Microbial Profile of Neonatal Septicemia and Antibiotic Susceptibility Pattern of the Isolates at A Tertiary Care Hospital, Western-India

Dr. Nidhi G. Sathwara[1], Dr.Atit D. Shah[2], Dr.Sumeeta T. Soni[3], Dr. M. M. Vegad[4], Dr.Dharmishtha Tada[5*]

[1] Assistant Professor, Department of Microbiology, GMERS Medical College and Hospital, Sola, Ahmedabad

[2] Associate Professor, Department of Microbiology, Smt. NHL Municipal Medical College, Ahmedabad

[3] Associate Professor, Department of Microbiology, B.J. Medical College and Civil Hospital, Ahmedabad

[4] Professor, Department of Microbiology, M. K. Shah Medical College & Research Center, Ahmedabad

[5] Tutor, Department of Microbiology, B.J. Medical College and Civil Hospital, Ahmedabad

***Corresponding Author:**Dr.Dharmishtha Tada
Email:nidhs777@gmail.com
DOI:10.56018/2023065

Abstract

Background: The emergence of multidrug-resistant microbial agents in hospitals is a strenuous task for clinicians to treat neonatal septicemia. It is one of the leading causes of mortality and morbidity in developing countries among neonates. **Aims**: To study the microbial profile of agents causing neonatal septicemia, their susceptibility pattern, risk factors, and review the antibiotic prophylaxis policy to limit the injudicious use of antimicrobial agents. **Material &Methods**: The present study included 2550 neonates less than 28 days with clinical manifestation of septicemia from neonatal intensive care unit at the Tertiary care teaching center in western India from December 2017 to May 2019. Aseptically collected blood inoculated into BacT/ALERT blood culture bottle. Further isolation, identification, susceptibility testing was done from the positive signal bottle and interpreted susceptibility according to the latest CLSI guidelines. **Result**: Microbiologically proven neonatal septicemia detected in 675(26.47%) patients. The predominant organisms isolated were Klebsiellapneumoniae 170 (25%). Pan-antibiotic resistance noted among 8(1.83%) gram-negative rods. **Conclusion**: Overall, increased emergence of resistance to the cephalosporin, penicillin group, and azole group of antibiotics. In the present study, fluoroquinolones, tetracycline and voriconazole are the better preferred.

Keywords: Neonatal septicemia, injudicious use of antimicrobial agents, review the antibiotic prophylaxis policy

Introduction

Neonatal sepsis is a systemic inflammatory condition of bacterial, viral, or fungal origin within the first 28 days of life associated with hemodynamic changes and clinical manifestations. It is one of the leading causes of mortality and morbidity in neonates. According to the age of onset, neonatal sepsis has two classes: (1) early-onset (within the first 72 hours of life) and (2) late-onset (after 72 hours but within the first 28 days of life). It assumed organisms acquired before and during delivery (or maternal-fetal infection) are mainly responsible for early-onset, and after delivery from the environment (nosocomial or community sources) are responsible for late-onset neonatal sepsis [1].

According to the World health organization, approximately 1.6 million neonatal deaths occur globally every year, from which 40% of all neonates die in developing countries. The risk factors are associated with neonatal septicemia: premature rupture of membrane, prolonged rupture, prematurity, UTI, poor nutrition, low birth weight, birth asphyxia, and congenital deformities. The various

diagnostic methods are available for neonatal septicemia include CRP, CBC, platelet count, and ESR, but the blood culture is the gold standard. There are epidemiological differences in the incidence, risk factors, microbial pattern, and antimicrobial susceptibility pattern of neonatal sepsis among different regions and countries in the world[2].

Aim

The objective of the present task is to study the microbial profile, antibiotic susceptibility pattern, risk factors, the incidence of neonatal septicemia. Also, limit the injudicious use of antimicrobial agents by reviewing the antibiotic prophylaxis policy.

Materials and Methods

Source of data

The study includes 2550 neonates with clinical manifestation of septicemia from neonatal intensive care unit at the Tertiary care teaching center, western side of India: December 2017 to May 2019.

Type of study: A prospective observational study.

Inclusion criteria

- The clinicians diagnosed neonates with clinical signs of sepsis and evidence of positive blood culture results.

Exclusion criteria

- Neonates were clinically diagnosed as sepsis but not confirmed by blood culture and were born outside of our center.

The proforma include age of onset, sex, type of isolates & associated risk factors.

The study has three parts

1. Sample collection
2. Sample processing and identification
3. Antibiogram

1] Sample collection and receiving[3]: The clinicians suspected signs of neonatal septicemia, then 0.5 to 5 ml of blood collected with aseptic precaution before starting antimicrobial therapy by the resident doctors and the nursing staff. The collected blood inoculates into pediatricBacT/ALERT blood culture bottles figure:1.The samples with duly filled LRF are received and accepted in the laboratory, then sample ID is generated using LIS.

2] Processing of samples done in the following ways[3]:

The labeled bottle loads into the BacT/ALERT 3D continuous automated monitoring system with expandable detection units with self-contained incubation (37◦c) chambers that analyze the color changes every ten minutes. The machine emits light and beep sound as soon as the threshold value reaches. That indicates positive growth. The bottles that did not show emission after seven days were considered no growth. The principle of BacT/ALERT is colorimetric detection of CO2 produced by growing microbes. Each bottle contained specialized Liquid Emulsion Sensors at the bottom of the culture bottle, visibly changing color in response to shifts in pH by rising CO2 levels.

Figure:1

Direct microscopy:

Smears were prepared from the positively signaled bottle using a needle syringe, on a clean glass slide; Gram staining was done and examined under the light microscope.

Processing of sample for culture[3]:

The blood from the all-positive signaled bottle was inoculated on MacConkey, blood, and chocolate agar plates. The plates were incubated aerobically at 37°C in an incubator, and results were read after

24 hours. All positive cultures were, identified by their characteristic colony morphology, compared gram staining from the direct and culture smears, and by the battery of biochemical reactions.
The following conventional biochemical tests were done:
Gram-positive bacteria: catalase, coagulase (tube & slide), mannitol fermentation, bile esculin slant &pyrrolidinyl peptidase test.
Gram-negative bacteria: Oxidase, Triple Sugar Iron, Citrate utilization, Phenylalanine Deaminase, Urease, Indole, Methyl Red, VogesProskauer, Sugar fermentation, Nitrate Reduction, Acetamide, Amino Acid Decarboxylase, and Oxidation/Fermentation tests.
The Yeast isolates: Germ tube test, sugar assimilation test. The yeast isolates were also inoculated into Sabouraud dextrose agar, corn meal agar, and CHROM agar for spp. identification.
3] Antibiogram of isolates[3]: Kirby Bauer disk diffusion test for antimicrobial susceptibility testing (AST) was performed after bacterial growth on the mentioned agar plates.
Suspension: At least 3-5 well-isolated colonies were selected using a sterile cotton swab and were transferred into the normal saline tube and mixed well. The turbidity of the suspension was adjusted to 0.5 % McFarland turbidity standard for bacteria and 5% McFarland turbidity standard for candida spp. A lawn culture was done on MHA for bacteria and MHA with glucose (2%) and methylene blue (50 µg/ml) for Candida species, then antibiotic disc was applied according to organisms & inverted plates were incubated aerobically at 37°C, and results were read after 18-24 hours.
Reading of plates and interpretation of results:
After incubation of plates, the results were read by the naked eye by using an antibiotic zone scale, and the zone of inhibition was measured in mm. The results were reported as follows: Susceptible(S), Susceptible dose-dependent(SDD), Intermediate(I), Resistant (R), and special tests were done for detecting MRSA, MBL, ESBL, and AmpC based on CLSI 2017 guidelines.

Quality control:

The reliability of the study findings was assured by implementing quality control (QC) measures throughout the whole laboratory works. All materials and equipment were validated and procedures aseptically managed. Culture media were checked for sterility and performance during the lot changes. CLSI recommended bacterial strains were used for quality control: Staphylococcus aureus ATCC 25923, Staphylococcus aureus ATCC 43300, Klebsiellapneumoniae ATCC 700603, Escherichia coli ATCC 25922, Enterococcus faecalis ATCC 29212**,** Pseudomonas aeruginosa ATCC 27853.

Detection of Various Resistance Pattern:

1. **Detection of Methicillin resistance**

A lawn culture of S. aureus was done on MHA then a 30µg cefoxitin disc was placed on it for checking methicillin resistance. For the quality purpose, S. aureus ATCC 25923 as a negative and ATCC 43300 as a positive control were used. If the zone of inhibition of 30µg cefoxitin disc was ≤ 21 mm indicates MRSA.

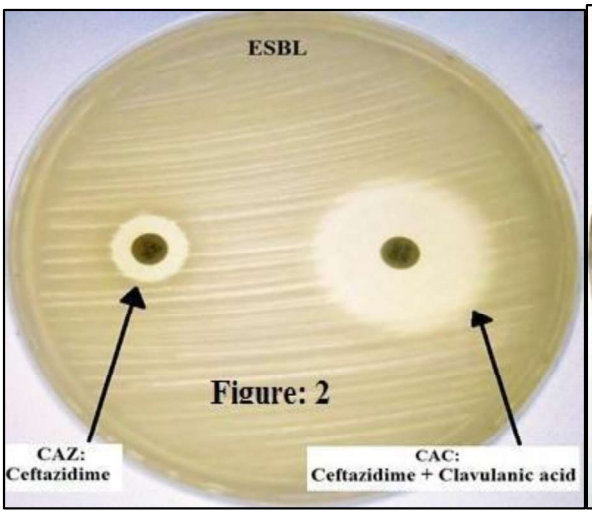

Figure: 2

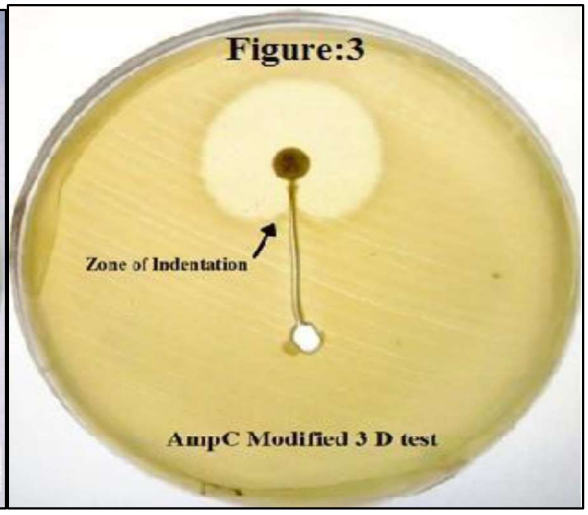

Figure:3

2. **Detection of ESBL**

Screening test: After a lawn culture of test isolates, discs of Ceftazidime (30µg) and Cefotaxime (30µg) were placed on the MHA plate. After incubation the zone of Ceftazidime ≤ 22mm and Cefotaxime ≤ 27mm were taken as an indicator of ESBL production which was confirmed by phenotypic combination disc test.
Phenotypic combination disc test: After a lawn culture of test isolates, discs of Ceftazidime (30 µg), and Ceftazidime plus clavulanic acid (30 µg/10 µg) were placed on the MHA plate more than 25 mm apart. After incubation, if the zone diameter around the disc with clavulanic acid is increased by ≥5 mm over the Ceftazidime (30 µg) disc alone, it confirmed ESBL production (figure:2).

3. Detection of Amplified cephalosporinase (ampc)

Screening Test: Isolates having ≤18mm zone to cefoxitin (30 µg) disc indicate AmpC β- Lactamases producer.
Confirmatory test for Ampcβ-lactamase:Modified three-dimensional test (MTDT)
After performing the lawn culture of ATCC 25922 E. Coli on MHA plates, the cefoxitin (30 µg) disc was placed on the center. By using a sterile blade, a linear slit (3 cm long) was made up to a point 3 mm away from the edge of the cefoxitin disc. With a sterile Pasteur pipette, a well of 8 mm diameter was made at the outer end of the slit, at a distance of 0.5 cm from the edge of the plate. The wells were loaded with organisms' inoculum until the well was full. After incubation, presence of indentation of growth around slit indicates AmpCproduction (figure:3).

4. Detection of Carbapenemases

Modified Hodge Technique:
After doing a lawn culture of E. Coli ATCC 25922 on MHA plates, we placed an ertapenem (10μg) disc in the center of MHA and had streaked the test isolates from the edge of the disk to the edge of the plate. The Cloverleaf appearance noted at the streaking line towards the ertapenem disc indicates carbapenemases production.
Detection of Class B Carbapenemase by phenotypic method combined disc synergy test:
A lawn culture of the test strain had done on the MHA plate, then Imipenem (10mcg) and Imipenem with EDTA were placed. After incubation, if the Zone diameter increased around the disc of the Imipenem with EDTA ≥5 mm over the Imipenem disc alone, indicate Metallo beta-lactamase production.

5. Colistin sulfate agar testing[3]

For coistin agar testing, powder forms of 2µg/ml Colistin had incorporated into the MHA plate. 32-36 inoculums of test organisms applied simultaneously into colistin-containing MHA plate by inoculums loop wire. After 24 hours of incubation at 37°C, if growth occurs indicates the organism is resistant to Colistin. Such strains under AMR Surveillance Program forward to NCDC New Delhi.
Antibiotics used:For Gram-positive organisms:Gentamicin (10 μg), amikacin (30μg), tetracycline (30 μg), ampicillin (10 μg), ampicillin-sulbactam (20μg), co-trimoxazole (25 μg), cefuroxime (30 μg), (ciprofloxacin, levofloxacin ((5 μg) each)), Penicillin G (10 units), erythromycin (15 μg), clindamycin (2 μg), cefoxitin (30 μg), (vancomycin, linezolid (30 μg) each)), high-level gentamicin (120 μg), for Gram-negative organisms: Gentamicin (10 μg), amikacin (30μg), tetracycline (30 μg), ampicillin (10 μg), ampicillin-sulbactam (20μg), co-trimoxazole (25 μg), cefuroxime (30 μg), (ciprofloxacin, levofloxacin ((5 μg) each)), Ceftazidime (30 μg),cefotaxime (30μg) &cefoperazone (75 μg),cefepime (30 μg), and imipenem (10μg) used. The anti-Pseudomonas antibiotics like piperacillin (100 μg), ticarcillin (75μg), mezlocillin (25μg), netilmicin (30 μg) &cefepime-tazobactam (40 μg) were used. The Antifungal discs like (Amphotericin & Nystatin (100 units, each)), (Ketoconazole &Miconazole (30 μg, each)), Fluconazole &Clotrimazole (10 μg, each)) and Voriconazole (1 mcg) were used.

Results

Among 2550 patients, 675(26.47%) were culture positive. Our study found gram-negative isolates 435(64.4%) as compared to gram-positive isolates 125 (18.5%) and Candida spp. 115 (17.03%).
Among 675 cases, Klebsiellapneumoniae 170 (25%), E. coli 155 (22.9%), Candida spp. 115 (17.03%), S. aureus 110 (16.29%), Pseudomonas aeruginosa 85 (12.59%), Acinetobacter spp. 25 (3.7%) and Enterococcus spp. 15 (2.2%) were isolated. The incidence of EONS was 419 (62.07%), and LONS was 256 (37.9%). The following risk factors, Preterm 155(22.9%), Low birth weight

85(12.59%), Fever with Jaundice 42(6.2%), Fever of unknown origins 22(3.25%), Poor feed 19(2.8%), Respiratory distress 18(2.6%) and Premature Rupture of Membrane 6(0.8%), Perinatal asphyxia 5 (0.7%) noted.

Antimicrobial Susceptibility Pattern:

Table 1: Antibiotics susceptibility pattern of Gram-positive organisms

Sr. No	Antibiotic	S. aureus resistance		Enterococcus spp. resistance	
		Number (n=110)	%	Number (n=15)	%
1	Penicillin G	85	77.2	07	46.6
2	Ampicillin	85	77.2	07	46.6
3	Cefuroxime	69	62.72	-	-
4	Cefoxitin	25	22.7	-	-
5	Ampicillin-sulbactam	69	62.72	-	-
6	Gentamycin	52	47.2	-	-
7	Amikacin	37	33.6	-	-
8	Tetracycline	16	14.5	05	33.3
9	Co-trimoxazole	52	47.2	-	-
10	Ciprofolxacin	29	26.3	05	33.3
11	Levofloxacin	29	26.3	04	26.6
12	Clindamycin	29	26.3	-	-
13	Erythromycin	78	70.9	06	40.0
14	Vancomycin	00	0.00	01	6.6
15	Lenozolid	00	0.00	00	00
16	High level Gentamycin	-	-	01	6.6

Table 2: Antibiotics susceptibility pattern of Gram-negative organisms

Sr. No	Antibiotic	Klebsiella spp. Resistance (n=170)	E.coli resistance (n=155)	Resistance in Enterobacteriaceae(%)
1	Ampicillin	*	96 (61.9%)	61.9
2	Cefuroxime	106 (62.3%)	95 (61.29%)	61.8
3	Ceftazidime	91 (53.5%)	81 (52.25%)	52.9
4	Cefotaxime	91 (53.5%)	81 (52.25%)	52.9
5	Cefepime	88 (51.7%)	79 (50.9%)	51.3
6	Ampicillin-sulbactam	79 (46.4%)	70 (45.16%)	45.8
7	Gentamycin	56 (32.9%)	47 (30.32%)	31.7
8	Amikacin	49 (28.8%)	40 (25.8%)	27.3
9	Tetracycline	46 (27.05%)	39 (25.16%)	26.2
10	Co-trimoxazole	59 (34.7%)	52 (33.54%)	34.1
11	Ciprofolxacin	44 (25.8%)	37 (23.8%)	24.9
12	Levofloxacin	41 (24.1%)	34 (21.9%)	23.1
13	Imipenem	2 (1.17%)	1 (0.6%)	0.92

Note: (*)Indicate intrinsic resistance

Antibiotics susceptibility pattern of Non fermenter organisms:

Acinetobacter spp. (n=25) demonstrated resistance to piperacillin, ticarcillin (8(32.0%) each)), ceftazidime 7(28%), ciprofloxacin 6(24%), (levofloxacin, Gentamycin, (5(20%)each)) & less

resistance to (cefepime, Amikacin, cefepime-tazobactam, (3(12%)each)), and no resistance was found against Imipenem.
P. aeruginosa(n=85) demonstrated high level of resistance to (piperacillin, ticarcillin (61(71.7%) each)), (ciprofloxacin, levofloxacin, ceftazidime (59(69.4%)each)), (aztreonam, Gentamycin, Netilmicin (46(54.11%)each)) & less resistance to (cefepime, Amikacin, cefepime-tazobactam, (21(24.7%)each)) while most were sensitive to imipenem 80(94.11%). All Gram-negative organisms were sensitive to colistin 100%.
Candida spp.(n=115**)** were highly resistant to azole group ranging from 60% to 90% and less resistant to Voriconazole 41(35.6%) & Nystatin 35 (30.4%) while most were sensitive to Amphotericin B (97.3%).
ESBL &AmpC producer: Among 155 E. coli, 46(29.6%) were ESBL & 57(36.7%) were AmpC producer. Among 170 Klebsiellapneumoniae, 33(19.4%) were ESBL & 37(21.7%) were AmpC producer.
Carbapenemase produced in 3(0.8%) Enterobacteriaceae detected by the modified Hodge test. Metallo-beta lactamases identified by CDST representing class A, B, and Class D beta-lactamases.
Metallo-beta lactamases production in 5(5.88%) P. aeruginosa identified by CDST representing class B beta-lactamases.
Multidrug resistance organism: Gram-negative rods: Pan-antibiotic resistance found in 8(1.83%) isolates: 1 E. coli, 2 Klebsiella pneumonia & 5 Pseudomonas aeruginosa.

Discussion
We have compared our study with various other studies onthe following basis:

1. The incidence& microbial pattern
2. Associated risk factors
3. Antibiogram of isolates

1) The incidence & microbial pattern

The incidence of neonatal septicemia found in the present study was 26.47%. The other study, by Yadav N.S. et, al[4] was (16.9%), by Gohel K et, al[5] was (9.2%), by VrishaliMuley et, al India[6] was (26.6%), by Hitesh Assudani et, al India[8] was (35.34%), by Bhat M. et, al India[9] was (48.3%), by Roy I. et, al India[10] was (47.5%), by Sharma et, al India[11] was (56%).
The microbial pattern in the various study are the following:The present study found Klebsiella pneumonia (25%) as the most common isolate, followed by E. coli (22.9%). The VrishaliMuley et al, India[6] found Klebsiellapneumoniae (35.04%) as the most common isolate, followed by Staphylococcus aureus (22.9%). Bhat M. et al, India[9] found Klebsiellapneumoniae (34.88%) as the most common isolate, followed by Staphylococcus aureus (32.5%).
The present study found 17.03%Candida spp. while others like Banerjee et al, India[14] found 27.5%, and Chander J et al, India[7] found 29.4%
The predominance of K. pneumoniae as the causative agent of neonatal sepsis may be due tothe harshness of the organism to survive in a hospital environment and the selective pressure of antimicrobial agents.So that resistant organisms lead to colonize and proliferate inneonates[6].

2) Associated risk factors

The sex-wise distribution: The study of JimbaJatsho et al[1] was found 52.3% in males and 47.7% in females, JyotiSonawane et al, India[12]was found 64.6% in males, and 35.39% in females, Hitesh Assudani et al, India[8] was found 76.7% in males and 23.28%in females. The present study found 57.7% in males and 42.2% in females.
The male infants confer less immunological protection compared to females. The reason behind such sex difference is X chromosome contains a gene involved in the function of the thymus or synthesis of immunoglobulins[1].
The age of onset in a different study: The present study found 59.4% EONS and 40.5% LONS.Our results were comparable with the study byJimbaJatsho et al[1] found 54.5% EONS and 45.5% LONS**,** Bhat M. et al, India[9]found 58.13% EONS and 41.8% LONS,andHiteshAssudani et al, India[8] found 56.03% EONS and 43.9% LONS.

3) Antibiogram of isolates

Imipenem was the most sensitive drug with < 6 % resistance. All Gram-negative isolates demonstrated resistance to tetracycline was 27%, co-trimoxazole was 34%,Ampicillin-sulbactam was 46%,cefotaxime was 52.8%, and ampicillin was 61.9%.

ESBL producer identified in 29.6% of E. coli & 19.4% of K. pneumonia. AmpC beta-lactamases producer identified in 36.7% of E. coli & 21.7% of K. pneumonia. The study found resistance for tetracycline was 14%, Co-trimoxazole was 47.2%, for gentamicin was 47.2%, ciprofloxacin was 26.3%, penicillin was 77.2%. Methicillin-resistant found in Staphylococcus aureus was 22.7%.

The study of Hitesh Assudani et al, India[8] found ESBL producer E. coli was 0.0% &K.pneumoniae was 37.50 %. Chandel DS et al[13] found ESBL producer E. coli was 33.33% &K.pneumoniae was 30.97 %. VrishaliMuley et al,India[6] noted ESBL producer E. coli was 25.0 % &K.pneumoniaewas 29.4 %.

The study of Salamat, Sonia et al[16] found AmpC beta- lactamases producer among gram negative isolates were 22% among them E. coli was 9.9% &K.pneumoniae was 5.7 %.

The study of Ahmad Mohamed Khadija et al [15] found ESBL producer 23% and AmpC beta-lactamases producer gram negative isolates were 59%. Similar results found in present study AmpC beta- lactamases producer is higher than ESBL producer.

Extensive use of invasive procedures and third generation cephalosporins should be restricted to avoid the emergence of AmpC beta-lactamases in neonates. Moreover, indiscriminate use of broad spectrum cephalosporins should be the cause of the emergence of AmpCbeta- lactamasesproducing bacteria[16].

The study by VrishaliMuley et al, India[6] found the following resistance patterns: in gram-negative isolates by co-trimoxazole, cefotaxime, ampicillin 50% to 73%, in Gram-positive isolates by co-trimoxazole 54.5%, ciprofloxacin 44.5%, penicillin 72.7%, gentamicin 44.5%, and MRSA 18.1%.

The study by Yadav N.S. et, al[4] noted: most effective antibiotic against Gram-positive bacteria was found to be gentamicin (93%) followed by amikacin (89%) and ofloxacin (85%). Among K. pneumonia and E. coli isolates, amikacin, gentamicin, meropenem, and imipenem were found to be 100% sensitive. Ampicillin, cefotaxime, and ceftazidime were found to be 100% resistive among K. pneumonia whereas amoxycillin was resistant towards all E. coli isolates. Ampicillin showed the highest resistivity 78% among Gram-positive and 91% among Gram-negative isolates.

The study by Salamat, Sonia et al[16] noted cefoxitin, gentamicin and amikacin resistance among gram negative orgasim were 90-99% whereas imepenem was 100 % sensitive.

The study by Gohel K et, al[5] noted: Staphylococcus aureus isolates exhibited resistance of oxacillin 70.6%, tetracycline 10%, vancomycin 21.6%. Enterococcus isolates exhibited resistance of tetracycline and vancomycin is respectively 33% and 40%. In gram-negative isolates exhibited resistance of amoxycillin, ceftazidime, ciprofloxacin 92% while Cefotaxime + clavulanate, Piperacillin + tazobactam exhibited 50% and tetracycline shows 72% to 84%resistence.

Ampicillin and amoxycillin which have been revealed as ineffective drugs in present study might be due to emergence of antimicrobial resistance genes in bacteria and inappropriate use of antibiotics prior to hospitalization of neonatal cases. Tetracycline are more sensitive in GPC rather than GNB.The initial empiric antibiotic use must therefore be a combination of drugs to cover for the prevalent bacterial organisms in that locality[4] as combination in prophylaxis reduce the emergence of antimicrobial resistance. Therefore, the knowledge of the etiological organisms of neonatal sepsis and their antibiotic susceptibility profile and reviewing prophylaxis policy is necessary for effective therapeutic intervention.

Conclusion

Based on the above findings following recommendations are given:

- To decrease the emergence of multidrug-resistant organisms,healthcare workers should be routinely screened for the presence of multidrug-resistant bacteria, and their education regarding hand hygiene and convenient aseptic techniques should be encouraged along with proper periodic implementation and monitoring of Antibiotics stewardship program and role of Hospital infection control committees.
- To Follow strict antimicrobial prophylaxis guidelines. In the present study,aminoglycosides, tetracycline, fluoroquinolones, and voriconazole are the better preferred. So, rather than choosing higher-level antibiotics, advise waiting for antibiotic sensitivity results.

Abbreviations

AmpC=AmpC β-lactamases,CBC=Complete Blood Count, CDC=Centre for Disease Control & Prevention, CLSI=Clinical and Laboratory Standards Institute, ESBL=Extended spectrum β-lactamases, ESR=Erythrocyte Sedimentation Rate, LIS=Laboratory Information System,LRF=Lab Request Form, MBL=Metalloβ-lactamases, MHA= Mueller Hinton Agar,MIC=Minimum Inhibitory Concentration, MRSA=Methicillin resistant Staphylococci, EONS=Early-onset neonatal sepsis, LONS=Late-onset neonatal sepsis, UTI = Urinary tract infection.

References

1. Jatsho J, Nishizawa Y, Pelzom D, Sharma R. Clinical and Bacteriological Profile of Neonatal Sepsis: A Prospective Hospital-Based Study. International Journal of Pediatrics. 2020;2020, 1835945, pp.1-9.
2. Thapa S, Sapkota LB. Changing Trend of Neonatal Septicemia and Antibiotic Susceptibility Pattern of Isolates in Nepal. Int J Pediatric. 2019, 3784529, pp.1-7
4. Patricia M. T. Bailey and scott'sdiagnostic microbiology 13 th edition, Elsevier US/UK, 2014, pp.867 - 874.
5. Yadav N.S., Sharma S., Chaudhary D.K. et al. Bacteriological profile of neonatal sepsis and antibiotic susceptibility pattern of isolates admitted at Kanti Children's Hospital, Kathmandu, Nepal. BMC Res Notes 11**,** 301, 2018,3394-6.
6. Gohel K, Jojera A, Soni S, Gang S, Sabnis R, Desai M. Bacteriological profile and drug resistance patterns of blood culture isolates in a tertiary care nephrourology teaching institute. Biomed Res Int. 2014; 2014 el:153747.
7. Muley VA, Ghadage DP, Bhore AV. Bacteriological Profile of Neonatal Septicemia in a Tertiary Care Hospital from Western India. J Glob Infect Dis. 2015 Apr-Jun;7(2):75-77
8. Chander J, Singla N, Sidhu SK, Gombar S. Epidemiology of Candida blood stream infections: experience of a tertiary care centre in North India.J Infect Dev Ctries, 7 (2013), pp. 670-675
9. Assudani HJ, Gusani JK, Mehta SJ, Agravat HH, Kothari K. Bacteriological profiles of septicaemia in neonates at tertiary care hospital, Gujarat, India. J Res Med Den Sci 2015;3(2): pp. 148-151.
10. Bhat M., Saini G.S.- Bacteriological profile and antibiotic sensitivity pattern of neonatal sepsis in a tertiary care hospital of northern India. Pediatric Review: International Journal of Pediatric Research, 3(11), pp. 831-834
11. Roy I, Jain A, Kumar M, Agarwal SK. Bacteriology of neonatal septicaemia in a tertiary care hospital of northern India. Indian J Med Microbiol. 2002 Jul-Sep;20(3):156-1599.
12. Sharma PP, Halder D, Dutta AK, Dutta R, Bhatnagar S, Bali A, Kumari S. Bacteriological profile of neonatal septicemia. Indian Pediatr. 1987 Nov;24(11):1011-1017
13. Sonawane JP, Kamath N, Shetty K, Swaminathan R - Bacteriological Profile and Antimicrobial Susceptibility of Blood Culture Isolates from Tertiary Care Hospital, Navi Mumbai- JMSCR 4 (10): 13116-13124.
14. Chandel DS, Johnson JA, Chaudhry R, Sharma N, Shinkre N, Parida S, Misra PR, Panigrahi P. Extended-spectrum beta-lactamase-producing Gram-negative bacteria causing neonatal sepsis in India in rural and urban settings. J Med Microbiol. PMID: 21183602, 2011 Apr;60(Pt 4):500-507
15. Banerjee B, R M SD, Baliga S. Clinico-microbiological study of candidemia in a tertiary care hospital of southern part of India. Iran J Microbiol. PMID: 26644875, 2015 Feb;7(1):55-61
16. Ahmad Mohamed Khadija et al. "Emergence of AmpC β-Lactamase– and Metallo-β-Lactamase–producing Klebsiella pneumonia." in Sebha, Libya, 2019; vol.27(1): 9-16.
17. Salamat, Sonia et al. "Detection of AmpC β-lactamase producing bacteria isolated in neonatal sepsis." Pakistan journal of medical sciences vol. 32,6 (2016): 1512-1516.