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Original Research Article

Spectrum of Gram-Negative Bacilli and Their Antibiotic Resistance in ICU Patients

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Abstract:

Background: A large number of hospital-acquired infections in intensive care units (ICUs) are caused by gram-negative bacteria (GNB). This has become a major clinical problem due to the increasing antibiotic resistance in these organisms, which has decreased treatment options, increased healthcare costs, lengthened hospital stays, and increased mortality. Empirical antibiotic treatment relies heavily on bacterial susceptibility testing.

Aim: In order to learn about the antibiotic resistance patterns of the various Gram-negative bacilli found in patients admitted to intensive care units.

Methodology: A retrospective observational study for Department of microbiology at Lord Buddha Koshi Medical College & Hospital in Saharsa, Bihar, India, researchers performed a retrospective observational study for a whole year. For this investigation, one hundred Gram-negative bacteria that were culture-positive were taken from patients in the intensive care unit. The clinical samples were examined according to standard microbiological protocol, and the bacteria that were isolated were identified by means of traditional biochemical testing. Following the guidelines set out by the CLSI, the Kirby-Bauer disc diffusion assay was used to determine antibiotic susceptibility.

Results: Among the 100 Gram-negative bacterial isolates, 34% were Klebsiella pneumoniae, 24% were Acinetobacter baumannii, 18% were Pseudomonas aeruginosa, and 14% were E. coli. Endotracheal aspirates accounted for 32% of the clinical specimens. Ampicillin, fluoroquinolones, and third-generation cephalosporins were all highly resistant, but carbapenems and colistin showed considerably higher susceptibility. Acinetobacter baumannii accounted for 58% of the multidrug-resistant isolates screened.

Conclusion: The study found that intensive care unit patients had a high prevalence of Gram-negative bacilli that were resistant to multiple drugs. The most common type of these bacteria was Klebsiella pneumoniae. The findings highlight the need of regular microbiological monitoring, local resistance pattern monitoring, antibiotic rationalisation, and appropriate antimicrobial stewardship.

Keywords: Gram-negative bacilli; Intensive Care Unit; Antimicrobial Resistance; Multidrug-Resistant Bacteria; Klebsiella pneumoniae; Antibiotic Susceptibility.

Introduction

Among the most important pathogens responsible for healthcare-associated infections (HAIs), (GNB) are especially prevalent in intensive care units (ICUs) throughout the world. Intensive care unit patients are particularly vulnerable to infection because of a number of factors, such as being hospitalised, having invasive procedures done, being on mechanical ventilation, having their immune systems suppressed, and taking a lot of broad-spectrum antibiotics [1]. The group of bacteria known as GNB, which includes Klebsiella pneumoniae, Escherichia coli, Pseudomonas aeruginosa, Acinetobacter baumannii, Enterobacter spp., and Proteus spp., is a common cause of infections such as ventilator-associated pneumonia, bloodstream infections, UTIs, SSIs, and catheter-related infections [2]. Diseases that have evolved resistance to antibiotics and are able to thrive in healthcare facilities have contributed to an increase in healthcare costs globally [3].

The development of antibiotic-resistant Gram-negative bacilli is a major concern in contemporary medicine [4]. The development and propagation of multidrug-resistant (MDR), extensively drug-resistant (XDR), and pan-drug-resistant (PDR) organisms have been facilitated by several factors, including the inappropriate and excessive use of antibiotics, the empirical use of broad-spectrum antimicrobials, horizontal gene transfer, and inadequate infection control practices [5]. There are now fewer options for treating serious infections due

to the compromised effectiveness of the most popular antimicrobials caused by ESBLs, AmpC β-lactamases, and carbapenemases [6].

One environment ripe for the development and spread of antibiotic resistance is intensive care units (ICUs) [7]. Colonisation and infection by opportunistic GNB are common in intensive care unit patients because of the intrusive medical equipment they typically require, including as endotracheal tubes, urine catheters, and central venous catheters [8]. Furthermore, there is a strong selection pressure for the survival and transmission of resistant strains due to repeated exposure to antimicrobials. Therefore, in order to help direct empirical treatments, optimise the antibiotic stewardship program, and lessen the impact of HAI, it is essential to continuously monitor bacteria and resistance patterns [9].

The range and resistance pattern of Gram-negative bacilli vary substantially across hospitals, regions, and even patient populations [10]. As a result, it is crucial to conduct hospital-specific surveillance studies, since empirical antibiotic therapy based on national and international recommendations may not correspond with the resistance patterns of the particular location [11]. When choosing an empirical antibiotic treatment, it is helpful to be aware of the most common microbial infections and how they have developed resistance to antibiotics [12].

An increasing number of Gram-negative bacteria in India are developing resistance to Several tertiary care hospitals have reported an increase in carbapenem-resistant Klebsiella pneumoniae, Acinetobacter baumannii, and Pseudomonas aeruginosa in their intensive care unit patients [13]. Treatment failures, an increased death rate, longer hospital stays, and increased expenses have all resulted from the increased incidence of multidrug-resistant pathogens [14]. This finding further supports the idea that regular surveillance studies are necessary to assess the local microbiology and resistance trend.

Methodology

Study Design: The purpose of this retrospective observational study was to investigate the resistance patterns and bacterial species composition of patients admitted to the intensive care unit (ICU). The distribution of Gram-negative bacteria and their susceptibility to current antimicrobial medications needed to be determined by reviewing microbiology laboratory data in order to conduct this investigation. The retrospective method of research was selected for this study.

Study Area: A retrospective observational study for Department of microbiology at Lord Buddha Koshi Medical College & Hospital in Saharsa, Bihar, India

Study Duration: The trial lasted for one year.

Study Population: All patients admitted to various intensive care units of Lord Buddha Koshi Medical College & Hospital with Gram-negative bacterial infections, as proven by culture, were considered study subjects. To avoid any bias or repetition in representing bacterial prevalence and sensitivity pattern, we included just the initial bacterial isolate from each patient.

Inclusion Criteria

- Patients admitted in any of the intensive care units during the study period.
- Subjects with clinical samples yielding Gram negative bacilli after bacterial culture.
- Subjects of all ages and sexes.
- Microbiological information complete in all aspects.

Exclusion Criteria

- Duplicate isolates from one patient.
- Gram positive bacterial and fungal isolates.
- Contaminated or improperly collected samples.
- Information incomplete in terms of microbiology and antimicrobial susceptibility test results.

Sample Size: This study utilised a total of one hundred Gram-negative bacterial isolates that tested positive for culture from intensive care unit patients who met the inclusion criteria. The various samples that were gathered throughout the course of the investigation were cultivated and examined for antibiotic resistance profiles and microbiological identification.

Sample Collection and Laboratory Procedures: Various clinical samples such as blood, urine, sputum, endotracheal aspirate, bronchoalveolar lavage, pus, swab specimens from wounds, and other sterile body fluids were collected aseptically from the ICU patients. The collected samples were promptly transferred to the Department of Microbiology for testing purposes.

The samples underwent incubation in the laboratory using bacteriological medium that were deemed suitable, including Blood Agar, MacConkey Agar, and Chocolate Agar. When feasible, we used automated techniques, biochemical testing, colony appearance, and Gram reaction to confirm the existence of Gram-negative bacilli. For subsequent examination, only Gram-negative bacterial strains that yielded positive results in these assays were taken into account.

Antimicrobial Susceptibility Testing: The Kirby-Bauer disc diffusion test was carried out using Mueller-Hinton agar plate in conformity with the Clinical and Laboratory criteria Institute (CLSI) criteria. The purpose of the test was to determine

whether antimicrobial drugs were effective in treating illnesses caused by Gram-negative bacteria. The antibiotics used included ampicillin, amoxicillin-clavulanic acid, ceftriaxone, cefotaxime, ceftazidime, cefepime, piperacillin-tazobactam, amikacin, gentamicin, ciprofloxacin, levofloxacin, trimethoprim-sulfamethoxazole, imipenem, meropenem, and colistin, among others, depending on the type of bacteria that were isolated. We analysed the results using CLSI criteria.

Data Collection: Data for analysis were obtained from the laboratory files of the microbiology laboratory through a well-designed data collection sheet. The variables included the demographics of the patients, ICU admission information, specimen type, bacteria isolated, and antimicrobial susceptibility profile. No identifiers of the patients were used to keep their identities confidential. Each isolate was assigned an identification number unique to the study.

2.9 Outcome Measures

The outcome variables for the study were:

- Spectrum of Gram-negative bacilli isolated from ICU patients.
- Frequency of various bacterial strains.
- The antibiotic susceptibility and resistance pattern of the isolates.
- The incidence of multi drug-resistant Gram-negative bacilli.

Statistical Analysis: The data was analysed using IBM's SPSS 27.0 software, which is manufactured by IBM and located in Armonk, NY, USA. Data analysis made use of statistical descriptions. Categorical variables were represented using percentages and frequency, while continuous variables were represented by mean ± SD. Tables and graphs were used to display the distribution of isolates together with their patterns of antibiotic resistance. For each set of categorical variables, we used a chi-square test to look for correlations. The significance level was determined to be P-value ≤ 0.05.

Results

The research made use of one hundred Gram-negative bacilli purified from intensive care unit patients. These were derived from a variety of sources, including endotracheal aspirate, blood, sputum, pus, urine, and other bodily fluids. One example of a bacterium is Klebsiella pneumoniae, while another is Pseudomonas aeruginosa. Antibiotic sensitivity tests revealed that third-generation cephalosporins and fluoroquinolones were much more resistant, but carbapenems and colistin showed better sensitivity.

Demographic Characteristics of ICU Patients: The study subjects' demographic information is presented in Table 1. The age group of 51–70 years old accounted for 46% of the 100 intensive care unit admissions, with the age group of 31–50 years old coming in second at 30%. Of the people that participated in the study, 36% were female and 64% were male. Over half of the patients in this research required an intensive care unit stay of more than seven days.

Table 1: Personal Details of Patients in the Intensive Care Unit(n = 100)

Parameter	(n)	(%)
Age Group (Years)		
18–30	12	12.0
31–50	30	30.0
51–70	46	46.0
>70	12	12.0
Gender		
Male	64	64.0
Female	36	36.0
Length of ICU Stay		
≤3 days	18	18.0
4–7 days	27	27.0
>7 days	55	55.0

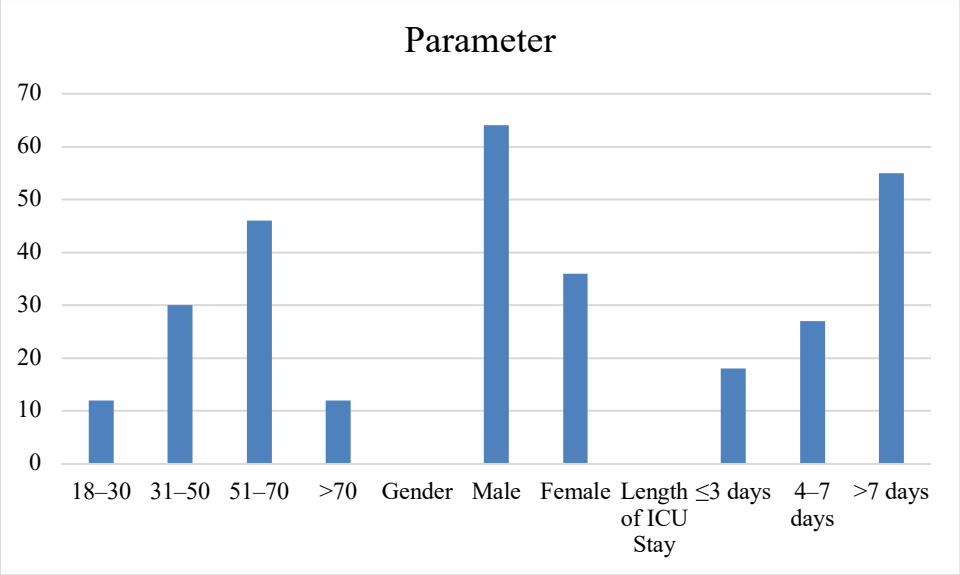

Figure 1: Graphical Representation of Demographic Characteristics of ICU Patients (n = 100)

Distribution of Clinical Specimens: The clinical specimen distribution for Gram-negative bacilli isolation is shown in Table 2. The endotracheal aspirate samples formed the most frequent sources (32%) of Gram-negative bacilli isolation, followed by the urine samples (22%), the blood samples (18%), and the sputum samples (15%). Pus and other sterile body fluid samples formed a smaller percentage.

Table 2: Distribution of Clinical Specimens (n = 100)		
Clinical Specimen	**Frequency (n)**	**Percentage (%)**
Endotracheal aspirate	32	32.0
Urine	22	22.0
Blood	18	18.0
Sputum	15	15.0
Pus/Wound swab	8	8.0
Other body fluids	5	5.0
Total	**100**	**100.0**

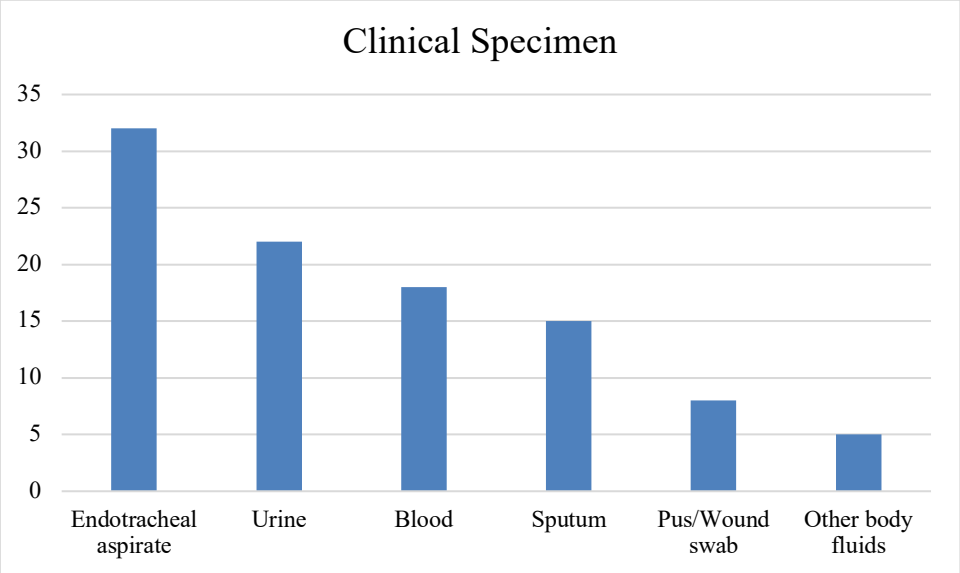

Figure 2: Graphical Representation of Distribution of Clinical Specimens (n = 100)

Endotracheal aspirates constituted the largest proportion of specimens, reflecting the high incidence of ventilator-associated respiratory infections among ICU patients.

Spectrum of Gram-Negative Bacilli: The Table below gives the frequencies of isolation of Gram negative bacteria. The leading bacteria isolated include Klebsiella pneumonia (34%) then followed by Acinetobacter baumannii (24%), Pseudomonas aeruginosa (18%), and finally E. coli (14%).

Table 3: Spectrum of Gram-Negative Bacilli Isolated from ICU Patients (n = 100)		
Bacterial Isolate	**Frequency (n)**	**Percentage (%)**
Klebsiella pneumoniae	34	34.0
Acinetobacter baumannii	24	24.0
Pseudomonas aeruginosa	18	18.0
Escherichia coli	14	14.0
Enterobacter spp.	6	6.0
Proteus spp.	4	4.0
Total	**100**	**100.0**

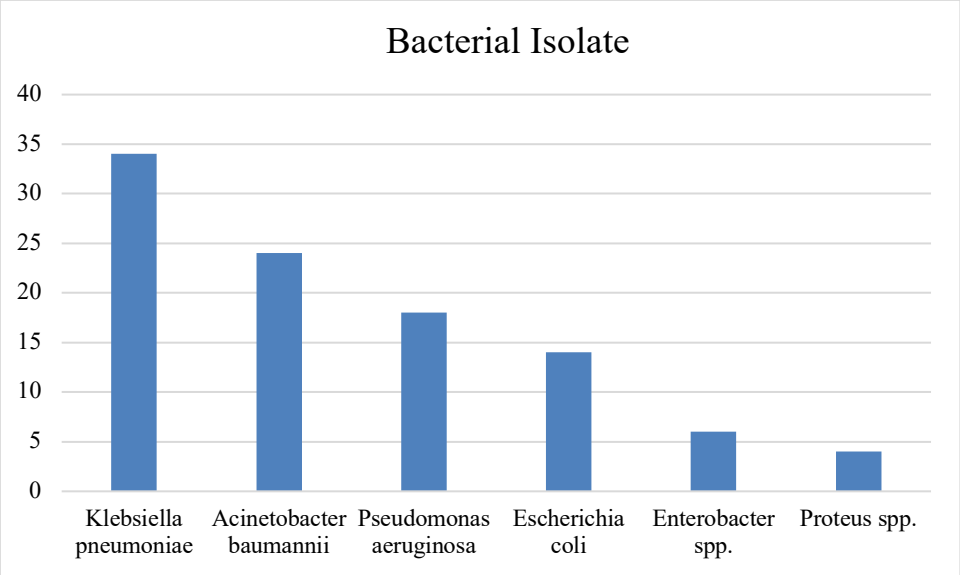

Figure 3: Graphical Representation of Spectrum of Gram-Negative Bacilli Isolated from ICU Patients (n = 100)

Klebsiella pneumoniae was the most frequently isolated Gram-negative pathogen, highlighting its important role in ICU-acquired infections.

Bacilli that are Gram-negative and Their Resistance to Antibiotics: The antibiotic resistance profile is depicted in Table 4. A high percentage of resistance was found against Ampicillin (92%), Ceftriaxone (85%), Cefotaxime (82%), and Ciprofloxacin (74%). However, a comparatively low percentage of resistance was found against Meropenem (28%), Imipenem (25%), and Colistin (8%).

Table 4: Bacilli that are Gram-negative and Their Resistance to Antibiotics(n = 100)		
Antibiotic	**Resistant n (%)**	**Sensitive n (%)**
Ampicillin	92 (92.0)	8 (8.0)
Ceftriaxone	85 (85.0)	15 (15.0)
Cefotaxime	82 (82.0)	18 (18.0)
Ceftazidime	76 (76.0)	24 (24.0)
Ciprofloxacin	74 (74.0)	26 (26.0)
Gentamicin	60 (60.0)	40 (40.0)
Amikacin	38 (38.0)	62 (62.0)
Piperacillin–Tazobactam	35 (35.0)	65 (65.0)
Imipenem	25 (25.0)	75 (75.0)
Meropenem	28 (28.0)	72 (72.0)
Colistin	8 (8.0)	92 (92.0)

Resistance to third-generation cephalosporins and fluoroquinolones was markedly high, whereas carbapenems and colistin demonstrated comparatively better antimicrobial activity.

Multidrug Resistance Pattern Among Gram-Negative Bacilli: The prevalence of multidrug-resistant pathogens is displayed in Table 5. About 58% of Gram-negative bacilli were resistant to more than one medication. Acinetobacter baumannii (79.2%), Klebsiella pneumoniae (64.7%), and Pseudomon had the highest rates of multidrug resistance among Gram-negative bacilli.

Table 5: Distribution of Multidrug-Resistant Gram-Negative Bacilli (n = 100)

Bacterial Isolate	Total Isolates	MDR Isolates n (%)
Klebsiella pneumoniae	34	22 (64.7)
Acinetobacter baumannii	24	19 (79.2)
Pseudomonas aeruginosa	18	9 (50.0)
Escherichia coli	14	5 (35.7)
Enterobacter spp.	6	2 (33.3)
Proteus spp.	4	1 (25.0)
Overall	**100**	**58 (58.0)**

Acinetobacter baumannii was among the Gram-negative bacteria that showed resistance to numerous medicines. The high prevalence of multidrug-resistant bacteria in intensive care units (ICUs) underscores the critical need for antibiotic stewardship and control.

Discussion

In an investigation carried out in the Department of Microbiology, Lord Buddha Koshi Medical College & Hospital in Saharsa, Bihar, antibiotic resistance patterns and types of Gram-negative bacilli in patients admitted to the intensive care unit were studied by Siwakoti et al. (2018) [16]. According to the study, Klebsiella pneumoniae turned out to be the most prevalent Gram-negative bacillus, followed by Acinetobacter baumannii, Pseudomonas aeruginosa, and Escherichia coli. These species of bacteria are known to cause health care associated infections; this fact has been previously proved by the research in hospitals Tran et al (2017) [17].

As it has been noted by the authors of the study, endotracheal aspirate was the most popular way of isolating bacteria, and most of the participants of the study were males at their twilight years Uc-Cachón et al., (2019) [18]. Thus, this finding proves that the presence of severe condition increases the risk of ventilator-associated pneumonia and infections related to medical equipment. This conclusion has been reached earlier since invasive interventions, prolonged ICU admission and comorbidities increase the risk of Gram-negative bacteria infections Vaithiyam et al., (2020) [19].

From the results of the study of antibiotic susceptibility patterns, it can be concluded that patients in ICUs suffer from the resistance of Gram-negative bacteria, since the isolates showed high resistance to ampicillin, third generation cephalosporins and fluoroquinolones. It is stated in the previous studies that the antibiotic overuse and prevalence of ESBL and carbapenemase-producing bacteria increase the problem of resistance.

In addition, it turned out that isolated strains are relatively sensitive to colistin, imipenem and meropenem. The issue of carbapenem resistance is especially important because these antibiotics are used as last resort therapy. Therefore, it is necessary to ensure the rational use of antibiotics.

High prevalence of multidrug resistant (MDR) Gram-negative bacilli, especially Acinetobacter baumannii and Klebsiella pneumoniae, is one of the main conclusions of the current study Zhu et al., (2017) [20]. Prolonged ICU stays lead to the increased costs of care and poor patient outcomes, and this tendency causes serious concerns. That is why antimicrobial stewardship programs, surveillance of resistance and infection control measures should be undertaken.

Besides the lack of molecular characterization of resistance genes, the main weaknesses of the current study are its retrospective design, relatively small number of patients (100 isolates) and the involvement of one center. Nevertheless, the findings on the geographical pattern of Gram-negative bacilli and their resistance to antibiotics are helpful for choosing appropriate empirical therapy.

Conclusion

This retrospective research helps reveal the trends of antibiotic resistance and the prevalence of Gram-negative bacilli among patients in the intensive care unit setting. After K. pneumoniae, A. baumannii and P. aeruginosa were found to be the most common pathogens. When compared to routinely prescribed medications, such as third generation cephalosporins and fluoroquinolones, which possess a high level of resistance, carbapenems and persistin appeared to be more effective against microorganisms. The increasing number of Gram-negative bacilli resistant to numerous therapies complicates the problem of healthcare-associated infections in ICU.

This knowledge highlights the importance of ongoing surveillance of microbiology results, local antibiograms, adequate medication prescription, and effective antimicrobial stewardship programs for the best empirical therapy and decrease in resistant bacteria development. Improvements in infection control programs for ICUs could assist in decreasing the rate of multidrug-resistant infections as well. Multicenter researches should be conducted in order to understand resistance patterns better and develop evidence-based medicine practices.

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