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Original Article

Clinical, Microbiological Characteristics and Predictors of Positive Cerebrospinal Fluid Culture Among Neonates with Suspected Meningitis in Kano, Nigeria: A Cross-Sectional Study

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ABSTRACT

Background:

Neonatal meningitis is a significant cause of mortality and morbidity in sub-Saharan Africa, and there is a dearth of data regarding its causes and diagnostic challenges. The aim of this research was to assess the clinical and microbiological characteristics of neonatal meningitis and to identify factors that predict a positive cerebrospinal fluid (CSF) culture in newborns suspected of having meningitis in Kano.

Methods: The hospital-based cross-sectional study enrolled 210 neonates with suspected meningitis at Aminu Kano Teaching Hospital and Murtala Muhammed Specialist Hospital. CSF samples of the enrollees were analyzed using conventional culture, latex agglutination, and 16S rRNA gene sequencing. Clinical and demographic data were collected using structured questionnaires. Multivariable logistic regression was performed to identify independent predictors of positive CSF culture.

Results: The culture positivity rate was low at 3.3%, with Streptococcus pneumoniae and Haemophilus influenzae as the predominant pathogens. Latex agglutination demonstrated higher sensitivity at 13.8%, detecting mixed infections and in a setting with prior antibiotic exposure. Molecular sequencing identified atypical organisms including Pantoea ananatis and Acinetobacter baumannii, but percentage identities of matches (96.5% and 93.5%, respectively) was low. Turbid CSF appearance (aOR: 8.25, 95% CI: 0.85–79.94, p=0.069) and positive latex agglutination (aOR: 0.05, 95% CI: 0.004–0.499, p=0.012) were identified as predictors of culture positivity. Antimicrobial resistance to ceftriaxone, ciprofloxacin, and amikacin was prevalent. Despite high hospital delivery rates (91%), a notable proportion of preterm neonates (55.6% of cases) had meningitis.

Conclusion: This study demonstrated the usefulness of rapid diagnostics in resource-limited settings. We recommend enhanced surveillance to address emerging pathogens and multidrug resistance.

Keywords: Bacteria, neonatal meningitis, latex agglutination, 16S rRNA sequencing, antimicrobial resistance, prematurity

INTRODUCTION

Neonatal meningitis is an acute infection of the meninges occurring in newborns within the first 28 days of life. Globally, the burden of neonatal meningitis is highest in the neonatal period, with an estimated incidence of 854.8 per 100,000 neonates (95% UI 609.2–1183.3) birth.[1] The incidence of neonatal meningitis is reported to be 0.1–0.4% of live births in sub-Saharan Africa, with approximately 50% mortality in untreated cases.[1, 2] An incidence of 1.9 per 1,000 live births was reported from Nigeria, with increased risk among low-birthweight infants and a mortality rate of approximately 33% [(3)]. Survivors may develop significant neurological sequelae, including cerebral palsy, seizures, hydrocephalus, hearing loss, and cognitive impairment. [4]

In low- and middle-income countries (LMICs), there are challenges in pathogen identification and antimicrobial resistance (AMR) surveillance.[5-7.] The aetiological spectrum in Nigeria differs from that in high-income countries (HIC). Gram-negative bacteria, particularly Klebsiella spp. and Escherichia coli, are prominent causes in neonates, while Gram-positive Staphylococcus aureus is also frequently isolated.[(3, 8] Notably, group B Streptococcus (GBS), a leading cause in developed countries, is rarely reported in Nigerian cohorts.[9-11] Streptococcus pneumoniae, Neisseria meningitidis, and Haemophilus influenzae type b remain important pathogens in infants and young children, with pneumococcus being the most common in children under five.[3, 5, 12]

There are, however, fewer studies on viral and other bacterial pathogens of neonatal meningitis from Nigeria compared to HIC. [12-14] This may be because of the limited availability of molecular diagnostic approaches in Nigeria. Where such diagnostic technologies are available however, studies have found a broader range of pathogens, including viral and parasitic agents. [5, 13, 14] This study aimed to identify the bacterial and viral causes of neonatal meningitis and predictors of culture positive CSF in two tertiary hospitals in Kano State, Nigeria, assess diagnostic yield of culture, latex agglutination, and molecular methods, and describe antimicrobial resistance patterns.

METHODS

Study Design and Setting

This was a cross-sectional study of neonates with suspected meningitis admitted to the neonatal units of Aminu Kano Teaching Hospital and Murtala Muhammed specialist hospital Kano, Nigeria. The study was carried out between June 2022 and May 2023.

Study Population

The study population consisted of admitted neonates aged 0–28 days. Neonates were included if:

1. Clinically suspected of meningitis according to the units' protocol; Suspected meningitis was defined as neonate with seizures in addition to other symptoms such as fever, lethargy, poor feeding, irritability, apnoea, or bulging fontanelle.
2. Clinical diagnosis of meningitis according to unit protocol.
3. Parental Consent

Neonates were excluded if[2]:

1. CSF samples for analysis were Inadequate
2. Parental consent was declined
3. Antibiotic exposure prior to lumbar puncture was experienced

Sample Size Determination

The sample size for this study was determined using the prevalence reported by Kumurya.[13]

Fisher's formula was used as presented in equation 1:
Fisher's formula was used as presented in equation 1 as follows;

$$S = \frac{Z^2 p(1-p)}{d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where S; sample size, Z; standard normal variant (at 5% type 1 error (P< 0.05) = 1.96, P; expected
proportion in population based on previous studies[13] = 12% prevalence and d; absolute error or precision (5%)
$1.96^2 \times 0.12(1-0.12)/0.05$
=162.269≈162.3. was the minimum sample size, however, 210 neonates were enrolled.
Neonates who met the inclusion criteria were consecutively recruited into the study

Data Collection
Data was collected using a predeveloped case report structured form. Information collected include sociodemographic characteristics, maternal obstetric history, delivery details, clinical presentation, laboratory findings, treatment history, clinical examination.

Cerebrospinal Fluid Collection and analysis
A trained physician performed lumbar puncture under aseptic conditions for each enrolled neonate. One mililitre of CSF samples were collected into sterile containers and transported immediately to the microbiology laboratory for analysis.

Direct Microscopy and Gram Staining
CSF samples were examined macroscopically for appearance (clear/turbid). Direct microscopy was performed to assess white blood cells (pus cells), and Gram staining was carried out for preliminary identification of organisms.

Cerebro Spinal Fluid Culture
CSF specimens were inoculated onto standard bacteriological media including blood agar, chocolate agar, and MacConkey agar and incubated aerobically at 37°C for 24–48 hours. Organisms were identified based on colony morphology, Gram reaction, and standard biochemical tests.

Latex Agglutination Testing
Latex agglutination testing was performed for rapid detection of common bacterial pathogens.

Molecular Analysis
DNA extraction was performed from selected CSF isolates, followed by polymerase chain reaction (PCR) amplification of the bacterial 16S rRNA gene. Gel electrophoresis was used to confirm amplification products. Sequencing was performed to identify bacterial isolates, and sequences were matched against GenBank reference sequences for species confirmation.

Data Analysis
Data were entered and analyzed using Stata version 16 (Stata Corp, College Station, TX, USA).
Descriptive statistics were used to summarize participant characteristics. Categorical variables were presented as frequencies and percentages, while continuous variables were summarized as means (standard deviation) or medians (interquartile range), as appropriate. Bivariate analysis was performed using Chi-square or Fisher's exact test to assess associations between independent variables and positive CSF culture.
Variables with p-values <0.20 at bivariate analysis or those with biological plausibility were entered into a multivariable logistic regression model to identify independent predictors of positive CSF culture. Adjusted odds ratios (aOR) with 95% confidence intervals were reported, and statistical significance was set at p< 0.05.

Ethical Considerations
Human Research Ethic Committee of Aminu Kano Teaching Hospital approved the study.
Written informed consent was obtained from caregivers of all the included neonates.

RESULTS

Maternal Demographics

A total of 210 neonates were enrolled. The majority (48.1%) of mothers were in the 26–35 years age bracket, 74.3% were housewives, and 73.2% had secondary level of education (Table 1). Maternal peripartum fever during the antenatal period was reported in 14.3% of cases, and 91% of deliveries occurred in hospitals (Tables 1 and 2).

Clinical Characteristics of the Neonates

Of the 210 neonates, 121 (57.6%) were male; 133(63.4%) presented with late-onset meningitis (8–28 days). 18/210 (8.6%) were preterm neonates (≤37 weeks) (Table 1). The most common presenting symptoms were fever 156/210 (74.3%), and convulsions (65.2%). (Table 3 shows the common symptoms among the neonates with meningitis).

Table 1: Mother and infant Characteristics

Variable	Frequency (%)
Gender	
Male	57.6
Female	42.4
Gestational Age	
Term	91.4
Preterm	8.6
Mode of Delivery	
Spontaneous vaginal delivery (SVD)	92.4
Caesarean section	7.6
Mother's Age	
Teen (<18 years)	0.95
18–25 years	38.6
26–35 years	48.1
>35 years	12.4
Occupation	
Housewives	74.3
Employed	13.3
Students	12.4
Education Level	
Primary	9.1
Secondary	73.2
Tertiary	17.7

Table 2: Socio-cultural risk Factors of Meningitis among the Neonates

Social- cultural factor	Frequency (n)	Percentage (%)
Uvulectomy	6	2.86
Female Genital Mutilation	2	0.95
Traditional Facial Marks	2	0.95
Place of Delivery		
Hospital	191	91.0
Home	19	9.0
Mode of Delivery		
C/Section	16	7.6
SVD	194	92.4

Table 3: Presenting Symptoms among the Neonates with Meningitis

Symptom	Frequency (n)	Percentage (%)
Fever	156	74.3
Convulsions	145	69
Irritability	31	14.8
Bulging Fontanel	40	19.0
Rashes	22	10.5
Poor Feeding	19	9.0
Jaundice	17	8.1
Vomiting and Diarrhea	2	1.0
Tachypnoea	2	1.0

CSF Characteristics

128/210 (61.0%) of the CSF samples were clear, and 26/210 (12.4%) were turbid in appearance. Biochemical analysis revealed hypoglycorrhachia (<2.5 mg/dL) in 37.1% and elevated protein (>40 mg/dL) in 31.4% of samples. Direct Gram stain showed pus cells in 30.0% of samples as shown in table 4.

Table 4: Summary of CSF Laboratory Findings

Parameter	Frequency (%)
CSF Colour	
Clear	61.0
Blood-stained	26.7
Turbid	12.4
Culture Results	
No bacterial growth	96.7
Culture positive	3.3
Direct Gram Stain (pus cells)	30.0
Indirect Gram Stain (organisms)	3.3
Latex Agglutination Results	
Negative	86.1
Positive	13.9
— *H. influenzae*	2.9
— *S. pneumoniae*	6.8
— Mixed (*Spneu* + *NM* + *HI*)	8.6
— *GBS* or *Neisseria*	<2.0
qRT-PCR for Echovirus 30	
Positive	0.48
Negative	99.52

Pathogen Detection

Latex Agglutination

Latex agglutination test identified pathogens in 13.9% (29/210) of cases. The following organisms were detected; H. influenzae (2.9%), S. pneumoniae (6.8%), and mixed infections (S. pneumoniae + N. meningitidis + H. influenzae) in 8.6% of samples. Less than 2.0% tested positive for GBS or Neisseria (Table 4). Latex agglutination demonstrated a four- fold higher detection rate compared to conventional culture (13.8% vs 3.3%)

CSF Culture

Seven of the 210 (3.3%) CSF culture was positive for bacteria. Streptococcus pneumoniae and Haemophilus influenzae were the predominant pathogens isolated, followed by Klebsiella pneumoniae and Proteus mirabilis. Isolates showed resistance to ceftriaxone, ciprofloxacin, and amikacin.

Molecular Analysis (16S rRNA Sequencing)

Molecular sequencing of isolates identified a mix of Gram-negative bacteria, including: Pantoea ananatis (96.5–96.9% identity), Escherichia coli (98.7% identity), Acinetobacter baumannii (93.5% identity), Methylobacterium radiotolerans (86.6% identity)

In 16S rRNA gene sequencing, a ≥98.7–99% identity is often considered the threshold for species-level identification. E. coli (98.7%) was very likely accurate species identification. Pantoea ananatis (~96.5–96.9%) was a close match but below the usual species cut-off; may be Pantoea sp. rather than definitively P. ananatis. Acinetobacter baumannii (93.5%) was quite low, indicating it is likely Acinetobacter genus but species determination is uncertain. Methylobacterium radiotolerans (86.6%) was very low match; might only be distantly related to this species and could be a different genus entirely.

Viral Detection

qRT-PCR detected Echovirus 30 in 1/210 (0.48%) of CSF samples.

Predictors of Positive CSF Culture

Bivariate Analysis

The following factors were significantly associated with positive CSF culture:

- Direct Gram stain showing pus cells (χ^2=6.11, p=0.013)
- Turbid CSF appearance (χ^2=23.27, p<0.001)
- Indirect Gram stain (χ^2=210.00, p<0.001)
- Positive latex agglutination (χ^2=24.94, p<0.001)

Factors not significantly associated included gestational age (p=0.583), gender (p=0.979), maternal fever (p=0.992), mode of delivery

(p=0.499), place of delivery (p=0.396), and maternal education (p=0.569). Uvulectomy showed borderline significance (p=0.065) (Table 5

Table 5: Univariate Analysis of Factors Associated with Positive CSF Culture in Neonatal Meningitis

Variable	Categories Compared	Chi-square (χ^2)	P-value	Interpretation
Direct Gram Staining	No pus cells vs Pus cells	6.11	0.013	Significant
CSF Colour	Not turbid vs Turbid	23.27	<0.001	Significant
Gestational Age	Premature vs Full term	0.30	0.583	Not significant
Gender	Female vs Male	0.001	0.979	Not significant
Indirect Gram Staining	Gram negative / Gram positive / No organism	210.00	<0.001	Significant
Latex Agglutination	Positive vs Negative	24.94	<0.001	Significant
Maternal Fever	No vs Yes	0.0001	0.992	Not significant
Mode of Delivery	C/S vs SVD	0.46	0.499	Not significant
Place of Delivery	Home vs Hospital	0.72	0.396	Not significant
Uvulectomy	No vs Yes	3.41	0.065	Borderline significance
Maternal Education	Tertiary vs Secondary	0.32	0.569	Not significant

Abbreviations: CSF = cerebrospinal fluid; SVD = spontaneous vaginal delivery; C/S = caesarean section

Multivariable Logistic Regression

The logistic regression model identified the following statistically significant predictors of a positive CSF culture (Table 6): Turbid cerebrospinal fluid was associated with an eight-fold increased likelihood of positive CSF culture, although this did not reach conventional statistical significance (aOR 8.25, 95% CI 0.85–79.94; p=0.069). A negative latex agglutination was independently associated with significantly reduced odds of culture positivity (aOR 0.05, 95% CI 0.004–0.499; p=0.012), implying that positive latex agglutination strongly predicted culture-confirmed meningitis. Full-term gestational age showed a protective trend (aOR: 0.12, 95% CI: 0.01–1.97, p=0.139). Gestational age (full-term vs. preterm), mode of delivery (SVD vs. C-section), and gender (male vs. female) were not statistically significant predictors of culture positivity in this study (all p-values >0.05)

Table 6: Multivariable Logistic Regression of Predictors of Positive CSF Culture in Neonatal Meningitis

Variable	Category	Adjusted Odds Ratio (aOR)	Std. Error	z-value	P-value	95% CI	Interpretation
CSF Colour	Turbid	8.25	9.56	1.82	0.069	0.85 – 79.94	Borderline association
Direct Gram Staining	Pus cells positive	1.29	1.44	0.23	0.818	0.15 – 11.47	Not significant
Gestational Age	Full term	0.12	0.17	-1.48	0.139	0.01 – 1.97	Protective trend
Uvulectomy	Yes	1.00	-	-	-	-	
Latex Agglutination	Negative	0.05	0.06	-2.53	0.012	0.004 – 0.499	Significant protective association
Constant	-	0.39	0.52	-0.71	0.476	0.03 – 5.28	-

Abbreviations: aOR = adjusted odds ratio; CI = confidence interval; CSF = cerebrospinal fluid.

Antimicrobial Resistance

Invitro antibacterial susceptibility profiles of the antibiotics tested against the pathogens isolated is described below. Fourteen percent (14%) of the isolates were resistant to amoxicillin, 29% were resistant to clindamycin, levofloxacin, bacitracin and cotrimoxazole, and 43% were resistant to oxacillin. For susceptibility, 100% were susceptible to ceftriaxone, erythromycin and susceptible to Ceftriaxone, Ceftazidime, Amikacin, meropenem, ciprofloxacin while resistant to Levofloxacin. Figure 1 presents Antimicrobial Sensitivity Test (AST) of commonly prescribed antibiotics against E. coli. The isolate was chloramphenicol.

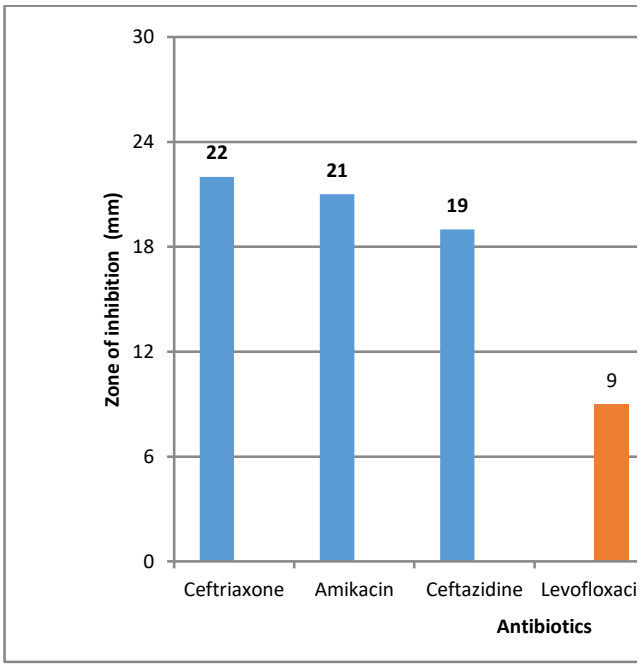

Figure 1: Antibacterial Susceptibility Profile of Escherichia coli Isolated from a Neonate.

Figure 2 shows AST result of Methylobacterium radiotolerance against the antibiotics Ceftriaxone, Levofloxacin, Meropenem, Ciprofloxacin, Cefotaxime and Amoxicillin. The bacterium was susceptible to Ceftriaxone, Levofloxacin, Meropenem, Ciprofloxacin, and Cefotaxime while resistant to Amoxicillin.

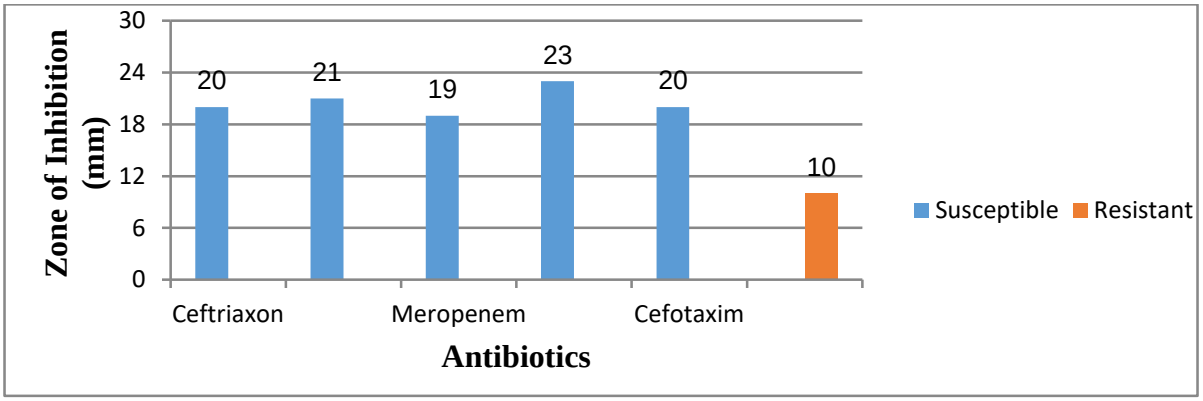

Figure 2: Antibacterial Susceptibility Profile of Methylobacterium radiotolerance Isolated from a Neonate CSF.

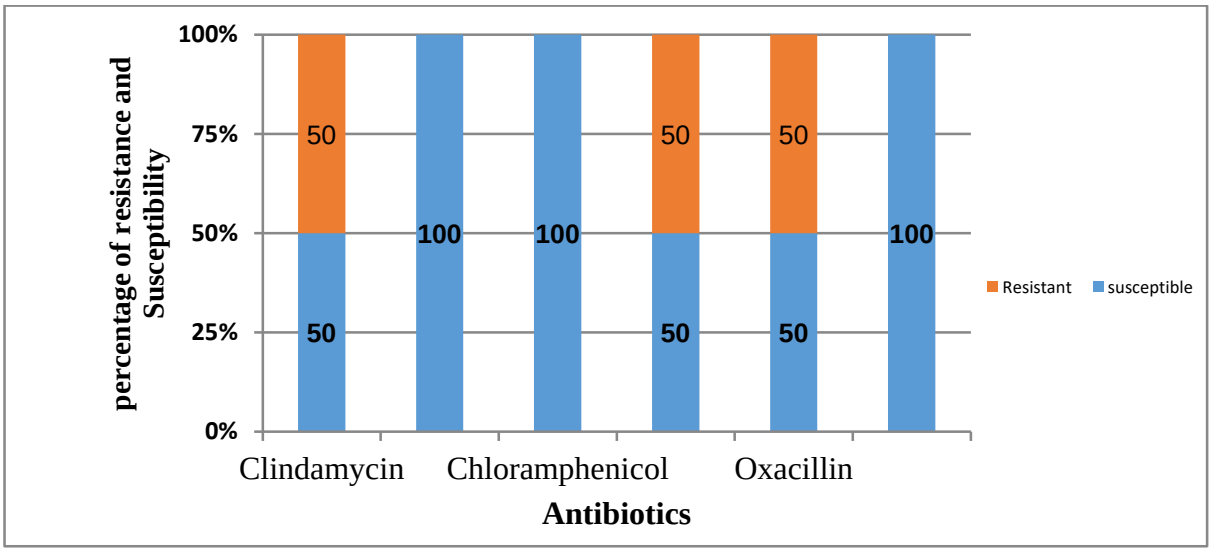

Figure 3 Antibacterial level of Resistance and Susceptibility

DISCUSSION

Our study found that CSF culture was positive in only 3.3% of the cases, this is consistent with the findings from other studies reporting 8.5%–12% culture positivity.[14-17] Similarly, two large Nigerian studies over several years reported a culture positivity rate of only 2-8% among under 5 children with suspected bacterial meningitis. [3, 14] This is also similar to findings from HIC where CSF culture positivity rate among suspected cases was low.[15, 16] Prior exposure to antibiotics, quality of culture media and poor specimen transport could be the reason for the observed low CSF culture yields, thereby limiting the sensitivity of culture in setting with high antibiotic exposure rate like Nigeria.[17-20] CSF culture yielded Streptococcus pneumoniae and Haemophilus influenzae as the leading causative agents of meningitis in Kano. This finding is consistent with reports from other sub-Saharan African countries where Pneumococcal and H. influenzae meningitis remain significant causes of childhood morbidity and mortality.[5, 20, 21] In contrast, Group B Streptococcus (GBS) was globally identified as the most common pathogen in neonatal meningitis, accounting for approximately 50% of pathogens from HIC. This is followed by Escherichia coli

(~14%) and Listeria monocytogenes (~4%) as the next important causative agents of bacterial meningitis in the newborn.[16,20.22] This finding indicates that these organisms persist despite the introduction of conjugate vaccines and may suggest poor vaccine uptake. Our data revealed that latex agglutination has a fourfold higher detection rate (13.8% vs 3%) compared to culture. Both single and mixed infections were identified. Similarly, a Brazilian study found the sensitivity of LA to be 93.0% and specificity of 100% for N. meningitidis C, H. influenzae type b, and S. pneumoniae combined,[25] Other studies reported the detection rate of latex agglutination (LA) for bacterial antigens in CSF varied by pathogen, ranging from approximately 50% to 100%, and it had high specificity.

The reported sensitivities of LA in HIC ranged from 78%–100% for Haemophilus influenzae type b, 67%–100% for Streptococcus pneumoniae, 69%–100% for Streptococcus agalactiae, and 50%–93% for Neisseria meningitidis.[6 23-25] However, LA results rarely changed management despite high sensitivity. This is because clinical decision to treat bacterial meningitis is based on clinical features and basic CSF findings. Treatment is altered only when culture and susceptability results is obtained. Latex agglutination test was reported to be more effective than bacterial culture for diagnosing bacterial meningitis [19, 23, 26] and may be indicated when negative results are obtained for CSF tested by bacterial culture and in the absence of PCR. [27, 28] The study found turbid cerebrospinal fluid (CSF) and a positive latex agglutination test to be independently associated with higher odds of a positive CSF culture among neonates evaluated for suspected meningitis. Turbid CSF had a greater than ninefold increase in the likelihood of culture positivity. These findings are consistent with previous studies which have reported that visible turbidity of CSF is often indicative of a high leukocyte count and bacterial load, increasing the probability of detecting the pathogen on culture,[29, 34] It was the strongest single clinical predictor in one large cohort.[18] Furthermore, a large Angolan study found that not-clear (turbid) CSF appearance was the strongest single clinical predictor of bacterial meningitis on multivariable analysis, though 25% of culture-proven cases had entirely normal CSF parameters. [30]

A study from Kenya, however, found that, turbid CSF predicted proven or probable bacterial meningitis in less than 40% of cases, and was seen in at least 1% of patients without bacterial meningitis.[33] Though turbid CSF can also result from traumatic LP (RBCs), high protein without infection, or non-bacterial causes, turbidity should prompt urgent empiric treatment in LMIC like Nigeria, because turbidity is reported to have a moderate positive predictive value and poor negative predictive value.[31]

Latex agglutination test had a higher sensitivity of identifying pathogens. Multivariate analysis found that a negative LAT was associated with a significant reduction in the odds of having a positive CSF culture (aOR 0.05, 95% CI 0.004–0.499; p=0.012). By inference, a positive latex agglutination was a strong predictor of culture-proven bacterial meningitis. The LAT detection of these organisms; H. influenzae (2.9%), S. pneumoniae (6.8%), and mixed infections (S. pneumoniae + N. meningitidis + H. influenzae) in 8.6% of samples is similar to the findings from a Ghanaian study.[28] The LAT has several advantages such as rapid turnover of results (results in ≤15 minutes), it is simple to perform, and does not require specialized equipment, it detects capsular polysaccharide antigens of common pathogens.[17,28] LA is particularly useful in cases where prior antibiotic therapy has rendered cultures negative, as antigen can persist in CSF after bacterial lysis. This is of particular importance in settings where rapid confirmation is critical on a background prior use of antibiotics. However, LAT does not detect Gram-negative organisms such as E. coli and Klebsiella, which are major neonatal pathogens making this a critical gap in the neonatal population. [19, 25]

CSF culture is the gold standard; it identifies the bacteria and antimicrobial susceptibility. The ability of culture to identify pathogens is sometimes compromised in LMICs, due to frequent pre-hospital antibiotic use and limited laboratory infrastructure. In such settings, the CSF turbidity and cytochemical analysis can guide initial management, even as these are

nonspecific and there may be overlap among different microorganisms. Gestational age, mode of delivery, and gender were not significantly associated with CSF culture positivity. Although full-term neonates appeared to have a lower risk compared to preterm infants, this did not reach statistical significance, possibly due to the small number of premature babies in the study or limited statistical power. Previous studies have reported that lower gestational age is associated with increased risk of neonatal meningitis, more severe disease presentation, higher mortality, and greater likelihood of neurodevelopmental sequelae.[6, 22, 35] Atypical organisms namely; Pantoea ananatis and Acinetobacter baumannii were identified with 16S rRNA gene sequencing. Another Nigerian studies, using multiplex real-time PCR, have similarly detected as few as 2 copies of E. coli, N. meningitidis, and S. pneumoniae, with results available in ~1.5 hours, and achieving >95% sensitivity and specificity.[12] There were discrepancies, however, between phenotypic identification by latex agglutination and genotypic identification by 16S rRNA gene sequencing. The latex agglutination detected additional pathogens in some specimens, that were not confirmed by 16S gene sequencing. This may be because of the inability of partial sequences to discriminate between closely related species, primer bias and false positive LAT.

Most isolates were susceptible to amikacin and meropenem, therefore, these agents are reliable therapeutic options for neonatal meningitis in Kano. This is consistent with previous reports from low- and middle-income countries showing preserved efficacy of aminoglycosides and carbapenems against neonatal Gram-negative pathogens, despite rising antimicrobial resistance.[38-41] Escherichia coli susceptibility to third-generation cephalosporins is reassuring, since it is a common neonatal meningitis pathogen; however, the observed resistance to ciprofloxacin may indicate emerging fluoroquinolone resistance, similar finding were reported globally.[41, 42]

Unusual environmental organisms namely; Methylobacterium radiotolerans and Pantoea ananatis were isolated in the study. This may be due to environmental contamination, invasive device-associated infections, or broader lapses in infection prevention practices within neonatal care settings. Particularly, the presence of these organisms in CSF might indicate nosocomial transmission. Hence the need for strengthened microbiological surveillance and environmental infection control. Acinetobacter baumannii, a pathogen well recognized for multidrug resistance and hospital outbreaks was also isolated.

The variable resistance to ciprofloxacin, amoxicillin, and ceftazidime observed across isolates in this study highlights the need for microbiological confirmation by culture and sensitivity testing in neonatal meningitis. Strengthening laboratory diagnostic capacity and infection prevention measures remains critical to reducing neonatal morbidity and mortality associated with bacterial meningitis.

STRENGTHS AND LIMITATIONS

This study contributes important data on the clinical and microbiological profile of neonatal meningitis in Kano, Nigeria. The use of multiple diagnostic modalities (culture, latex agglutination, and molecular sequencing) provided comprehensive pathogen identification. The relatively small sample size and hospital-based recruitment may limit generalizability to community settings. Additionally, some neonates might have received antibiotics prior to presentation despite formal exclusion criteria, potentially lowering culture positivity. Sequencing did not cover full 16S region or multiple loci, limiting resolution for species-level identification.

CONCLUSION

Streptococcus pneumoniae and H. influenzae remain key pathogens in neonatal meningitis in Kano, Nigeria, with notable detection advantages of latex agglutination test over standard culture. The emergence of multidrug-resistant strains and uncommon pathogens pose challenge to clinical management. To improve outcomes, there is an urgent need to scale up rapid diagnostics, strengthen laboratory infrastructure, and implement local AMR surveillance frameworks. Enhanced training on neonatal sepsis recognition, particularly for peripheral healthcare workers, and reinforcement of infection prevention practices in delivery settings could also mitigate disease burden.

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