Rwanda Medical Journal RMJ

ORIGINAL ARTICLE Open Access

Prevalence and outcome of bacterial meningitis among children of less than 10 years along the Kilombero valley in Morogoro, Tanzania

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ABSTRACT

INTRODUCTION: Bacterial meningitis is among the febrile, lethal and life-threatening diseases in neonates and children under 10 years, especially in low-income countries. The study determined the prevalence and outcome of the disease among neonates, infants and children less than 10 years admitted at St. Francis Referral Hospital.
METHODS: A hospital-based study was carried out among 856 children less than ten years, with or without fever for 10 months; clinical and laboratory records were reviewed. Data analysis was done using Chi-square and independent t-test to establish the odds ratio of acquiring the disease.
RESULTS: Out of 856 records of children with fever 656 had signs of meningitis, 71 children underwent lumbar puncture where 49.3% and 50.7% were female and male respectively; Aged 0-2 years (47.9%), 3 – 5 years (19.7%) and 6 – 10 years (32.4%). 62% of the patients had neurological signs, 56.3% had >45mmol/dl CSF (cerebrospinal fluid) glucose concentration and 85.9% had >50mg/dl of the CSF protein concentration. *Escherichia coli, Klebsiella pneumoniae, Haemophilus influenzae* and *Neisseria meningitides* were mostly isolated from the CSF samples at the hospital. Location (OR) = 3.1; p = 0.0017), parity of the mother (OR = 3.8; p = 0.008), Neurological signs (OR = 4.5; p = 0.001) and elevated CSF protein (OR = 4.5; p = 0.001) were the factors associated with bacterial meningitis infection among children.
CONCLUSION: Meningitis is a life-threatening infection in children under 10 years. Thus, microbial isolation should be established in most hospitals to improve early case identification and reporting at health facilities and the national level.

Keywords: Meningitis, *Escherichia coli, Neisseria spp*, Under-Ten Children, Prevalence

INTRODUCTION

Bacterial meningitis is an inflammation of the meninges caused by bacteria; it is one of the infections that cause significant loss of life in children in developing countries, thus affecting prenatal, neonatal, and post-natal life [1,2]. Neonatal meningitis is one of the most important and dangerous infections and is a major cause of morbidity and mortality worldwide, despite

***Corresponding author:** P. B. Madoshi, St Francis University College of Health and Allied Sciences, Ifakara, Tanzania, Email: bmadoshi@gmail.com; **Potential Conflicts of Interest (CoI):** All authors: no potential conflicts of interest disclosed; **Funding:** All authors: All authors: no funding has been sought or gained for this project; **Academic Integrity.** All authors confirm that they have made substantial academic contributions to this manuscript as defined by the ICMJE; **Ethics of human subject participation:** The study was approved by the local Institutional Review Board. Informed consent was sought and gained where applicable; **Originality:** All authors: this manuscript is original has not been published elsewhere; **Review:** This manuscript was peer-reviewed by three reviewers in a double-blind review process; **Type-editor:** Ahmed (USA).

Received: 06th July 2021; **Initial decision given:** 16th September 2021; **Revised manuscript received:** 14th October 2021; **Accepted:** 30th January 2022.
 Publisher: Rwanda Biomedical Centre (RBC)/Rwanda Health Communication Center, P. O. Box 4586, Kigali. ISSN: 2079-097X (print); 2410-8626 (online)

Citation for this article: P. B. Madoshi; Z. E. Sanga; K. A. N. Ngarawa et al. Prevalence and outcome of bacterial meningitis among children of less than 10 years along the Kilombero valley in Morogoro, Tanzania. Rwanda Medical Journal, Vol. 79, no. 1, p. 50-56, 2022. https://dx.doi.org/10.4314/rmj.v79i1.7

improved health care services [3,4,5]. In addition, patients infected with bacteria resistant to multiple antimicrobials used for meningitis management are at a high risk of losing life [6,7,8]. The associated clinical signs of bacterial meningitis include apnoea, fever, hypothermia, lethargy, seizures, bulging fontanel, nuchal rigidity, nausea, vomiting, coma, etc. However, the patient's age influences the clinical presentation of bacterial meningitis [9,10].

The diagnosis of the disease is generally a challenge in most health facilities because of the insufficient resources such as practitioners who can perform a lumbar puncture, appropriate equipment and access to microbiology; furthermore, bacterial meningitis causes fever. Hence misdiagnosis is common, especially where the empirical diagnosis is common. This has caused some paucity of the definitive diagnosis because of the failure to differentiate other febrile diseases based on clinical features [10,11]. Due to unreliable diagnosis, the treatment of acute bacterial meningitis is delayed. As a result, patients suffer from the long term sequelae of the disease [7,8,10]. A study done in Tanzania on bacterial meningitis has reported a prevalence of 18.6% [9]. This calls for the improvement of the diagnostic facilities for early and effective diagnosis as well as early treatment to cater for risk factors for mortality in children under the age of ten years. In addition, most cases of meningitis might go unreported due to either antibiotics prescribed without laboratory evidence, lack of sensitivity of the diagnostic techniques, or delayed presentation of cases [11,12] .

Furthermore, Abdallah et al. [9] described meningitis as associated with *Escherichia coli, Listeria monocytogenes, Streptococcus pneumoniae*, Group B *Streptococcus* and *Klebsiella spp.* Chambuso et al. [12] established that meningitis is commonly caused by *S. pneumoniae, Haemophilus influenzae, Group B Streptococcus, E. coli* and *Mycobacterium tuberculosis*. Boskabadi et al. [14], working in neonatal meningitis, reported that K. pneumoniae and Enterobacter aerogenes were the most prevalent bacterial isolates in samples from patients. Thus, there are localized differences in terms of the prevalence and distribution of the causative agent of bacterial meningitis. There is a number of reference logbooks and treatment documentation of suspected cases of meningitis in most referral hospitals. However, the actual incidence of the disease and the outcome of the current management practices are unknown, which calls for a new evaluation and research on the disease in most hospitals. Even though the conjugate Haemophilus influenza B (Hib) vaccine has been introduced in the Tanzanian immunization regime in children, the vaccine does not effectively control meningitis caused by other bacteria in the country. Thus, it is anticipated that meningitis could still be one of the diseases causing morbidity and mortalities, especially in resource-limited communities. This study intended to determine the prevalence of the clinical presentation, laboratory parameters, and outcome of bacterial meningitis among neonates and children younger than 10 years who were admitted at the ST Francis Referral Hospital.

METHODS

Study design: The study retrospectively reviewed patient records suspected of having acute bacterial meningitis for a period of ten months January – October 2020 at St Francis Referral Hospital (SFRH). SFRH is a referral, research and teaching hospital; it serves the Kilombero valley population with four administrative districts of Ifakara, Mlimba, Mahenge and Malinyi, a catchment of more than one 1.5 million people. The hospital has the capacity to conduct latex agglutination tests using the cerebrospinal fluid and carry out conventional bacteriology such as bacterial culture and isolation.

The required information was retrieved from hospital archives which included laboratory books and Microsoft Excel used for data entry at the hospital. The patients' biodata were obtained through patients' information provided by the reception (registry). Medical records were reviewed to extract demographic data and information on clinical and laboratory findings. Furthermore, the inclusion criteria were positive cerebrospinal fluid (CSF) cultures, age of the patients' records (0 days to 10 years old), and CSF parameters such as white blood cell (WBC) counts, particularly neutrophils, glucose, lactate dehydrogenase and chloride levels. In neonates, 72 hours were considered the earliest and were excluded. Meanwhile, the patient records with partial data were excluded from the study.

Case definition: A case was considered when the data showed that the patient was less than ten years, bacterial meningitis suspects with fever and two or more clinical presentations of the disease. Furthermore, the confirmed cases were those whose cerebrospinal fluid analysis for glucose, protein concentration, white blood cell count and cerebral spinal fluid cultures bacterial growth.

Data Analysis: The data were analyzed using the Statistical Package for the Social Sciences (SPSS version 20). Descriptive statistics were used to demonstrate the demographic characteristics of the patient's information. The Chi-square test was used to analyze the relationship of variables with a nominal scale. The independent t-test was used to analyze the relationship between variables and manage the normalities within variables. The $p < 0.05$ value was considered statistically significant. Moreover, the likelihood Ratio Chi-square was used to calculate the Odds ratio among factors at a 95% confidence interval.

This study was permitted by the St. Francis University College of Health and Allied Sciences Ethical Review Board to be conducted (SFUCHAS/EC/13/2021). Meanwhile, St. Francis Referral Hospital provided permission to access the archived patient information (SFRH/EC/2021/06).

The patient's consent to participate in the study was sought. Each patient in the study consented either by writing (those who could) or agreed orally that their information could be accessed and used in the study. Confidentiality was highly insisted and observed during data analysis and result publication.

RESULTS

The study was carried out using archived patient data at St. Francis Referral Hospital (SFRH) for 10 months (January to October 2020) in the department of paediatrics and child health. In this study, data of 856 patients were accessed to obtain the desired information on bacterial meningitis. Patients' information was categorized based on location, gender, age, antibiotic use before admission, the antibiotics prescribed by peripheral health facilities and presented clinical signs of bacterial meningitis (Table 1).

It was shown that the highest number of patients were from Ifakara 37 (52.1) town and the most affected age was 0-2 years old 34 (47.9%), whereas 30 (42.3%) of the patients had already used some antibiotics prior to being referred (Table 2).

Table 1: Demographic presentation of the analyzed information

Category		Frequency (n, %)
Gender	Male	417 (48.7%)
	Female	439 (51.3%)
Location	Malinyi	53 (6.2%)
	Ifakara	494 (57.7%)
	Mahenge	248 (29%)
	Others	61 (7.1%)
Age	0- 2 yrs	293 (34.2%)
	3-5yrs	276 (32.2%)
	6-10yrs	287 (33.5%)
Parity	first	60 (7%)
	Second	240 (28%)
	Three and more	556 (65%)
Antibiotic use*	Yes	309 (36.1%)
	No	547 (63.9%)
Delivery Mode[&]	Normal	701 (81.9%)
	Caesarean section	155 (18.1%)

**Antibiotic use before arriving at the hospital or after arriving at the hospital; [&]Only relevant for neonates*

Table 2: Demographic presentation of the children with bacterial meningitis

Category		Frequency (n, %)
Location	Malinyi	3 (4.2)
	Ifakara	37 (52.1)
	Mahenge	16 (22.5)
	Others	15 (21.1)
Age	0- 2 yr	34 (47.9)
	3-5yr	14 (19.7)
	6-10yr	23 (32.4)
Gender	Male	35 (49.3)
	Female	36 (50.7)
Mother's parity	first	14 (19.7)
	Second	13 (18.3)
	>three	44 (62)
Antibiotic use	Yes	30 (42.3)
	No	41 (57.7)

Table 3: Clinical presentation of the children suspected of meningitis

Category		Frequency (n, %)
Fever	Yes	53 (74.6)
	No	18 (254)
Neurological signs	only 1	25 (35.2)
	Multiple	44 (62.0)
	None	2 (2.8)
Digestive system	only 1	23 (32.4)
	Multiple	15 (21.1)
	None	33 (46.5)
Anaemia	Moderate	21 (29.6)
	Severe	25 (35.2)
	Normal	25 (35.2)

The biodata showed that 656 children were diagnosed with clinical signs associated with meningitis, where lumbar puncture was done in 71 children in order to collect the CSF for bacterial culture. The result showed that 61 CSF samples had growth while 10 samples were negative CSF culture. Table 4 shows laboratory results following culturing the CSF: It was shown that the prevalence of isolation was high for E. coli than other bacteria (K. pneumoniae, N. meningitis, Haemophilus influenza and unspecified bacterial species). Archived data have shown that 8 children lost life due to bacterial meningitis. All children whose biodata were accessed had been documented to be covered with vaccinations against meningitis.

Diagnosis on haematological parameters associated with cerebral spinal fluid showed that 53.5% of patients had white blood cells (WBC) count of more than 10,000cells/ml. The glucose levels among patients were found to be >45 mmol/dl (56.3%), the cerebrospinal fluid protein was found to be >50 mg/dl (85.9%). Statistically, the death of the patients was associated with the location of the patients and their first pregnancy (primigravida). The mothers with the first delivery, their babies experienced more meningitis complications than mothers with multiple deliveries; however, this study could not establish the justification of that. The children who developed neurological signs were more likely to lose life than those without such signs ($p = 0.001$) and those patients whose cerebrospinal fluid (CSF) glucose was low had a high risk of dying than those with high CSF glucose (Table 5).

Table 4: Isolation of bacteria in meningitis diagnosed children

Bacterial Isolation	Frequency (n)	(%)
Klebsiella pneumonia	11	15.5
Neisseria meningitis	7	9.9
Escherichia coli	29	40.8
Haemophilus influenza	9	12.7
None specific growth	5	7.0
No bacterial growth	10	14.1

DISCUSSION

This study aimed to report the prevalence, clinical presentation and factors associated with poor outcomes of bacterial meningitis at SFRH. The analysis of the patients' information showed that meningitis remains one of the major causes of morbidities and mortalities in children in Kilombero valley. The analysis of the patient biodata showed that 8.3% of the 857 children had meningitis, with a case fatality rate of 11.3% in children less than 10 years old. These findings could be explained based on cellular and humoral immune systems competence in neonates, infants and children less than 10 years old. Furthermore, based on the topography of the Kilombero valley factors like late reporting of the cases, antibiotic mismatch among prescribers and related fever complications in children. The infection of the meninges at this age category has been reported worldwide to be 0.2 to 6.1 cases per 1,000 live births [1,8]. In general, the clinical presentations of bacterial meningitis are not specific, which might not help establish an early diagnosis in infected patients; meanwhile, the commonest bacteria that cause the disease are Gram-negative [10,15].

The patients were grouped into three categories depending on their age: The archived biodata showed that children aged 6 -10 years had lost life more than the children in other categories. However, no bacterial isolation was done specifically focusing on this age group. It could be suspected that children of that age are less cared for by their guardians, especially in rural areas where they participate in various economic

Table 4: Statistical presentation of the clinical signs in relation to disease outcome (patient recovery or death)

Category		Bacterial Meningitis Outcome		Odds Ratio	p-value
		Recovered	Died		
Location	Malinyi	2	1	3.1	0.017
	Ifakara	3	34		
	Mahenge	1	15		
	Others	2	13		
Age	0- 2 yr	3	31	1.5	0.549
	3-5yr	1	13		
	6-10yr	4	19		
Gender	Male	5	30	1	0.46
	Female	3	33		
Parity	first	4	10	3.8	0.008
	Second	3	10		
	>three	1	43		
Neurological signs	only 1	3	22	4.5	0.001
	More than one signs*	3	41		
	None	2	0		
CSF Glucose level (mg/dl)	>45	7	33	4.6	0.056
	<45	1	30		
CSF Neutrophils level	>50	5	18	3.9	0.059
	<50	3	45		
CSF Protein (mg/dl)	<50	3	7	4.8	0.041
	>50	5	56		
CSF bacterial culture	Bacterial growth	3	58	0.17	0.383
	No Bacterial growth	5	5		

activities. The age dependence of bacterial meningitis has also been reported by other scholars elsewhere. Bor and Çokuğraş [10] reported similar findings when working with the majority of children below five years. In Turkey, Abdallah et al. [9] worked with children under 13 years old, Ceyhan et al. [17] when working with children of 1 month to 17 years old. This is because most bacterial meningitis infections commonly occur at such ages; our results showed that the odds ratio of the outcome of the disease was 1.5. This can be translated that there is a 1.5 likelihood of acquiring bacterial meningitis as age progresses in children. Thus, age is one of the outcome predictors of fatal meningitis. Therefore, it is necessary to have a comprehensive understanding of the disease in such susceptible populations with respect to age, pathogen association, underlying pathophysiology and other associated factors.

The patients' information was analyzed for the bacteriological results obtained following CSF sample collection and culture. Only 13 (15.6%) had bacterial growth in contrast to Abdallah et al. [9], who obtained an identification rate of 2.5% when using the conventional methods of CSF analysis, Gram stain and culture. However, the lower rates of identification have been reported in Ghana (3.3%) by Owusu et al. [12] and Fenta et al. [18] reported a 6.9% isolation rate of bacteria in CSF. However, our findings were similar in Kenya (17.9%) by Laving et al. [19] and Bangladesh (14.4%) by Sultana et al. [20] and Khalessi and Afsharkhas [3]. Statistically, the isolation of bacteria was not significant on the disease outcome among patients.

The number of births of the mothers in this study was used as one of the parameters to determine the outcome of the disease. The results have shown that women who had the first pregnancy are relatively at risk of giving birth to a baby with bacterial meningitis or infected after birth. The results showed that children from mothers with first-time pregnancies succumbed to bacterial meningitis where 4 were lost. This could be explained by the fact that the first pregnancy is associated with gestational problems such as premature rapture of membranes (PROM), chorioamnionitis and hypertension, as previously described by Barichello et al. [21] and Boskabadi et al. [13].

The study also analyzed the prognosis of the patient with respect to laboratory parameters which included glucose (>45 or <45mg/dl), neutrophils (>50 or <50) and protein (<50 or >50mg/dl) levels in the cerebrospinal fluid. The results have shown that children who had relative high glucose levels in the CSF (>45mg/dl) recovered more than those with low CSF glucose concentration. Other authors have reported these findings; Tan et al. [10] described high CSF protein concentration in bacterial meningitis related to poor disease outcomes. However, their results contrasted with this study because they reported that CSF protein content remained higher. At the same time, its glucose concentration decreased in the patients with poor outcomes compared to those with good outcomes. The increase in CSF protein and neutrophils might affect the patient's recovery from bacterial meningitis. This could be hypothesized that clearance of the bacteria causing the infection is likely to multiply more in cerebrospinal fluid with high protein concentration compared to a lower protein concentration.

As limitations, this study presents results used as a routine diagnosis of bacterial meningitis at St Francis hospital. However, the work lacked the disease management and antimicrobial sensitivity test component since the authors were only working on archived data and antimicrobial sensitivity test is not routinely done at the hospital. However, it is worth reporting such cases to share scientific knowledge and generate data for the scientific world. As much as the proper diagnosis and management of the bacterial disease are crucial, research on bacterial meningitis resulting in optimal antimicrobial therapy in poor resource communities is highly advocated.

CONCLUSION

Children in the Kilombero valley, especially neonates and less than five years, are at risk of meningitis infection, resulting in neurologic signs and other related complications with poor prognosis; thus, an early and effective diagnosis might provide timely diagnosis management. The authors insist on awareness creation among parents, health practitioners and community workers on the prompt reporting and management of the disease at all levels should be as effective as possible. In addition, the negative clinical parameters are not a rationale for exclusion of diagnosis for bacterial meningitis in a health centre; thus, thorough testing and clinical examinations are necessary procedures to manage bacterial meningitis optimally.

Acknowledgement: The researchers would acknowledge the support given by the SFRH management, ST Francis University College of Health and Allied Sciences and the laboratory technicians at SFRH for supporting the diagnosis

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