



BACTERIAL ETIOLOGY AND ANTIBIOTIC SUSCEPTIBILITY IN ACUTE EXACERBATIONS OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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Abstract

Background: Exacerbations of chronic obstructive pulmonary disease are acute conditions that increase the rate of hospitalization and are accompanied by both clinical decline and high mortality. Bacterial infections are the most central in causing these exacerbations and antimicrobial resistance is increasing thus making effective treatment plans harder.

Objective: To identify the bacterial pathogens that cause the acute exacerbation of chronic obstructive pulmonary disease and assess their pattern of antibiotic susceptibility, which can be used to guide evidence based antimicrobial choice.

Duration and place of study: This study was conducted at KVSS Site Hospital Karachi from October 2024 to October 2025

Methodology: The study was an observational one that involved 120 patients aged 40 years and above who were diagnosed with acute exacerbation of chronic obstructive pulmonary disease and who were not in any way exposed to antibiotic treatment in the recent past. The sputum samples that were of high quality were subjected to Gram staining and bacterium culture. Testing of the antibiotic susceptibility was conducted according to the guidelines of the Clinical and Laboratory Standards Institute, by implementing the method of the Kirby Bauer disc diffusion.

Results: The microbial growth was found to be significant in 90 sputum samples which comprised 75 percent of the study population. The dominant ones were gram negative with 84.4 percent of the isolates. *Klebsiella pneumoniae* (32.2 percent) and *Pseudomonas aeruginosa* (26.7 percent) were the most common isolated pathogens. *Streptococcus pneumoniae* (11.1 percent) and *Haemophilus influenzae* (10 percent) were also frequently found amongst Gram positive bacteria. The bacterial isolates were found to have multidrug resistance in 41.1 percent of the isolates and *Pseudomonas aeruginosa* and *Acinetobacter baumannii* had the highest rate of resistance.

Conclusion: The most predominant pathogen in acute exacerbation of chronic obstructive pulmonary disease is gram negative bacteria with high levels of multidrug resistance. Regular sputum culture and antibiotic susceptibility testing are imperative to inform a specific antimicrobial treatment, enhance clinical results, and reduce the development of antimicrobial resistance.

Keywords: Acute Exacerbation of Chronic Obstructive Pulmonary Disease; Bacterial Pathogens; Antibiotic Susceptibility; Multidrug Resistance

Introduction

COPD is a chronic respiratory illness that is characterized by permanent airflow blockage, airways chronic inflammation, and lung structural changes. It is one of the leading causes of morbidity and mortality on the world level and remains one of the greatest volumes of pressure on the health care systems in particular in the low- and middle-income countries [1]. Acute exacerbations of chronic obstructive pulmonary disease (AECOPD) are the acute worsening of the symptoms of respiration, and most frequently involve dyspnea, cough and sputum production, which requires additional medical attention and frequent hospitalization [2].

AECOPD is a serious determinant causing the development of the disease that results in the rapid decline of lung functionality, low quality of life, high expenditures on healthcare, and mortality rates [3]. The recurrent exacerbation is associated with long-term adverse results that comprise frequent hospitalization and respiratory failure [4]. The current studies of the cause and impact of these exacerbations are therefore significant to simplify the treatment of patients and contribute to the improvement of clinical outcomes.

Infectious agents are known to be the most common precipitating factors of AECOPD that cause up to 70 percent of cases [5]. The bacterial infections constitute a considerable proportion of them, whether as single infections or in conjunction with the viral agents [6]. Stabilization of COPD is known to cause colonization of the lower airways with bacteria, but the change in the magnitude or the acquisition of new strains can lead to the acute inflammatory response, which subsequently leads to exacerbations [7]. There is the need to understand etiology of bacteria in AECOPD with the perspective of concluding on the best antimicrobial treatment.

Bacterial spectrum of AECOPD varies depending on disease severity, antibiotic history, comorbidity and the local microbial trends [8]. In mild to moderate diseases, *Haemophilus influenzae*, *Streptococcus pneumoniae*, and *Moraxella catarrhalis* are commonly isolated whereas Gram negative organisms including *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii* are more frequently isolated in severe conditions and in hospitalized patients [9,10]. This growing resistance of Gram negative bacilli to AECOPD has been of concern because of inherent mechanisms of resistance and the lack of treatment solutions [11].

Antibiotic therapy is still one of the pillars of the treatment of moderate to severe AECOPD especially in cases where patients are characterized by high levels of sputum purulence, volume and dyspnea [12]. Clinical judgment and local treatment protocols are often used to make empirical choices in the selection of antibiotics. Nonetheless, the poor use of antibiotics has led to the rise and diffusion of antimicrobial resistance which is a fundamental health menace on a worldwide level [13]. Respiratory pathogens are also being reported to contain multidrug resistant organisms and this has resulted in longer hospitalization periods, increased costs in treatment and poor patient outcomes [14].

The increased percentage of multidrug resistance in bacterial isolates in AECOPD highlights the significance of microbiological assessment, such as sputum culture and antibiotic susceptibility test [15]. Taking into consideration the clinical significance of AECOPD and the problem of the alteration of antimicrobial resistance, the research goals are to identify the pathogenesis of bacteria in acute exacerbation of chronic obstructive pulmonary disease and estimate the trend of the antibiotic sensitivity of microorganisms. It will be used to make the rational use of antibiotics, to enable specific treatment, as well as to be used in enhancing patient management of AECOPD.

Methodology

This was a cross-sectional research which was conducted among patients diagnosed with the acute exacerbation of chronic obstructive pulmonary disease. The sample size was 120 patients, and the non-probability consecutive sampling was used to recruit the sample. Clinical history, physical examination and previous spirometric evidence where available required participants to have known diagnosis of chronic obstructive pulmonary disease between 40 years and above. Acute exacerbation was recognized as a recent aggravation of respiratory symptoms that comprised of enhanced dyspnea, coughs and sputum, which needed additional medical attention.

The study included patients who came with acute exacerbation of chronic obstructive pulmonary disease, and had a good clinical profile to extend sputum samples. The participants who had undergone systemic or inhaled antibiotic within 48 hours prior to the study were excluded so as to reduce the impact of the previous antimicrobial exposure on the culture findings. Active pulmonary tuberculosis, bronchiectasis, lung malignancy and other chronic respiratory infections among the patients were also excluded. The inadequate samples as per the sputum quality criteria were not subjected to any further processing.

All the participants were expected to provide expectorated sputum samples collected according to the standard aseptic measures. To minimize contamination of the oropharynx, patients were asked to rinse their mouths using clean water before expectoration. Samples were taken to the microbiology laboratory immediately. Quality of the sputum was determined both macroscopically and microscopically and the sample with excessive number of epithelial cells was discarded to guarantee representative samples of the lower respiratory tract.

The gram staining of all acceptable sputum samples was performed to provide the initial examination of the morphological and cellular structure of bacteria. This was followed by inoculations of the samples on the proper culture media such as blood agar, chocolate agar and MacConkey agar plates. The cultures were inoculated in a standard condition and analyzed in regard to the bacteria growth after 24 or 48 hours. Detection of bacterial isolates -Bacterial isolates were identified using traditional microbiological procedures based on colony morphology, Gram reaction and actual biochemical tests.

Kirby Bauer disc diffusion test was conducted on all important bacterial isolates to determine the susceptibility to antibiotics. The antibiotic discs were selected among the regularly used drugs that can be used to treat respiratory tract infections and they include beta lactams, cephalosporins, fluoroquinolones, aminoglycosides and carbapenems. Results on the interpretation of the susceptibility were done according to the guidelines issued by the Clinical and Laboratory Standards Institute. Multidrug resistance was considered as the resistance to no less than a single antimicrobial agent in three or more antibiotic classes.

All the participants were recorded with demographic information such as age, and sex. The structured data collection form was used to record clinical variables, including presenting symptoms, smoking history, previous exacerbations hospitalizations, and comorbid conditions. Microbiological variables comprised of type of bacterial isolate, Gram staining properties and antibiotic susceptibility patterns.

A statistical software package was used to enter and analyze the data. Demographic variables, frequency of bacterial isolates and antibiotic susceptibility patterns were summarized using descriptive statistics. The frequencies and percentages were used to express the categorical variables, whereas means and standard deviations were used to express the continuous variables. The findings were tabled and figures were used where necessary.

Results

The study involved 120 patients living with the acute exacerbation of chronic obstructive pulmonary disease. The participants were of mean age 63.2 years old with the prevalence of males (n = 78, 65%) over females (n = 42, 35%). The majority of the patients (n = 88, 73.3% smoked) and 32 (26.7% non-smoked). Most patients were found to have an elevation of dyspnea (n = 114, 95%),

productive cough (n = 108, 90%), and elevation of purulence of sputum (n = 84, 70%). AECOPD (46 patients) had prior hospitalizations related to the same in the last year (38.3%).

Table 1. Demographic and Clinical Characteristics of Study Population (n = 120)

Characteristic	Frequency n (%)
Age (years), mean $\pm$ SD	63.2 $\pm$ 9.5
Sex	
- Male	78 (65)
- Female	42 (35)
Smoking History	
- Smoker	88 (73.3)
- Non-smoker	32 (26.7)
Symptoms at Presentation	
- Increased dyspnea	114 (95)
- Productive cough	108 (90)
- Increased sputum purulence	84 (70)
Prior Hospitalization for AECOPD	46 (38.3)

It was observed that significant bacterial growth occurred in 90 sputum samples which is 75 percent of the study population. The gram negative organisms were the most prevalent with 84.4% of the isolates (n = 76), Gram positive were present in 15.6 percent of the isolates (n = 14).

The most common Gram negative bacteria that were isolated were *Klebsiella pneumoniae* (n = 29, 32.2%), *Pseudomonas aeruginosa* (n = 24, 26.7%), and *Acinetobacter baumannii* (n = 15, 16.7%). *Streptococcus pneumoniae* (n = 10, 11.1) and *Haemophilus influenzae* (n = 9, 10) were the most frequent Gram positive Gram positive bacteria.

Table 2. Distribution of Bacterial Isolates in AECOPD Patients (n = 90)

Bacterial Species	Gram Type	Frequency n (%)
<i>Klebsiella pneumoniae</i>	Negative	29 (32.2)
<i>Pseudomonas aeruginosa</i>	Negative	24 (26.7)
<i>Acinetobacter baumannii</i>	Negative	15 (16.7)
<i>Haemophilus influenzae</i>	Positive	9 (10.0)
<i>Streptococcus pneumoniae</i>	Positive	10 (11.1)
Total		90 (100)

Antibiotic susceptibility testing revealed high rates of resistance among Gram negative isolates. Multidrug resistance (MDR), defined as resistance to at least one agent in three or more antibiotic classes, was observed in 37 of 90 isolates (41.1%). *Pseudomonas aeruginosa* exhibited the highest MDR rate at 62.5%, followed by *Acinetobacter baumannii* at 66.7%. Gram positive bacteria showed comparatively lower resistance rates, with 22% of *Streptococcus pneumoniae* isolates resistant to multiple antibiotics.

Table 3. Multidrug Resistance Among Common Bacterial Isolates (n = 90)

Bacterial Species	Total Isolates	MDR n (%)
<i>Klebsiella pneumoniae</i>	29	12 (41.4)
<i>Pseudomonas aeruginosa</i>	24	15 (62.5)
<i>Acinetobacter baumannii</i>	15	10 (66.7)
<i>Streptococcus pneumoniae</i>	10	2 (20.0)
<i>Haemophilus influenzae</i>	9	0 (0)
Total	90	37 (41.1)

Discussion

The current research assessed the etiology and the antibiotic susceptibility amongst patients that presented with acute exacerbation of chronic obstructive lung disease. The results show a very high prevalence of bacterial infections as positive sputum cultures of patients were found in 75 percent. This finding supports the proven role of bacterial pathogens as a key precipitant of acute exacerbations and consistent with previous reports, which have recorded bacterial implication in over two thirds of all hospitalized AECOPD patients [16].

The current study showed a preponderance of Gram negative organisms with more than 80 percent of all the isolates. The predominantly identified pathogens were *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. The same trends have been described by Eller et al., that reported an increasing trend of Gram negative bacilli in patients with severe exacerbations of the disease that necessitated hospitalizations [17]. The further isolation of these organisms can be explained by the high stage of diseases, frequent contacts with hospitals and frequent taking antibiotics which contribute to colonization and infection with resistant Gram negative bacteria.

Conversely, previous researches have reported more prevalence of *Haemophilus influenzae* and *Streptococcus pneumoniae* especially in patients with mild to moderate COPD [18]. The comparatively low prevalence rate of these organisms in the current study might be due to variations in the patient qualities, such as smoking status and past history of exacerbation. These results indicate the dynamicity of bacterial profiles in AECOPD and the need to conduct local surveillance periodically in order to inform empirical treatment.

The bacterial isolates that had multidrug resistance were 41.1 percent and the highest resistance was observed in *Pseudomonas aeruginosa* and *Acinetobacter baumannii*. This is in line with other studies that have shown that Gram negative non fermenting bacilli are often related to multidrug resistance and lack of treatment alternatives [19]. Ko et al. also found the resistance high in the *Pseudomonas aeruginosa* isolates in hospitalized AECOPD patients, which resulted in a more complex treatment process and increased hospitalization [20].

The multidrug resistance rate is moderately high in the present study compared to other studies in the region. Falagas et al. pointed out that the difference in the pattern of resistance is affected by local practices of prescribing antibiotics and practices of ensuring control of the infection [21]. The high percentage of multidrug resistant organisms found highlights the importance of the judicious use of antibiotics and supports the importance of the antimicrobial stewardship program in respiratory care practices.

These findings have great clinical implications. The use of empirical antibiotic therapy is still widely applied in treatment of AECOPD, especially in moderate and severe cases. Nevertheless the number of resistant Gram negative organisms in this study is high, which implies that empirical treatment in the absence of microbiological confirmation would be inefficient or improper in a significant proportion of patients. Individual antibiotic therapy on the basis of sputum culture and susceptibility testing can enhance the clinical results, decrease the number of treatment failures, and decrease the additional emergence of antimicrobial resistance.

This study has some limitations although it has strengths. No viral pathogens and atypical bacteria were assessed and this could have caused underestimation of non bacterial exacerbation causes. Also, the severity of COPD was not stratified on spirometric grading, which would have offered additional information on the correlation between severity of the disease and the etiology of the bacterial strains. However, the study presents useful information on bacterial profiles and resistance patterns that may be used to guide local treatment approaches.

Finally, the current research illustrates that the acute exacerbations of the chronic obstructive pulmonary disease are closely correlated with Gram negative bacterial infections that have a high degree of multidrug resistance. These results highlight the need to conduct regular sputum culture and antibiotic susceptibility as a way of assisting in reasonable antimicrobial use and enhancing patient management.

Conclusion

According to the current study, bacterial infection is a prominent etiologic agent of exacerbation of chronic obstructive pulmonary disease, and a considerable proportion of patients show positive bacterial growth of sputum. The most prevalent causative pathogens were identified to be gram negative pathogen and particularly *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* suggesting the shift of the bacteria profile to drug resistant ones in the hospitalized patients with AECOPD. This was identified to possess a massive burden of multidrug resistance especially against Gram negative isolates and this is a substantial problem to empirical antibiotic treatment. The findings underscore the ineffectiveness of the conventional empirical treatment measures and the importance of microbiological validation through the assistance of the sputum culture and antibiotic susceptibility testing. Local resistance information can also be used to improve clinical outcomes and reduce unwarranted exposure to antibiotics through individual antimicrobial therapy and further the transmission of antimicrobial resistance. The implementation of the conventional bacteriological measure into the AECOPD management can, therefore, be a crucial step in the streamlining of the management of patients and higher antimicrobial stewardship.

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Conflict in the interest

The authors had no conflict related to the interest in the execution of this study.

Permission

Prior to initiating the study, approval from the ethical committee was obtained to ensure adherence to ethical standards and guidelines.

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