e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15(3); 544-551

Original Research Article

A Hospital-Based Observational Assessment of the Demographics and Antimicrobial Susceptibility Patterns of Lower Respiratory Tract Infections in Intensive Care Unit

Monti Bori[1], Anup Gohatre[2], Ajeet Kumar[3]

[1]**Senior Resident, Department of Anaesthesia, Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India**

[2]**Senior Resident, Department of Anaesthesia, Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India**

[3]**Senior Resident, Department of Anaesthesia, Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India**

Received: 05-12-2022 / Revised: 25-12-2022 / Accepted: 21-01-2023

Corresponding author: Dr. Anup Gohatre

Conflict of interest: Nil

Abstract

Aim: The aim of the present study was to assess the distribution and antimicrobial susceptibility patterns of lower respiratory tract infections over a six–month period in the medical and surgical intensive care units of a teaching hospital in UP region.

Methods: This was a retrospective study conducted at Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India for the period of 6 months. This institution is an academic teaching hospital and is one of the local tertiary referral units. 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 and forty patients were enrolled for the study after considering the inclusion and exclusion criteria.

Results: A total of 140 patients were included in the study, out of which 98 (70%) were males. Amongst different age groups, maximum patients were above 60 y (25%) and the least were between 18–30 y (14.28%). The bacteria were isolated predominantly from the tracheal aspirate (85.72%), compared to broncho–alveolar lavage (14.28%) with a statistically significant difference between them. Out of all the isolated organisms, A. baumannii (n = 44; 31.42%), P. aeruginosa (n = 35; 25%) and Klebsiella (n = 32; 22.85%) 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%), S. aureus and Enterococcus were equal (n = 4; 4%). In the gram–negative isolates, A. baumannii was most susceptible to colistin (93.87%) followed by minocycline (81.63%) and amikacin (65.30%). 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 most common bacterial infections among patients in neurological intensive care units (NICUs), occurring in 10-25% of all intensive care unit (ICU) patients and resulting in high overall mortality, which may range from 22% to 71%. Infection and antibiotic resistance are important public health issues. [1-4] One of the major problems world-wide is the increase in antibiotic resistant strains of bacteria, mainly in hospitals and also in the community, which has proved difficult to control without considerable resources and expenditure. [5]

Recent reports have also described antimicrobial-resistant organisms as “nightmare” bacteria that result in excessive deaths and disastrous spending. [6] 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.

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. Hence, it is important to implement antimicrobial stewardship strategies personalized to the geographic location. [12]

The aim of the present study was to assess the distribution and antimicrobial susceptibility patterns of lower respiratory tract infections over a six–month period in the medical and surgical intensive care units of a teaching hospital in UP region. [13]

Materials and Methods

This was a retrospective study conducted at Banaras Hindu University (BHU), Varanasi, Uttar Pradesh, India for the period of 6 months. This institution is an academic teaching hospital and is one of the local tertiary referral units. 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. 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. One hundred and forty patients were enrolled for the study after considering the inclusion and exclusion criteria.

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	98 (70)
Female	42 (30)
Age groups	
18-30 years	20 (14.28)
31-40 years	22 (15.71)
41-50 years	28 (20)
51-60 years	35 (25)
>60 years	35 (25)
Underlying medical conditions	
Diabetes Mellitus	42 (30)
Respiratory pathology	28 (20)
Nephrological pathology	26 (18.57)
Malignancy	20 (14.28)
Others	24 (17.14)

A total of 140 patients were included in the study, out of which 98 (70%) were males. Amongst different age groups, maximum patients were above 60 y (25%) and the least were between 18–30 y (14.28%). The underlying major medical conditions of the LRTI were diabetes mellitus (30%), respiratory pathology (20%), nephrological pathology (18.57%) and malignancy (14.28%); while 17.14% 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	44 (89.80)	5 (10.20)	55.37-86.45	<0.001
P. aerugeniosa	25 (71.42)	10 (28.58)	33.56-73.94	<0.001
Klebsiella	30 (93.75)	2 (6.25)	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	120 (85.72)	20 (14.28)	63.09-80.71	<0.001

The bacteria were isolated predominantly from the tracheal aspirate (85.72%), compared to broncho–alveolar lavage (14.28%) with a statistically significant difference between them. Out of all the isolated organisms, A. baumannii (n = 44; 31.42%), P. aeruginosa (n = 35; 25%) and Klebsiella (n = 32; 22.85%) 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=49	P. aeruginosa n=35	Klebsiella 32	E. coli 12
Amikacin	32 (65.30)	7 (28)	8 (25)	3 (25)
Ampicillin	0	2 (8)	4 (12.5)	2 (16.66)
Aztreonam	23 (46.93)	0	0	3 (25)
Cefoperazone+Sulbactam	20 (40.81)	5 (20)	12 (37.5)	4 (33.34)
Cefepime	4 (12.24)	7 (28)	8 (25)	8 (66.66)
Ciprofloxacin	8 (16.32)	12 (48)	10 (31.25)	3 (25)
Colistin	46 (93.87)	10 (40)	30 (93.75)	11 (91.66)
Cotrimoxazole	3 (6.12)	6 (24)	10 (31.25)	6 (50)
Doripenem	12 (24.48)	15 (60)	24 (75)	9 (75)
Gentamicin	25 (51.02)	10 (40)	13 (40.62)	5(41.66)
Imipenem	13 (26.53)	12 (48)	12 (54.54)	7 (58.33)
Levofloxacin	20 (40.81)	0	0	3 (25)
Meropenem	18 (36.73)	14 (56)	22 (68.75)	2 (16.66)
Minocycline	40 (81.63)	5 (20)	8 (25)	10 (83.34)
Piperacillin/Tazobactam	10 (20.40)	8 (32)	0	3 (25)
Tigecycline	48 (97.95)	6 (24)	20 (62.5)	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 (93.87%) followed by minocycline (81.63%) and amikacin (65.30%). With regard to P. aeruginosa, it was observed that only around half of the isolates were susceptible to doripenem (60%) 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 (93.75%) followed by doripenem (75%), meropenem (68.75%) and tigecycline (62.5%).

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. 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 India. [26,27]

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.

References

1. Goel N, Chaudhary U, Aggarwal R, Bala K. Antibiotic sensitivity pattern of gram-negative bacilli isolated from the lower respiratory tract of ventilated patients in the intensive care unit. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2009 Jul; 13(3): 148.
2. Kumari HV, Nagarathna S, Chandramuki A. Antimicrobial resistance pattern among aerobic gram-negative bacilli of lower respiratory tract specimens of intensive care unit patients in a neurocentre. Indian journal of chest diseases and allied sciences. 2007 Jan 30;49(1):19.
3. Hospital-acquired pneumonia in adults: Diagnosis, assessment of severity, initial antimicrobial therapy, and preventive strategies. A consensus statement, American Thoracic Society, November 1995. Am J Respir Crit Care Med. 1996; 153:1711-25.
4. Gonlugur U, Bakici MZ, Ozdemir L, Akkurt I, Icagasioglu S, Gultekin F. Retrospective analysis of antibiotic susceptibility patterns of respiratory isolates of Pseudomonas aeruginosa in a Turkish University Hospital. Annals of Clinical Microbiology and Antimicrobials. 2003 Dec;2(1):1-4.
5. Ayliffe GA, Fraise AP, Geddes AM, Mitchell K. Control of Hospital Infection: A Practical Handbook. 4th ed. London: Arnold; 2000; 1-10.
6. Frieden T. Antibiotic resistance threats in the United States. Current. 2013; 114: 22-50.
7. Thu TA, Rahman M, Coffin S, Harun-Or-Rashid M, Sakamoto J, Hung NV. Antibiotic use in Vietnamese hospitals: A multicenter pointprevalence study.

Am J Infect Control. 2012; 40(9): 840-844.
8. Navaneeth BV, Belwadi MR. Antibiotic resistance among gram-negative bacteria of lower respiratory tract secretions in hospitalized patients. Indian J Chest Dis Allied Sci. 2002; 44(3): 173-176.
9. Pittet D. Nosocomial pneumonia: Incidence, morbidity and mortality in the intubated-ventilated patient. Schweiz Med Wochenschr. 1994; 124 (6):227-235.
10. Morehead RS, Pinto SJ. Review article. Ventilator-associated pneumonia. Arch Intern Med. 2000; 160:19 26-1936.
11. Dicker RC, Burton AH, Dean JA, Dean AG. In: Epiinfoversion 5: a word processing database and statistics programme for epidemiology on microcomputers. Georgia: USD, Incoperated; 1990.
12. Guzek A, Rybicki Z, Korzeniewski K, Mackiewicz K, Saks E, Chciałowski A, Zwolińska E. Etiological factors causing lower respiratory tract infections isolated from hospitalized patients. Respiratory Infections. 2015:37-44.
13. Uzoamaka M, Ngozi O, Johnbull OS, Martin O. Bacterial etiology of lower respiratory tract infections and their antimicrobial susceptibility. Am J Med Sci. 2017 Nov;354(5):471–475.
14. Veena KHB, Nagarathna S, Chandramuki A. Antimicrobial resistance pattern among aerobic gram-negative bacilli of lower respiratory tract specimens of intensive care unit patients in a neurocentre. Indian J Chest Dis Allied Sci. 2007; 49(1): 19-22.
15. Falagas ME, Mourtzoukou EG, Vardakas KZ. Sex differences in the incidence and severity of respiratory tract infections. Respir Med. 2007 Sep;101(9):1845–63.
16. Vijay S, Dalela G. Prevalence of LRTI in patients presenting with productive cough and their antibiotic resistance pattern. J Clin Diagn Res. 2016 Jan;10(1): DC09–12.
17. Humphreys H, Newcombe RG, Enstone J, Smyth ET, McIlvenny G, Davies E, et al. Four country healthcare–associated infection prevalence survey: pneumonia and lower respiratory tract infections. J Hosp Infect. 2010 Mar;74(3):266–70.
18. Khan S, Priti S, Ankit S. Bacteria etiological agents causing lower respiratory tract infections and their resistance patterns. Iran Biomed J. 2015;19(4):240–6.
19. Ullah B, Ahmed S, Shahariar M, Yesmine S. Current trend of antibiotic resistance in lower respiratory tract infections (LRTIs): an experience in a teaching hospital in Bangladesh. Bangladesh Pharma J. 2016 Aug 10; 19(1):85–91.
20. Parajuli NP, Acharya SP, Mishra SK, Parajuli K, Rijal BP, Pokhrel BM. High burden of antimicrobial resistance among gram negative bacteria causing healthcare associated infections in a critical care unit of Nepal. Antimicrobial Resistance & Infection Control. 2017 Dec;6(1):1-9.
21. Bhatta DR, Hamal D, Shrestha R, Supram HS, Joshi P, Nayak N, Gokhale S. Burden of multidrug resistant respiratory pathogens in intensive care units of tertiary care hospital. Asian Journal of Medical Sciences. 2019 Mar 1;10(2):14-9.
22. Hsu LY, Apisarnthanarak A, Khan E, Suwantarat N, Ghafur A, Tambyah PA. Carbapenem–resistant acinetob acter baumannii and enterobacteriaceae in South and Southeast Asia. Clin Microbiol Rev. 2017 Jan;30(1):1–22.
23. Gill JS, Arora S, Khanna SP, Kumar KH. Prevalence of multidrug–resistant, extensively drug–resistant, and pandrug–resistant Pseudomonas aeruginosa from a tertiary level intensive care unit. J Glob Infect Dis. 2016 Oct;8(4):155–9.

24. Trinh TD, Zasowski EJ, Claeys KC, Lagnf AM, Kidambi S, Davis SL, Rybak MJ. Multidrug-resistant Pseudomonas aeruginosa lower respiratory tract infections in the intensive care unit: prevalence and risk factors. Diagnostic microbiology and infectious disease. 2017 Sep 1;89(1):6 1-6.
25. Tenover FC. Mechanisms of antimicrobial resistance in bacteria. The American journal of medicine. 2006 Jun 1;119(6): S3-10.
26. Upadhyay V, Kumar A, Jayesh AK. A Study of microbial colonization and their antibiotic resistance pattern in endotracheal aspirate cultures in intensive care unit patients at a tertiary care hospital of Eastern UP, India. Int J Curr Microbiol App Sci. 2018;7(4):22 98–306.
27. Chola J. M., Albert M. T., Jules N. T., Manteka K., Herman T. K., Shombo Mutangala N., Prosper K. L., Xavier K. K., Prosper K. M. K., & Baptiste K. S. Z. J. Profil Hématologique, Biochimique Et Hormonal Au Cours De La Grossesse: Cas Des Pre-Eclamptiques Versus Gestantes En Bonne Sante Apparente Dans La Ville De Lubumbashi, RDC. Journal of Medical Research and Health Sciences. 2022; 5(12): 2355–2367.