e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(9); 147-150

Original Research Article

Study of Bacteriological Assessment and Antibiogram of Bronchoalveolar Lavage Fluid from Patients with Respiratory Tract Infections: A Cross-Sectional Analysis

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Received: 01-06-2026 / Revised: 15-07-2026 / Accepted: 21-08-2026
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Conflict of interest: Nil

Abstract

Background: Globally, respiratory tract infections are a major cause of both mortality and morbidity. Geographically and across time, the most common bacterial agents and their patterns of antibiotic resistance vary. The sensitivity and specificity of diagnostic methods for lung infections have been enhanced by bronchoalveolar lavage. Since the use of empirical therapy with conventional drugs has become more difficult due to the evolution of antibiotic resistance in frequently isolated pathogens, the current study aims to identify bacterial isolates and their sensitivity pattern.

Methods: Over a period of nine months, from July 2025 to March 2026, BAL fluid samples from patients with respiratory infections having bronchoscopy at MMCH, Madhubani, Bihar, were collected under aseptic settings and processed in accordance with normal practice. According to CLSI recommendations, the Kirby-Bauer disc diffusion method was used to test the antimicrobial susceptibility.

Results: 104 (38.5%) of the 270 samples were positive for growth. Six of these were fungal isolates and 98 were bacterial isolates. The age group of 51–60 years old had the highest isolation rate, followed by 61–70 years old. The most frequently isolated species were GNB, with Klebsiella pneumoniae accounting for 60% of the total, followed by Pseudomonas (30%) and E. coli (8%). Allcephalosporin resistance and amikacin sensitivity were seen, followed by piperacillin-tazobactam and various aminoglycosides.

Conclusion: When diagnosing respiratory infections, BAL has increased both sensitivity and specificity. Antibiotic resistance and the evolving pattern of bacterial infections are responsible for an updated antibiogram, monitoring of bacterial isolates, and other susceptibility.

Keywords: Bronchoalveolar lavage, Respiratory infection, Antimicrobial sensitivity, Bacterial isolates.

DOI: 10.25258/ijcpr.18.9.23

Introduction

The most frequent cause of disease in patients of all ages is bacterial respiratory infections.[1] The body uses this systemic route to take in new oxygen and expel carbon dioxide. The upper and lower respiratory tracts are the two categories into which the respiratory systems are divided.[2]

The nose, nasal passages, paranasal sinuses, pharynx, and portion of the larynx above the vocal folds make up the upper respiratory tract anatomy. The common cold, tonsillitis, pharyngitis, laryngitis, rhino sinusitis, and otitis media are the URTIs that frequently occur.[3] The larynx, vocal folds, trachea, bronchi, bronchioles, and alveoli are all parts of the lower respiratory system. The most frequent respiratory tract infections are pneumonia, bronchiolitis, and tracheitis. It can have serious consequences that could result in hospitalization and even death.[4] Infections that cause symptoms like coughing with expectoration, dyspnea, wheezing, chest pain or discomfort, or potentially fatal infections that typically last between one and three weeks are classified as pulmonary infections.[5, 6] Bacteria and viruses are the most frequent causes of infections in these patients. Moraxella catarrhalis, Streptococcus pneumoniae, and Haemophilus influenzae are the most common bacteria linked to exacerbations.[7]

Due to variations in the frequency of antibiotic administration, environmental conditions, and ventilation in critically sick patients, the bacteriological profile of lung infections differs even within the same nation. Additionally, the microbiology lab faces challenges due to the growing range of new infections.[8] Bacterial

etiological agents and a lack of timely and suitable access to treatment are primarily responsible for the high death rate of these illnesses in these patients. Finding the causative agent is essential for effective antimicrobial therapy. For bacteriological diagnosis, the right material must be obtained. The sensitivity and specificity of diagnostic methods for the identification of lung infections have increased since the development of bronchoscopy and quantitative invasive procedures like bronchoalveolar lavage.[9] The best sample for recovering pathogens' cellular and noncellular components from the lower respiratory tract's epithelial surface is broncho alveolar lavage (BAL).[10] Although it was once only used as an investigative and research tool, it is now more frequently used as a diagnostic tool. Since less than 50% of patients with lung infections have a diagnosis from a sputum culture, early diagnosis and appropriate antibiotic selection are essential for the treatment of these individuals. The problem becomes more complicated if the sputum culture report is equivocal or the patient responds poorly to the drugs that have been found to be sensitive.

Material and Methods

Between July 2025 and March 2026, the Department of Microbiology at Madhubani Medical College and Hospital in Madhubani, Bihar, carried out this cross-sectional prospective study. Aseptic procedures were followed when collecting BAL fluid specimens, which were then promptly sent to the lab for processing. The study comprised 270 BAL fluid samples in total. The consistency, color, and smell of these samples were closely examined. Pus cells, epithelial cells, bacteria, and yeast cells were examined under a microscope using Gram stain and wet mount preparation.

They were then infected using a sterile 4mm nichrome loop on Mac Conkey Agar, Blood Agar, and Chocolate Agar, and they were cultured for 24 to 48 hours at 370C using standard laboratory procedures. The following day, the Petri plates were examined for any signs of bacterial growth and their morphological, cultural, and biochemical traits were used to identify them. The material was inoculated on Saborauds dextrose agar [SDA] for fungal growth, incubated for seven days at 370C, and growth was monitored.

In accordance with Clinical and Laboratory Standards Institute guidelines [CLSI]-2014, the Kirby-Bauer disc diffusion method was used to test bacterial isolates for antibiotic susceptibility. According to CLSI criteria, zone diameter was measured in millimeters and interpreted.

This study comprised patients aged 20 to 70 who presented with symptoms such as fever with purulent sputum, respiratory difficulties, and physical features suggestive of consolidation. Pregnant women and patients with heart conditions were not included in this study.

Results

Male patients made up 156 (57.77%) of the 270 samples, while female patients made up 114 (42.23%). The age range of 51–60 years old accounted for the bulk of instances, with 61–70 years old coming in second. The age group of 18 to 30 years old had the fewest cases. 104 (38.5%) of the 270 samples that were processed showed growth on culture. Gram negative bacteria (GNB) made up the majority of the isolates. Of the 104 isolates, six were fungi and 98 were GNB. Klebsiella pneumoniae 30 (60%) was the most common GNB, followed by Pseudomonas aeruginosa 30 (30%), Escherichia coli 8 (8%), and Aspergillus Niger 6 (6%).

The age group of 51–60 years old had the most isolates, followed by 61–70 years old, while the age group of 18–30 years old had the fewest. Amikacin, piperacillin-tazobactam, imipenem, gentamycin, and tobramycin were the most effective treatments for Klebsiella and Pseudomonas. They also displayed mild resistance to ciprofloxacin and resistance to cephalosporins.

Table 1: Age and sex distribution of subjects

Age Groups (in years)	Male	Female	Total
18-30	14	10	24
31-40	2	32	34
41-50	30	12	42
51-60	74	28	102
61-70	36	32	68
Total	156	114	270

Table 2: Spectrum of bacterial isolates from BAL fluid

Isolates	No. of patients	Percentage
Klebsiella	60	60.0%
Pseudomonas	30	30.0%
Esch.coli	8	8%
Aspergillus niger	6	6%
Total	104	

Table 3: Occurrence of isolates in different age groups

Isolates	18-30 N=24	31-40 N=34	41-50 N=42	51-60 N=102	61-70 N=68	Total
Klebsiella	6(25%)	6(17.4%)	12(12%)	22(21%)	14(11%)	60
Pseudomonas	4(16.66%)	4(11.74%)	4(9.52%)	12(11.76%)	6(8.82%)	30
Esch.coli	2(6.33%)	0	0	4(3.92%)	2(2.94%)	8
Aspergillus niger	0	0	0	4(3.92%)	2(2.94%)	6

Table 4: Resistant pattern of gram-negative isolates

Antibiotic	Klebsiella (60)	Pseudomonas (30)	E.coli (8)
Amikacin	8(13%)	6(20%)	2(25%)
Piperacillintazobactm	12(20%)	8(27%)	-
Gentamycin	12(20%)	8(27%)	-
Tobramycin	12(20%)	8(27%)	-
Cephalexin	50(83%)	20(67%)	6(75%)
Cefuroxime	48(80%)	24(80%)	4(50%)
Ceftriaxone	48(80%)	24(80%)	4(50%)
Cefepime	52(87%)	24(80%)	2(25%)
Ciprofloxacin	40(67%)	18(60)	2(25%)
Tetracycline	32(53%)	20(67%)	4(50%)
Imipenem	12(20%)	6(20%)	-

Discussion

Because of their prevalence and socioeconomic effect, chronic respiratory disorders pose a public health concern in both developed and developing nations. They have a higher global mortality and morbidity rate and are the second most frequent cause of hospital-acquired infections. Patients with serious respiratory infections frequently develop pneumonia as a consequence.

In order to assess BAL fluid, a useful diagnostic tool, the current investigation was carried out to ascertain the bacterial etiology in patients with respiratory infections. Gram stain results were used to evaluate the quality of BAL fluid, which was then followed by culture and sensitivity tests. Out of the 270 samples gathered for this study, 104 had positive BAL cultures.

With 98 and 6 fungal growths, GNB were the most common organisms among them. These findings are consistent with research conducted by Goel et al. [11] and Barsanth et al. [12].

The age range of 51–60 years old had the highest number of positive cases, followed by 61–70 years old. This could be because as people age, more respiratory instances are seen, which weakens the host's defenses.[13] According to Table 1, males had a higher rate of isolation (58%) than females (42%), which was consistent with findings from Shah et al. [14] and Birasen Behera et al. [15].

Klebsiella pneumoniae was the most common bacterial isolate among culture-positive GNB cases in this investigation, followed by Pseudomonas and E. coli, which is consistent with research by Madhavi et al., [16] Ratna S et al., [17] Veena et al., and Viswanath et al. [18].

All of the GNB isolates in our investigation were resistant to cephalosporins but susceptible to amikacin, piperacillin-tazobactam, gentamycin, tobramycin, and imipenem.

Similar results were noted by Regha IR et al. [19], Goel et al. [11], Barsanti et al. [12], and Olugbue V. Onouha et al. [20]. Inadequate therapy may be the cause of this cephalosporin resistance. Additionally, Klebsiella and Pseudomonas in our investigation showed ciprofloxacin resistance, which is consistent with Regha IR et al. [19].

The majority of the gram-negative isolates in our investigation showed sensitivity to amikacin, piperacillin, and tazobactam, with imipenem coming in second. As a result, it may be among the most effective combinations for treating gram-negative bacterial infections, which are comparable to the research published by Olugbue V. Onouha et al. [20].

Conclusion

Finding the microbiological profile of BAL fluid isolated from pulmonary infections was the primary goal of the study.

The current study's findings show how common gram-negative isolates are. Since the majority of isolates are extremely resistant to cephalosporin and other widely used antibiotics, the study also recommends routine antimicrobial sensitivity testing.

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