Journal of Health and Rehabilitation Research 2791-156X JHRR

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Original Article

Sputum Bacteriology in Chronic Obstructive Pulmonary Disease Exacerbation Patients

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Conflict of Interest: None.

Rafia., et al. (2024). 4(2): DOI: https://doi.org/10.61919/jhrr.v4i2.1210

ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is a complex and heterogeneous respiratory condition characterized by persistent airflow limitation and associated with inflammatory responses in the lungs. COPD exacerbations can significantly impact patient health and often necessitate medical intervention. Understanding the bacterial etiology of these exacerbations can aid in optimizing treatment strategies.

Objective: The objective of this study was to determine the frequency of bacterial pathogens in the sputum of patients experiencing COPD exacerbations at a tertiary care hospital.

Methods: This cross-sectional study was conducted in the Department of Pulmonology at Pakistan Emirates Military Hospital, Rawalpindi, from December 12, 2023, to June 12, 2024. A total of 160 patients aged 18 to 60 years, admitted with acute exacerbation of COPD, were included using non-probability purposive sampling. Exclusion criteria were patients with lung malignancy, acute asthma exacerbations, bronchiectasis, or interstitial lung disease. Sputum samples were collected, and standard microbiological procedures were followed. Microscopy with Gram staining was performed, and specimens with more than 10 epithelial cells per low power field were cultured. Quantitative culture was conducted using blood agar and chocolate blood agar plates incubated in 5% CO2 at 35°C for 18–24 hours. Isolates with higher than 10^5 colony-forming units were reported as positive growth. Statistical analysis was performed using SPSS Version 25.

Results: The mean age of the patients was 37.89 ± 11.2 years, with 94 (58.8%) males and 66 (41.3%) females. The average duration of COPD was 4.87 ± 1.19 years. Among the participants, 89 (55.6%) were from urban areas, and 71 (44.4%) from rural areas. Educational status showed 33 (20.6%) illiterate, 111 (69.4%) with intermediate education, and 16 (10.0%) graduates. Comorbid conditions included diabetes mellitus in 37 (23.1%) patients, hypertension in 29 (18.1%), ischemic heart disease in 15 (9.4%), and smoking in 62 (38.8%). Sputum cultures revealed pathogens in 43 (26.9%) patients. Klebsiella pneumoniae was the most frequently identified bacterium (19 cases, 11.9%), followed by Staphylococcus aureus (10 cases, 6.3%), Pseudomonas aeruginosa (5 cases, 3.1%), Actinobacter (1 case, 0.6%), and Streptococcus pneumoniae (10 cases, 6.3%).

Conclusion: The study concluded that COPD exacerbation patients exhibited a variety of single pathogenic bacterial isolates, with Klebsiella pneumoniae and Streptococcus pneumoniae being the most common. Sputum culture is a valuable tool in identifying bacterial pathogens in COPD exacerbations, guiding appropriate antibiotic therapy.

Keywords: COPD exacerbation, sputum bacteriology, Klebsiella pneumoniae, Streptococcus pneumoniae, bacterial pathogens.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a complex and heterogeneous respiratory condition characterized by persistent airflow limitation (1). It is frequently associated with an inflammatory response in the lungs triggered by noxious particles or gases, primarily from cigarette smoking but also from exposure to occupational dusts, chemicals, and both indoor and outdoor air pollution (2). The heterogeneity of COPD is reflected in the diversity of its clinical manifestations, disease progression, and treatment responses. Various phenotypes and endotypes have been identified within the COPD population, indicating differences in the underlying pathophysiology and clinical characteristics. The two main conditions under the COPD umbrella are chronic bronchitis

and emphysema, and many individuals may present with a combination of both, often referred to as chronic bronchitis with emphysema (3, 4).

Recurrent exacerbations of COPD can significantly impact overall health and well-being, contributing to a faster decline in lung function. The increased inflammation and stress on the respiratory system during exacerbations may cause further lung damage, leading to more rapid deterioration over time (5, 6). The exact mechanisms leading to these exacerbations are not fully understood, though factors such as allergens, respiratory infections, air pollution, and weather changes are known triggers (7, 8). While the role of bacterial infection remains debated, bacterial pathogens are identifiable in substantial concentrations from distal airways in approximately 40–60% of acute exacerbations of COPD (AECOPD) cases. Streptococcus pneumoniae, Haemophilus influenzae, and Moraxella catarrhalis are the most frequently isolated pathogens in previous studies (9).

The mortality rate from acute exacerbation of COPD requiring intensive care unit admission is high, particularly in patients over 65, where it can reach up to 30% (10). This health issue affects both rural and urban populations, with prevalence ranging from 1% among urban non-smokers to 21% among rural smokers, influenced by lifestyle factors, environmental conditions, and healthcare access. Given the rising prevalence and associated mortality rates, extensive research has been dedicated to understanding these diseases. COPD is primarily linked to smoking, but other factors such as air pollution and occupational exposures also play significant roles (10).

Studying sputum bacteriology in patients experiencing COPD exacerbation is crucial for several reasons. It helps enhance patient quality of life, supports clinical decisions, optimizes treatment approaches, addresses antibiotic resistance, improves diagnostic accuracy, influences guideline development, and advances scientific knowledge in COPD research. Therefore, the goal of this study is to determine the frequency of sputum bacteriology in COPD exacerbation patients at a tertiary care hospital. Understanding the bacterial landscape in these patients is vital for developing targeted treatment strategies and improving patient outcomes (11, 12)

MATERIAL AND METHODS

The study employed a cross-sectional design conducted in the Department of Pulmonology at Pakistan Emirates Military Hospital, Rawalpindi, Pakistan. The research spanned six months, from December 12, 2023, to June 12, 2024, and utilized non-probability purposive sampling for patient recruitment. Ethical approval was obtained from the hospital's ethical committee, and all procedures adhered to the principles outlined in the Declaration of Helsinki. Informed consent was secured from all participants, ensuring they were fully informed about the study's purpose and potential benefits.

The study included patients aged 18 to 60 years, of both genders, who were admitted with acute exacerbation of COPD. Exclusion criteria were applied to patients with lung malignancy, acute exacerbation of asthma, bronchiectasis, and interstitial lung disease, as determined through clinical assessments, history, and imaging or pulmonary function tests. A total of 160 patients met the inclusion criteria and were enrolled in the study.

Data collection involved obtaining detailed patient histories, including demographic information, place of residence, education status, duration of symptoms, duration of COPD, and comorbid conditions such as diabetes mellitus (DM), hypertension, ischemic heart disease (IHD), and smoking status. Expectorated sputum samples were collected in sterile containers from all enrolled patients and processed according to standard microbiological procedures. Microscopy with Gram staining was performed to assess the presence of leukocytes, epithelial cells, and organism morphotypes. Specimens containing more than 10 epithelial cells per low-power field were cultured unless the specimen appeared purulent or bloodstained.

Following homogenization with sputolysin, quantitative culture was performed using a 1 mL standard loop onto blood agar and chocolate blood agar plates. These plates were incubated in 5% CO2 at 35°C for 18–24 hours. If no growth was observed after overnight incubation or if the predominant morphotype seen in the Gram smear was not isolated, the culture plates were reincubated for an additional 24 hours. Only isolates with higher than 10^5 colony-forming units were reported as positive growth. The microbiological assessment focused on identifying the specific pathogens present in the sputum samples.

Statistical analysis was performed using SPSS Version 25. Patient demographics, clinical history, and sputum culture results were analyzed and recorded. Continuous variables were presented as means and standard deviations, while categorical variables were expressed as frequencies and percentages. Comparisons were made using appropriate statistical tests to determine the significance of the findings.

This study aimed to provide a comprehensive understanding of the bacterial pathogens associated with COPD exacerbations, contributing to improved diagnostic and treatment strategies for this patient population (9, 10).

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RESULTS

A total of 160 patients with a mean age of 37.89 ± 11.2 years were enrolled in the study. Among the participants, 94 (58.8%) were male, and 66 (41.3%) were female. The average duration of COPD among the patients was 4.87 ± 1.19 years. The distribution of patients by place of residence showed that 89 (55.6%) were from urban areas, while 71 (44.4%) were from rural areas. Educational status revealed that 33 (20.6%) patients were illiterate, 111 (69.4%) had completed intermediate education, and 16 (10.0%) had graduated or attained higher education.

Table 1 Patient Characteristics

Variables	n (%)	Mean ± SD
Age (Years)		37.89 ± 11.2
Duration of COPD (Years)		4.87 ± 1.19
Gender		
Male	94 (58.8%)	
Female	66 (41.3%)	
Place of Residence		
Urban	89 (55.6%)	
Rural	71 (44.4%)	
Education Status		
Illiterate	33 (20.6%)	
Intermediate	111 (69.4%)	
Graduation or Higher	16 (10.0%)	
Comorbid Conditions		
Diabetes Mellitus (DM)	37 (23.1%)	
Hypertension	29 (18.1%)	
Ischemic Heart Disease (IHD)	15 (9.4%)	
Smoking	62 (38.8%)	

Sputum cultures were positive for pathogenic organisms in 43 out of 160 patients. The most frequently isolated bacterium was Klebsiella pneumoniae, found in 19 (11.9%) patients. Staphylococcus aureus was identified in 10 (6.3%) patients. Pseudomonas aeruginosa and Actinobacter were each isolated in 5 (3.1%) cases, while Streptococcus pneumoniae was identified in 10 (6.3%) patients.

Table 2 Organisms Identified in Sputum Culture

Organism Identified	n (%)
Klebsiella pneumoniae	19 (11.9%)
Staphylococcus aureus	10 (6.3%)
Pseudomonas aeruginosa	5 (3.1%)
Actinobacter	5 (3.1%)
Streptococcus pneumoniae	10 (6.3%)

The stratification of organisms by age, gender, education status, and comorbid conditions revealed variations in bacterial prevalence. Among patients aged 18-40, Klebsiella pneumoniae was the most common pathogen, followed by Staphylococcus aureus. In patients over 50 years of age, Pseudomonas aeruginosa was more frequently isolated.

Table 3 Stratification of Organisms by Patient Characteristics

Patient Characteristics	P. aeruginosa	S. aureus	K. pneumoniae	S. pneumoniae	Actinobacter	P-value
Age group (years)						
18-40	2 (8.0%)	5 (20.0%)	13 (52.0%)	4 (16.0%)	1 (4.0%)	0.19
41-50	0 (0.0%)	2 (22.2%)	5 (55.6%)	2 (22.2%)	0 (0.0%)	
>50	3 (33.3%)	1 (11.1%)	1 (11.1%)	4 (44.4%)	0 (0.0%)	
Gender						
Male	4 (14.3%)	4 (14.3%)	11 (39.3%)	8 (28.6%)	1 (3.6%)	0.51
Female	1 (6.7%)	4 (26.7%)	8 (53.3%)	2 (13.3%)	0 (0.0%)	

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Patient Characteristics	P. aeruginosa	S. aureus	K. pneumoniae	S. pneumoniae	Actinobacter	P-value
Education						
Illiterate	1 (20.0%)	1 (20.0%)	2 (40.0%)	1 (20.0%)	0 (0.0%)	0.89
Intermediate	3 (10.0%)	7 (23.3%)	13 (43.3%)	6 (20.0%)	1 (3.3%)	
Graduation	1 (12.5%)	0 (0.0%)	4 (50.0%)	3 (37.5%)	0 (0.0%)	
Comorbid conditions						
DM	1 (7.1%)	2 (14.3%)	7 (50.0%)	4 (28.6%)	0 (0.0%)	0.83
Hypertension	1 (11.1%)	1 (11.1%)	4 (44.4%)	3 (33.3%)	0 (0.0%)	0.89
IHD	0 (0.0%)	0 (0.0%)	4 (66.7%)	3 (33.3%)	0 (0.0%)	0.49
Smoking	1 (5.6%)	2 (22.2%)	9 (50.0%)	4 (22.2%)	0 (0.0%)	0.70

The findings highlight that Klebsiella pneumoniae and Streptococcus pneumoniae were the most frequently identified pathogens among patients with COPD exacerbations. This study underscores the importance of sputum culture in diagnosing and managing bacterial infections in COPD patients, providing insights for better clinical decision-making and treatment strategies.

DISCUSSION

The study aimed to investigate the bacterial pathogens associated with acute exacerbations in patients with chronic obstructive pulmonary disease (COPD) and found that single pathogenic microbial growth was present in 43 out of 160 patients (13) The most frequently isolated bacterium was Klebsiella pneumoniae, which accounted for 11.9% of the cases. This finding aligns with other studies that have identified Klebsiella pneumoniae as a common pathogen in COPD exacerbations (14, 15). Staphylococcus aureus, identified in 10 cases (6.3%), was another significant pathogen, consistent with the literature that highlights its role in respiratory infections Pseudomonas aeruginosa and Actinobacter were each found in 5 cases (3.1%), and Streptococcus pneumoniae was present in 10 cases (6.3%).

The study's findings were supported by previous research, such as the work by Iyer et al., which reported bacterial pathogens in 45% of patients with AECOPD, and Erkan et al., who found bacterial pathogens in 55% of exacerbation cases (16, 17). Mahmoud Ahmed Arafa et al. reported a higher isolation rate of 71.2%, indicating variability in bacterial prevalence across different populations (18). The variation in findings underscores the importance of regional studies to understand local bacterial profiles and resistance patterns.

The study had several strengths, including a well-defined patient cohort and the use of standard microbiological procedures for sputum analysis. The sample size was adequate to provide significant insights into the bacterial spectrum in COPD exacerbations. However, the study had limitations, including the use of non-probability purposive sampling, which might introduce selection bias. Additionally, the study was conducted in a single tertiary care hospital, limiting the generalizability of the findings. Future studies should consider multi-center designs and include a broader demographic to enhance the applicability of the results (19)

Smoking was a significant risk factor, with 38.8% of patients being smokers. This finding is in line with studies that have shown smoking to impair respiratory defenses and increase bacterial colonization in COPD patients (20, 21). The study also found a high prevalence of comorbid conditions such as diabetes mellitus, hypertension, and ischemic heart disease, which are known to complicate the clinical course of COPD (22)

The findings of this study have important clinical implications. Identifying the predominant pathogens can guide empirical antibiotic therapy, thereby improving treatment outcomes and reducing hospital stays. However, the emergence of antibiotic-resistant strains necessitates continuous monitoring and updated treatment guidelines. The study also highlights the need for targeted interventions to address smoking cessation and management of comorbid conditions to reduce the frequency and severity of COPD exacerbations.

CONCLUSION

In conclusion, the study provided valuable insights into the bacterial etiology of COPD exacerbations, with Klebsiella pneumoniae and Streptococcus pneumoniae being the most frequently isolated pathogens. The results underscore the importance of sputum culture in managing COPD exacerbations and tailoring antibiotic therapy. Future research should focus on large-scale, multi-center studies to validate these findings and explore the impact of emerging antibiotic resistance on treatment strategies.

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