, the median GCS score was 11, mortality was 10.90%, and death or severe neurological deficit occurred in 17.10%. Age above 50 years, seizures or focal neurological signs, a GCS score of 10 or less, and an APACHE II score above 13 were associated with adverse outcome. Their mortality rate was close to the overall mortality of 10.53% in the present study, although their population consisted entirely of critically ill adults. The present findings particularly show that neurological complications identify a subgroup with a much greater requirement for ICU admission and ventilatory support.[13]

Overall, the study demonstrates that neurological complications remain a major contributor to morbidity and mortality in bacterial meningitis. Although complications occurred in 40.00% of patients, the overall mortality was 10.53%; mortality increased to 18.42% among patients with neurological complications.

Durand et al. (1993), in a review of 493 episodes among 445 adults, reported an overall mortality rate of approximately 25%, and 197 episodes (40%) were hospital-acquired. The lower mortality in the present study may reflect differences in study

population, the inclusion of younger patients, advances in antimicrobial and intensive care management, and a potentially smaller proportion of nosocomial infections. Nevertheless, the present results are consistent with the earlier observation that bacterial meningitis continues to cause substantial neurological disability despite treatment. Early identification of low GCS, seizures, delayed presentation, bacteremia, and older age may help clinicians recognize high-risk patients and institute closer neurological monitoring, timely neuroimaging, appropriate antimicrobial therapy, seizure control, and intensive supportive care.[14]

CONCLUSION

The study concludes that neurological complications are common among patients with bacterial meningitis and contribute significantly to morbidity and mortality. Seizures, altered mental status, cranial nerve palsy, and hearing impairment were the most frequent complications. Older age, low admission GCS, positive blood culture, delayed presentation, and seizures at admission were significantly associated with neurological complications. Early diagnosis, prompt antimicrobial therapy, close neurological monitoring, and timely intensive care support are essential to improve patient outcomes.

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