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Rising Trend of Staphylococcal Lower Respiratory Infections: A Growing Concern

Priyanka Joshi[1], Jyoti Gupta[2]*

[1]Department of Pulmonary Medicine, Mahaveer Institute of Medical Sciences and Research, Bhopal, Madhya Pradesh, India
[2]Associate Professor, Department of Microbiology, Mahaveer Institute of Medical Sciences and Research, Bhopal, Madhya Pradesh, India

***Address for Correspondence:** Dr. Jyoti Gupta, Associate Professor, Department of Microbiology, Mahaveer Institute of Medical Sciences and Research, Bhopal, Madhya Pradesh, India
E-mail: drjyoti93@gmail.com

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ABSTRACT

Background: The emergence of multidrug-resistant pathogens such as *Staphylococcus* sp. represents a significant clinical challenge. Rapid identification of staphylococcal lower respiratory tract infections (LRTIs) and determination of their susceptibility to antibiotics is crucial for optimizing therapeutic outcomes and minimizing hospitalization expenses.

Methods: A prospective cross-sectional investigation was conducted. A total of 456 clinical specimens were examined for the presence of *Staphylococcus* species following standard bacteriological protocols. Isolates that were Gram-positive and catalase-positive underwent further analysis to assess antimicrobial susceptibility patterns based on the CLSI guidelines. Data were processed using the SPSS (v.21).

Results: The study predominantly included elderly individuals, with an average age of 58.97±7.20 years. Out of 456 samples, *Staphylococcus aureus* (*S. aureus*) was isolated in 24 cases of LRTI (prevalence 5.26%). The prevalence was notably higher among males compared to females, and all affected patients required hospitalization. The majority of isolates were acquired from sputum samples, pleural fluid and endotracheal secretions. Pneumonia was the most common clinical presentation, followed closely by empyema and sinusitis. Notably, all isolates exhibited susceptibility to ceftaroline, linezolid, and vancomycin.

Conclusion: *S. aureus*-associated LRTI accounted for 5.26% of cases. Early microbiological diagnosis plays a pivotal role in effectively managing staphylococcal infections, as antimicrobial resistance patterns and clinical manifestations may differ across geographical regions. Prompt identification can facilitate timely intervention, thereby reducing treatment costs and hospital stays.

Key-words: *Staphylococcus aureus,* Lower Respiratory Tract Infection, Pneumonia, Vancomycin

INTRODUCTION

Lower respiratory tract infection (LRTI) refers to an acute infectious condition affecting the trachea, airways, and lungs and includes both pneumonia and bronchitis. Pneumonia can lead to severe complications such as empyema, characterized by pus accumulation in the pleural cavity due to microbial activity.

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Pleural infections represent a prevalent and growing concern in thoracic medicine, contributing to considerable morbidity and mortality rates. Annually, approximately four million individuals develop pneumonia, with nearly 50% of them progressing to para-pneumonic effusion. The predominant microorganisms responsible for pleural infection include *Staphylococcus aureus, Streptococcus pyogenes* and *Streptococcus pneumoniae*, which are frequently associated with severe infections.[1-3]

Pulmonary infections caused by *S. aureus* are particularly common among elderly individuals and hospitalized patients with significant coexisting medical conditions. These infections are often complicated by abscess formation, cavitary lesions, and empyema containing

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necrotic material or infected fluid.[4,5] The increasing prevalence of multidrug-resistant *Staphylococcus* species remains a major concern, particularly strains resistant to methicillin.[6] Recent global studies indicate that methicillin-resistant *Staphylococcus* strains are no longer confined to hospital-acquired infections but have become significantly linked to community-acquired cases as well.[7,8] Consequently, clinicians encounter challenges in selecting appropriate antimicrobial therapy to optimize treatment outcomes.[9]

Regular surveillance of *Staphylococcus* species at the level of institutes is essential for devising timely treatment protocols.[10] The prevalence and antibiotic resistance patterns of *Staphylococcus* species vary by geographic location. This study aimed to assess the incidence of *Staphylococcus* infections and evaluate their antimicrobial susceptibility patterns to facilitate the rational selection of therapeutic agents and ensure effective management.

MATERIALS AND METHODS

Place of study- This prospective cross-sectional study was conducted at the Department of Microbiology, Mahaveer Institute of Medical Sciences and Research, Bhopal, Madhya Pradesh, India.

Sample size- The minimum required sample size for estimating proportions was determined using a standard statistical formula. The calculation was based on z value at a 95% confidence level (1.96), an assumed proportion of 50% (0.5), and a confidence interval of ±5% (0.05).

The formula applied was: $\mathbf{n = z^2 (p)(1-p)/c^2}$

where, z represents the standard normal deviation, p is the proportion assumed for response selection, and c denotes the confidence interval. Based on this computation, a minimum of 385 samples was required to meet statistical requirements. To ensure robustness, 456 isolates were included in this study.

Inclusion & Exclusion Criteria- Clinical specimens from patients of all age groups were incorporated into this study. All these samples were screened for the presence of *Staphylococcus* species. As the focus of the study was on isolating *Staphylococcus* species, only aerobic culture and antimicrobial susceptibility testing were performed. Duplicates were excluded to ensure that each isolate represented a unique patient case.

Sample Collections and Processing- Respiratory samples were collected to identify pathogens responsible for pneumonia and bronchopneumonia, whether of community-acquired or hospital-acquired origin. Early morning sputum specimens, obtained following a coughing episode, were collected in sterile wide-mouth containers. These samples underwent Gram staining and microscopy. Only specimens with a significant presence of pus cells were processed further. The Endotracheal Aspirate (ETA) procedure involved sterile suctioning using a 12F, 22-inch catheter inserted approximately 30 cm into the endotracheal tube. The initial aspirate was castoff, while the second one was collected following the instillation of 5 mL of saline into the trachea using a mucus collection tube. The Bronchoalveolar Lavage (BAL) technique involved infusing 100–300 mL of sterile saline into a lung area through a bronchoscope to retrieve cellular and proteinaceous material from alveolar and interstitial spaces. A portion of the retrieved fluid was gathered in a screw-caped, sterile, leak-proof container.[11]

Identification of organisms- Upon receipt, specimens were inoculated onto blood agar and MacConkey agar, followed by incubation at 37°C for 24 hours. Simultaneously, a direct smear from the sample was prepared, Gram-stained, and studied under the oil immersion lens. After 24 hours of incubation, colonies were Gram-stained to confirm the presence of Gram-positive cocci in clusters. Positive isolates underwent a catalase test to distinguish *Staphylococcus* from *Streptococcus* species. Catalase-positive colonies were further tested for coagulase activity using both slide and tube coagulase methods. The tube coagulase test was performed at 37°C for 4 hours; if no clot formation was observed, the tube was incubated at room temperature and reassessed after 18–24 hours.[12,13] A well-isolated colony was subsequently suspended in peptone water and incubated at 37°C for 4 hours. The bacterial suspension was then compared with a 0.5 McFarland turbidity standard, adjusting as needed by adding peptone water or extending incubation. This standardized bacterial suspension was used for antibiotic susceptibility checking and biochemical analysis following standard protocols.

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Antibiotic susceptibility testing- The susceptibility profile of *Staphylococcus* isolates was assessed by the Kirby-Bauer disc diffusion technique. Additional testing for minimum inhibitory concentration (MIC) of ceftaroline as well as vancomycin was performed using test strips, following the Clinical and Laboratory Standards Institute (CLSI) guidelines. [14,15]

Statistical Analysis- Data analysis was performed using SPSS software version 21.0, applying appropriate statistical tests, including the Chi-square test. A p-value of ≤0.05 was considered statistically significant.

RESULTS

The study predominantly comprised elderly individuals, with an average age of 58.97±7.20 years. A total of 24 cases of staphylococcal LRTI were identified, with a significantly higher proportion of male patients compared to females (Table 1). All cases were reported from inpatient departments (IPD), with no outpatient department (OPD) cases, indicating the severity of these infections requiring hospitalization.

Table 1: Basic profiling of *Staphylococcal* LRTI cases

Variables	n	%	p-value
Male	23	5.04	<0.01
Female	1	0.22	
IPD Cases	24	5.26	<0.01
OPD Cases	0	0	

Sputum was the most commonly obtained specimen for microbiological diagnosis, accounting for 83.33% of cases, followed by pleural aspiration and endotracheal (ET) aspirate (Table 2). All patients were diagnosed with LRTI, with empyema being the most frequently observed co-morbidity (12.50%). A majority of patients (66.67%) had received azithromycin before hospital admission, while a smaller proportion had been treated with amikacin or amoxiclav. Notably, 16.67% of patients had no history of prior antibiotic use.

Table 2: Clinical profile of *Staphylococcal* LRTI cases

Parameters	n	%	p-value
Specimen			
Sputum	20	83.33	<0.01
Pleural aspiration	3	12.50	
ET Aspirate	1	4.17	
Clinical Diagnosis			
LRTI	24	100.00	-
Co-morbidity			
Empyema	3	12.50	0.29
Sinusitis	1	4.17	
Prior Antibiotics taken			
Azithromycin	16	66.67	<0.05
Amikacin	3	12.50	
Amoxyclav	1	4.17	
None	4	16.67	

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Antimicrobial susceptibility testing of *Staphylococcal* isolates revealed complete resistance to penicillin, cefoxitin, erythromycin, tetracycline, chloramphenicol, and ofloxacin (Table 3). Clindamycin and trimethoprim/ sulfamethoxazole showed limited efficacy, with resistance observed in 79.17% and 66.67% of isolates, respectively. Rifampin retained relatively higher sensitivity, with 83.33% of isolates being susceptible. However, resistance to gentamicin was markedly high (91.67%). Encouragingly, all isolates demonstrated 100% sensitivity to linezolid, vancomycin, and ceftaroline, indicating their continued efficacy against Staphylococcal LRTI.

Table 3: Antibiotic susceptibility pattern of *Staphylococcal* isolates

Antibiotics	Sensitive		Resistant	
	n	%	n	%
Penicillin	0	0	24	100
Cefoxitin	0	0	24	100
Erythromycin	0	0	24	100
Tetracycline	0	0	24	100
Chloramphenicol	0	0	24	100
Ofloxacin	0	0	24	100
Clindamycin	5	20.83	19	79.17
Trimethoprim/sulfamethoxazole	8	33.33	16	66.67
Rifampin	20	83.33	4	16.67
Gentamycin	2	8.33	22	91.67
Linezolid	24	100	0	0
Vancomycin (MIC)	24	100	0	0
Ceftaroline (MIC)	24	100	0	0

DISCUSSION

Staphylococcal lower respiratory tract infections (LRTIs) are amongst the most prevalent infectious diseases globally.[16] The rising incidence of *Staphylococcus aureus* in LRTIs is a significant issue for public health, particularly caused by the emergence of multidrug-resistant strains, which pose significant challenges in managing patients with underlying comorbidities and predisposing conditions. The presence of methicillin-resistant *Staphylococcus aureus* (MRSA) further limits therapeutic options, necessitating region-specific antimicrobial resistance data to guide effective treatment strategies.

In the present study, *S. aureus* was isolated from 24 out of 456 (5.262%) LRTI cases. A higher prevalence was observed among male patients compared to females, with all affected individuals requiring hospitalization. The mean age of patients was 58.97±7.20 years. The findings align with previous studies.[17-19] However, other studies have stated a notably higher incidence of *S. aureus* LRTIs.[16,21] A five-year research in Italy demonstrated an annual incidence ranging between 12.7% and 16.2%.[20]

The increasing yearly trend in *S. aureus* LRTIs is concerning, highlighting the need for timely pathogen isolation and antimicrobial susceptibility testing, particularly in patients with clinical diagnoses of LRTI. Notably, 3 out of 24 patients (12.50%) in the present study developed empyema, a secondary infection often linked to either tuberculosis or pneumonia, where prior antibiotic treatment plays a critical role in patient outcomes. Despite the widespread availability of antibiotics effective against pneumonia, empyema continues to contribute to significant morbidity and deaths, even in developed nations, because of multidrug resistance and incorrect antimicrobial treatment.

Prior antimicrobial use was noted in 16 out of 24 (66.67%) patients, who had received azithromycin before presenting to the tertiary care center. All isolated *S. aureus* strains were identified as MRSA and exhibited resistance to multiple first-line antibiotics. However, second-line drugs, including ceftaroline, linezolid, and vancomycin, demonstrated 100% susceptibility. This finding is consistent with previous studies.[21,22] Furthermore, all *S. aureus* strains underwent screening

for inducible clindamycin resistance.[7,8] The resistance to erythromycin was attributed to the presence of erm genes, which encode ribosomal methylases, leading to inducible clindamycin resistance. Since antibiotics sharing the same target site may exhibit cross-resistance, conventional antimicrobial susceptibility testing may fail to accurately determine clindamycin susceptibility in erythromycin-resistant strains. Consequently, detecting inducible resistance is essential to prevent therapeutic failure.

CONCLUSIONS

The present study identified a significant association between *S. aureus* with lower respiratory tract infections. Notably, all isolated strains exhibited susceptibility to ceftaroline, linezolid, and vancomycin, a finding that is distinct but consistent with literature conducted in India. This highlights the potential for effective and cost-efficient management of *Staphylococcus* infections, provided that timely microbiological diagnosis is performed. Early identification of the pathogen, considering regional variations in clinical presentation and antimicrobial susceptibility patterns, can facilitate targeted therapy, thereby reducing both treatment costs and hospital stay durations.

CONTRIBUTION OF AUTHORS

Research concept- Priyanka Joshi, Jyoti Gupta
Research design- Jyoti Gupta
Supervision- Priyanka Joshi
Materials- Priyanka Joshi
Data collections- Priyanka Joshi, Jyoti Gupta
Data analysis and interpretation- Priyanka Joshi, Jyoti Gupta
Literature research- Jyoti Gupta
Writing article- Priyanka Joshi
Critical review- Priyanka Joshi, Jyoti Gupta
Article editing- Jyoti Gupta
Final approval-Priyanka Joshi, Jyoti Gupta

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