Microbiology Research Journal International

Volume 33, Issue 7, Page 1-8, 2023; Article no.MRJI.104563
ISSN: 2456-7043
(Past name: British Microbiology Research Journal, Past ISSN: 2231-0886, NLM ID: 101608140)

Epidemiological Aspect and Antibiotic Susceptibility Profile of Bacteria Responsible for Meningitis in Children in the Pediatrics Department of the CHU Donka National Hospital of Conakry, Guinea

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/MRJI/2023/v33i71390

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/104563

Original Research Article

Received: 16/06/2023
Accepted: 22/08/2023
Published: 24/08/2023

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ABSTRACT

Introduction: Meningitis represents a major public health problem in the tropical countries
Objective: To determine the sensitivity to antibiotics of bacteria associated with meningitis in children at Donka National Hospital in Conakry.
Methods: This is a prospective and descriptive cross-sectional study conducted from January 20th to April 20th, 2022. A total of 110 cerebrospinal fluids samples (CSF) from suspected children were cultured on different agar media.
Results: The results showed that 13 samples were positive. Three different bacterial species were identified: *Streptococcus pneumoniae* (54%=7/13), *Hemophilus influenzae* b (31%=4/13) and *Escherichia coli* (15%=2/13). Males predominated, with a sex ratio (M/F) of 1.6. The commune of Ratoma was the most represented with 36%. The most clinical manifestations were fever (54%), vomiting (35%), meningeal stiffness (20%), convulsion (24%) and headache (27%). All the *Streptococcus pneumoniae* strains were susceptible to levofloxacin and ofloxacin (100%), while 57% of these strains were susceptible to amikacin, 43% to tobramycin as well as to nitrofurantoin and 29% to gentamicin. For *Hemophilus influenzae*, 75% of the strains were susceptible to gentamicin as well as to tobramycin, ciprofloxacin, levofloxacin, and ofloxacin, while the susceptibility to amikacin was 50%. Finally, all *Escherichia coli* strains were sensitive to ciprofloxacin, levofloxacin, ofloxacin and nitrofurantoin, while only 50% of these strains were susceptible to amikacin and tobramycin.
Conclusion: This study showed that three bacterial species were associated to meningitis in children, of which *Streptococcus pneumoniae* was mainly encountered. Quinolones and aminoglycosides were the most active antibiotic families on these strains studied. The study populations being made up of children and the fact that quinolones are not recommended in this category of patients, aminoglycosides should be chosen for the empirical treatment of children. However, the treatment of cases of meningitis requires antibiotic treatment whenever possible based on the results of an antibiogram.

Keywords: Antibiotic; sensitivity; bacterial meningitis; children; Donka University Hospital.

1. INTRODUCTION

Meningitis is an inflammatory process, generally infectious in origin, affecting the meninges. In 70-80% of cases, meningitis is viral in origin. It is generally benign, and recovery is usually spontaneous. In 20-25% of cases, infectious meningitis is caused by bacteria. This is a serious condition; as spontaneous recovery is virtually fatal. Less than 5% of cases are due to non-pyogenic bacteria, parasites or neoplastic processes [1]. The incidence of bacterial meningitis in industrialized countries is between 2.5 and 10 per 100,000 inhabitants, whereas it is 10 times higher in developing countries. 2/3 of these cases occur in children under the age of 5 [2]. Bacterial meningitis is an infection of the membranes (meninges) and the cerebrospinal fluid that surrounds the brain and spinal cord. After the perinatal period, three bacteria, transmitted from human to human via respiratory secretions, are responsible for most bacterial meningitis: *Neisseria meningitidis*, *Streptococcus pneumoniae* and *Hemophilus influenzae*. Every year, there are an estimated one million cases of meningitis worldwide, 200,000 of which are fatal. The case-fatality rate depends on age and the bacteria involved, ranging from 3% to 19% in developed countries. A higher case-fatality rate (37%-60%) has been reported in developing countries [3]. In Sahelian Africa, between the 300 mm isohyets in the north and 1100 mm in the south, more than 10,000 cases of cerebro-spinal meningitis are recorded each year, with more than 10% of deaths. This region, known as Lapeyssonnie's "meningitis belt", stretches from the Red Sea to the Atlantic. Meningococcal meningitis differs from other bacterial meningitis in its epidemic potential. Serogroup A is the main cause of epidemics in Africa and Brazil, serogroup B is the most widespread in Europe, and serogroup C, which causes endemic outbreaks in the United States and Europe, has appeared in Africa: Nigeria (1975), Chad (1976), Ethiopia (1977) [4]. During epidemics, children and young adults are the most affected, with a very high rate of around 1,000 per 100,000 inhabitants, i.e. 100 times the rate of sporadic or endemic disease. The *Neisseria meningitidis* serogroups responsible for epidemics are *Neisseria meningitidis* A, C and W135 [5]. Meningitis in infants, young children and the

elderly is generally caused by *Streptococcus pneumoniae*. It is endemic in Africa, with no seasonal upsurge or epidemic outbreak. Its prognosis is severe, with a fatality rate of 30-60%. *Haemophilus influenzae* meningitis occurs almost exclusively in children under the age of 5. The peak incidence of infection is between 6 and 7 months of age, and most cases are due to germs with a type b polysaccharide capsule (Hib) [3]. According to the World Health Organisation (WHO), there are an estimated 650 million cases of *Haemophilus influenzae* type b infection in children aged 0-4 years worldwide, and between 250,000 and 400,000 deaths each year due to *Streptococcus pneumoniae*. Around 70% of child pneumonia deaths per year occur in Africa and South-East Asia. The annual incidence is 250 per 100,000 in children under the age of 5 [6]. *Streptococcus pneumoniae* is the agent of frank lumbar pneumonia. It is also responsible for cases of meningitis and septicaemia [7]. The bacterium responsible for serious and fatal meningitis is Neisseria meningitidis. In the Republic of Guinea, in 2017, the country recorded 1,103 cases of meningitis in all administrative regions, including 11 cases in the Boké region, 281 cases in Conakry, 251 cases in Faranah, 133 cases in Kankan, 24 cases in Kindia, 19 cases in Labé, 9 cases in Mamou and the worst affected region was Nzérékoré with 366 cases [8]. In 2013, a prospective study recorded 480 suspected cases of meningitis notified in 21 health districts. The average age was 18 years and 62.5% were men. Vaccination status was unknown for all patients. The highest attack rates were observed in Siguiri (3.2 per 10,000), Kankan (2.6 per 10,000) and Dabola (3.9 per 10,000).

The locality of Kintinian in Siguiri was the only one to cross the epidemic threshold. The germs identified were *Hemophilus influenzae* (1 time), pneumococcus (2 times), *Neisseria meningitidis* A (4 times) and W135 (10 times), with a total of 17 positive samples. All these germs were sensitive to chloramphenicol, ceftriaxone and ciprofloxacin. The average length of hospital stay was 6.5+or-2 days. Case fatality was 14%. The 2013 epidemic was characterized by the emergence of Neisseria *meningitidis* W135 [9].

2. MATERIALS AND METHODS

This was a prospective and descriptive cross-sectional study lasting 3 months, from 20 January to 20 April 2022. Our study included all children admitted to the Pediatric Department of the Donka National Hospital during the survey period. The sample was simple random and the sample size (N=110) was obtained using the formula of Schwartz Françoise (2016). Our study included all children who came to the laboratory with a report card or examination booklet on which the cytobacteriological examination of the cerebrospinal fluid (CSF) or bacteriology of the cerebrospinal fluid (CSF) was mentioned. Cytology, Gram staining and antibiotic susceptibility testing were carried out on all CSF samples.

2.1 Epidemiological Variables

- Age
- Sex
- Residence

2.2 Biological Variables

- Cytology
- Gram stain
- Pastorex kit
- Culture
- Identification
- Antibiogram

2.3 Data Collection Methods

We used the following documents for data collection:

- Pre-prepared survey forms,
- Consultation notebooks,
- Laboratory registers.

2.4 Data Collection and Analysis

Our data are collected, entered, processed and analyzed, using Word and Excel software from the 2010 Office pack and SPSS.

3. RESULTS

The results of Table 1 show that, on Gram staining, the most common morphological types of positive cultures were Gram-positive diplococci (11 cases of 13, 85%), Gram-negative bacilli (2/13= 15%) and germ-free samples (97/110= 88.18%). The high prevalence of Gram-positive diplococci compared with other bacteria in cerebrospinal fluid could be explained by the children's exposure to this bacterium and the resulting septicemia, since CSF is a sterile fluid.

Table 1. Search for bacteria in children with bacterial meningitis according to gram stain

Gram	Number	Percentage
Gram-negative bacilli	2	1.81
Gram-positive diplococci	11	10
Absence of germs	97	88.18
Total	110	100

Table 2. Overall prevalence of CSF infections after culture in children with meningitis

Cultures	Number	Percentage
Positive	13	11.81
Negative	97	88.18
Total	110	100

This Table 2 shows that of the 110 CSF samples analysed, 13 contained bacteria, a prevalence of 12%, compared with 97 negative samples, or 88%. The high prevalence of meningeal infections could be due to children's exposure to bacterial infections and their vulnerability because of their weak immune system.

Table 3. Identification of bacterial species involved in bacterial meningitis in children

Bacterial species isolated	Number	Percentage
Escherichia coli	2	15
Haemophilus influenzae	4	31
Streptococcus pneumoniae	7	54
Total	13	100

The Table 3 shows that of the 13 children with meningitis, the bacterium *Streptococcus pneumoniae* was the most common with 7 cases, a prevalence of 54%, followed by *Haemophilus influenzae* b with 31% and Escherichia coli with 15%.

The high prevalence of *Streptococcus pneumoniae* in meningeal infections could be due to septicaemic respiratory infections.

Table 4. Overall sensitivity to antibiotics of the different species isolated from urinary

Bacterial species	Antibiotics	SN (%)	IN (%)	RN (%)	NDN (%)	Total
Streptococcus pneumoniae						
	Amikacin	4(57)	1(14)	2(29)	0(00)	7(100)
	Gentamicin	2(29)	5(71)	0(00)	0(00)	7(100)
	Tobramicin	3(43)	2(29)	2(29)	0(00)	7(100)
	Ciprofloxacin	3(43)	2(29)	2(29)	0(00)	7(100)
	Ofloxacin	7(100)	0(00)	0(00)	0(00)	7(100)
	Levofloxacin	7(100)	0(00)	0(00)	0(00)	7(100)
	Nitrofurantoine	2(29)	3(43)	2(29)	0(00)	7(100)
Haemophilus influenzae						
	Amikacin	2(50)	1(25)	1(25)	0(00)	4(100)
	Gentamicin	3(75)	0(00)	1(25)	0(00)	4(100)
	Tobramicin	3(75)	0(00)	1(25)	0(00)	4(100)
	Ciprofloxacin	3(75)	1(25)	0(00)	0(00)	4(100)
	Ofloxacin	3(75)	0(00)	1(25)	0(00)	4(100)
	Levofloxacin	3(75)	0(00)	1(25)	0(00)	4(100)
	Nitrofurantoine	1(25)	2(50)	1(25)	0(00)	4(100)
Escherichia coli						
	Amikacin	1(50)	1(50)	0(00)	0(00)	2(100)
	Gentamicin	2(100)	0(0)	0(00)	0(00)	2(100)
	Tobramicin	1(50)	0(00)	1(50)	0(00)	2(100)
	Ciprofloxacin	2(100)	0(00)	0(00)	0(00)	2(100)
	Ofloxacin	2(100)	0(00)	0(00)	0(00)	2(100)
	Levofloxacin	2(100)	0(00)	0(00)	0(00)	2(100)
	Nitrofurantoine	2(100)	0(00)	0(00)	0(00)	2(100)

Legends: S: Sensitivity; I: Intermediate; R: Resistance; N: Number

From this Table 4, we can see that of the 7 children suffering from *Streptococcus pneumoniae* meningitis, Aminosides (GEN) were more effective against the germ. Amikacin was effective in four children (57%), followed by Trobramycin (43%) and Gentamicin (29%). Ofloxacin and Levofloxacin were highly sensitive, at 100% (7/7). The Nitrofurans class is represented by a single antibiotic, Nitrofurantoine, which was effective in two cases, i.e. 29% (2/7), intermediate sensitivity in 43% (3/7) and resistant in 29% of cases (2/7).

Aminosides (TOB) were more effective against Haemophilus influenzae. In 4 children, Tobramycin and Gentamicin were effective on three samples, i.e. 75% (3/4), followed by Amikacin, i.e. 50% (2/4). Sensitivity to Ciprofloxacin, Ofloxacin and Levofloxacin in the treatment of 3 out of 4 children was observed, i.e. 75% (3/4). Nitrofurantoin was effective in one case, i.e. 25% (1/4), and was resistant in one case tested, i.e. 25% (1/4).

Aminosides (GEN) were more effective against Escherichia coli as, in two samples tested, Gentamicin was 100% effective (2/2) followed by Tobramycin and Amikacin with 50% each. Ciprofloxacin, Ofloxacin and Levofloxacin were 100% (2/2) effective in treating two out of two children. Nitrofurantoine was effective on all samples, i.e. 100% (2/2).

Table 5. Breakdown of children with bacterial meningitis by epidemiological parameters

Parameters	Number	Pourcentage
Sexe		
Male	8	62
Female	5	38
Age groups		
0-5 months	2	15
6-12 months	2	15
1-5 years old	5	34
6 years and over	4	31
Education		
Enrolled	3	23
Not attending school	10	77
Residence		
Kaloum	-	-
Dixinn	3	23
Matam	1	8
Ratoma	6	46
Matoto	3	23
Kaloum	-	-

This Table 5 shows that of the 13 children with bacterial meningitis, children aged 1 to 5 years were the most affected, with 5 cases, i.e. a prevalence of 34%. The table shows that of the 13 children with bacterial meningitis, the majority were male, with 8 cases (62%) and a sex ratio of 1.2 in favour of males, compared with 5 cases (38%) in favour of females.

The high prevalence of males in this study is random and could be explained by their greater frequency of use than females in our study. In this table, we note that of the 13 children with bacterial meningitis, children from Ratoma Commune were the most represented in the city of Conakry with 6 cases, or 46%. They were followed by children from the Communes of Dixinn and Matoto, with 23% each. Children from the Commune of Matam accounted for only 8%.

The high prevalence in Ratoma Commune can be explained by the fact that it is one of the largest and most densely populated communes in Conakry. More children came from this commune than from any other during our survey period. These results show that more than half of the children were not attending school, with 10 cases, or 77%, while children attending school accounted for only 23%. This is a peculiarity which could partly be explained by the low number of cases of meningitis in this present study, because most of the time children in this age group contract meningitis at school.

4. DISCUSSION

Of a total of 110 children received in the laboratory, 13 CSF samples contained bacteria, i.e. 12% compared with 88% of negative samples. The 13 positive samples were distributed between 7 for *Streptococcus* with 54%, *Haemophilus influenzae* b with 31% and 15% for Escherichia coli. 51.85% of the children were under 5 years of age, with a median age of 4.6 months. The age group most affected was between 1 and 5 years, with 34%. The male sex ratio was 62, with a sex ratio of 1.2 (Table 5).

With regard to the epidemiology of the germs incriminated in bacterial meningitis in children, our results are comparable to those of certain authors:

A study carried out by Thabet L. et al in 2002 at the Tunis Children's Hospital reported that

Streptococcus B and Escherichia coli were the most predominant. In children aged between three months and three years, *Haemophilus influenzae* was the main bacterium isolated (75%), followed by Pneumococcus (22%). In children aged over three years, *Streptococcus pneumoniae* was the main bacterium (57%), followed by *Neisseria meningitidis* (30%) [10] and by Ben Haj Khalifa A. et al., 2010, in the region of Monastir, Tunisia (1999-2006), reported that *Enterobacteria* and group B streptococci were the pathogens most frequently identified in neonatal meningitis. *H. Influenzae* was the predominant micro-organism in children aged between three months and five years (36.3%), followed by *S. Pneumoniae* (28.8%). *S. Pneumoniae* was the main bacterium, responsible for 47% of cases in children aged over five years [11].

Recently, a study conducted in Libya in 2022 by Al-Ojali et al. Showed that a total of 103 meningitis cases were identified with a definite causative agent [12].Indeed, the data from this study show that the majority of meningitis cases were caused by Gram-positive bacteria with 55%. These data are partly comparable with those found in the present study where Gram positives accounted for 54%.

On the other hand, concerning the identified species of meningitis cases, our data are different from those reported by these authors. Indeed, the data reported by these authors show that the most common pathogen isolated was coagulase-negative staphylococci, (26%), while the most common gram negative organism was *E. coli*, (15.5%). Organisms isolated respectively from CSF culture were coagulase-negative Staphylococci, n=27(26%), followed by *E. coli.* (15.5), then *Staphylococcus aureus*, (14.6%), followed by *Streptococcus pneumoniae* (11.7%), and *Klebsiella pneumonia*, (9.7%) [12]. These observations show that if *Streptococcus pneumoniae* is the main species identified in our study, this species was weakly identified in Libya in 2022 in the studies carried out by Al-Ojali et al., [12]. On the other hand, our results are comparable, in terms of predominance of identified bacterial species, to those reported in 2011 in Iran by Haghi-Ashtiani MT. et al [13].

In the present study, the antibiotic sensitivity tests showed that all the *Streptococcus pneumoniae* strains were susceptible to levofloxacin and ofloxacin (100%), while the sensitivity of these strains was 57% to amikacin, 43% to tobramycin as well as to nitrofurantoin and 29% to gentamicin. For *Hemophilus influenzae* strains the most active antibiotics were gentamicin (75%), tobramycin (75%), ciprofloxacin (75%), levofloxacin (75%) and levofloxacin (75%). Also, 50% of Hemophilus influenzae were susceptible to amikacin. Finally, all *Escherichia coli* strains (4/4= 100%) were sensitive to ciprofloxacin, levofloxacin, ofloxacin and nitrofurantoin, while only 50% (2/4) of the strains were susceptible to amikacin and tobramycin (Table 4). The frequencies of antibiotic sensitivity of our strains of *Streptococcus pneumoniae* to aminoglycosides and quinolones are partly comparable to those reported in 2022 in Libya by Al-Ojali et al., [12].

On the other hand, the frequencies of antibiotic sensitivity of our strains are different from those founded in other studies. Indeed, Ben Haj Khelifa et al., reported in Tunisia in the region of Monastir (1999-2006) that 38.8% of *Streptococcus pneumoniae* strains were less sensitive to penicillin. Rates of resistance to amoxicillin and cefotaxime were 4.1% in both cases. Only one strain of *Neisseria meningitidis* (6.2%) showed reduced sensitivity to penicillin. 22.9% of *Hemophilus Influenzae* strains produced β-lactamase. The rate of resistance of *Enterobacteria* to third-generation cephalosporins was 25%. In our study, the rate of nosocomial meningitis was 24.4%. The departments most affected were neurosurgery, pediatrics and intensive care. The increasing prevalence of meningitis caused by pneumococci with low susceptibility to penicillin G makes it difficult to provide adequate treatment [10]. A study carried out by L. Thabet et al in 2002 at the Tunis Children's Hospital showed that 33% of *Hemophilus influenzae* strains are resistant to ampicillin through the production of a penicillinase and 56% of pneumococci have reduced sensitivity to penicillin [11]. Quinolones and aminoglycosides were the most active families of antibiotics on the strains studied. The study populations being made up of children and the fact that quinolones are not recommended in this category of patients, aminoglycosides should be chosen for the empirical treatment of children.

5. CONCLUSION

In the present study, the affected age group was between 1 and 5 years. The male sex was more represented with a sex ratio of 1.6.

Three bacterial species were identified in 13 cases of bacterial meningitis. The main species was *Streptococcus pneumoniae*, followed by *Hemophilus influenzae* and finally *Escherichia coli*.

The results of antibiograms showed that the strains of *Streptococcus pneumoniae* were mainly sensitive to levofloxacin, ofloxacin and amikacin. For *Hemophilus influenzae* strains the most active antibiotics were gentamicin, tobramycin, ciprofloxacin, levofloxacin, levofloxacin. Finally, both *Escherichia coli* strains were sensitive to ciprofloxacin, levofloxacin ofloxacin and nitrofurantoin, while only half of the strains were sensitive to amikacin and tobramycin. Aminoglycosides should be started as empirical therapy till the antibiogram or chemogram report is available when clinical profile is highly suggestive of bacterial meningitis and risk of morbidity and mortality is high.

CONSENT

As per international standard or university standard, parent(s) written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

ACKNOWLEDGEMENTS

The authors would like to thank the heads of the Paediatrics Laboratory of the Donka National Hospital and the Microbiology Laboratories of the Biology Department and the Faculty of Health Sciences and Techniques of the Gamal Abdel Nasser University of Conakry for their support in carrying out this work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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DOI: 10.1556/AMicr.58.2011.4.3
PMID: 22207285

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/104563