ISSN: 1607-8322, e-ISSN: 2220-5799 **Anaesthesia, Pain & Intensive Care**
Vol 25(6); December 2021 DOI: 10.35975/apic.v25i6.1699

ORIGINAL RESEARCH **INTENSIVE CARE**

Demographics and antimicrobial susceptibility patterns of lower respiratory tract infections in intensive care unit of a teaching hospital in South India

Bharath Cherukuri

N.R.I Academy of Sciences, Mangalagiri Road, Chinakakani-522503 Guntur District, AP, India.

Correspondence: Bharath Cherukuri; E-mail: bharathcherukuri@yahoo.com; Phone: 87854869367

Abstract

Aim: We aimed to study the distribution and antimicrobial susceptibility patterns of lower respiratory tract infections over a six–month period in the medical and surgical intensive care units at NRI Academy of Medical Sciences, in the Southern Region of India.

Methodology: This was a retrospective study conducted from June 2019 to December 2019. The study included all patients of either gender, aged above 18 y, admitted in the medical and surgical intensive care units for whom specimens for culture were positive for lower respiratory tract infections. The data was compared for the location, type, number of isolates and their antibiotic susceptibility. The data was analyzed using the

Medcalc™ software.

Results: A total of 114 patients were included in the study, out of which 78 (68.4%) were males. The maximum patients were above 60 y (29.8%). Gram–negative pathogens accounted for majority of the isolates (89%). The bacteria were isolated predominantly from the tracheal aspirate (86.8%). Out of all the isolated organisms, *Acinetobacter baumannii* (n = 34; 29.8%), *pseudomonas aeruginosa* (n = 29; 25.4%) and *Klebsiella* (n = 27; 23.7%) were the most common gram–negative isolates, whereas in the gram–positive isolates, *Staphylococcus aureus* and *Enterococcus* were equally isolated (n = 4; 3.5%). *A. baumannii* was most susceptible to colistin (97.1%) followed by minocycline (70.6%) and amikacin (64.7%). Whereas, with *P. aeruginosa*, it was observed that only around half of the isolates were susceptible to doripenem (51.7%) and it was also observed that most of the isolates were resistant to all the commonly used antibiotics.

Conclusion: This current study provides useful information regarding the causative organisms of lower respiratory tract infections occurring in the intensive care units and their antibiotic susceptibility patterns. 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.

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

Citation: Cherukuri B. Demographics and antimicrobial susceptibility patterns of lower respiratory tract infections in intensive care unit of a teaching hospital in South India. Anaesth. pain intensive care 2021;25(6):757-762; **DOI:** 10.35975/apic.v25i6.1699

Received: March 29, 2021**, Reviewed:** July 26, 2021**, Accepted:** October 18, 2021

1. 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. Hence, it is important to implement antimicrobial stewardship strategies personalized to the geographic location. Due to these reasons, we studied the distribution and antimicrobial susceptibility patterns of LRTI over a six-month period in the medical and surgical ICUs at NRI Academy of Medical Sciences, in the Southern Region of India.

2. Methodology

2.1 Study design and population

This was a retrospective study conducted at NRI Academy of Medical Sciences between June 2020 to December 2020. This institution is an academic teaching hospital and is one of the local tertiary referral units. There are 15 beds in medical and surgical ICUs, apart from an exclusive pediatric ICU. 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 1428; out of whom, 287 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 fourteen patients were enrolled for the study after considering the inclusion and exclusion criteria.

2.2 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.

2.3 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.

2.4 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.

3. Results

3.1 Study population

A total of 114 patients were included in the study, out of which 78 (68.4%) were males. Amongst different age groups, maximum patients were above 60 y (29.8%) and the least were between 18–30 y (11.4%) as seen in Table 1. The underlying major medical conditions of the LRTI were diabetes mellitus (27%), respiratory pathology (21%), nephrological pathology (18%) and malignancy (12%); while 18% of the patients had had other medical conditions, including electrolyte imbalance, hormonal imbalance, or miscellaneous causes such as poisoning.

3.2 Bacteria isolated

Of the causative pathogens, gram–negative pathogens accounted for majority of isolates (89%). The bacteria were isolated predominantly from the tracheal aspirate (86.8%), compared to broncho–alveolar lavage (13.2%) with a statistically significant difference between them as seen in Table 2. Out of all the isolated organisms, *A. baumannii* (n = 34; 29.8%), *P. aeruginosa* (n = 29; 25.4%) and *Klebsiella* (n = 27; 23.7%) were the most common gram–negative isolates; whereas in the gram–

Table 1: Demographic Characteristics of Patients

Variable	N (%)
Gender	
Males n	78 (68.4)
Females %	36 (31.6)
Age group	
18 – 30 years	13 (11.4)
31- 40 years	16 (14.1)
41- 50 years	22 (19.3)
51- 60 years	29 (25.4)
> 60 years	34 (29.8)
Total	114

positive isolates, *S. aureus* and *Enterococcus* were equal (n = 4; 3.5%). Other pathogenic bacteria were *E. coli* (n = 12; 10.5%) followed equal number of *Pneumococcus* and *CONS* (n = 2; 1.8%) as seen in Table 2.

3.3 Susceptibility patterns of isolates

The susceptibility pattern of different organisms is shown in Tables 3 and 4. 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 (97.1%) followed by minocycline (70.6%) and amikacin (64.7%). With regard to *P. aeruginosa*, it was observed that only around half of the isolates were susceptible to doripenem (51.7%) 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 (77.8%) followed by doripenem (59.3%), meropenem (55.6%) and tigecycline (51.9%). In the gram–positive isolates, *S.*

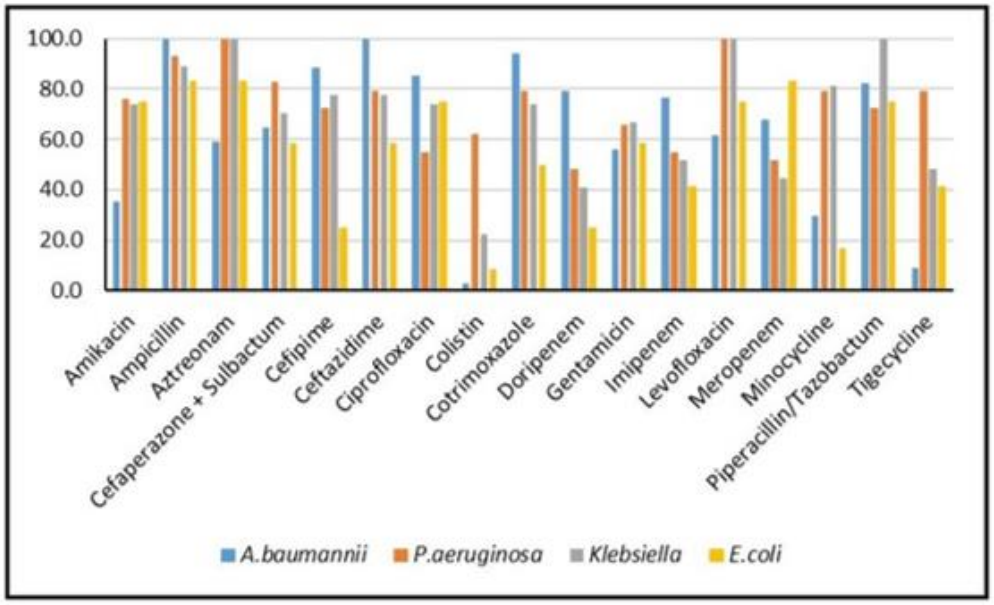

Figure 1: Microorganism resistance to the common antibiotics

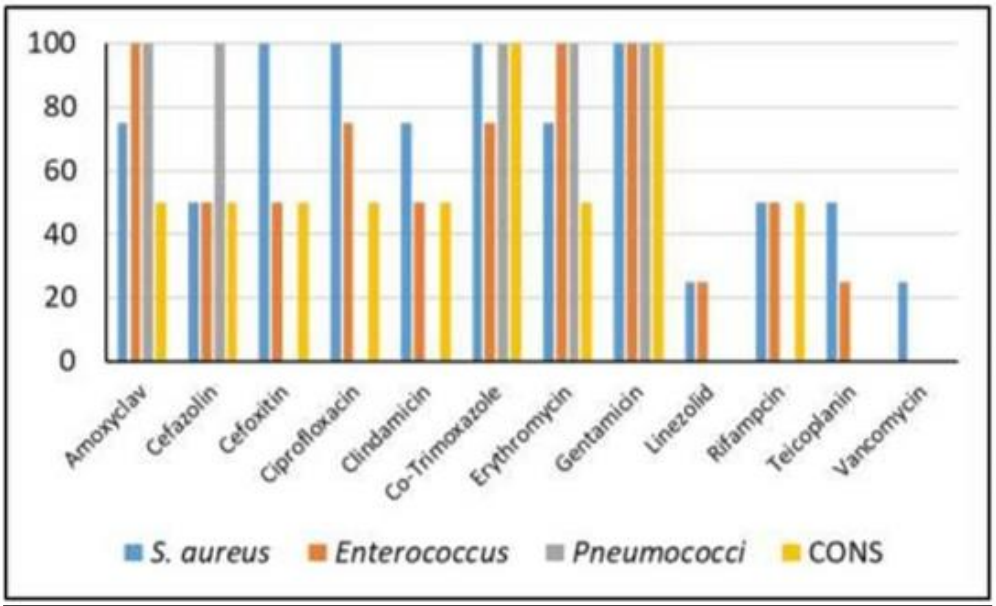

Figure 2: Microorganism resistance to the common antibiotics

Table 2: Bacteria Isolated from the Lower Respiratory Tract from ICU Patients

Organism	Tracheal aspirate	Broncho-alveolar lavage	95 % CI	p-value
	N (%)	N (%)		
A. baumannii	30 (88.2)	4 (11.8)	55.37 – 86.45	< 0.001
P. aeruginosa	23 (79.3)	6 (20.7)	33.56 – 73.94	< 0.001
Klebsiella	25 (92.6)	2 (7.4)	62.62 – 92.76	< 0.001
E. coli	10 (83.3)	2 (16.7)	26.80 – 83.55	< 0.01
S. aureus	4 (100)	0 (0)	NA	NA
Enterococcus	4 (100)	0 (0)	NA	NA
Pneumococci	1 (50)	1 (50)	- 57.34 – 57.34	NS
CONS	2 (100)	0 (0)	NA	NA
Total n (%)	99 (86.8)	15 (13.2)	63.09 – 80.71	< 0.001

NA: Not applicable; NS: Not significant

Table 3: Susceptibility Pattern of Gram-negative Isolates

Antibiotic	A. baumannii	P. aeruginosa	Klebsiella	E. coli
Amikacin	22 (64.7)	7 (24.1)	7 (25.9)	3 (25.0)
Ampicillin	0 (0)	2 (6.9)	3 (11.1)	2 (16.7)
Aztreonam	14 (41.18)	0 (0)	0 (0)	2 16.7)
Cefoperazone + Sulbactam	12 (35.3)	5 (17.2)	8 (29.6)	5 (41.7)
Cefepime	4 (11.7)	8 (27.6)	6 (22.2)	9 (75.0)
Ceftazidime	0 (0)	6 (20.7)	6 (22.2)	5 (41.7)
Ciprofloxacin	5 (14.7)	13 (44.8)	7 (25.9)	3 (25.0)
Colistin	33 (97.1)	11 (37.9)	21 (77.8)	11 (91.7)
Cotrimoxazole	2 (5.8)	6 (20.7)	7 (25.9)	6 (50.0)
Doripenem	7 (20.6)	15 (51.7)	16 (59.3)	9 (75.0)
Gentamicin	15 (44.1)	10 (34.5)	9 (33.3)	5 (41.7)
Imipenem	8 (23.5)	13 (44.8)	13 (48.2)	7 (58.8)
Levofloxacin	13 (38.2)	0 (0)	0(0)	3 (25.0)
Meropenem	11 (32.4)	14 (48.3)	15 (55.6)	2 (16.7)
Minocycline	24 (70.6)	6 (20.7)	5 (18.5)	10(83.3)
Piperacillin/Tazobactam	6 (17.6)	8 (27.6)	0 (0)	3 (25.0)
Tigecycline	31 (91.2)	6 (20.7)	14 (51.9)	7 (58.3)

Data presented as n (%)

aureus was equally susceptible to linezolid (75%) and vancomycin (75%); and 100% of the isolates of *Enterococcus* were susceptible to vancomycin.

4. Discussion

In the recent years, there has been steep rise in the antibiotic resistance among pathogens causing LRTI due to different mechanisms. Hence, it is important to draw a plan to use the most appropriate empirical therapy based on the local epidemiology and susceptibility patterns. In this context, we carried out this study to provide contemporary information on the patterns of demographics and antimicrobial susceptibility of LRTI in the ICUs at our hospital.

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.[7,8] Similar results were observed in the study by Humphrey et al.[9] 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.[8]

In our study, the incidence of gram–negative organisms was 89%, while only 11% were gram–positive. The results are in accordance with the study of Khan et al.[10] Other studies have reported a varied incidence of gram–positive (9–22%) and gram–negative (78–91%) bacteria.[11,12] 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%

Table 4: Susceptibility Pattern of Gram-positive Isolates. Data presented as n (%)

Antibiotic	S. aureus	Enterococcus	Pneumococci	CONS
Amoxyclav	1 (25.0)	0 (0)	0 (0)	1 (50.0)
Cefazolin	2 (50.0)	2 (50.0)	0 (0)	1 (50.0)
Cefoxitin	0 (0)	2 (50.0)	1 (50.0)	1 (50.0)
Ciprofloxacin	0 (0)	1 (25.0)	1 (50.0)	1 (50.0)
Clindamycin	1 (25.0)	2 (50.0)	1 (50.0)	1 (50.0)
Cotrimoxazole	0 (0)	1 (25.0)	0 (0)	0 (0)
Erythromycin	1 (25.0)	0 (0)	0 (0)	1 (50.0)
Gentamicin	0 (0)	0 (0)	0 (0)	0 (0)
Linezolid	3 (75.0)	3 (75.0)	1 (50.0)	2 (100)
Rifampicin	2 (50.0)	2 (50.0)	1 (50.0)	1 (50.0)
Teicoplanin	2 (50.0)	3 (75.0)	1 (50.0)	2 (100)
Vancomycin	3 (75.0)	4 (100)	1 (50.0)	2 (100)

were gram–positive isolates.[13] 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.[14] However, other studies have reported *Klebsiella* or *P. aeruginosa* as the most common bacterial pathogens causing LRTI in the ICU.[15–17] In our study *S. aureus* and *Enterococcus* were the most isolated gram–positive bacteria, which is similar to the results of other studies done in India where S. aureus was the most isolated gram–positive organism.[18,19]

Antibiotic resistance (Figures 1 and 2) is a major problem in patients admitted in ICU. Moreover, resistance of gram–negative pathogens to carbapenems is even worrisome. 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.[20,21] 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*.[22,23] 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.[24] 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. [25]

5. Limitations

There were certain limitations, as it was a retrospective study and was done in a single center for a limited duration. Larger, multi–center studies at country level are recommended.

6. 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.

7. Conflicts of interest

None declared by the author.

8. Author's contribution

BC conceived the idea, conducted the study and was the sole author of this manuscript.

9. References

1. Greene G, Hood K, Little P, Verheij T, Goossens H, Coenen S, et al. Towards clinical definitions of lower respiratory tract infection

(LRTI) for research and primary care practice in Europe: an international consensus study. Prim Care Respir J. 2011 Sep;20(3):299–306, 6 p following 306. [PubMed] DOI: 10.4104/pcrj.2011.00034

2. Feldman C, Shaddock E. Epidemiology of lower respiratory tract infections in adults. Expert Rev Respir Med. 2019 Jan;13(1):63–77. [PubMed] DOI: 10.1080/17476348.2019.1555040
3. GBD 2016 Lower Respiratory Infections Collaborators. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of lower respiratory infections in 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Infect Dis. 2018 Nov;18(11):1191–1210. [PubMed] DOI: 10.1016/S1473–3099(18)30310–4
4. Panda S, Nandini BP, Ramani TV. Lower respiratory tract infections–bacteriological profile and antibiogram pattern. Int J Curr Res Rev. 2012 Nov 1;4:149–55. [FreeFullText]
5. Guzek A, Rybicki Z, Korzeniewski K, Mackiewicz K, Saks E, Chciałowski A, et al. Etiological factors causing lower respiratory tract infections isolated from hospitalized patients. Adv Exp Med Biol. 2015;835:37–44. [PubMed] DOI: 10.1007/5584_2014_23
6. 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. [PubMed] DOI: 10.1016/j.amjms.2017.06.025
7. 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. [PubMed] DOI: 10.1016/j.rmed.2007.04.011
8. 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. [PubMed] DOI: 10.7860/JCDR/2016/17855.7082
9. 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. [PubMed] DOI: 10.1016/j.jhin.2009.10.010
10. 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. [PubMed] DOI: 10.7508/ibj.2015.04.008
11. Huaimin X, Cheng WU. Bacterial Infection of Lower Respiratory Tract in Comprehensive Intensive Care Unit. Chinese J Nosoconmiol. 2005;3.
12. He R, Luo B, Hu C, Li Y, Niu R. Differences in distribution and drug sensitivity of pathogens in lower respiratory tract infections between general wards and RICU. J Thorac Dis. 2014 Oct;6(10):1403–10. [PubMed] DOI: 10.3978/j.issn.2072–1439.2014.09.22
13. 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. DOI: 10.3329/bpj.v19i1.29243
14. 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. Antimicrob Resist Infect Control. 2017 Jun 15;6:67. [PubMed] DOI: 10.1186/s13756–017–0222–z
15. Regha IR, Sulekha B. Bacteriological profile and antibiotic susceptibility patterns of lower respiratory tract infections in a tertiary care hospital, Central Kerala. Int J Med Microbiol Trop Dis. 2018;4(4):186–90. DOI: 10.18231/2581–4761.2018.0040
16. 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 J Crit Care Med. 2009 Jul–Sep;13(3):148–51. [PubMed] DOI: 10.4103/0972–5229.58540
17. Akter T, Murshed M, Begum T, Nahar K, Duza SS, Shahnaz S. Antimicrobial resistance pattern of bacterial isolates from intensive care unit of a tertiary care hospital in Bangladesh. Bangladesh J Med Microbiol. 2014;8(1):7–11. DOI: 10.3329/bjmm.v8i1.31052
18. Khety Z, Mohanta G, Jain S, Dawoodi S. Changing antimicrobial resistance pattern of isolates from an ICU over a 3 year period. J Assoc Physicians India. 2017 Feb;65(2):13–16. [PubMed]
19. Bali N, Kakru D, Bashir H, Lone S, Farhana A, Koul P. Lower respiratory tract infections in intensive care units. a four year study from north India. J Adv Med Med Res. 2016:1–9. DOI: 10.9734/BJMMR/2016/21636
20. Bhatta DR, Hamal D, Shrestha R, Supram HS, Joshi P, Nayak N, et al. Burden of multidrug resistant respiratory pathogens in intensive care units of tertiary care hospital. Asian J Med Sci. 2019 Mar 1;10(2):14–9. DOI: 10.3126/ajms.v10i2.21098
21. Hsu LY, Apisarnthanarak A, Khan E, Suwantarat N, Ghafur A, Tambyah PA. Carbapenem–resistant acinetobacter baumannii and enterobacteriaceae in South and Southeast Asia. Clin Microbiol Rev. 2017 Jan;30(1):1–22. [PubMed] DOI: 10.1128/CMR.masthead.30–1
22. 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. [PubMed] DOI: 10.4103/0974–777X.192962
23. Trinh TD, Zasowski EJ, Claeys KC, Lagnf AM, Kidambi S, et al. Multidrug–resistant pseudomonas aeruginosa lower respiratory tract infections in the intensive care unit: prevalence and risk factors. Diagn Microbiol Infect Dis. 2017 Sep;89(1):61–66. [PubMed] DOI: 10.1016/j.diagmicrobio.2017.06.009
24. Tenover FC. Mechanisms of antimicrobial resistance in bacteria. Am J Med. 2006 Jun;119(6 Suppl 1):S3–10; discussion S62–70. [PubMed] DOI: 10.1016/j.amjmed.2006.03.011
25. 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):2298–306. DOI: 10.20546/ijcmas.2018.704.263