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ORIGINAL ARTICLE

Exploring the Risk Factors and Occurrence of Meningitis in Infants and Toddlers Aged 6-18 months with Initial Seizure and Fever

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ABSTRACT

Background: Meningitis is a serious neurological condition in infants and toddlers, often presenting with fever and seizures. Early diagnosis is critical, as delayed management can lead to severe complications, including neurological deficits and death. Identifying risk factors can help in early intervention and improved patient outcomes.

Objective: To explore the risk factors and occurrence of meningitis in infants and toddlers aged 6-18 months presenting with initial seizures and fever.

Study Design: A cross-sectional analytical study.

Study Setting: The study was conducted at Department of Paediatrics Sahiwal Teaching Hospital over six months from April 2023 to September 2023.

Materials and Methods: A total of 150 infants and toddlers aged 6-18 months presenting with fever and seizures were included. CSF analysis was performed to confirm meningitis. Demographic data, vaccination status, nutritional history, and clinical parameters were recorded. Risk factors were analyzed using statistical tests, with $p<0.05$ considered significant.

Results: Meningitis was diagnosed in 38.7% of cases. Incomplete vaccination (69.0% vs. 32.6%, $p<0.001$), recurrent infections (55.2% vs. 30.4%, $p=0.002$), and malnutrition (50.0% vs. 21.7%, $p<0.001$) were significantly higher in meningitis patients. Mortality was 10.3% in meningitis cases compared to 1.1% in non-meningitis cases ($p=0.02$).

Practical Implication: Early identification of risk factors such as incomplete vaccination, recurrent infections, and malnutrition can help in the timely diagnosis and management of meningitis, reducing morbidity and mortality.

Conclusion: Incomplete vaccination, recurrent infections, and malnutrition were key risk factors for meningitis. Early identification and preventive measures, including vaccination, can help reduce morbidity and mortality.

Keywords: Bacterial meningitis, febrile seizures, infants, lumbar puncture, neurological complications, Pakistan, risk factors, vaccination status

INTRODUCTION

Meningitis is a life-threatening condition characterized by inflammation of the meninges, the protective membranes covering the brain and spinal cord.[1] Among the early clinical manifestations of meningitis, seizures and fever often serve as alarming symptoms, prompting urgent medical evaluation.[2] Infants aged 6-18 months are particularly vulnerable, as their blood-brain barrier is still developing, making them more prone to bacterial and viral infections that can lead to meningitis.[3] According to the World Health Organization (WHO), bacterial meningitis alone accounts for approximately 250,000 deaths annually worldwide, with a significant proportion occurring in low- and middle-income countries.[4] Sub-Saharan Africa, known as the "Meningitis Belt," experiences frequent epidemics, particularly due to Neisseria meningitidis. In South Asia, meningitis remains a significant cause of morbidity and mortality in infants and young children. Streptococcus pneumoniae, Haemophilus influenzae type B (Hib), and Neisseria meningitidis are the leading bacterial pathogens responsible for meningitis in this region.[5]

Pakistan has a high burden of infectious diseases, and meningitis is no exception. According to local epidemiological studies, bacterial meningitis is frequently caused by S. pneumoniae and Hib, with a significant number of cases reported in infants. Furthermore, seasonal variations and outbreaks in densely populated regions contribute to the fluctuating prevalence of meningitis.[6] Meningitis occurs when infectious agents, such as bacteria, viruses, fungi, or parasites, invade the central nervous system (CNS), leading to inflammation of the meninges. In bacterial meningitis, pathogens typically enter the bloodstream through the respiratory tract or middle ear and breach the blood-brain barrier.[7] Several risk factors predispose infants aged 6-18 months to meningitis, particularly those presenting with initial seizures and fever. These risk factors include age and an immature immune system, as infants within this age group have an underdeveloped immune response, making them more susceptible to infections.[8] Incomplete vaccination is another major risk factor, as lack of immunization against Hib, pneumococcus, and meningococcus significantly increases the risk of bacterial meningitis.[9] Recurrent respiratory or ear infections, such as upper respiratory tract infections and otitis media, can serve as sources of bacterial invasion into the CNS.[9] Nutritional deficiencies also play a role, as malnourished infants have compromised immunity, increasing their vulnerability to infections. Additionally, environmental factors like seasonal variations, poor sanitation, and lack of access to healthcare exacerbate the risk of meningitis.[10]

Meningitis in infants and toddlers aged 6-18 months with initial seizure and fever is a critical pediatric emergency requiring prompt recognition and management. Given the high burden of disease globally and particularly in Pakistan, understanding the epidemiology, pathophysiology, and risk factors associated with meningitis is essential for early intervention. Strengthening vaccination programs, improving healthcare accessibility, and increasing awareness among caregivers can significantly reduce the morbidity and mortality associated with meningitis in this vulnerable population. Further research is needed to explore the genetic, environmental, and socioeconomic determinants contributing to the disease burden in different settings.

MATERIALS AND METHODS

After approval from the hospital's ethical review board (ERB), this cross-sectional study was conducted at Department of Paediatrics over a period of six months at Sahiwal Teaching Hospital over six months from April 2023 to September 2023. A total of 150 infants and toddlers aged 6-18 months presenting with initial seizure and fever were included. The sample size was calculated using the WHO sample size calculator, considering a confidence level of 95%, an expected prevalence of meningitis in febrile seizures of

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20%, and a margin of error of 7%. Patients were selected using consecutive non-probability sampling.[13]

All patients underwent a detailed clinical evaluation, including history-taking and physical examination. Fever was defined as a rectal temperature of ≥38°C. Seizures were classified based on duration, type, and associated symptoms. Lumbar puncture was performed in all cases to obtain cerebrospinal fluid (CSF) for analysis, including cell count, protein, glucose, and culture. Additional laboratory investigations included complete blood count, C-reactive protein (CRP), and blood cultures. Neuroimaging, including computed tomography (CT) or magnetic resonance imaging (MRI), was performed in selected cases based on clinical indications.

Patients with pre-existing neurological disorders, metabolic conditions, or recent antibiotic use were excluded. Data were collected using a structured proforma and analyzed using SPSS version 25.0. Descriptive statistics were used to summarize baseline characteristics, and categorical variables were analyzed using the chi-square test. Logistic regression was performed to identify independent risk factors for meningitis. A p-value <0.05 was considered statistically significant.

RESULTS

The study included 150 infants and toddlers aged 6-18 months with initial seizure and fever. The majority (56.7%) were aged between 6-12 months, while 43.3% were between 13-18 months. Males were more commonly affected (60.0%) than females (40.0%). Fever duration was ≤2 days in 30.0% of cases, 3-5 days in 50.0%, and >5 days in 20.0%. Generalized seizures were more frequent (73.3%) compared to focal seizures (26.7%). CSF abnormalities were detected in 38.7% of patients, while 61.3% had normal findings as given in table 1.

Microbiological analysis of CSF showed that Streptococcus pneumoniae was the most common bacterial pathogen, found in 14.7% of cases, followed by Haemophilus influenzae (12.0%) and Neisseria meningitidis (8.0%). Viral pathogens, including enteroviruses and herpes simplex virus (HSV), were detected in 24.0% of cases. No organism was identified in 41.3% of patients as given in table 2.

Several risk factors were associated with meningitis. Incomplete vaccination was significantly higher in patients with meningitis (69.0%) compared to those without meningitis (32.6%) (p<0.001). A history of recurrent infections was present in 55.2% of meningitis cases versus 30.4% in non-meningitis cases (p=0.002). Poor nutritional status was observed in 50.0% of meningitis patients, whereas it was only 21.7% in those without meningitis (p<0.001). A family history of seizures was not significantly different between the two groups (p=0.08) as given in table 3.

CSF findings showed that WBC count >100 cells/mm³ was significantly higher in meningitis cases (86.2%) compared to non-meningitis cases (13.0%) (p<0.001). Elevated CSF protein levels (>100 mg/dL) were observed in 72.4% of meningitis patients versus 19.6% of non-meningitis cases (p<0.001). CSF glucose levels <40 mg/dL were found in 75.9% of meningitis patients compared to 15.2% of those without meningitis (p<0.001) as given in table 4.

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 150)

Variables	Characteristic	n (%)
Age Group (months)	6-12	85 (56.7)
	13-18	65 (43.3)
Gender	Male	90 (60.0)
	Female	60 (40.0)
Fever Duration (days)	≤2 days	45 (30.0)
	3-5 days	75 (50.0)
	>5 days	30 (20.0)
Seizure Type	Generalized	110 (73.3)
	Focal	40 (26.7)
CSF Abnormalities	Present	58 (38.7)
	Absent	92 (61.3)

Outcomes varied significantly between groups. Full recovery was observed in 69.0% of meningitis patients, whereas 92.4% of non-meningitis patients recovered completely (p<0.001). Neurological sequelae were more frequent in meningitis cases (20.7%) compared to 6.5% in non-meningitis cases (p=0.01). Mortality was significantly higher in meningitis patients (10.3%) than in those without meningitis (1.1%) (p=0.02) as given in table 5.

Table 2: Microbiological Findings of CSF Analysis (n = 150)

Pathogen Identified	n (%)
Streptococcus pneumoniae	22 (14.7)
Haemophilus influenzae	18 (12.0)
Neisseria meningitidis	12 (8.0)
Viral (Enterovirus, HSV)	36 (24.0)
No Organism Detected	62 (41.3)

Table 3: Risk Factors Associated with Meningitis (n = 150)

Risk Factor	Meningitis Present (n=58)	Meningitis Absent (n=92)	p-value
Incomplete Vaccination	40 (69.0)	30 (32.6)	<0.001
History of Recurrent Infections	32 (55.2)	28 (30.4)	0.002
Poor Nutritional Status	29 (50.0)	20 (21.7)	<0.001
Family History of Seizures	14 (24.1)	12 (13.0)	0.08

*Statistically significant at p<0.05

Table 4: Comparison of CSF Findings in Meningitis vs. Non-Meningitis Cases

Parameter	Meningitis (n=58)	No Meningitis (n=92)	p-value
CSF WBC count (>100 cells/mm³)	50 (86.2)	12 (13.0)	<0.001
CSF Protein (>100 mg/dL)	42 (72.4)	18 (19.6)	<0.001
CSF Glucose (<40 mg/dL)	44 (75.9)	14 (15.2)	<0.001

*Statistically significant at p<0.05

Table 5: Outcome of Patients Based on Meningitis Diagnosis

Outcome	Meningitis (n=58)	No Meningitis (n=92)	p-value
Fully Recovered	40 (69.0)	85 (92.4)	<0.001
Neurological Sequelae	12 (20.7)	6 (6.5)	0.01
Mortality	6 (10.3)	1 (1.1)	0.02

*Statistically significant at p<0.05

DISCUSSION

Meningitis is a life-threatening neurological condition that commonly affects infants and toddlers, often presenting with fever and seizures. Globally, bacterial and viral meningitis remain major causes of morbidity and mortality. In Pakistan, a high burden of meningitis is attributed to incomplete vaccination, poor hygiene, and limited healthcare access.[12] Pathogens such as Streptococcus pneumoniae, Haemophilus influenzae, and Neisseria meningitidis are leading causes. Key risk factors include incomplete immunization, recurrent infections, and malnutrition. Early identification and management are crucial to improving outcomes in affected children.[13,14]

The demographic profile of our study, which included 125 children, showed a predominance of male patients (60%) with a mean age of 10.6 months (±4.2). This aligns with findings from Mustafa et al. (2023), who reported that 64.1% of their cohort were male, and the mean age was 11.24 ± 2.86 months.[19] Our study also showed that most patients were between 6-12 months of age, a group at higher risk for febrile seizures, which is consistent with the findings of Yaqub et al. (2015), who noted that children under six years old are a high-risk group for febrile seizures.[18]

Our study identified meningitis in 16.3% of febrile seizure patients, a frequency that is somewhat higher than the 10.3%

reported by Mustafa et al. (2023)[17] and 15% by Mahamuduzzaman et al. (2022).[19] The variation in meningitis frequency across studies may be attributed to differences in patient populations, diagnostic practices, and the clinical setting. Nevertheless, the presence of meningitis in a significant proportion of febrile seizure patients supports the recommendation for lumbar puncture (LP) as a crucial diagnostic tool in this population, as emphasized by Heydarian et al. (2014)[15] and Yaqub et al. (2015).[18] In terms of seizure types, generalized seizures were more prevalent in our study, accounting for 73.3% of cases, which is in line with findings from Al-Mendalawi et al. (2015), where 89.6% of patients had generalized seizures. Generalized seizures are commonly associated with febrile seizures and have been linked to a higher risk of complications, such as meningitis, which is consistent with our results. Heydarian et al. (2014) also reported generalized seizures as being more common, with a significant association between this type of seizure and meningitis.[15]

Regarding clinical features, our study found that 42.4% of patients with meningitis had a fever duration of 3-5 days, a finding similar to Muthaffar et al. (2024), who also observed prolonged fever in febrile seizure patients.[16] Fever duration has been shown to correlate with an increased likelihood of infections, including meningitis, and our findings align with previous studies that emphasize the need for early evaluation of febrile seizures with prolonged fever. In our study, cerebrospinal fluid (CSF) analysis played a pivotal role in diagnosing meningitis, with significant CSF abnormalities observed in patients with meningitis, including elevated white blood cell (WBC) count, high protein levels, and low glucose levels. These findings are consistent with those of Mahamuduzzaman et al. (2022), who reported similar CSF profiles in bacterial and viral meningitis cases, particularly pleocytosis with low glucose and high protein levels.[17] Our study found that 38.7% of patients with meningitis exhibited CSF abnormalities, in line with findings from Yaqub et al. (2015), who documented a significant relationship between CSF protein, glucose levels, and the presence of meningitis.[18]

We also noted that the frequency of meningitis was higher among patients with incomplete vaccinations, which mirrors the findings of Mustafa et al. (2023) and Heydarian et al. (2014). In our study, 69.0% of patients with meningitis had incomplete vaccinations, highlighting the importance of immunization in reducing the risk of bacterial infections, including meningitis. Vaccination status was not reported as a significant factor in other studies such as Al-Mendalawi et al. (2015), which suggests that variations in vaccination rates and local health policies may account for differing findings.

In terms of outcomes, our study found that 69.0% of meningitis patients fully recovered, while 10.3% experienced mortality. This aligns with findings from Muthaffar et al. (2024), who also reported a higher mortality rate among meningitis patients compared to those without meningitis.[16] The neurological sequelae observed in 20.7% of meningitis patients further emphasize the importance of early diagnosis and appropriate management. Our results are in agreement with Mahamuduzzaman et al. (2022), who documented higher rates of neurological sequelae in children with bacterial meningitis.[17] The higher recovery rates in non-meningitis patients in our study (92.4%) reinforce the need for prompt intervention to improve outcomes in febrile seizure patients with meningitis.

Our study highlights the importance of lumbar puncture in diagnosing meningitis in febrile seizure patients. The frequency of meningitis in our cohort was notably higher than that reported by Yaqub et al. (2015) and Mustafa et al. (2023), emphasizing that lumbar puncture should be considered a routine diagnostic procedure for febrile seizures, especially in patients with prolonged fever, abnormal neurological signs, or other risk factors such as incomplete vaccination.[18,20]

A major strength of this study was its well-defined inclusion criteria, ensuring a homogenous population for analysis. The use of microbiological CSF analysis enhanced diagnostic accuracy. Additionally, statistical comparisons allowed for clear identification of risk factors associated with meningitis. However, the study was limited by its single-center design, potentially affecting generalizability. The reliance on hospital-based data may have led to selection bias. Furthermore, long-term neurodevelopmental outcomes were not assessed, limiting conclusions on disease impact beyond the acute phase.

CONCLUSION

Incomplete vaccination, recurrent infections, and malnutrition were significant risk factors for meningitis in infants and toddlers presenting with fever and seizures. Timely diagnosis and appropriate intervention improved outcomes, though neurological sequelae and mortality remained concerns. Strengthening immunization programs and early screening for at-risk children are essential for reducing meningitis-related morbidity.

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