The emerging antibiotic-resistant bacterial pathogens in the NICU: A single-center prospective study

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Abstract

introduction: Neonatal sepsis is a global health problem that leads to high mortality and increased hospital costs.

Aim and objectives: This study sought to assess the predominance of neonatal sepsis and its associated risk factors, pathogen distribution, and antibiotic susceptibility among hospitalized neonates.

Methods: A prospective study was done in the NICU of Fayoum University Hospital from November 2022 to November 2024. The study included 179 neonates with culture-proven sepsis. Clinical and laboratory data were collected, comprising different cultures and antibiotic sensitivity tests.

Results: The culture-proven sepsis incidence was 14.8%, classified as early-onset sepsis (39%) and late-onset sepsis (61%). Early-onset sepsis is more common in newborns with maternal disease. Klebsiella was the most prevalent pathogen and increased considerably in late-onset sepsis, followed by CONS. Gram-positive cocci and gram-negative bacilli demonstrated strong resistance to penicillins and cephalosporins.

Conclusion: In Egypt, Antibiotic resistance is an increasing challenge in treating neonatal sepsis. Therefore, constant monitoring of changes in microbial flora, their susceptibility to antibiotics, the prudent use of antibiotics, and the antibiotic cycling approach should be implemented to address this problem.

Keywords: Culture-proven sepsis, Early-onset sepsis, Late-onset sepsis, Gram-positive cocci, Antibiotic susceptibility, Klebsiella.

Introduction:

Neonatal sepsis, or bloodstream infection (BSI) in neonates, is a primary reason for morbidity and mortality in neonatal intensive care units (NICUs) worldwide. Reports indicate an occurrence of one to five cases per 1,000 live births [1]. The highest rates of BSI worldwide are found in Asia and Africa [2]. Early onset sepsis (EOS) and late-onset sepsis (LOS) are the usual classifications of neonatal sepsis [3].

Because the symptoms and signs of sepsis are frequently non-specific, clinicians need to exhibit a high degree of suspicion [4]. Blood culture, C-reactive protein (CRP), lactate, interleukin-6 (IL-6), interleukin-8 (IL-8), and absolute neutrophil count are among the laboratory tests that are helpful for diagnosing sepsis [5]. Blood culture is still considered the gold standard for diagnosing sepsis today, but it has certain intrinsic drawbacks, as it takes at least three to five days [5].

This leads to the administration of antibiotic therapy for a large number of neonates who are suspected of suffering from sepsis or who have potential risk factors for sepsis [4].

The bacterial organisms that cause neonatal sepsis and their antibiotic resistance patterns differ depending on the common antibiotics used in the neonatal department and the prevalent local pathogens in different geographical places and times [6]. Regular hospital assessments of bacterial infections and antibiotic resistance patterns are critical for determining the best antibiotic regimen and lowering newborn mortality in neonatal sepsis [7].

Aim of the study: This study aims to determine the common pathogens and their antibiotic resistance patterns causing neonatal sepsis at Fayoum University Hospital.

Methods

Ethics approval and consent to participate

All the legal guardians or parents of included neonates provided signed informed consent. The Local Ethics Committee of the Faculty of Medicine, Fayoum University, approved the current study (code number R441), which is in line with the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials:

The data that support the findings of this study are available upon request due to patients' confidentiality.

Competing interests

The authors declare that they have no competing interests.

Funding
This research did not obtain any grant from funding agencies.

Study design:

A prospective hospital-based study was done in the NICU of Fayoum University Hospital from November 2022 to November 2024.

Sample size:

All neonates were admitted to the NICU of Fayoum University Hospital during the study period.

Patient

This study included 1215 neonates admitted over 2 years to the Fayoum University Hospital NICU. Of these, 179 cases were diagnosed with culture-proven sepsis.

Inclusion criteria: All neonates from both genders (Preterm or full term) diagnosed with sepsis based on clinical manifestations, abnormal laboratory findings (CBC, CRP), and positive microbiological culture.

Exclusion criteria: Neonates with multiple congenital anomalies, hypoxic-ischemic encephalopathy, inborn errors of metabolism, or refusal to participate by patients' guardians.

Study procedure

All the included neonates were subjected to the following

1. Detailed maternal and neonatal history: including gestational age, mode of delivery, maternal illness, and postnatal age.
2. General and systemic neonatal examination
3. Laboratory evaluation including sepsis workup:

- Complete blood count (CBC) with differential: A whole blood sample was processed using Sysmex XN 1000 (Japan).
- Quantitative CRP: A serum sample was processed using latex agglutination on Cobas C311 (Roche, Germany) [8].
- Blood culture, was done on neonates with suspected sepsis.

Following NICE and AAP recommendations, we employed an aminoglycoside and ampicillin as first-line antibiotic therapy for neonatal sepsis [9]. Cefotaxime was added if clinical improvement did not occur or if meningitis was suspected. Occasionally, endotracheal aspirate cultures were taken from patients on mechanical ventilation if there were clinical indications of ventilator-associated pneumonia, including higher oxygen consumption, elevated settings of ventilator support, deteriorating findings on radiographs, or variations in the consistency, color, or volume of the tracheal aspirate. CSF (Cerebrospinal fluid) culture was performed when meningitis was strongly suspected or in neonates with worsening clinical status despite antibiotic therapy. Urine culture was done for cases with LOS or congenital anomalies of the urinary tract or unexplained indirect hyperbilirubinemia. Pus from skin was cultures for a case presented by skin abscesses.

Lastly, our studied culture-proven sepsis neonates were classified into Early-onset sepsis and late-onset sepsis. According to the timing of sepsis diagnosis, neonates were classified into two groups: those diagnosed with EOS ≤72 hours of life and those diagnosed with LOS >72 hours of life [10].

Microbiological sampling and Sample processing

After aseptic collection of samples, pus, CSF, and endotracheal aspirates were inoculated onto solid media (Blood and MacConkey agar), while urine samples were inoculated onto cysteine lactose electrolyte-deficient (CLED) agar medium. Blood samples were inoculated into Bactec blood culture bottles, processed in Bactec, and subcultured onto Blood and Macconkey agar.

The Kirby-Bauer modified disc diffusion technique was utilized to determine the antibiotic susceptibility of each bacterial isolate, following the guidelines defined by the Clinical and Laboratory Standards Institute (CLSI) [11]. According to the CLSI criteria and the Minimum Inhibitory Concentration (MIC) values, the organisms were identified as either susceptible or resistant to these antibiotics. Multidrug-resistance (MDR) organisms are defined as those that have developed non-susceptibility to at least one agent in three or more antibiotic groups [12].

Statistical analysis of data:

Version 22 of the Statistical Package for the Social Science (SPSS) software was utilized to arrange, tabulate, and statistically analyze the data collected (SPSS Inc, USA). The independent t-test was utilized to compare early- versus late-onset sepsis. The quantitative data were presented as means and standard deviations (SD). Numbers and percentages were used to present the qualitative data, and the chi-square (χ^2) test was conducted to determine significance. A significance level of $P < 0.05$ was chosen for interpreting the results of the significance tests.

Results

Throughout the study period, 1215 cases were hospitalized: of these, 179 (14.7%) neonates were diagnosed with culture-proven sepsis, which was classified into two categories: early-onset sepsis (39%) and late-onset sepsis (61%).

Table 1: Demographic and maternal data of the studied cases.

	Early onset (N=70)		**Late-onset (N=109)**		**P-value**
Gender					
Male	42	40.0%	63	60.0%	0.770
Female	28	37.8%	46	62.2%	
Type of Maternal illness					
Diabetes mellitus	7	35.0%	13	65.0%	<0.001*
Hypertension	3	42.9%	4	57.1%	
PROM	16	84.2%	3	15.8%	
Preeclampsia	4	80.0%	1	20.0%	
Fever	3	50.0%	3	50.0%	
obstructed labor	1	50.0%	1	50.0%	
Mode of delivery					
Vaginal	23	33.3%	46	66.7%	0.213
Cesarean section	47	42.7%	63	57.3%	
Gestational age (weeks)	34±4	27-40	37±3	29-43	<0.001*
Postnatal age (days)	2±1	1-9	13±8	4-31	<0.001*

PROM: premature rupture of membranes, *Significant at p<0.05

Table 1 displays that most of our cases were males. This table suggests that EOS is more likely to occur in newborns with maternal health conditions.

Table 2: Clinical data findings among the study group.

	onset of sepsis				**P-value**
	Early onset (N=70)		**Late onset (N=109)**		
Weight(kg)	1.92±0.7	0.8-3.3	2.38±0.7	1-4	<0.001*
Poor Moro reflex	27	46.6%	31	53.4%	0.158
Poor Suckling reflex	44	42.7%	59	57.3%	0.249
Seizures	12	35.3%	22	64.7%	0.613
Poor activity	33	42.9%	44	57.1%	0.372
Hypotonia	18	58.1%	13	41.9%	0.017*
Hypotension	40	53.3%	35	46.7%	<0.001*
Delayed capillary refill	34	54.8%	28	45.2%	0.002*
Apnea	19	47.5%	21	52.5%	0.217
Ventilatory support					
Absent	24	29.3%	58	70.7%	0.018*
CPAP	13	38.2%	21	61.8%	
Mechanical ventilator	33	52.4%	30	47.6%	
Temperature instability	20	58.8%	14	41.2%	0.009*
Respiratory distress	57	46.3%	66	57.3%	0.003*
Feeding intolerance	22	36.1%	39	63.9%	0.549

Oliguria	10	38.5%	16	61.5%	0.942
bleeding tendency	27	52.9%	24	47.1%	0.017*
Sclerema	16	53.3%	14	46.7%	0.080
Hospital stays (days)	16±12	1-62	19±11	3-55	0.191
Outcome					
Discharge	45	36.9%	77	63.1%	0.625
Death	24	44.4%	30	55.6%	
Referred	1	33.3%	2	66.7%	

CPAP: continuous positive airway pressure. *Significant at p<0.05

Table 2 demonstrates that the predominant clinical manifestation was respiratory distress, followed by poor suckling. This table suggests that EOS occurs more commonly in neonates with lower birth weights. The mortality rate was 30.2%.

Table 3: Sepsis workup findings among the study group.

	Early onset sepsis (N=70) Mean ± SD	**Late-onset sepsis (N=109)** Mean ± SD	**P- value**
Hemoglobin (g/dl)	13.5±3.2	11.7±3.1	<0.001*
Platelets (10^3/mm^3)	225±132	215±141	0.62
TLC (10^3/mm^3)	23.3±33.7	14.2±9.4	0.03*
Immature /Total neutrophils	0.19±0.10	0.22±0.12	0.215
Quantitative CRP (mg/L)	34±43	30±35	0.230

TLC: total leukocytic count, CRP: C-reactive protein, *Significant

Table 3 shows that there was a statistically significant difference between EOS, and LOS as regards TLC, and hemoglobin but no statistically significant difference in platelets, and I/T ratio.

Table 4: Bacteriological profile of isolates.

	onset of sepsis				P-value
	Early onset (N=71)		Late onset (N=118)		
Blood culture growth	54	42.7%	71	57.3%	0.134
Endotracheal aspirate culture	13	36.1%	23	63.9%	0.096
Urine culture	3	16.7%	15	83.3%	0.005*
CSF culture	1	16.7%	5	83.3%	0.102
Pus culture	0	0.0%	4	100.0%	
Organism					
E. Coli	6	31.6%	13	68,4%	0.108
Klebsiella	18	28.1%	46	71.9%	<0.001*
Pseudomonas	6	42.9%	8	57.1%	0.593
staph aureus	11	47.8%	12	52.2%	0.845
CONS	9	34.6%	17	65.4%	0.617

Enterobacter	9	56.2%	7	43,8%	0.617
Streptococci	0	0.0%	3	100.0%	
Acinetobacter	7	53.8%	6	46,2%	0.782
Enterococci	1	100.0%	0	0.0%	
Candida non albicans	2	22.2%	7	77.3%	0.096
Candida albicans	1	100.0%	0	0.0%	
Resistance pattern					
MDR	33	45.2	40	54.8	0.174
ESBL	7	25.9	20	74.1	0.012*
MRSA	9	45	11	55	0.655

CSF: Cerebrospinal fluid, E. Coli: Escherichia coli, CONS: Coagulase-negative staphylococci, MDR: Multidrug resistance, ESBL: Extended-spectrum beta-lactamase, MRSA: Methicillin-resistant Staphylococcus aureus.

Table 4 shows 125 positive blood cultures, 36 positive endotracheal aspirate cultures, 18 positive urine cultures, 6 positive CSF cultures, and 4 positive pus cultures. Positive urine cultures increased significantly with LOS. Gram-negative bacilli were the predominant isolates (66%) and increased significantly with LOS. ESBL prevalence increased significantly in LOS.

Table (5): Antibiotics susceptibility patterns of gram-positive cocci.

	Staph aureus		**CONS**		**Streptococci**		**Enterococci**		**Total**	
	S/N	**R/N**	**S/N**	**R/N**	**S/N**	**R/N**	**S/N**	**R/N**	**S/N**	**R/N**
Ampicillin-sulbactam	0/6	6/6	3/8	5/8	0/1	1/1	1/1	0/1	4/16	12/16
Amoxicillin-clavulanic	2/9	7/9	1/10	9/10	0/1	1/1	-	-	3/20	17/20
piperacillin tazobactam	0/1	1/1	-	-	-	-	-	-	0/1	1/1
Cefoxitin	0/17	17/17	1/19	18/19	-	-	0/1	1/1	1/37	36/37
Ceftazidime	0/3	3/3	0/5	5/5	0/2	2/2	0/1	1/1	0/11	11/11
Cefepime	0/2	2/2	0/2	2/2	0/1	1/1	-	-	0/5	5/5
Cefotaxime	0/9	9/9	0/10	10/10	0/1	1/1	0/1	1/1	0/21	21/21
Cefoperazone	1/6	5/6	0/3	3/3	-	-	-	-	1/9	8/9
Cefoperazone-sulbactam	1 /2	1 /2	4/4	0/4	-	-	1/1	0/1	6/7	1/7
Imipenem	0/1	1/1	0/1	1/1	-	-	1/1	0/1	1/3	2/3
Ertapenem	0/1	1/1	-	-	-	-	-	-	0/1	1/1

Meropenem	0/3	3/3	1/1	0/1	-	-	-	-	1 /4	3 /4
Vancomycin	18/20	2/20	22/22	0/22	0/1	1/1	1/1	0/1	41/44	3/44
Teicoplanin	11/13	2/13	12/14	2/14	1 /2	1 /2	1/1	0/1	25/30	5/30
Clindamycin	7/18	11/18	9/17	8/17	2/3	1/3	0/1	1/1	18/39	21/39
Erythromycin	1/9	8/9	0/13	13/13	2/3	1/3	0/1	1/1	3/26	23/26
Amikacin	5/8	3/8	6/11	5/11	0/2	2/2	1/1	0/1	12/22	10/22
Gentamycin	3/16	13/16	5/16	11/16	2/3	1/3	1/1	0/1	11/36	25/36
Colistin	1/1	0/1	-	-	-	-	-	-	1/1	0/1
Polymyxin	1/1	0/1	2/2	0/2	1/1	0/1	-	-	4/4	0/4
Ciprofloxacin	7/19	12/19	10/17	7/17	0/2	2/2	1/1	0/1	18/39	21/39
Levofloxacin	3/10	7/10	7/10	3/10	1 /2	1 /2	-	-	11/22	11/22
Tigecycline	3/3	0/3	5/6	1/6	-	-	-	-	8/9	1/9
Linezolid	10/12	2/12	9/10	1/10	0/1	1/1	1/1	0/1	20/24	4/24

CONS: Coagulase-negative staphylococci, S: Susceptible, R: Resistant, N: Number of tested organisms, -: not tested.

Table 5 demonstrates the patterns of antibiotic resistance of gram-positive cocci. High resistance was noted with the penicillin antibiotics group and cephalosporins. The least resistance patterns were observed for polymyxin, vancomycin, tigecycline, and Linezolid.

Table (6): Antibiotics susceptibility patterns of gram-negative bacilli.

	E-coli		**klebsiella**		**Pseudomonas**		**Enterobacter**		**Acinetobacter**		**Total**	
	S/N	**R/N**	**S/N**	**R/N**	**S/N**	**R/N**	**S/N**	**R/N**	**S/N**	**R/N**	**S/N**	**R/N**
ampicillin - sulbactam	2/12	10/12	3/48	45/48	0/9	9/9	1/14	13/14	0/9	9/9	6/92	86/92
Amoxicillin-clavulanic	1/7	6/7	1/39	38/39	0/7	7/7	1/9	8/9	0/7	7/7	3/69	66/69

Piperacillin	-	-	2/4	2/4	2/3	1/3	-	-	-	-	4/7	3/7
Cefoxitin	4/17	13/17	4/58	54/58	0/11	11/11	0/15	15/15	0/13	13/13	8/114	106/114
Ceftazidime	2/17	15/17	4/53	49/53	1/13	12/13	0/13	13/13	0/12	12/12	7/108	101/108
Cefepime	3/12	9/12	3/51	48/51	0/8	8/8	3/13	10/13	0/1	10/10	9/94	85/94
Cefoperazone	0/2	2/2	0/8	8/8	0/3	3/3	-	-	0/1	1/1	0/14	14/14
Cefotaxime	1/16	15/16	3/56	53/56	0/11	11/11	0/13	13/13	0/13	13/13	4/109	105/109
Cefoperazone-sulbactam	4/10	6/10	5/25	20/25	2/3	1/3	0/6	6/6	1/8	7/8	12/52	40/52
ceftazidime avibactam	-	-	4/8	4/8	-	-	-	-	-	-	4/8	4/8
Imipenem	9/16	7/16	24/57	33/57	3/11	8/11	5/13	8/13	5/10	5/10	46/107	61/107
Meropenem	9/16	7/16	7/39	32/39	1/10	9/10	5/10	5/10	0/9	9/9	22/84	62/84
Aztreonam	1/1	0/1	1/4	3/4	0/1	1/1	-	-	-	-	2/6	4/6
Teicoplanin	1/3	2/3	2/3	1/3	-	-	-	-	0/1	1/1	3/7	4/7
Clindamycin	0/1	1/1	1/10	9/10	0/2	2/2	0/1	1/1	-	-	1/14	13/14

Gentamycin	3/12(25%)	9/12(75%)	3/29(10%)	26/29 (90%)	1/6(17%)	5/6	1/9	8/9	0/3	3/3	8/59	51/59
Amikacin	2/7	5/7	6/29	23/29	2/6	4/6	3/8	5/8	0/4	4/4	13/54	41/54
Colistin	9/12	3/12	35/37	2/37	6/6	0/6	8/8	0/8	3/5	2/5	61/68	7/68
Polymyxin	7/7	0/7	25/29	4/29	9/10	1/10	5/5	0/5	4/5	1/5	50/56	6/56
Ciprofloxacin	5/15	10/15	11/46	35/46	1/8	7/8	1/10	9/10	4/12	8/12	22/91	69/91
Levofloxacin	3/11	8/11	10/33	23/33	1/7	6/7	2/7	5/7	4/7	3/7	20/65	45/65
Tigecycline	7/7	0/7	30/36	6/36	1/6	5/6	9/9	0/9	4/8	4/8	51/66	15/66
Linezolid	-	-	-	-	-	-	0/1	1/1	-	-	0/1	1/1

E. Coli: Escherichia coli, S: Susceptible, R: Resistant, N: Number of tested organisms, -: not tested

Table 6 displays the antibiotic resistance patterns of gram-negative bacilli. They showed high resistance to penicillin, cephalosporins, vancomycin, and linezolid. They showed the least resistance to colistin, polymyxin, and tigecycline.

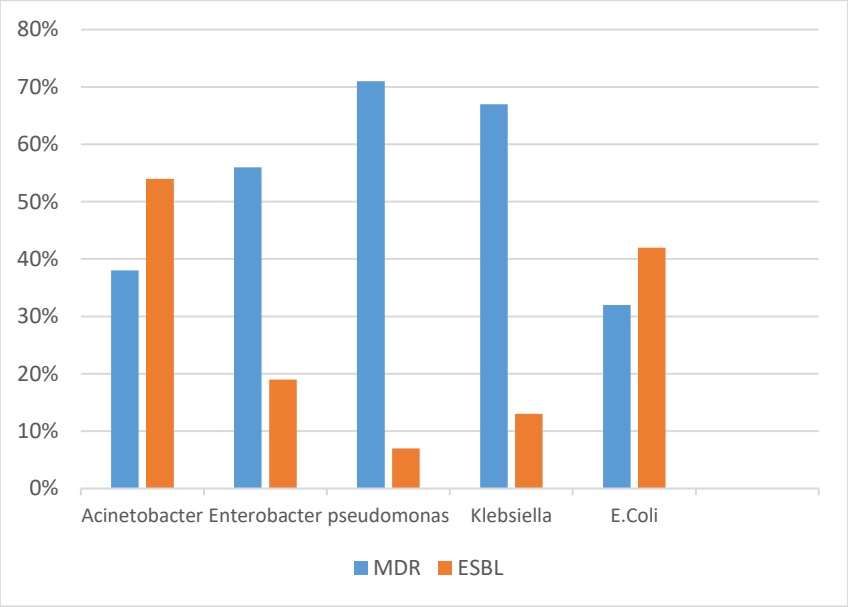

Figure (1): Proportion of MDR and ESBL in gram-negative bacilli.

MDR: Multidrug resistance, ESBL: Extended-spectrum beta-lactamase

The proportion of MDR was 32%, 67%, 71%, 56%, and 38% among *E. coli*, *Klebsiella*, *Pseudomonas*, *Enterobacter*, and *Acinetobacter*, respectively, while the

proportion of ESBL was 42%, 13%, 7%, 19%, and 54% among the same organisms, as presented in **Figure (1)**.

Discussion

Despite advances in healthcare, neonatal sepsis remains a major cause of morbidity and mortality. Its incidence in developing countries is 3–20 times higher than in developed nations [13].

In our investigation, the culture-proven sepsis rate was 14.8%. Ansari et al. [14] reported comparable results (12.6%). However, a study from Nepal indicated a lower incidence rate of 2.1% [15]. Al-Shamahy et al. observed a far higher incidence rate (57%) [16]. Sample size variations, antibiotic administration, unusual organisms, and effective infection control can influence the culture positivity rates in neonatal septicemia.

We discovered that late-onset sepsis occurred more frequently than early-onset disease, consistent with a report from Nigeria [17]. However, Ogundare et al. [18] observed that early-onset disease was more prevalent.

Males were shown to have a greater risk than females of developing septicemia (58.7%), which is consistent with both the Gianoni study from Ethiopia, which reported rates of 52% and 58.1%, respectively. However, the mechanism is not fully characterized or clear. It is thought to be complex, involving genetic, immune, and hormonal components [19].

Our findings were consistent with Jabiri et al. [20], who discovered that PROM may raise the potential risk of susceptibility to ascending infections during pregnancy.

Lower gestational age was related to EOS in the current work, which is in line with studies from Mexico, which revealed that preterm neonates have a higher risk of EOS while LOS is not significant [21]. This is because premature infants have a limited ability to raise neutrophil production and impaired neutrophil function [22]. However, this contradicts the findings of Awoala and Nnenna [23], who observed that premature babies suffered more frequently from LOS, most likely due to prolonged hospital stays.

In the current investigation, the most prevalent presenting symptom was respiratory distress (68.7%), followed by poor suckling (57.5%). In Jain et al.'s investigation, respiratory distress (42.6%) was the most common presenting symptom [24]. Nonetheless, in the Magzoub et al. study, the most frequent presenting symptom was fever (63.33%), followed by respiratory distress [25].

In this study, the overall mortality rate for septic infants was 30.2%. This rate is lower than the sepsis-related mortality reported in another study in Egypt [26]. Numerous publications reviewed from various poor countries found a broad range of infection-related neonatal mortality, from 8 to 80 percent [27].

Blood cultures accounted for 66.1% of all positive cultures, followed by endotracheal specimens (19.1%). This is congruent with Buthelezi et al. [28]. We agreed with Samayam et al. [29], who mentioned that positive urine cultures were greater in LOS than in EOS.

Gram-negative isolates accounted for 66.1% of neonatal septicemia cases, which is consistent with the results of Roy et al. [30]. In contrast, another international research found gram-positive cocci [31]. Klebsiella pneumoniae was the most common organism in both EOS and LOS. This outcome was consistent with Egyptian reports across two decades [32][33][34]. However, other Egyptian reports identified CONS as the primary cause of sepsis in 2011/2012 [26]. These data confirm the hypothesis that the variety of organisms causing sepsis varies by place and changes over time, even within the same site [35].

The distribution of organisms in our study was similar between EOS and LOS. These findings are consistent with those of Zaidi et al., who demonstrated that the distinction between EOS and LOS routes of infection and pathogens may not be accurate in developing countries [36].

In agreement with Patel et al. [37], we concluded that CoNS was the most prevalent gram-positive organism. The incidence of MRSA within Staphylococcus aureus in our work was 87%, versus 70.4% in the research by Kamath et al. [38] In the same work, ESBL generation for Klebsiella and E. coli was 81.8% and 73.1%, respectively, compared to 13% and 42% in the current study.

The low incidence of streptococci (1.6%) in this study can be attributed to various factors, including the presence of less virulent species, high concentrations of transplacental protective antibodies, and unreported early neonatal or premature deaths and stillbirths [39].

In agreement with Mohsen et al. [40], gram-positive cocci demonstrated the greatest resistance to penicillin antibiotics and cephalosporins. Gram-positive cocci showed the least resistance to polymyxin, vancomycin , tigecycline, and linezolid. Recent investigation have demonstrated favorable susceptibility patterns for vancomycin and linezolid[41].

Our findings indicate that gram-negative isolates exhibit higher resistance to third-generation cephalosporins. This trend aligns with recent studies, which have widely documented the rising predominance of resistance to these antibiotics [42]. Our investigation found substantial levels of aminoglycoside resistance. Even within the aminoglycoside spectrum, we agreed with several authors who found that amikacin—being less commonly administered in their units—was more effective than gentamicin, which was used more frequently [43].

The rising incidence of MDR gram-negative bacteria, coupled with a relative lack of novel antibiotics to combat them, has led to the renewed use

of other drug classes, such as polymyxins and colistin [44].

Selecting an appropriate empiric antibiotic treatment at Fayoum University's NICU remains challenging. Strict infection control procedures, handwashing, and antibiotic policies are used to combat antibiotic resistance in NICUs; still, continuous surveillance is essential for tracking trends, risk factors, and outbreak management [45].

This study has limitations. It was done at a single hospital; thus, the antibiotic resistance patterns reported may not be representative of the situation nationwide, even though other reports from our country align with our findings.

Conclusion:

This study demonstrated that LOS was more prevalent than EOS. Both gram-negative bacilli and gram-positive cocci exhibited high resistance to a variety of broad-spectrum antibiotics. According to this study's recommendations for international standards, the use of antibiotics in both community and hospital settings should be restricted. Antimicrobial resistance may be mitigated through continuous monitoring of microbial flora changes, antibiotic susceptibility, prudent antibiotic use, and the antibiotic cycling approach

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