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Original Research Article

A Cross Sectional Assessment of the Distribution and Antimicrobial Susceptibility Patterns of Lower Respiratory Tract Infections

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Abstract

Aim: The aim of the present study was to assess the distribution and antimicrobial susceptibility patterns of lower respiratory tract infections in the medical and surgical intensive care units of Nalanda Medical College and Hospital, Patna, Bihar, India

Methods: This was a retrospective study conducted at Department of Anaesthesia & Intensive Care, for the period of 12 months. However, this study was restricted only to the medical and surgical ICUs. Total number of patients (medical and surgical admissions) seen at our Institute during the study period was 1200; out of whom, 200 patients required intensive care. One hundred patients were enrolled for the study after considering the inclusion and exclusion criteria.

Results: A total of 100 patients were included in the study, out of which 70 (70%) were males. Amongst different age groups, maximum patients were above 60 y (30%) and the least were between 18–30 y (12%). The underlying major medical conditions of the LRTI were diabetes mellitus (30%), respiratory pathology (20%), nephrological pathology (18%) and malignancy (14%). The bacteria were isolated predominantly from the tracheal aspirate (85%), compared to broncho–alveolar lavage (15%) with a statistically significant difference between them. Out of all the isolated organisms, A. baumannii (n = 30; 30%), P. aeruginosa (n = 24; 24%) and Klebsiella (n = 22; 22%) were the most positive isolates, S. aureus and Enterococcus were equal (n = 4; 4%). In the gram–negative isolates, A. baumannii was most susceptible to colistin (93.34%) followed by minocycline (80%) and amikacin (66.66%). With regard to P. aeruginosa, it was observed that only around half of the isolates were susceptible to doripenem (62.5%) and it was also observed that most of the isolates were resistant to all the commonly used antibiotics. In the gram–positive isolates, S. aureus was equally susceptible to linezolid (75%) and vancomycin (75%); and 100% of the isolates of Enterococcus were susceptible to vancomycin.

Conclusion: Gram–negative pathogens were predominantly responsible for lower respiratory tract infections. Moreover, antimicrobial resistance rate was high with the most commonly used antibiotics and also to higher antibiotics such as carbapenems.

Keywords: Antimicrobial susceptibility; Intensive Care Unit; Lower Respiratory Tract Infection; Antibiotic; Resistance

Introduction

Lower respiratory tract infections (LRTI) are the infections of the trachea, bronchi and lungs. Though there is no uniform definition for LRTI, most of the definitions include pneumonia, influenza, bronchitis including acute exacerbations in chronic obstructive pulmonary disease, and bronchiolitis in this broad term. [1,2] LRTI have been one of the major contributors of human morbidity and mortality. As per the Global Burden of Disease study, funded by the Bill and Melinda Gates foundation, in the year 2016 nearly 2.38 million deaths were the result of LRTI, making it the sixth leading cause of death for all ages. [3] It has been estimated that LRTI account

for 4.4% of all hospital admissions and 6% of all out–patient consultations. [4]

In addition, amongst the hospital admissions, managing LRTI in the intensive care units (ICUs) is challenging as the patients present with different diseases with varied epidemiological, clinical and microbiological aspects. Amongst hospitalized patients, the most common organisms causing LRTI are gram–negative bacteria such as Klebsiella, Escherichia coli (E. coli), Acinetobacter baumannii (A. baumannii), Pseudomonas aeruginosa (P. aeruginosa), gram–positive organisms like Staphylococcus aureus (S. aureus) and occasionally fungi. [5,6] However, the microbiological etiology and susceptibility is variable depending on the geographical location.

The impact of antimicrobial-resistant organisms is more severe in low and medium-income countries. [7] Highly resistant strains of Gram-negative bacilli (GNB) continue to spread rapidly in hospitals causing therapeutic problems in many parts of the world, especially for developing countries because isolation facilities are not enough to admit all the patients with infections due to resistant organisms. [8,9] Recent surveillance information from the national nosocomial infection surveillance system of the Centers for Disease Control of USA showed hospital-acquired pneumonia (HAP) or commonly known as 'nosocomial pneumonia' is the most typical infection within the ICUs. [10,11] Nosocomial bacteria are multi-drug resistant that are hard to eradicate by available antibiotics.

The aim of the present study was to assess the distribution and antimicrobial susceptibility patterns of lower respiratory tract infections in the medical and surgical intensive care units of a teaching hospital in Bihar region.

Materials and Methods

This was a retrospective study conducted Department of Anaesthesia & Intensive Care, Nalanda Medical College and Hospital, Patna, Bihar, India for the period of 12 months. However, this study was restricted only to the medical and surgical ICUs. Total number of patients (medical and surgical admissions) seen at our Institute during the study period was 1200; out of whom, 200 patients required intensive care. One hundred patients were enrolled for the study after considering the inclusion and exclusion criteria. The study included all patients of either gender, aged above 18 y, admitted in the medical and surgical ICUs, whose cultures were positive for LRTI. The patients with negative cultures, the patients in whom more than one species of the same organism were isolated and patients with incomplete case records were excluded from the study.

Data and Variables: The demographic data (gender and age) and the bacterial isolates were collected from the medical records using a structured data collection tool. The age was stratified into five groups, e.g., 18–30, 31–40, 41–50, 51–60 and more than 60 y. The bacterial isolates were documented as per the results of the region of the lower respiratory tract from which the organism was isolated, gram stain, isolate's identity and antimicrobial susceptibility. As per the records, uniform procedures were followed for sample collection, culture and sensitivity testing.

Sample Collection: The samples were kept in Cary–Blair transport medium until processed for gram staining and culture. The samples were inoculated on blood agar (with 5% sheep blood) and MacConkey agar plates. Later, they were incubated aerobically at 35°C–37°C for 24–48 h. Aseptic precautions were followed during these procedures. The identification and characterization of isolates were performed based upon gram staining and microscopic characteristics using standard microbiological methods.

Statistical Analysis: For the descriptive analysis, frequency (n) and percentage (%) were used to express the qualitative variables. The data was compared for the type and the number of isolates. To test the statistically significance in differences, either the chi–square test or Fisher's exact test was performed for the qualitative variables. When the p–value was inferior to the alpha error (5%) at 95% confidence interval, a statistical significance was considered. The data was analyzed using the Medcalc® software.

Results

Table 1: Demographic details

Variables	N%
Gender	
Male	70 (70)
Female	30 (30)
Age groups	
18-30 years	12 (12)
31-40 years	13 (13)
41-50 years	20 (20)
51-60 years	25 (25)

>60 years	30 (30)
Underlying medical conditions	
Diabetes Mellitus	30 (30)
Respiratory pathology	20 (20)
Nephrological pathology	18 (18)
Malignancy	14 (14)
Others	18 (18)

A total of 100 patients were included in the study, out of which 70 (70%) were males. Amongst different age groups, maximum patients were above 60 y (30%) and the least were between 18–30 y (12%). The underlying major medical conditions of the LRTI were diabetes mellitus (30%), respiratory pathology (20%), nephrological pathology (18%) and malignancy (14%); while 18% of the patients had had other medical conditions, including electrolyte imbalance, hormonal imbalance, or miscellaneous causes such as poisoning.

Table 2: Bacteria isolated from the lower respiratory tract from ICU patients

Organism	Tracheal aspirate	Broncho-alveolar lavage	95% Cl	P Value
A. baumannii	26 (86.66)	4 (13.34)	55.37-86.45	<0.001
P. aerugeniosa	18 (75)	6 (25)	33.56-73.94	<0.001
Klebsiella	20 (90.90)	2 (9.10)	62.62-92.76	<0.001
E. Coli	10 (83.34)	2 (16.66)	26.80-83.55	<0.001
S. Aureus	4 (100)	0	NA	0.80
Enterococcus	4 (100)	0	NA	0.110
Pneumococci	1 (50)	1 (50)	-57.34-57.34	0.550
CONS	2 (100)	0	NA	0.660
Total	85 (85)	15 (15)	63.09-80.71	<0.001

The bacteria were isolated predominantly from the tracheal aspirate (85%), compared to broncho–alveolar lavage (15%) with a statistically significant difference between them. Out of all the isolated organisms, A. baumannii (n = 30; 30%), P. aeruginosa (n = 24; 24%) and Klebsiella (n = 22; 22%) were the most positive isolates, S. aureus and Enterococcus were equal (n = 4; 4%). Other pathogenic bacteria were E. coli (n = 12; 12%) followed equal number of Pneumococcus and CONS (n = 2; 2%).

Table 3: Susceptibility pattern of Gram-negative isolates

Antibiotic	A baumanii n=34	P. aeruginosa n=24	Klebsiella 22	E. coli 12
Amikacin	20 (66.66)	6 (25)	6 (27.27)	3 (25)
Ampicillin	0	2 (8.34)	3 (13.64)	2 (16.66)
Aztreonam	14 (46.66)	0	0	3 (25)
Cefoperazone+Sulbactam	12 (40)	5 (20.83)	8 (36.36)	4 (33.34)
Cefepime	4 (13.34)	7 (29.16)	6 (27.27)	8 (66.66)
Ciprofloxacin	5 (16.66)	12 (50)	7 (31.82)	3 (25)
Colistin	28 (93.34)	10 (41..66)	20 (90.90)	11 (91.66)
Cotrimoxazole	2 (6.66)	6 (25)	7 (31.82)	6 (50)
Doripenem	7 (23.34)	15 (62.5)	16 (72.72)	9 (75)
Gentamicin	15 (50)	10 (41.66)	9 (40.90)	5(41.66)
Imipenem	8 (26.66)	12 (50)	12 (54.54)	7 (58.33)
Levofloxacin	12 (40)	0	0	3 (25)
Meropenem	11 (36.66)	14 (58.34)	15 (68.18)	2 (16.66)
Minocycline	24 (80)	5 (20.84)	6 (27.27)	10 (83.34)
Piperacillin/Tazobactam	6 (20)	8 (33.34)	0	3 (25)
Tigecycline	29 (96.66)	6 (25)	14 (63.64)	10 (83.34)

There were different sets of antibiotics used for different organisms, and patterns of susceptibility were obtained for different pathogens. In the gram–negative isolates, A. baumannii was most susceptible to colistin (93.34%) followed by minocycline (80%) and amikacin (66.66%). With regard to P. aeruginosa, it was observed that only around half of the isolates were susceptible to doripenem (62.5%) and it was also observed that most of the isolates were resistant to all the

commonly used antibiotics. Whereas, Klebsiella showed maximum sensitivity to colistin (90.90%) followed by doripenem (72.72%), meropenem (68.18%) and tigecycline (63.64%).

Table 4: Susceptibility pattern of Gram-positive isolates

Antibiotic	S. aureus n=4	Enterococcus n=4	Pneumococci n=2	CONS n=2
Amoxiclav	1 (25)	0	0	1 (50)
Cefazolin	2 (50)	2 (50)	0	1 (50)
Cefoxitin	0	2 (50)	1 (50)	1 (50)
Ciprofloxacin	0	1 (25)	1 (50)	1 (50)
Clindamycin	1 (25)	2 (50)	1 (50)	1 (50)
Cotrimoxazole	0	1 (25)	0	0
Erythromycin	1 (25)	0	0	1 (50)
Gentamicin	0	0	0	0
Linezolid	3 (75)	3 (75)	1 (50)	2 (100)
Rifampicin	2 (50)	2 (50)	1 (50)	1 (50)
Teicoplanin	2 (50)	3 (75)	1 (50)	2 (100)
Vancomycin	3 (75)	4 (100)	1 (50)	2 (100)

In the gram–positive isolates, S. aureus was equally susceptible to linezolid (75%) and vancomycin (75%); and 100% of the isolates of Enterococcus were susceptible to vancomycin.

Discussion

Lower respiratory tract infection (LRTI) is common in an intensive care unit (ICU), with increased from 10% to 25%, and mortality from 22% to 71%. Antibiotic resistance is a crucial public health issue. [12,13] The antibiotic-resistant strains of bacteria are the major problem during infection control, especially for these places where considerable resources and costs are unavailable. [1,14] Recent reports have also described antimicrobial-resistant organisms as “nightmare” bacteria that result in excessive deaths and disastrous spending. [6]

In this study, LRTI were more common in males than in females. This could be due to the differences in lifestyle, and in anatomic, behavioral, and socioeconomic factors between the two, which include smoking, tobacco usage, alcohol intake, and environmental exposure etc., causing decreased local immunity in the respiratory tract due to defective mucociliary clearance, mucous plugging, collapse of the airway and weakness of the respiratory muscle. [15,16] Similar results were observed in the study by Humphrey et al. [17] We observed that the elderly population was the most at risk of LRTI. Age distribution of bacteria isolates showed that patients aged more than 50 y were found to be highly susceptible to pathogenic bacteria. This could be attributed to the decreasing immunity and pulmonary defense mechanisms, underlying chronic diseases such as malnutrition, diabetes mellitus, emphysema, uremia etc.[16] In our study, the incidence of gram–negative organisms was 88%, while only 12% were gram–positive. The results are in accordance with the study of Khan et al. [18]

The results of these studies along with the current study demonstrate the increasing incidence of gram–negative pathogens causing LRTI in the ICUs. However, contrasting results were reported in a study done in Bangladesh in which it was observed that 89% were gram–positive isolates. [19] Among the gram–negative isolates, A. baumannii was the most common pathogen to be isolated, which was observed to be around 30% followed by P. aeruginosa, Klebsiella and E. coli. Similar results were observed in a study by Parajuli et al. who reported A. baumannii was the most common respiratory pathogen in the ICU. [20] The most common isolate of our study A. baumannii, showed lower susceptibility to most of the antibiotics tested including carbapenems namely doripenem, imipenem and meropenem at 20.6%, 23.5% and 32.4% respectively. In the recent times, similar patterns of low susceptibility of A. baumannii to carbapenems have been observed globally. [21,22] However, majority of the multi–drug resistant isolates of A. baumannii were susceptible to colistin. P. aeruginosa isolates revealed resistance to commonly used antibiotics but showed highest susceptibility to doripenem at 51.7%. Other studies in India and globally have also reported similar patterns of resistance for P. aeruginosa. [23,24] Among other gram–negative bacteria, Klebsiella and E. coli showed the highest sensitivity with colistin. Altogether, lower susceptibility was observed towards aminoglycosides, cephalosporins, fluoroquinolone and penicillin group of antibiotics. This could be due to an extensive use of these drugs in the past few years and drug resistance mechanisms such as production of enzymes, decreased uptake of drugs and efflux pumps. [25] Among gram–positive bacteria, S. aureus and enterococci were the most common isolates. These isolates demonstrated maximum susceptibility to linezolid at 75%. Similar results were observed in a study by Singh et al. conducted in North India. [26]

Conclusion

This current study provides useful information regarding the microbiology of lower respiratory tract infections occurring in the ICUs and their antibiotic susceptibility patterns. We observed that gram–negative pathogens were predominantly responsible for LRTI. Antimicrobial resistance rate was high with the most commonly used antibiotics and also to newer antibiotics such as carbapenems. It is highly recommended that large scale multi–center studies are done to collect country–level data to guide empirical therapy in this geographical area.

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