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ABSTRACT:
Whilst the advent of vaccination against the common causative pathogens and improved hygiene have reduced the incidence in high income countries, bacterial meningitis remains a common cause of childhood morbidity and mortality in low- and middle-income countries. Confirmation of the diagnosis depends on laboratory examination of cerebrospinal fluid. The aim of this study was to determine the incidence of laboratory confirmed meningitis in children diagnosed with clinical meningitis admitted to Port Moresby General Hospital. The records of cerebrospinal fluid findings from children aged less than 13 years presenting with suspected meningitis were examined retrospectively. Macroscopy, microscopy, gram stain and bacterial culture data were gathered from the microbiology log. Descriptive statistics, were used to analyse the data. All 906 cerebrospinal fluid samples were examined macroscopically while 9 (1%) had microscopy only and 897 (99.0%) had microscopy and culture performed. A laboratory-confirmed diagnosis was possible for 412/906 (45.5%) children, but a definite pathogen was identified in only 16/412 (3.9%). *Streptococcus pneumonia* was the leading isolate followed by *Neisseria meningitides.* The majority of children who had laboratory confirmed diagnoses were less than 2 years old. Meningitis is still a common cause of admission, and *Streptococcus pneumonia*, and *Neisseria Meningitides* are important pathogens in children in Papua New Guinea. There is an urgent need to improve routine vaccination coverage.

Keywords: Cerebrospinal fluid, Bacterial pathogens, Meningitis, Children, Port Moresby, Papua New Guinea

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INTRODUCTION:

Bacterial meningitis is still a significant cause of mortality and morbidity among children worldwide [1, 2]. Young children living in communities that have low socioeconomic status and poor medical infrastructure are at highest risk of dying [3, 4]. Meningitis can be caused by viruses, fungi or bacteria but bacteria are associated with the highest frequency and a high morbidity and mortality.

Studies from previous decades showed that *Streptococcus pneumoniae*, *Haemophilus*

influenza B and *Neisseria meningitides* were the leading causes of bacterial meningitis in young children under five years of age [2, 5-7]. The clinical features of bacterial meningitis vary but commonly children develop neck stiffness, bulging fontanel, positive Kernig's and Brudzinski signs, fever, altered conscious level, vomiting, convulsion and purpuric rash [8, 9]. Both clinical and laboratory diagnosis are often made more difficult following the administration of antibiotics before presentation to the hospital. The diagnosis of bacterial meningitis cannot be clearly distinguished from other common childhood illnesses such as encephalitis and other severe bacterial infections because their clinical features overlap. Laboratory examination of cerebrospinal fluid is the only way to confirm the diagnosis [1, 10-14]. Cerebrospinal fluid (CSF) culture and gram staining are the gold standard and widely used in low resource settings. Latex agglutination and Polymerase Chain Reaction (PCR) can also be used but are expensive. Each of the CSF examination techniques has its own challenges in terms of its predictive assumptions, availability, affordability, expertise and the effect of prior antibiotic treatment [15].

Prevention and effective treatment are key to reducing the incidence, morbidity and mortality from bacterial meningitis. The introduction of effective conjugate bacterial vaccines against, *Streptococcus pneumoniae* and *Haemophilus influenza* and the availability of third generation cephalosporin, has contributed to reduction in under five mortality in many countries [10, 16-18].

The aim of this study was to determine the proportion of laboratory confirmed cases of meningitis in children with an initial diagnosis of clinical meningitis who were admitted to Port Moresby General Hospital.

METHODOLOGY:

Study design and setting: This was a retrospective analysis of laboratory records from 2017 to 2021 at Port Moresby General Hospital microbiology section of the pathology laboratory. Purposive sampling was used to collect the data, on children aged 13 years and younger who were admitted with the clinicians' diagnosis of suspected meningitis and who underwent lumbar puncture.

Data collection strategy: We collected information from the CSF sample registry. The variables obtained were, age, year of collection, macroscopic findings, microscopic findings-differential white cell counts, red blood cells, gram stain, Indian ink, and culture. Data on protein and sugar, and acid-fast staining (AFB) for tuberculosis (TB) was not recorded in the microbiology section.

In the present study laboratory confirmed meningitis was defined as follows:

- for infants > 1 month and children up to 13 years, presence of polymorphs, lymphocytes or positive gram stain or culture.

- for neonates: polymorphs > 10 in the first week and 0 if aged more than 1 week [8, 19]. Lymphocytes > 20 in the first weekof life, and > 6 in more than 1 week of age.

Statistical analysis: relevant data from samples were abstracted and entered into Microsoft Excel version 2013, and analysed using IBM SPSS statistics software version 22. Median, interquartile ranges, frequency and percentages were used to describe the data.

Ethical approval was obtained from the School of Medicine and Health Sciences ethics committee and permission granted by Port Moresby General Hospital to perform data collection.

RESULTS:

Records of 906 cerebrospinal fluid samples from children with an admitting diagnosis of meningitis were examined. Of the 906, 57.7% (523) were males and 42.3 % (383) were females. The median age was 5 months (Interquartile range 2-15 months). The majority of all the children were aged 12 months and below (Table 1). From the 5 years data, there was almost equal distribution of cases with normal CSF and laboratory confirmed diagnosis (Table 2).

Table 1. Age groups of children with CSF (n = 906)

Age groups	N (%)
< 1 month	127 (14)
1-12 months	529 (58.4)
> 12 months-60 months (5 years)	158 (17.4)
> 60 months (5 years)	91 (10)
Unknown	1 (0.1)

CSF examination findings:

Macroscopy. Six hundred and seventy-seven (74.7%) of the 906 samples were reported as clear fluids with no clots, 4 (0.4%) grossly blood stained with no clots, 81 (8.9%) slightly blood stain with no clots, 92 (10.2%) Xanthochromic with no clots, 2 (0.2%) grossly turbid and 50 (5.5%) slightly turbid.

Microscopy culture and sensitivity. Of the 906 samples, 9 (1.0 %) have microscopy only, and 897 (99.0%) had microscopy, culture and sensitivity performed. There was no growth on culture of 881 (98.2%) of the 897 samples and species were identified in 16 (1.8 %) (Table 3).

Table 2. Laboratory incidence of meningitis over five-year periods (2017-2021)

Diagnosis (n = 906)	**N (%)**
Normal CSF	494 (54.5)
Laboratory confirmed	412 (45.5)
Isolation rate:	16 (1.8)

Proportion per year n = 906	**N (%) (n = 906)**	**Normal CSF (n = 494) N (%)**	**Abnormal CSF (n = 412) N (%)**
2017	151 (16.7)	85 (17.2.)	66 (16.0)
2018	134 (14.8)	84 (17.0)	50 (12.1)
2019	168 (18.5)	87 (17.6)	81 (19.7)
2020	239 (26.4)	126 (25.5.)	113 (27.4)
2021	214 (23.6)	112 (22.7)	102 (24.8)

Table 3. Total frequency of pathogens identified in CSF samples over the five years period (2017 – 2021), n =897

Pathogens Identified	**Counts: N (%)**
Streptococcus. Pneumonia	6 (0.7)
Neisseria. Meningitides	2 (0.2)
Hemophilus. Influenza	1 (0.1)
Escherichia. Coli	1 (0.1)
Pseudomonas. Aeruginosa	1 (0.1)
Enterobacter. Sakazakii	1 (0.1)
Citrobacter. Freundii	1 (0.1)
Acinetobacter. Anitratus	1 (0.1)
Streptococcus Species	1 (0.1)
Cryptococcus. Neoformans	1 (0.1)
Total	16 (1.8)

Gram stain was performed on all (906) samples. The results show that 792 (87.4%) had no organism seen, 14 (1.5 %) had organism seen, and 100 (11.0 %) has only pus seen. There were

16 bacterial pathogens that were identified by culture, including the 14 that were seen on gram staining.

Differential white cell count. Of the 906 samples, polymorphs were seen in 319 (35.2%), 397 (43.8 %) had lymphocyte presence and 501 (55.3 %) had red blood cell presence. The median polymorph count was 8 (Interquartile range 2-40, range 0-9220), lymphocyte 8 (Interquartile range 2-32, range 1-3100) and red blood cell 21 (Interquartile range 4-205, range 0-44800).

Indian ink and cryptococcal antigen. Of the 906 samples, only 1 (0.1%) was Indian ink and cryptococcal antigen test positive.

DISCUSSION:

Bacterial meningitis remains a disease of concern in children because of its high mortality and morbidity. Early and accurate diagnosis and prompt treatment is required to avoid death and prevent complications. For the effective and prompt treatment of bacterial meningitis, knowledge of the clinical characteristics, aetiology, and antimicrobial susceptibility of the causative organisms are crucial. CSF examination is needed to establish the diagnosis. Delays in diagnosis and treatment can lead to long-term problems such as hearing loss, learning disabilities, hydrocephalus, and death [7, 17, 20].

The diagnosis of meningitis in children is challenging because symptoms and signs are not specific. Lumbar puncture and examination of CSF is the practical way to make a diagnosis in most of the low–and-middle income countries (LMIC). Since the risks of missing the diagnosis are considerable, it is inevitable that some children without meningitis may have a lumbar puncture and normal CSF. In our study more than half of the children who were admitted with suspected meningitis had normal CSF, and slightly over 45% had laboratory confirmed diagnosis. Whilst children who do not have meningitis are often subjected to lumbar puncture, children with meningitis may have contraindications to lumbar puncture, such as evidence of raised intracranial pressure or being dangerously sick.

Because of the severity of the disease, children suspected of having meningitis are often started on antibiotic treatment before there is an opportunity for a safe lumbar puncture. This adversely affects the likelihood of obtaining a positive bacterial culture and the effect on pleocytosis makes the diagnosis of aseptic viral and tuberculous meningitis difficult [21].

In this study, the highest number of cases of suspected meningitis was in 2020. This may be related to the Covid-19 pandemic, which had an adverse impact on routine vaccination coverage, health seeking behaviour, and the availability of health services.

Microbial culture and identification remains the gold standard for diagnosis of bacterial meningitis. Only 16 of the CSF samples grew bacteria on culture and of these six were Streptococcus pneumoniae and two were

Neisseria meningitides. Studies from South Asia, PNG and Portugal reported similar CSF culture findings [1, 7, 10, 12-14, 22]. Other bacteria capable of causing meningitis such as Group B streptococcus which, since the introduction and high vaccination coverage of Haemophilus influenza B (HiB) and pneumococcal vaccines are the leading causes in developed countries are less frequent in LMICs like PNG, where vaccination coverage is poor [23].

The highest incidence and mortality of bacterial meningitis is usually in infants and young children. The disease is to a large extent preventable by vaccination with routine vaccines. Vaccination coverage in PNG is one of the lowest in the world with less than 40% of eligible children receiving the third dose of HiB and pneumococcal vaccines [24]. Improving coverage should be a national priority.

CONCLUSION:

Meningitis remains a common cause of admission of children aged less than five years of age in PNG. Streptococcus pneumoniae and Neisseria meningitides were the major bacterial pathogens in the present study. Major efforts are required to improve routine vaccination coverage in PNG.

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