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Etiology of bloodstream infections among pediatric patients in Bauchi metropolis, north-east Nigeria

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Abstract

Background: The prevalence of bacterial infections in children is increasing by the day, this gives a cause for concern regarding the high rate of bloodstream infection (BSI) and associated mortality in developing countries. Physical signs and symptoms may be useful but have limited specificity which would be addressed with bacteriologic blood culture. This study was aimed at determining the etiologic agents of bacteremia and the prevalence in pediatric patients aged 0-5years.

Methods: Two hundred and sixty- two (262) blood samples were analyzed from children aged 0-5years, attending hospitals within Bauchi metropolis with features suggestive of septicemia. Samples were collected under aseptic conditions and automated blood culture was done on BacT/ALERT 3D Biomerieux, Germany. Positive blood culture was sub-cultured on blood agar and MacConkey agar and identified on Vitek2 (bioMèrieux, France) automated system after gram staining. Changes in pathogen distribution according to age and gender were determined by the chi-square test and statistical significance confirmed if a two-tailed *p*-value was not more than 0.01.

Results: Bacteria was isolated in 119 (45.4) of samples with highest rate among neonates 54(45.3). *Staphylococcus aureus* 21 (17.6) was the most predominant organism isolated across all age groups with a higher occurrence in patients<1year old. A chi-square test of independence for culture positivity and age/gender at p<.01 was not significant

Conclusion: In this study both Gram-positive and Gram-negative bacteria are implicated in pediatric bloodstream infections. *Staphylococcus aureus* was the most predominant organism followed by members of the Enterobacterales *(Enterobacter* spp, *Klebsiella* spp and *Escherichia coli*).

Keywords: Bloodstream infections; Pediatrics; Bacteria; *Staphylococcus aureus*

1. Introduction

Bloodstream infection (BSI) is caused by pathogenic microorganisms that invade the blood causing bacteremia and/or septicemia which is manifested by inflammatory reaction. This has been attributed to be the main cause of death in children [1]. Markwart *et al* [2] in a review reported a mortality rate of 40% resulting from sepsis. A recent review also reported 25% mortality rate in children all over the world and 26.5% of the global morbidity caused by pediatric BSIs [3]. Although data of pediatric BSIs in Africa is scarce, high rates of fatality predominated by *K. pneumoniae, E. coli* and

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S. aureus have been reported [4]. According to previous reports, about three million newborn deaths were recorded annually out of which 36% was due to neonatal sepsis. This death rate is above four times higher in Africa however the trend in research for etiology of such occurrence remains very low in developing countries including Nigeria [4]. The prevalence of bacterial infections in children is increasing by the day which gives a cause for concern regarding the high rate of bloodstream infection (BSI) and associated mortality in our environs. Childhood infections are caused by both Gram-positive and Gram-negative bacteria as well as *Candida* spp and are typically characterized by clinical features including fever, hypothermia, respiratory distress, reduced activity, feeding intolerance among others [4, 5]. It is a major contributor to morbidity and mortality of children less than five years of age. Data from Nigeria on the etiologic agents of pediatric BSI has been scanty and mostly based on the conventional blood culture and identification methods; this poses a challenge for data comparison with studies in Sub-Saharan African countries and other parts of the world, where modern culture and identification techniques are employed [6].

High rates of BSI associated with bacterial pathogens have been reported in Nigeria, [1] South Korea [7]; India, [8] and several others. Some scholars are of the view that the leading cause of bloodstream infections is predominantly microorganisms of the family *Enterobacteriacea* [9] while others show that Gram-positive bacteria are the leading cause of these infections [4,10]. Infections can be established on the basis of etiological agent recovered from blood which paves way for the prevalence of bacterial profile which in turn provides guidance to commence empirical treatment which is essential in managing childhood infections.

This study was aimed at identification of the etiologic agents of bacteremia and the prevalence in pediatric patients aged <5years.

2. Materials and method

2.1. Study design

This was a prospective, cross-sectional study of pediatric patients aged 0–5years who attended selected hospitals and presenting with signs and symptoms suggestive of sepsis. This study was carried out in Bauchi metropolis, Bauchi state, North-east Nigeria. A total of Two hundred and sixty- two (262) children were sampled from August 2021 to January 2022.

2.2. Bacteriological culture

A sterile syringe was used to collect 1-2ml of intravenous blood and inoculated into BactAlert culture bottles immediately and incubated at 37°C for 24-48 hrs. All samples were incubated within 2 hours of sampling. Blood culture testing was carried out using the Automated Blood Culture System (BacT/ALERT 3D from Biomerieux, Germany) which is a quantitative blood culture system that monitors bacterial growth via calorimetric detection of Carbon 1V oxide (CO_2) produced by the organisms inside the blood culture bottle.

2.3. Bacterial identification

Positive blood cultures were sub-cultured on blood agar and MacConkey agar. Colonies were identified by Gram stain, and biochemical identification performed using Vitek2 (bioMèrieux, France) automated system according to the manufacturer's instructions.

2.4. Statistical analysis

Data was analyzed using the International Business Machine (IBM) Statistical Product and Service Solutions (SPSS) version 22. Frequency tables were generated for categorical variables such as gender, age and organisms isolated. Changes in pathogen distribution according to age and gender were determined by the chi-squared (χ^2) test and statistical significance confirmed if a two-tailed *p*-value was not more than 0.01 at 99% level of confidence.

3. Results

A total of 262 blood samples were collected [147(56.1%) male and 115(43.9%) female]. Table 1 shows that 119(45.4%) yielded positive cultures while 143(54.6) yielded no growth. Gram positive organisms were 58(22.1 %) while Gram negative organisms were 61(23.3 %). The rate of organisms isolated was highest in the neonatal age group54 (45.2%) (Table2). Table 3 shows bacterial isolation according to gender 63 (52.9 %) male against 56(47.1 %) female infections was recorded. A total of 58(22.1 %) Gram positive organisms, with the most prevalent organism being *Staphylococcus aureus* 21(17.6%) across all age groups with a higher occurence in patients<1year was recorded. On the other hand

61(23.3 %) Gram negative organisms were isolated with *Enterobacter* spp 20(16.8%) being the most predominant with the highest occurrence in patients >4weeks to 1year, while *Klebsiella* spp and *E. coli* followed mostly in patients < 1 year

Table 1 Distribution of Blood Culture Positivity In Relation To Gender

Sex	Gram positive n(%)	Gram negative n(%)	No growth n(%)	Total n(%)
Male	28 (19.0)	35(23.8)	84(57.1)	147(56.1)
Female	30(26.0)	26(22.6)	59(51.3)	115(43.9)
	58(22.1)	61(23.3)	143(54.6)	262(100)

A chi square test of independence at *p< .01* shows that there was no significant association between gender and Gram reaction, $X^2 (1, N=119) = 0.9, p=.32$.

Table 2 Occurrence of Bacteria In Relation To Age

Age	Gram-positive n(%)	Gram-negative n(%)	No Growth n(%)	Total n(%)	Infection rate (%)
<= 4wks	30(51.2)	24(39.)	49(34.3)	103(39.3)	45.2
>4wks-1yr	12(20.7)	16(26.2)	56(39.2)	84(32.1)	23.5
>1yr- 2yrs	8(13.8)	13(21.3)	21(14.7)	42(16.0)	17.6
>2yrs- yrs	8(13.8)	8(13.1)	17(11.9)	33(12.6)	13.5
Total	58(22.1)	61(23.3)	143(54.6)	262(100)	

A chi square test of independence at p< .01 shows that there was no significant association between age and Gram reaction, $X^2 (1, N=119) = 2.3, p=.50$.

Table 3 Percentage Occurrence of Bloodstream Organisms Isolated

Isolate	Male	Female	Percentage Occurence
Gram positive organisms			
Staphylococcus aureus	13(20.6)	8(14.2)	21(17.6)
Staphylococcus scuiri	6(9.5)	8(14.2)	14(11.8)
Kochuria spp	4(6.3)	4(7.1)	8(6.7)
Others	4(6.3)	9(16.1)	13(10.9)
Gram-Negative Organisms			
Escherichia coli	9(14.3)	5(8.9)	14(11.8)
Klebsiella spp	9(14.3)	8(14.2)	17(14.3)
Enterobacter spp	11(17.5)	9(16.1)	20(16.8)
Raoultella spp	2(3.2)	0(0.0)	2(1.7)
Seratia spp	2(3.2)	2(3.2)	4(3.4)
Rhizobium spp	1(1.6)	1(1.8)	2(1.7)
Others	2(3.2)	2(3.6)	4(3.4)
Total	63(52.9)	56(47.1)	119(45.4)

4. Discussion

A total of 119(45.4 %) bacterial pathogens were isolated from blood cultures of children with suspected bloodstream infections and 143(54.6 %) yielded no growth. This prevalence rate is comparable to 48.9% which was earlier reported

[11]. Out of the blood samples yielding growth, a prevalence rate of 45.2% was obtained in the neonatal group (<=4weeks) and it was the highest occurrence in this study, this rate seemed to decrease with increase in age. The high occurrence in neonatal age group agrees with the results of Oyekale *et al* [1] This high rate of infection in neonates could be due to their developing immune system which can easily be compromised by these pathogens, that the occurrence of BSIs peaks in the first year of life also that age group is an important factor in pathogen distribution [12]. This rate is within a comparable range of rates reported of neonatal bacteremia in some parts of Nigeria 30.8 % [11], 50.6 % [13] and 55 % [14] in Illorin, Calabar and Ife respectively. The prevalence rate in this study is however higher than 29.4% previous reports in Nigeria [1] but lower than the 49.6% reported in South Korea [7]. Reports have it that the prevalence of blood stream infections alongside the causative agents varies across regions, seasons and from place to place [1, 15].

Staphylococcus aureus was the predominant isolate (17.6%) across all age groups but the highest occurrence was in the neonatal group (<4weeeks). The predominance of this organism could possibly be during delivery by way of mother to child, environment- acquired or otherwise. This is in consonance with reports from previous studies where *Staphylococcus aureus* 41.4% predominated as the leading etiologic agent across all age groups [16, 17]. Similarly, *Staphylococcus aureus* has been reported to be the most commonly identified pathogen regardless of age and sex in South –Asia as well as the most commonly identified pathogen in children [1, 7, 15,18, 19]. Although this study agrees with several scholars, a multicenter study reported on the contrary that *Salmonella* spp are the most common cause of childhood bacteremia in the Central (Abuja) and North Eastern (Kano) part of Nigeria [16].

In this study, even though *Staphylococcus aureus* (Gram positive) was the most commonly identified organism, an overall prevalence rate of 23.3 % Gram negative organisms was obtained against 22.1 % Gram positive. Findings of this study completely agree with Shao *et al* [17] where Coagulase negative *Staphylococcus aureus* (*CoNS*) was the principal pathogen causing BSI in children closely followed by gram negative *E. coli*. Our results also corroborates with other findings in other regions in Nigeria where *S. aureus*, *CoNS* and *K. pneumoniae* were the prevalent pathogens [20]. Of the Gram negative organisms isolated in this study, *Enterobacter spp* was mostly isolated followed by *Klebsiella spp.* and *E. coli* and high prevalence was obtained amongst patients< 1year old agreeing with results from South-east Nigeria where *S. aureus* and gram-negative rods (*Pseudomonas spp* and *coliform*) were the leading cause of septicemia in children [21]. The isolation of pathogenic bacteria in children aged <five years poses a high risk of infection to those yet infected within the study area. The total prevalence rate of 45.3% is considerably high; such a trend needs urgent attention to curb the alarmingly increasing morbidity and mortality rate of our children. This suggests that infections by these agents constitute a significant threat to child survival in this locality and other developing country settings. A good knowledge of the organisms responsible for BSI(S) in Bauchi Metropolis and Nigeria at large would help in the right choice of antibiotics for treatment whereas untreated bacteremia can progress to focal infection and sepsis which can be fatal. A chi-square test of independence at *p<.01* showed that there was not significant association between occurrence of isolates and gender/ age.

5. Conclusion

This study has shown that both Gram-positive and Gram-negative bacteria are implicated in bloodstream infections in Bauchi, North-east Nigeria. *Staphylococcus aureus* was the most predominant organism followed by members of the *Enterobacteriacea* (*Enterobacter* spp, *Klebsiella* spp and *Escherichia coli*). Epidemiological studies like this provide useful information on the profile of microorganisms in circulation to guide practice and policies that would ensure effective treatment and control of same.

Compliance with ethical standards

Disclosure of conflict of interest

There was no conflict of interest

Statement of ethical approval

Ethical approvals were obtained from the Bauchi State Ministry of Health and Abubakar Tafawa Balewa University Teaching Hospital, Bauchi to undergo this study.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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