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Bacterial Agents of Neonatal Septicaemia: a Prospective Study in Zaria

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Abstract

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Background: Neonatal septicaemia is a common cause of morbidity and mortality in the tropics. The aetiological and antibiotic sensitivity patterns of this condition are continuously changing, hence the need for continuous surveillance of the newborn unit.

Objectives: To determine the bacterial agents of neonatal septicaemia and their antibiotics sensitivity patterns in Zaria.

Patients and Methods: Babies admitted into the Newborn Unit of Ahmadu Bello University Teaching Hospital, Zaria with diagnosis of septicaemia were studied. The results were analyzed with EPI info 6 software. Statistical significance was set at $p < 0.05$.

Results: Sixty-nine (32.7 percent) of 211 infants studied were in-born. Seventy-five (35.5 percent) had proven septicaemia. The male: female ratio of the septicaemic neonates was 1.2:1. The incidence of septicaemia for in-born neonates was 17.6 per 1000 live births. Gram-negative bacteria predominated in early-onset septicaemia and Gram-positive agents in late-onset infections. Important isolates included *Staphylococcus aureus* (42.9 percent), *Escherichia coli* (19.5 percent), Streptococcus species (11.0 percent), *Klebsiella pneumoniae* (7.8 percent) and *Proteus mirabilis* (6.5 percent). The sensitivity of the pathogens to commonly used antibiotics was generally low. However, gentamicin still retained good sensitivity rates.

Conclusion: The agents of septicaemia were similar to earlier patterns. A combination therapy that includes gentamicin appeared most appropriate for empirical treatment of septicaemia in our environment.

Key words: Bacterial agents, neonates, septicaemia, antibiotics, Zaria

Introduction

NEONATAL septicaemia is associated with high morbidity and mortality.[1-3] It has been well documented that the bacterial agents of neonatal septicaemia and their sensitivity to antibiotics tend to vary from place to place and from time to time in the same environment.[4,5] It is therefore pertinent that the bacterial isolates and their antibiotic sensitivity pattern be continually monitored, so as to detect any deviation from the earlier pattern.[3,5] Appropriate and prompt antibiotic therapy is pivotal to reducing complications that could arise from the disease, therefore a stand-by empirical treatment protocol, which can only be determined by sensitivity studies, is necessary. This study was carried out to determine the current aetiological agents of neonatal septicaemia and their antibiotic sensitivity in this locality.

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Patients and Methods

This was a prospective study of patients admitted into the Special Care Baby Unit (SCBU) of Ahmadu Bello University Teaching Hospital (ABUTH), Zaria, from 25 May 2004 to 31 May 2005. The hospital is a tertiary health centre that serves as a paediatric referral centre for Kaduna, Katsina and Zamfara states and parts of Niger, Nassarawa, Kano, Plateau, Jigawa and the Federal Capital Territory. Informed consent was obtained from the caregivers of all the

recruited patients, while ethical clearance was obtained from the Medical Ethics Committee of the hospital before commencement of the study. Consecutive newborns (in-born or out-born) that presented to the SCBU of the hospital with the risk factors for and/or clinical features of neonatal septicaemia were studied. Babies who had had antibiotics prior to presentation to the unit and those whose mothers had antibiotics treatment during the last two weeks of pregnancy were excluded from the study. The babies were evaluated clinically and the presenting clinical features were recorded. Blood, cerebrospinal fluid, urine and swabs of discharges were obtained aseptically before commencement of antibiotics. Bacteriological studies of the specimens were carried out in the microbiology department of the hospital using standard procedures.[5] Antibiotic sensitivity study of the isolates was done by the Kirby-Bauer technique.[7]

The patients were treated with appropriate doses of intravenous penicillins and intramuscular gentamicin, and were carefully monitored until discharge. Antibiotic changes when carried out, were dictated by the patients' clinical responses and the antibiotic sensitivity results.

All data were entered into Epi Info version 6 and analysed. Associations were tested using Chi square

Table I

Distribution of Bacterial Isolates according to the Age (days) at Presentation

Isolates	*Age at Presentation (days) and Number of Infants*			
	0 – 2 *n (%)*	*3 - 7* *n (%)*	*8 - 28* *n (%)*	*Total*
Gram-positive	10 (40.0)	20 (71.4)	10 (41.7)	40
Staphylococcus aureus (S. aureus)	7 (28.0)	18 (64.3)	8 (33.3)	33
Streptococcus pyogenes (S. pyogenes)	2 (8.0)	2 (7.1)	-	4
Untyped Streptococcus	1 (4.0)	-	1 (4.2)	2
Streptococcus pneumoniae (S. pneumoniae)	-	-	1 (4.2)	1
Gram-negative	15 (60.0)	8 (28.6)	14 (58.3)	37
Escherichia coli (E. coli)	6 (24.0)	5 (17.9)	4 (16.7)	15
Klebsiella pneumoniae (K. pneumoniae)	1 (4.0)	1 (3.6)	4 (16.7)	6
Proteus mirabilis (P. mirabilis)	2 (8.0)	1 (3.6)	2 (8.3)	5
Citrobacter species	1 (4.0)	-	2 (8.3)	3
Acinetobacter species	2 (8.0)	-	1 (4.2)	3
Enterobacter species	2 (8.0)	-	-	2
Alcaligenes species	1 (4.0)	-	-	1
Pseudomonas aeruginosa (P. aeruginosa)	-	-	1 (4.2)	1
Aeromonas species	-	1 (3.6)	-	1
Total	25**	28**	24	77

** One of the patients in each of the asterisked groups had double isolates.

or Fisher's exact tests where appropriate, while statistical significance was set at $p < 0.05$.

Results

Of the 573 neonates admitted into the newborn unit of the hospital during the study period, 211 (36.8 percent) satisfied the inclusion criteria. Out of this number, 69 (32.7 percent) were in-born, 142 (67.3 percent) were out-born; 122 (57.8 percent) were males and 89 (42.2 percent) were females. The ages of the 211 patients studied ranged from birth to 28 days, with a mean (± 1SD) of 7.5 (± 6.7) days.

Seventy-five (35.5 percent) of the 211 neonates had culture-proven septicaemia, while 136 (64.5 percent) had sterile blood cultures. Twenty-one (28.0 percent) of the 75 septicaemic neonates were delivered at the ABUTH delivery suite, while 54 (72.0 percent) were out-born, giving the prevalence of septicaemia among babies born in ABUTH and among those brought from outside as 30.4 percent (21/69) and 38.0 percent (54/142), respectively ($X^2 = 0.86$, df = 1, $p = 0.3535$).

One thousand two hundred and sixty-eight babies were delivered in the hospital during the period of study, 78 of them were stillbirths, while 1190 were live births. Twenty-one of the in-born live births had positive blood culture results; thus the incidence of neonatal septicaemia among in-born infants was 17.6 per 1000 live births.

Bacterial isolates

There were 77 isolates in 75 neonates with septicaemia; two of the neonates had double isolates namely, S. aureus and E. coli. Forty (51.9 percent) of the isolates were gram-positive, while 37 (48.1 percent) were gram-negative. A distribution of the isolates according to the age of the neonates at presentation is shown in Table I. Gram-negative bacteria predominated among neonates with early-onset septicaemia, while Gram-positive agents predominated in those with late-onset infection, although the difference was not statistically significant ($X^2 = 1.47$, df = 1, $p = 0.226$). *Staphylococcus aureus* septicaemia was more common among the out-born than the in-born ($p = 0.0325$; Table II), while streptococcal septicaemia occurred mainly among in-born babies (Fisher's exact, p-value = 0.0054). The frequency of isolation of E. coli, Citrobacter species and Acinetobacter species were higher among in-born than out-born infants, although the differences were not significant ($p > 0.05$).

Of the 75 septicaemic babies, eight (10.7 percent) had meningitis. The same organisms were isolated from the cerebrospinal fluid and the blood in six of them, and they included S. aureus, S. pneumoniae, E. coli and P. mirabilis. The predominant bacterial isolate from the swabs of the eye, umbilical and skin discharges from the neonates was S. aureus (73.7 percent). Urine cultures yielded positive growths in five of the septicaemic infants, all of which were K. pneumoniae.

Antibiotic Sensitivity Pattern

Gram-positive bacteria were generally more sensitive to the commonly used antibiotics than the Gram-negative bacteria (Tables III and IV). Most of the isolates were sensitive to ofloxacin, ciprofloxacin, chloramphenicol, ceftriaxone, coamoxiclav,

Table II

Distribution of the Isolates in Relation to Place of Delivery

Organisms	*Place of Delivery*				
	In-born(%) (n=22)	*Out-born (%)(n=55)*	*Total (n=77)*	χ^2	*p-value*
S. aureus	5 (22.7)	28 (50.9)	33	4.01	0.0452
Streptococcus species	6 (27.3)	1 (1.8)	7	Fisher's exact	0.0018
E. coli	6 (27.3)	9 (16.4)	15	Fisher's exact	0.3421
K. pneumoniae	-	6 (10.9)	6	Fisher's exact	0.1745
P. mirabilis	1 (4.5)	4 (7.3)	5	Fisher's exact	1.0000
Citrobacter species	2 (9.1)	1 (1.8)	3	Fisher's exact	0.1945
Acinetobacter species	2 (9.1)	1 (1.8)	3	Fisher's exact	0.1945
Enterobacter species	-	2 (3.6)	2	Fisher's exact	1.0000
Others**	-	3 (5.5)	3	Fisher's exact	0.5534

** *Pseudomonas aeruginosa (1), Acromonas species (1), Alkaligenes species (1)*

Table III

Gram-Positive Bacteria and their In-Vitro Antibiotic Sensitivity Rates

	Antibiotic Sensitivity (%)											
Isolates(n)	*Amp*	*Cx*	*Amx*	*Cu*	*Ch*	*Ery*	*Gen*	*Cfx*	*Cro*	*Cfr*	*Cfl*	*Cpr.S.*
aureus (33)	33.3	45.5	54.5	87.9	93.9	84.8	81.8	87.9	90.9	30.3	100.0	100.0
S. pyogenes (4)	0.0	75.0	75.0	100.0	100.0	25.0	75.0	75.0	75.0	50.0	100.0	100.0
S. pneumoniae (1)	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
Untyped Streptococcus (2)	50.0	0.0	50.0	100.0	50.0	100.0	0.0	50.0	100.0	50.0	100.0	100.0
Overall susceptibility	30.0	47.5	57.5	90.	92.5	80.0	70.5	85.0	90.0	32.5	100.0	100.0

Amp Ampicillin Chl - Chloramphenicol Amx-Amoxycillin Cfr- Cefuroxime Cx Cloxacillin Gen-Gentamycin Cfx-Cefuroxime Cua - Co-amoxiclav Cro – Ceftriaxone Ery-Erythromycin Cpr-Ciprofloxacin Ofl-Ofloxacin

Table IV

Gram-Negative Bacteria and their In-Vitro Antibiotic Sensitivity Rates

	*Antibiotic Sensitivity (%)**										
Isolates(n)	*Amp*	*Amx*	*Cua*	*Cot*	*Chl*	*Ery*	*Gen*	*Cfx*	*Cro*	*Cfr*	*Cpr*
E. coli (15)	20.0	46.6	73.3	13.3	100.0	60.0	93.3	53.3	80.0	80.0	100.0	80.0
K. pneumoniae (6)	0.0	0.0	33.3	0.0	66.6	33.3	83.3	33.3	66.6	83.3	100.0	100.0
P. mirabilis (5)	0.0	20.0	40.0	40.0	40.0	20.0	60.0	20.0	100.0	100.0	100.0	100.0
Citrobacter (3)	33.3	33.3	66.6	33.3	33.3	0.0	33.3	33.3	66.6	66.6	100.0	100.0
Acinetobacter(3)	0.0	0.0	33.3	0.0	0.0	66.6	66.6	0.0	33.3	66.6	100.0	100.0
Others (5)	0.0	0.0	20.	20.0	40.0	20.0	80.0	0.0	80.0	80.0	100.0	80.0
Overall susceptibility	10.8	24.3	51.4	16.2	64.9	40.5	78.4	32.4	75.7	78.4	100.0	97.3

* Key: see Table III above.

cefuroxime, erythromycin and gentamicin, but 30.0 percent of the Gram-positive and 10.8 percent of the Gram-negative bacteria were sensitive to ampicillin.

Discussion

The bacterial isolation rate of 35.5 percent obtained in this study was low even though other workers have reported similar figures from Ilorin[8] and Lagos.[9] Bacterial isolation rate of about 60.0 percent has been documented in some parts of Nigeria.[10] Such differences in bacterial isolation rates may be attributable to differences in selection criteria, volume of blood samples, laboratory and personnel factors. In addition, the level of sincerity of the respondents of the various studies might also be contributory, since some mothers may not voluntarily divulge the

history of antibiotic self-medications, with consequent inclusion of neonates of such mothers in the studies. The exact role of these factors in this study could not be determined.

Most of the positive cultures in the present study were monomicrobial; only two patients, both of whom were delivered at a Primary Health Care Centre, had polymicrobial infection. Reports from other regions[7,12] of Nigeria confirm this situation. Polymicrobial infection has been reported as mostly being hospital-acquired.[12] Continuous surveillance of infection in hospitals might help to clarify the polymicrobial nature of nosocomial infections.

Gram-negative bacteria predominated among isolates from neonates with early-onset infection. Other workers[5,7] have recorded similar observation. The reason for the predominance of Gram-negative bacteria in early neonatal septicaemia could be related to the colonization of maternal genitalia by Gram-negative enteric bacilli which could gain access to the foetus by ascending infection following prolonged rupture of the foetal membranes or during passage of the baby through the birth canal at delivery. The role of Gram-positive bacteria in neonatal septicaemia was also obvious particularly among infants with late-onset infection. The high prevalence of Gram-positive septicaemia in this category of patients is closely related to the predominance of S. aureus in the blood of out-born babies, thus highlighting the role of the community in the acquisition of Gram-positive bacteria. Apart from handlers of babies in the community, deliveries outside hospitals are usually conducted by less skilful birth attendants who may be harbouring these organisms in their hands and nostrils and who may employ unhygienic methods in delivery.[9]

The spectrum of isolates in the present study is similar to those of earlier reports.[13-15] Important pathogens isolated were S. aureus, E. coli, K. pneumoniae, P. mirabilis and Streptococcus species, the most common agents being S. aureus and E. coli. This is in agreement with the findings of workers in Nigeria and parts of tropical Africa.[7,10,7,11] In contrast, recent reports of studies on neonates with septicaemia in non-tropical countries[16-18] show the predominance of coagulase-negative staphylococci and group B streptococci (GBS) septicaemia. The continued rarity of GBS septicaemia in this locality, in spite of the high maternal vaginal GBS colonization rate in Nigeria[19] warrants further studies. One organism of note in this study is *Klebsiella pneumoniae*, which ranked as the fourth commonest bacterial isolates. Barely 10 years earlier, Klebsiella species was rated first among all the bacterial isolates in the unit.[14] Although the reasons for the difference in prevalence of Klebsiella septicaemia are not known, the relegation of Klebsiella species to the present position demonstrates the continued changes in the predominant aetiological agent of septicaemia in this locality, and underscores the need for continual surveillance of the neonatal unit.

Antibiogram of the isolates showed decreasing sensitivity to commonly used antibiotics, especially those in the penicillin group. These findings have far reaching consequences in therapy since the penicillins, particularly ampicillin and cloxacillin, are commonly used for empirical treatment of neonates with septicaemia in the unit. The report of workers[5] from Lagos showed similar decreasing antibiotics sensitivity. The relatively free, uncontrolled use of antibiotics, especially the penicillins, might have contributed to this increasing resistant pattern.[20] In spite of the general increase in the prevalence of antibiotic resistant pathogens, some drugs, like the quinolones and the third-generation cephalosporins, have retained good sensitivity rates. However, the use of quinolones in newborns is controversial on account of the potential damage it may cause to the growth plate of growing bones.[21] Similarly, the routine use of third-generation cephalosporins for suspected neonatal septicaemia is not recommended because of the potential for rapid emergence of resistant organisms[21] and the cost of the drug.

Although sensitivity to chloramphenicol was excellent, there should be caution in its use in newborns in view of the potential danger of grey baby syndrome associated with high doses and other side effects of the drug.[21,22] Unlike cloxacillin, gentamicin had high *in-vitro* activity against S. aureus (81.8 percent). Reports from Jos[11] and Ile-Ife[12] also indicate a high sensitivity of S. aureus to gentamicin, thus supporting the recommendation of some workers[13,21] to use only gentamicin in the empirical treatment of neonatal septicaemia.

Like the Gram-positive bacteria, Gram-negative organisms also showed high degrees of resistance to all drugs tested except the quinolones. Although the third generation cephalosporins have been very useful in the treatment of Gram-negative infections, the resistant rate of 21.6 to 24.3 percent in this study spells a precarious state in the future if nothing is done to arrest the growing resistance pattern. On the contrary, gentamicin has retained good sensitivity rate despite heavy usage, thus the continued role of gentamicin in combination therapy for neonatal septicaemia appears to be justified.

Conclusion

Both the Gram-negative and Gram-positive bacteria have continued to play significant role in neonatal morbidity in this locality. Although the spectrum of bacteria in this study is similar to that from previous

reports, the change in the prevalence of Klebsiella septicaemia supports the need for continual surveillance in the unit. A combination therapy that includes gentamicin appears to be the most appropriate for the empirical treatment of neonatal septicaemia.

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Differential diagnoses of our case include Goldenhar syndrome,[3,12] Hanhart syndrome,[6-12] and OFD syndromes types I- IX.[6,9,12,13] Goldenhar syndrome, also known as oculo-auricular-vertebral (OAV) syndrome, has unilateral deformity of the external ear, facial asymmetry and vertebral anomalies. It occurs sporadically though autosomal dominant and recessive patterns have both been described in some families. Hanhart syndrome is a spectrum of hypoglossia - hypodactylia and in the severest form aglossia - adactylia. The major findings in this entity is rudimentary tongue and meromelia.[12,13] Other findings include micrognathia and peromelia. Although, once thought to be an autosomal dominant disorder, non-Mendelian pattern of inheritance has also been described.[6,7,12]

Orofaciodigital syndrome type I was first described in 1961 by Gorlin *et al*.[12] Significant features are cleft of the jaw and tongue in the area of the lateral incisors and canines, syndactyly, clinodactyly, and brachydactyly. Other findings include small nostrils, lobulated tongue with harmatomas, irregular and asymmetrical cleft of the palate, aberrant hyperplastic oral frenula, and spotty alopecia. In addition, there is severe malformation of the brain. OFD type II is the closest differential to our case. It was described in 1941 by Mohr.[12,13] The features include polydactyly, syndactyly, brachydactyly, lobulated tongue with papilliform protuberances, angular form of the alveolar process of the mandible, and supernumerary sutures in the skull. Other findings include cleft palate, pectus excavatum and tachycardia.[12] OFD type III was first described in 1971. The features are limb anomalies, mental retardation, lobulated tongue, harmatoma on the tongue, dental anomalies, bifid uvula, post axial hexadactyly of hands and feet, pectus excavatum, short sternum, kyphosis, hypertelorism and myoclonic jerks.[12] OFD type IV is characterized by lobulated tongue, pseudocleft of the lip, hyperplastic frenula, pre- and post-axial polydactyly of hands and feet, broad nasal root, lingual hamartomata, severe talipes equinovarus, mesomelic limb shortness associated with tibial hypoplasia and severe bilateral deafness.

Morphologically, the closest differential to our case is Mohr syndrome (OFD type II). The features in our case are compared and contrasted with those of Mohr syndrome in Table I which shows that there are features which differentiate our case from Mohr syndrome..

The challenges experienced in the management of the present case included financial constraints of the parents and their unwillingness to attend follow-up clinic. The basic investigations carried out were done from the department's purse. Genetic studies, though considered, were not readily available and these were to be finalized if patient had presented for follow-up. Although from the literature, the diagnosis of oral-facial-digital syndromes is essentially clinical, identifying the specific type necessitates further radiological and genetic studies which our centre lacked at the time the child presented. The rarity of the case coupled with a dearth of literature on children of African origin with OFD is the other reason for this report. In addition, some neglect or outright abuse of this baby could not be completely ruled out as refusal of the parents to bring the child for follow up may just be a manifestation of their disinterest in the baby because of the abnormalities.

Table I

Comparison between Mohr Syndrome (OFD type II) and the Present Case

Features	*Mohr Syndrome*	*Present Case*
General appearance	Usually small for gestational age	Appropriate for gestational age
Nose	Broad and depressed nasal bridge	Bilateral outgrowth in the nostrils
Skull bone	Supernumery sutures	Normal suture lines
Tongue	Tongue cleft, nodular	Severe hypoglossia
Urogenital system	No reported anomalies	Micropenis
Chest	Pectus excavatum	Pectus carinatum
Lip/palate	Midline partial cleft of the lip with occasional cleft of the palate	No cleft in lip; palatal irregularity without cleft.

We suggest the formation of a national or regional centre for genetic studies where dysmorphic babies can be seen, or in the alternative, specimens from such cases can be sent for detailed studies at no or highly subsidized cost.

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