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Research Article

ANTIBIOTIC SUSCEPTIBILITY PATTERNS OF MICROBIAL ISOLATES FROM BLOOD CULTURE IN THE NEONATAL INTENSIVE CARE UNIT OF HAMAD MEDICAL CORPORATION (HMC), DOHA, QATAR

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ABSTRACT

Introduciton: Neonatal sepsis is the leading cause of death in neonatal ICUs of hospitals. Because of wide use of broad spectrum antibiotics bacterial resistance pattern gets change from time to time. This study was aimed identify antibiotic susceptibility pattern of bacteria causing sepsis in neonatal intensive care unit (NICU) of Hamad Medical Corporation (HMC), Qatar.

Methodology : The study was retrospective and data of the study population was collected from the unit sepsis workup log-book, patients' medical records etc. Data was analysed by using SPSS 18.0 version.

Result : Out of 2,851 blood culture sent to the laboratory 302 were positive. These cultures were obtained from 176 neonates resulting in sepsis incidence rates of 6.4 cases per 1,000 live births and case-fatality rates of 17%. All gram negative bacilli were sensitive to amikacin and meropenem and to a lesser extend to cefotaxime and gentamicin. Twenty-one percent of gram negative bacilli were multidrug-resistant. All fungi isolated were Candida spp. almost all of them were sensitive to flucytosine and to a lesser extend to caspofungin, amphotericin B, and fluconazole. Overall 21% of fungi expressed resistance to antifungal agents commonly used in neonates (fluconazole, amphotericin B, and caspofungin).

Conclusion: Our study shows that the current patterns of isolates and their susceptibility data should be considered while developing empiric treatment protocols. Our experience showed high incidence rates of fungal sepsis and high risk of fungal sepsis-associated mortality in neonates. On-going susceptibility studies in addition to good infection control practices and sensible antibiotics use will decrease the rates of sepsis, guarantee success of sepsis management and maintain the potency of available antibiotics.

Keywords: Sepsis, Fungi, Gram negative bacilli.

INTRODUCTION

Incidence of infections is very high in neonatal units of hospitals.Neonatal sepsis is the leading cause of death within the first twenty eight days of life, particularly in preterm and very low birth weight (VLBW less than 1500 g) babies[1]. The overall case-fatality rates from neonatal sepsis range from 2% to as high as 50% . There are Approximately 7 cases of neonatal sepsis per 1,000 live births; this figure may increase to 162 cases per 1,000 live births in case of VLBW neonates[2]. In developed countries constant surveillance in this field has helped in identifying antibiotic resistance pattern. Because of wide use of broad spectrum antibiotics the resistance pattern of microorganism get change year by year, therefore, epidemiologic studies of infected patients and the antimicrobial sensitivity of the causative organisms are essential in identifying the empiric antibiotic protocol required for each unit[3-5]. This study was done to identify antibiotic susceptibility pattern of bacteria causing sepsis in neonatal intensive care unit (NICU) of Hamad Medical Corporation (HMC), Qatar.

AIM AND OBJECTIVES

AIM-To investigate bacterial susceptibility patterns in the neonatal intensive care unit of Hamad Medical Corporation, Doha, Qatar.

OBJECTIVES

Identify patients admitted to the neonatal intensive care unit between August 2006 and June 2008 who have culture-proven sepsis.

To check susceptibility of isolated microorganisms for antibiotics commonly use in neonates.

Methodology

Study Type-Retrospective

Study Site -Neonatal Intensive Care Unit (NICU) of Hamad Medical Corporation in Qatar, Doha.

Study Population

All the neonates admitted in NICU during the specified period and had culture proven sepsis.

Data Collection

The data for the study was collected from the unit sepsis workup log-book, patients' medical records, patient's microbiological data release in electronic Medical Records (eMR) and microbiology department electronic records. The patient-sepsis characteristics were collected including patient identification number (HMC or HC number), sex, gestational age, birth weight, type of sepsis (early-onset or late-onset) and presence of lines (peripheral or central). The patients' microbiological data including susceptibility patterns of isolated microorganisms for antibiotics commonly use in neonates were taken.

Data analysis: Data was analyzed using Statistical Package for the Social Sciences (SPSS 18.0) package. Descriptive statistics have been calculated for all the collected variables.

RESULTS

During study period (August 2008 – June 2010), there were 27,601 live births at the Women's Hospital, Hamad Medical Corporation, of which 3,497 (12.7%) were admitted to NICU (Figure 1). A total of 2,851 blood sample for blood culture were obtained, out of which 302 (10.6%) were positive. These positive blood cultures sampled obtained from 176 neonates, giving an overall incidence rate for sepsis of 6.4 per 1,000 live births, and 50 per 1,000 admissions (5%) to the NICU.

DEMOGRAPHICS OF STUDY POPULATION

The demographic data of neonates with positive blood culture are given in Table 1. Over sixty percent (60.8%) of the study population

are male with a male-to-female ratio of 1.5:1. Preterm neonates made up more that 80% of the population.

Table 1: Demographics of the Study Population

		Number (%)n = 176
Gender	Male	107 (60.8)
	Female	69 (39.2)
Gestational age	Term	32 (18.2)
	Preterm	144 (81.8)
Type of sepsis	Early-onset	30 (17.0)
	Late-onset	146 (83.0)
Type of organism	GPC	120 (68.2)
	GNB	30 (17.0)
	Fungi	26 (14.8)
Birth weight (g)	<1,000 g (ELBW)	64 (36.4)
	>1,000 g	112 (63.6)
Survival	Died	30 (17.0)
	Survivedto Discharge	146 (83.0)
CVL	Yes	6 (3.4)
	No	170 (96.6)

Preterm < 37 week gestational age, ELBW = Extremely low birth weight, CVL = Central venous line

Infection due to gram positive organisms represented 66% of the study population while 18% and 16% have developed fungal and gram negative sepsis respectively. Thirty neonates (17%) developed their first episode of sepsis at or before 3 days of life (early-onset sepsis) while the remaining 146 (83%) developed sepsis after three days of life (late-onset sepsis). Out of the study population, sixty four (36%) are extremely low birth weight (<1,000g).

MORTALITY

Thirty septic neonates died during hospitalization (Table 1). Neonates who developed fungal sepsis were nearly 10 times more likely to die during hospitalization than those who developed gram positive or gram negative sepsis (Relative risk (RR), 9.7; p-value < 0.05) (Table 2). Septic extremely low birth weight (<1,000g) neonates were found 3 times more likely to die during hospitalization compared to larger neonates (RR, 2.75; p-value < 0.05). The relatively fewer death in neonates infected with gram positive sepsis resulted in a significantly lower relative risk of dying during hospitalization when compared with other organisms. However this mathematical fallacy must not be interpreted as a protective effect (RR, 0.27; p-value < 0.05). There was no significant increased risk of dying during hospitalization in septic males compared with female (p-value >0.05). On the other hand septic neonates who had central venous lines (CVL) were almost 5 times more likely to die during hospitalization compared to those with no CVL however this was not statistically significant (p-value > 0.05).

Table 2:Mortality Statistics

Variables	**Number (%)**	**RR**	**CI_{95}**	**P-value**
Gram negative sepsis	3 (10)	0.49	(0.13-1.73)	NS
Gram positive sepsis	13 (10.8)	0.27	(0.12-0.62)	< 0.05
Fungal sepsis	14 (53.8)	9.7	(3.85-24.7)	< 0.05
Male sex	17 (15.8)	0.81	(0.36-1.8)	NS
ELBW (< 1000g)	17 (26.5)	2.75	(1.23-6.13)	< 0.05
Term	4 (12.5)	0.64	(0.2-2.0)	NS
CVL	3 (50)	5.29	(1.01-27.64)	NS

ELBW = Extremely low birth weight, Term ≥ 37 week gestational age, CVL = Central venous line
NS = Non-significant, CI_{95} = 95% Confidence interval, RR = Relative risk

Septic term neonates were more likely to survive to discharge when compared with septic preterm neonates but this also was not statistically significant (p-value > 0.05).

ANTIBIOTIC SUSCEPTIBILITY

Gram positive *cocci*

Susceptibility patterns of gram positive cocci are shown in table 3 and 4. Almost all CoNS were found sensitive to vancomycin and teicoplanin, only 2 *Staphylococcus Epidermidis* and 1 *Staphylococcus haemolyticus* isolates were found resistant to teicoplanin and no resistant was reported for vancomycin. Moreover 6 *Staphylococcus Epidermidis* and 2 *Staphylococcus haemolyticus* isolates were reported as intermediate sensitive (high minimum inhibitory concentration, MIC) to teicoplanin. Only 7.5% (12/160) of CoNS were methicillin-sensitive (i.e. sensitive to penicillins and/or cephalosporins). Nearly all *Staphylococcus Epidermidis*, *Staphylococcus capitis*, and *Staphylococcus hominis*, and all *Staphylococcus haemolyticus*, and *Staphylococcus warneri* were methicillin-resistant CoNS (MRCoNS).

TABLE 3:Sensitivity patterns of gram positive cocci (GPC)

Organism (Number)	**Oxacillin (%)**	**Penicilln G (%)**	**Gentamicin (%)**	**Vancomycin (%)**	**Ampicillin (%)**	**Teicoplanin (%)**
Coagulase-negative staphylococci**(18)	0	0	0	0	0	0
Enterococcus faecalis (15)	0	0	9 (60)	15 (100)	15 (100)	0
Enterococcus gallinarum (1)	0	0	0	0	1 (100)	0
MRAS (4)	0	0	4[¥] (100)	4 (100)	0	4 (100)
Micrococcus species** (3)	0	0	0	0	0	0
Staphylococcus aureus (15)	15 (100)	1 (6.6)	15 (100)	15 (100)	0	15 (100)
Staphylococcus capitis (22)	1 (4.5)	0	1 (4.5)	22 (100)	0	22 (100)
Staphylococcus caprae (1)	0	0	0	1 (100)	0	1 (100)
Staphylococcus chromogenes (1)	0	0	1 (100)	1 (100)	0	1 (100)
Staphylococcus epidermidis (71)	8 (11.3)	0	28 (39.4)	71 (100)	0	64[$] (90.1)
Staphylococcus haemolyticus (35)	0	0	0	35 (100)	0	34[€] (97.1)

Staphylococcus hominis (5)	1 (20)	0	2¥ (40)	5 (100)	0	5 (100)
Staphylococcus warneri (6)	0	0	0	6 (100)	0	6 (100)
Staphylococcus pasteuri (1)	1 (100)	0	1 (100)	1 (100)	0	1 (100)
Streptococcus viridans** (3)	0	1 (33.3)	0	1 (33.3)	0	0
Group B streptococcus (10)	0	7 (70)	0	7 (70)	6 (60)	0

**** Probable contaminant, ¥ = One isolate is intermediate sensitive, € = Two isolates are intermediate sensitive, $ = Six isolates are intermediate sensitive, 0 = No sensitivity was reported by the laboratory, MRSA = Methicillin-resistant Staphylococcus aureus**

All *Staphylococcus aureus* were sensitive to oxacillin and gentamicin, while nearly all the isolates were resistant to penicillin G and ampicillin. Other gram positive cocci were sensitive to ampicillin including 2 high level gentamicin resistant (HLGR) *Enterococcus faecalis* and 1 vancomycin-resistant *Enterococcus gallinarum* (VRE). Most Group B *streptococcus* isolates reported were sensitive to antimicrobials commonly use in neonates (penicillin G, ampicillin and vancomycin). Moreover no resistant for Group B *streptococcus* was reported by the laboratory. Aside from 1 *Streptococcus viridans* isolates which was sensitive to penicillin G and vancomycin, there were no susceptibility data found for isolates labeled by the laboratory as contaminant.

TABLE 4: Resistance patterns of gram positive cocci (GPC)

Organism (Number)	Oxacillin (%)	Penicilln G (%)	Gentamicin (%)	Vancomycin (%)	Ampicillin (%)	Teicoplanin (%)
Coagulase-negative staphylococci**(18)	0	0	0	0	0	0
Enterococcus faecalis (15)	0	1 (6.6)	3§ (20.0)	0	0	0
Enterococcus gallinarum (1)	0	0	0	1 (100)	0	0
MRSA (4)	4 (100)	4 (100)	0	0	0	0
Micrococcus species** (3)	0	0	0	0	0	0
Staphylococcus aureus (15)	0	14 (93.3)	0	0	13 (86.6)	0
Staphylococcus capitis (22)	21 (95.4)	22 (100)	21 (95.4)	0	0	0
Staphylococcus caprae (1)	1 (100)	1 (100)	1 (100)	0	1 (100)	0
Staphylococcus chromogenes (1)	1 (100)	1 (100)	0	0	0	0
Staphylococcus epidermidis (71)	62 (87.3)	71 (100)	40 (56.3)	0	67 (94.3)	2 (2.8)
Staphylococcus haemolyticus (35)	35 (100)	35 (100)	35 (100)	0	35 (100)	1 (2.8)
Staphylococcus hominis (5)	4 (80)	5 (100)	3 (60)	0	0	0
Staphylococcus warneri (6)	6 (100)	6 (100)	6 (100)	0	5 (83.3)	0
Staphylococcus pasteuri (1)	0	1 (100)	0	0	1 (100)	0
Streptococcus viridans** (3)	0	0	0	0	0	0
Group B streptococcus (10)	0	0	0	0	0	0

**** Probable contaminant, § = Two isolates are High Level Gentamicin Resistant, 0 = No resistant was reported by the laboratory, MRSA = Methicillin-resistant Staphylococcus aureus**

Gram negative bacilli

Susceptibility patterns of gram negative *bacilli* are shown in Table 5 and 6. All gram negative bacilli were sensitive to amikacin and meropenem and to a lesser extent to cefotaxime and gentamicin. All gram negative bacilli were resistant to ampicillin with the exception of *Haemophilus influenzae* which was 75% sensitive to ampicillin. A multi-drug resistant gram negative bacillus was isolated. *Citrobacter freundii* was found to be resistant to ampicillin, cefotaxime, gentamicin, and piperacillin/tazobactam. Extended-Spectrum Beta-Lactamase (ESBL) producing *Escherichia coli* was also isolated. They were found resistant to ampicillin, cefotaxime and to a lesser extent to gentamicin, and sensitive to amikacin, meropenem and piperacillin/tazobactam.

TABLE 5:Sensitivity Patterns of Gram Negative Bacilli (GNB)

Organism (Number)	Ampicillin (%)	Cefotaxime (%)	Gentamicin (%)	Meropenem (%)	Piperacillin/ tazobactam (%)	Cefepime (%)	Amikacin (%)
Acinetobacter baumannii (6)	0	6 (100)	6 (100)	6 (100)	6 (100)	6 (100)	6 (100)
Citrobacter freundii (2)	0	0	0	2 (100)	0	2 (100)	2 (100)
Escherichia coli (2)	0	2 (100)	2 (100)	2 (100)	2 (100)	2 (1000	2 (100)
Escherichia coli (ESBL) (7)	0	0	2 (28.5)	7 (100)	7€ (100)	0	7 (100)
Enterobacter aerogenes (6)	0	6€ (100)	6 (100)	6 (100)	6€ (100)	6 (100)	6 (100)
Enterobacter cloacae (4)	0	1 (25)	4 (100)	4 (100)	4¶ (100)	4 (100)	4 (100)
Klebsiella pneumoniae (16)	0	15 (93.7)	15 (93.7)	16 (100)	14¥ (87.5)	15 (93.7)	16 (100)
Pseudomonas aeruginosa (1)	0	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)
Serratia marcescens (4)	0	4 (100)	4 (100)	4 (100)	4 (100)	4 (100)	4 (100)
Haemophilus influenzae (4)	3 (75)	0	1 (25)	2 (50)	0	0	0

¥ = One isolate is intermediate sensitive, € = Two isolates are intermediate sensitive, ¶ = Three isolates are intermediate sensitive
0 = No sensitivity was reported by laboratory

TABLE 6:Resistance Patterns of Gram Negative Bacilli (GNB)

Organism (Number)	Ampicillin (%)	Cefotaxime (%)	Gentamicin (%)	Meropenem (%)	Piperacillin/tazobactam (%)	Cefepime (%)	Amikacin (%)
Acinetobacter baumannii (6)	0	0	0	0	0	0	0
Citrobacter freundii (2)	2 (100)	2 (100)	2 (100)	0	2 (100)	0	0
Escherichia coli (2)	2 (100)	0	0	0	0	0	0
Escherichia coli (ESBL) (7)	7 (100)	7 (100)	4 (57.1)	0	0	7 (100)	0
Enterobacter aerogenes (6)	6 (100)	0	0	0	0	3 (50)	0
Enterobacter cloacae (4)	4 (100)	3 (75)	0	0	0	0	0
Klebsiella pneumoniae (16)	16 (100)	1 (6.2)	1 (6.2)	0	2 (12.5)	1 (6.2)	0
Pseudomonas aeruginosa (1)	0	0	0	0	0	0	0
Serratia marcescens (4)	4 (100)	0	0	0	0	0	0
Haemophilus influenzae (4)	1 (25)	0	0	0	0	0	0

0 = No resistant was reported by laboratory

Aside from ampicillin, no antibiotic resistant was reported for *Acinetobacter baumannii*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Serratia marcescens*, and *Haemophilus influenzae*. Seventy-five percent (3/4) of *Enterobacter cloacae* isolated were resistant to cefotaxime while one third (2/6) of *Enterobacter aerogenes* were intermediate sensitive. Most of intermediate sensitivity of gram negative bacilli was reported with piperacillin/tazobactam, a drug not commonly uses in neonates.

FUNGI

Susceptibility patterns of fungi are shown in Table 7 and 8. The resistant to antifungal agents commonly used in our NICU (fluconazole, amphotericin B, and caspofungin) was 21% (12/57). The resistant was equally distributed between the three antifungal agents. Seven percent (2/29) of *Candida albicans* isolates were resistant to fluconazole and flucytosine, and no resistant was reported for amphotericin B or caspofungin. Of 18 *Candida parapsilosis* isolated 17% (3/18) were resistant to amphotericin B, and 11% (2/18) were resistant to caspofungin, and no resistant was reported for fluconazole or flucytosine. Three *Candida glabrata* were isolated, 67% (2/3) were resistant to fluconazole and 33% (1/3) were resistant to caspofungin.

TABLE 7:Sensitivity Patterns of Fungi

Microorganism (Number)	Fluconazole (%)	Amphotericin B (%)	Flucytosine (%)	Caspofungin (%)
Candida albicans (29)	16£ (55.1)	25∞ (86.2)	23∞ (79.3)	25∞ (86.2)
Candida glabrata (3)	1 (33.3)	1Θ (33.3)	3 (100)	2 (66.3)
Candida lusitaniae (2)	2 (100)	2 (100)	2 (100)	2 (100)
Candida parapsilosis (18)	16Θ (88.8)	9Þ (50)	18 (100)	14Θ (77.7)
Candida tropicalis (1)	1 (100)	0	1 (100)	1 (100)
*Candida spp.** (4)	4 (100)	3 (75)	4 (100)	3 (75)

*** Three isolates from one patient, Θ = The drug sensitivity test was not performed for 2 samples, ∞ = The drug sensitivity test was not performed for 4 samples, Þ = The drug sensitivity test was not performed for 6 samples, £ = The drug sensitivity test was not performed for 11 samples, 0 = No resistant was reported by laboratory**

Most of fungi isolated were sensitive to flucytosine and to a lesser extent to fluconazole, caspofungin, and amphotericin B. Several times sensitivity tests were not performed due to lack of one of antifungal agent (Table 7). Eighty-six percent (25/29) of *Candida albicans* isolated were found sensitive to amphotericin B and to caspofungin, the remaining 14% (4/29) were neither tested for amphotericin B nor for caspofungin. The sensitivity of *Candida albicans* to fluconazole was done for 18 of 29 isolates, 55% (16/29) were found sensitive. The test was not available for11 isolates. All *Candida parapsilosis* isolates were sensitive to flucytosine, 89% (16/18) to fluconazole, and 78% (14/18) to caspofungin. Six *Candida parapsilosis* isolates were not tested for amphotericin B, and 2 were not tested for fluconazole and for caspofungin. There were 4 isolates labeled by the laboratory as *Candida* species without specifying the species types, 3 of them isolated from 1 neonate. All of them were sensitive to fluconazole and flucytosine and 3 (75%) of them were sensitive to amphotericin B and caspofungin.

TABLE 8: Resistance Patterns of Fungi

Microorganism (Number)	Fluconazole (%)	Amphotericin B (%)	Flucytosine (%)	Caspofungin (%)
Candida albicans (29)	2 (6.8)	0	2 (6.8)	0
Candida glabrata (3)	2 (66.6)	0	0	1 (33.3)
Candida lusitaniae (2)	0	0	0	0
Candida parapsilosis (18)	0	3 (16.6)	0	2 (11.1)
Candida tropicalis (1)	0	0	0	0
*Candida spp.** (4)	0	1 (25)	0	1 (25)

*** Three isolates from one patient, 0 = No resistant was reported by laboratory**

DISCUSSION

As it was revealed by other studies, the vast majority of GPC in late-onset sepsis were CoNS [2,5]. Most of them (>90%) were Methicillin-resistant (MRCoNS) i.e. resistant to penicillins (e.g. oxacillin) and cephalosprins (e.g. cefotaxime) and sensitive to vancomycin and teicoplanin. This resulted in over-utilization of vancomycin and teicoplanin in our NICU. Methicillin-resistant CoNS in our NICU started the mutation process, which already resulted in an emergence of resistance to teicoplanin[6]. In addition, 1 VRE was isolated, this might be due to over-utilization of vancomycin[7]. All other gram positive sepsis including group B streptococcal sepsis could be treated by penicillin G or ampicillin[8]. Unlike report from Israel, our data revealed no resistance to meropenem and amikacin[3]. However resistance to beta-lactam antibiotics is not uncommon[9], therefore meropenem should be highly restricted and preserved for treatment of serious infections and amikacin should be used as an alternative in case of gentamicin resistance. Aside from 75% of *Haemophilus influenzae,* all other GNB were resistant to ampicillin consistent with other reports[2,10]. Multidrug-resistant GNB has been reported from NICUs around the world[11,12]. Twenty percent of GNB isolated during our study were multidrug-resistant which is less than figures from Pakistan and Italy[13,14]. However it's very important to develop strategies for monitoring, controlling, and preventing emergence of resistance strains. Resistance of GNB to gentamicin and cefotaxime is 7% and 20% respectively. This is comparable with resistance rates in Israel [3] and much less than rates from Pakistan[13]. Resistance to cefotaxime is worrisome. It's most likely from over-

utilization of cefotaxime previously in our NICU as a first line treatment for EOS[15]. Fortunately, *Klebsiella pneumoniae* in our NICU is still highly sensitive to cefotaxime and gentamicin, dissimilar to others where it's sensitive only to carbapenems[16, 17].

Most of fungi isolated in our sample were at least sensitive to one of the antifungals commonly used in neonates (amphotericin B and fluconazole), in addition to caspofungin. Currently, caspofungin is frequently used due to increased incidence of non-*albicans* fungal isolates e.g. *Candida glabrata* which are frequently resistant to fluconazole and amphotericin B[18]. The overall resistance reported by the laboratory to amphotericin B, fluconazole, and caspofungin were 11%, 9% and 8% respectively.

Internationally the incidence rates of neonatal sepsis is between 3.5 cases per 1,000 live births in North America and 38 cases per 1,000 live births in Asia[19]. The incidence rate in our NICU was 6.4 cases per 1,000 live births. This falls on the lower side of international figures, and within North American range (3.5 to 8.9)[19]. It's lower than Saudi Arabia (12.4)[20], Iraq (9.2)[21], and United Kingdom (8.4)[20], approximately equal to Nigeria (6.5), and higher than United Arab Emirates (3.4)[22], and Israel (6.1)[3].

Out of 148 neonatal deaths during the study period (5.3 cases per 1,000 live births), 30 developed sepsis, resulting in case-fatality rate of 17% (30/176). Case-fatality rates reported in the literature varies between 2% and 50%[2]. Our rates are lower than in Iraq (28%)[22], Nigeria (27.3%)[14], and United Arab Emirates (24.5%)[22], and higher than in Saudi Arabia (13%)[20], United Kingdom (9%)[20], and United States (3%)[2].

CONCLUSION

Our study shows that the current patterns of isolates and their susceptibility data should be considered while developing empiric treatment protocols. Although sepsis in our NICU is still manageable by the commonly used antibiotics, development of some resistance to glycopeptides and emergence of a relatively low number of multidrug-resistant gram negative bacilli is worrisome. Our experience showed high incidence rates of fungal sepsis and high risk of fungal sepsis-associated mortality in neonates. On-going susceptibility studies in addition to good infection control practices and sensible antibiotics use will decrease the rates of sepsis, guarantee success of sepsis management and maintain the potency of available antibiotics

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