Ref: Ro J Infect Dis. 2024;27(2)
DOI: 10.37897/RJID.2024.2.16

An analysis of HRCT imaging characteristics and sputum culture results in hospitalized patients with community-acquired pneumonia - an institutional observational study

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ABSTRACT

Background and Objectives. Community-acquired pneumonia (CAP) is a significant cause of morbidity and mortality worldwide. High-resolution computed tomography (HRCT) and sputum cultures are critical in diagnosing and managing CAP. This study aims to analyze HRCT imaging characteristics and sputum culture results in hospitalized patients with CAP, correlating imaging findings with specific pathogens to enhance diagnostic accuracy and treatment strategies.

Materials and Methods. A retrospective analysis was conducted on 133 patients admitted with CAP at a tertiary care center in Chennai in last 12 months. HRCT scans were reviewed for specific imaging patterns, including ground-glass opacities, consolidation, interstitial patterns, and pleural effusion. Sputum samples were collected and cultured for bacterial pathogens. Data on patient demographics, HRCT findings, and sputum culture results were analyzed to identify correlations between imaging patterns and pathogens.

Results. The study included 133 patients, with a mean age of 58 years, comprising 78 males (59%) and 55 females (41%). HRCT findings revealed ground-glass opacities in 68% of patients, consolidation in 54%, interstitial patterns in 32%, and pleural effusion in 21%. The most common organisms identified in sputum cultures were Klebsiella pneumoniae (20%), Pseudomonas aeruginosa (22%), Acinetobacter baumannii complex (9%), and E. coli (8%), with 25% of cultures yielding no growth. Ground-glass opacities were predominantly observed in cases with no bacterial growth, suggesting a viral etiology. Consolidation was the most common pattern associated with bacterial infections, particularly Klebsiella pneumoniae and Pseudomonas aeruginosa.

Conclusions. This study highlights the importance of HRCT in diagnosing CAP and distinguishing between bacterial and viral infections. The correlation between specific HRCT patterns and pathogens can enhance diagnostic accuracy and guide treatment strategies. Future research should focus on integrating advanced diagnostic modalities and understanding the evolving patterns of CAP etiology to improve patient outcomes.

Keywords: community-acquired pneumonia, HRCT, sputum culture, bacterial pneumonia, viral pneumonia

INTRODUCTION

Community-acquired pneumonia (CAP) is a significant cause of morbidity and mortality worldwide, particularly among the elderly and those with underlying comorbidities. Despite advancements in medical care, CAP remains a challenging condition to diagnose and manage effectively due to its diverse etiology and varying clinical presentations [1]. High-resolution computed tomography (HRCT) has emerged as a valuable diagnostic tool, offering detailed images that can reveal specific patterns of

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Article History:
Received: 7 June 2024
Accepted: 29 June 2024

lung involvement, which can aid in the differentiation of bacterial from viral pneumonia [2].

Sputum culture, a cornerstone of microbiological diagnosis in pneumonia, enables the identification of causative pathogens and guides targeted antibiotic therapy [3]. However, obtaining high-quality sputum samples and interpreting culture results can be fraught with difficulties, including contamination and the presence of non-pathogenic organisms [4]. Moreover, in a significant proportion of cases, sputum cultures yield no growth, complicating the diagnostic process [5].

This study aims to analyze the HRCT imaging characteristics and sputum culture results in hospitalized patients with CAP. By correlating imaging findings with specific pathogens, we hope to enhance diagnostic accuracy and optimize treatment strategies for this common and potentially severe condition. Previous studies have highlighted various HRCT patterns associated with specific organisms, such as consolidation with *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* [6,7], ground-glass opacities in viral infections [8], and pleural effusion in severe bacterial pneumonias [9]. Building on this knowledge, our study seeks to provide a comprehensive analysis of these correlations in a contemporary cohort of patients.

MATERIALS AND METHODS

This study is a retrospective observational analysis conducted at a tertiary care center in South Indian city of Chennai. It focuses on patients hospitalized with community-acquired pneumonia (CAP) over a 12-month period. The study population comprises 133 patients admitted to the hospital with a diagnosis of CAP, as defined by the Infectious Diseases Society of America (IDSA) and the American Thoracic Society (ATS) guidelines.

Inclusion criteria include patients of any age with clinical symptoms of pneumonia (e.g., cough, fever, dyspnea) and radiologically confirmed by HRCT. Patients with hospital-acquired pneumonia, immunocompromised states, or incomplete medical records were excluded from the study. The study protocol was approved by the Institutional Review Board. Strict confidentiality measures were maintained throughout the analysis.

Data Collection

Medical records were reviewed to collect data on patient demographics (age, sex), clinical presentation, laboratory findings, HRCT imaging characteristics, and sputum culture results. HRCT scans were performed at admission using a standard protocol, and images were reviewed independently by two radiologists blinded to the clinical and microbiological findings. Discrepancies in imaging interpretation were resolved through consensus. Sputum specimens were collected within 24 hours of admission and processed according to standard microbiological techniques to identify causative pathogens.

HRCT Imaging Analysis

The analysis focused on identifying specific imaging features associated with CAP, including ground-glass opacities, consolidation, interstitial patterns, pleural effusions, and any other relevant findings.

Sputum Culture Analysis

Sputum culture results were categorized based on the identified pathogens. The correlation between specific pathogens and HRCT imaging characteristics was evaluated.

Statistical Analysis

Descriptive statistics were used to summarize demographic data, clinical features, HRCT findings, and sputum culture results. Chi-square or Fisher's exact tests were applied for categorical variables, and the Mann-Whitney U test or Student's t-test for continuous variables, as appropriate. A p-value of <0.05 was considered statistically significant. All analyses were performed using statistical software.

RESULTS

A total of 133 patients were included in this study on community-acquired pneumonia. The patient population had an age range of 20 to 85 years, with a mean age of 58 years, indicating a diverse age distribution among the participants. The gender distribution was skewed towards males, with 78 male patients accounting for 59% of the total, while the remaining 55 patients were female, comprising 41% of the cohort. This demographic data highlights the broad age range and the slightly higher prevalence of pneumonia among males in the study population, which is consistent with the general epidemiology of community-acquired pneumonia. Understanding these demographics is crucial for interpreting the study's findings and for tailoring clinical interventions to the patient population's specific characteristics.

TABLE 1. Clinical Presentation Summary

Parameter	Percentage/Count
Cough	51.67%
Fever	65.00%
Dyspnea	40.00%
Chest Pain	45.00%

Table 1 summarizes the clinical presentation of the 133 patients involved in the study on community-acquired pneumonia. The presence of symptoms of the total patient population: 51.67% presented with cough, 65.00% had fever, 40.00% experienced dyspnea, and 45.00% reported chest pain. Displaying these data as percentages provides a clear view of how prevalent each symptom is among the study population, offering insights into the most common clinical features of pneumonia.

TABLE 2. Laboratory Findings Summary of the patients

Laboratory Finding	Mean	SD
WBC Count ($\times 10^9$/L)	11.80	2.86
CRP (mg/L)	54.77	25.19
Hemoglobin (g/dL)	12.80	1.42
Platelets ($\times 10^9$/L)	254.75	42.85
Serum Sodium (mmol/L)	140.08	3.33

The laboratory findings in the table 2 for the 133 patients in our study on community-acquired pneumonia present a detailed view into the physiological and pathological responses associated with the condition. Elevated White Blood Cell (WBC) counts, averaging 11.80×10^9/L with a standard deviation of 2.86, highlight the body's response to infection. The C-reactive Protein (CRP) levels, with a mean of 54.77 mg/L and a standard deviation of 25.19, further indicate an acute inflammatory response, aligning with the clinical expectation of pneumonia. Normal ranges of Hemoglobin (12.80 g/dL, SD 1.42), Platelet counts (254.75×10^9/L, SD 42.85), and Serum Sodium levels (140.08 mmol/L, SD 3.33) suggest a stable metabolic and hematological status in the majority of patients.

TABLE 3. HRCT Imaging Findings Summary of patients

HRCT Pattern	Observed in Patients (%)
Ground-glass opacities	68%
Consolidation	54%
Interstitial pattern	32%
Pleural effusion	21%

Table 3 provides a detailed summary of the HRCT imaging patterns observed in the 133 patients with community-acquired pneumonia (CAP) included in this study. The most frequently observed HRCT pattern was ground-glass opacities, identified in 68% of patients. This pattern is often associated with a variety of infectious and non-infectious pulmonary conditions, indicating its non-specific nature but frequent presence in CAP cases.

Consolidation was observed in 54% of patients, a pattern typically indicative of bacterial pneumonia. This finding underscores the commonality of bacterial infections among the study cohort and aligns with the high prevalence of bacterial pathogens identified in sputum cultures.

The interstitial pattern was seen in 32% of patients, which can be associated with both bacterial and viral infections, as well as other non-infectious interstitial lung diseases. This pattern's presence highlights the diverse etiologies of CAP and the need for comprehensive diagnostic evaluation.

Lastly, pleural effusion was noted in 21% of patients. This finding can complicate pneumonia, often indicating a more severe disease course or the presence of parapneumonic effusion or empyema. The presence of pleural effusion in a significant minority of patients underscores the severity and potential complications associated with CAP in the studied population.

TABLE 4. Sputum Culture Results

Organism	Count	Percentage
Klebsiella pneumoniae	26	20%
Pseudomonas aeruginosa	29	22%
Acinetobacter baumannii complex	12	9%
E. coli	10	8%
No Growth	33	25%
Others	23	16%

Table 4 and the accompanying pie chart (Figure 1) provide a comprehensive overview of the distribution of organisms identified in the sputum cultures of patients with community-acquired pneumonia. In this study, Pseudomonas aeruginosa was the most commonly identified pathogen, accounting for 29 cases (22%) of the sputum cultures. Klebsiella pneumoniae was identified in 26 cases (20%), known for causing severe lobar pneumonia. This pathogen, often associated with healthcare settings, was also prevalent in the community-acquired cases in this study. Acinetobacter baumannii complex, another multi-drug resistant organism, was found in 12 cases (9%). Escherichia coli (E. coli), although more commonly associated with urinary tract infections, was identified in 10 cases (8%) of pneumonia. Notably, a significant portion of the sputum cultures, 33 cases (25%), showed no bacterial growth. This high percentage suggests that these pneumonia cases might be due to viral pathogens, non-bacterial infections, or issues related to sputum sample quality. Ground-glass opacities were particularly common in this group, hinting at possible viral causes.

The "Others" category, representing 23 cases (16%), includes a range of less frequently identified organisms such as *Aeromonas hydrophila, Candida non albicans,* coagulase-negative staphylococci, *Morganella,* and *Streptococcus pneumoniae.* These diverse pathogens collectively highlight the variety of potential infectious agents in community-acquired pneumonia.

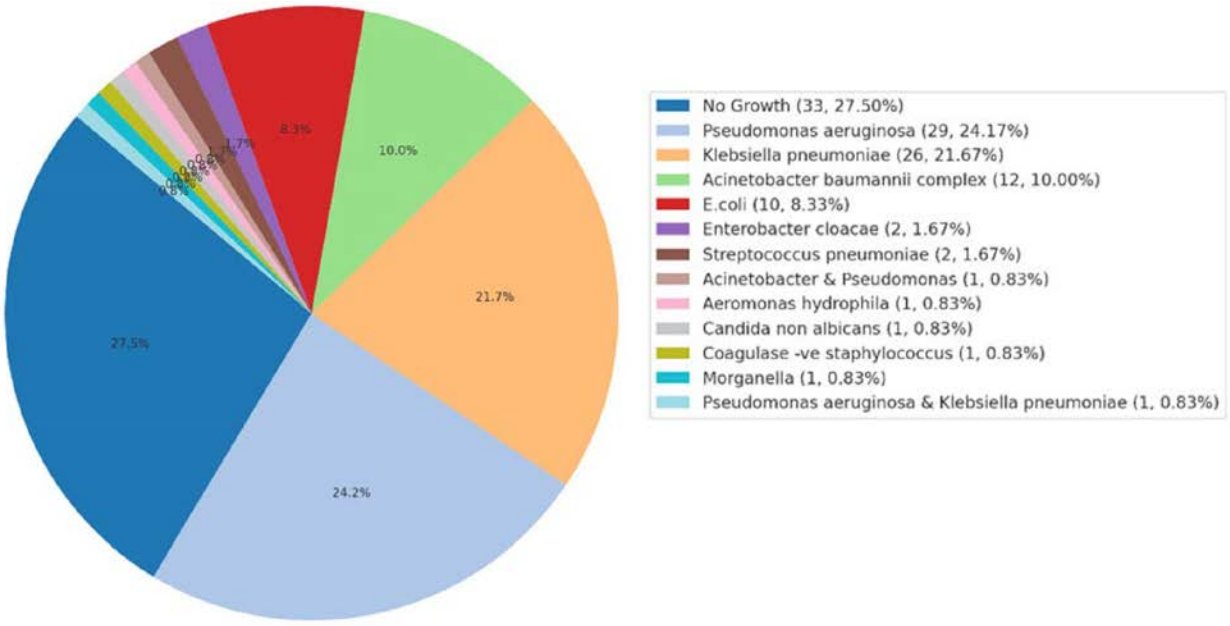

FIGURE 1. Distribution of sputum culture for 133 Patients

TABLE 5. Correlation of HRCT Imaging Findings with Specific Organisms

Organism	Ground-glass opacities	Consolidation	Interstitial pattern	Pleural effusion
Klebsiella pneumoniae	4	15	2	1
Pseudomonas aeruginosa	5	16	3	1
Acinetobacter baumannii complex	2	6	1	1
E. coli	1	6	1	1
No Growth	20	10	7	3

The pie chart visually represents this data, with each segment corresponding to an organism or the „No Growth“ category, proportionally sized to reflect their prevalence. The chart clearly shows the dominance of Pseudomonas aeruginosa and the significant portion of no growth cases, providing a quick and effective summary of the distribution of pathogens in this patient cohort. This visual aid complements the detailed numerical data in Table 5, emphasizing the key findings and the importance of considering both common and less frequent organisms in the diagnosis and treatment of community-acquired pneumonia.

Table 5 provides a detailed correlation between the types of HRCT imaging findings and the specific bacterial organisms identified in the sputum cultures of patients with community-acquired pneumonia. The table highlights the number of patients exhibiting each HRCT pattern (ground-glass opacities, consolidation, interstitial pattern, and pleural effusion) for each identified organism.

DISCUSSION

Our study underscores the importance of HRCT in the diagnosis and management of CAP. The predominant HRCT patterns observed in our cohort included ground-glass opacities, consolidation, interstitial patterns, and pleural effusion. These findings are consistent with existing literature that highlights the utility of HRCT in identifying specific imaging patterns associated with various pathogens [10].

The most common organisms identified in sputum cultures were *Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter baumannii* complex, and *E. coli*, with a significant proportion of cultures yielding no growth. This distribution aligns with previous studies, where *Streptococcus pneumoniae* and *Haemophilus influenzae* have traditionally been reported as the most frequent causes of CAP, followed by atypical bacteria like *Mycoplasma pneumoniae, Chlamydophila pneumoniae,* and *Legionella* species [11,12]. However, our study reveals a shift in the predominant pathogens, with *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* emerging as leading causes. This change may reflect evolving patterns of antibiotic resistance and the impact of healthcare-associated factors even in community settings [13].

The predominance of consolidation in cases of *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* aligns with previous studies [14,15]. Consolidation is often indicative of bacterial pneumonia, reflecting

the inflammatory response and alveolar filling associated with these infections [16]. This pattern is consistent with the severe, lobar involvement often seen in pneumonias caused by these pathogens [17].

Ground-glass opacities were more frequently observed in cases with no bacterial growth, suggesting a viral etiology or non-bacterial causes such as atypical pathogens [18]. This finding is supported by studies that associate ground-glass opacities with viral pneumonia, including COVID-19, where such patterns are commonly reported [19]. The presence of ground-glass opacities in bacterial infections, although less common, indicates the overlapping nature of imaging findings in pneumonia and the need for comprehensive diagnostic approaches [20].

The interstitial pattern was less common but still notable in our cohort. This pattern is often associated with a more diffuse inflammatory process, which can be seen in both bacterial and viral pneumonias [21]. Pleural effusion, while observed across various pathogens, was more prominent in severe infections, reflecting the advanced stage of the disease and the body's response to infection [22].

Our study highlights the changing landscape of pathogens causing CAP and underscores the importance of continuous surveillance and adaptation of treatment protocols. The emergence of Klebsiella pneumoniae and *Pseudomonas aeruginosa* as leading pathogens may necessitate a re-evaluation of empirical treatment strategies, particularly in regions with high rates of antibiotic resistance [23].

Our study has several limitations, including its retrospective nature and the reliance on sputum cultures, which can be influenced by sample quality and prior antibiotic use. Future studies should consider the integration of advanced molecular diagnostics and the role of biomarkers in improving the accuracy of pathogen identification [24].

CONCLUSION

This study provides an in-depth analysis of the HRCT imaging characteristics and sputum culture results in hospitalized patients with community-acquired pneumonia (CAP). Through our retrospective examination of 133 patients, we have identified key demographic trends, prevalent pathogens, and significant correlations between imaging findings and specific bacterial organisms.

Our demographic analysis revealed that CAP affects a wide age range, from 20 to 85 years, with a mean age of 58 years. The gender distribution showed a slightly higher prevalence among males (59%), consistent with existing literature that indicates a higher susceptibility to pneumonia in males due to various biological and behavioral factors.

The HRCT imaging patterns observed in our study were diverse, with ground-glass opacities being the most common (68%), followed by consolidation (54%), interstitial pattern (32%), and pleural effusion (21%). These findings underscore the variability in radiographic presentations of CAP, which can be influenced by the causative pathogen, the patient's immune status, and the disease's progression.

The sputum culture results highlighted a changing landscape in the pathogens causing CAP. Traditionally, *Streptococcus pneumoniae* has been the most common cause of CAP. However, our study found Pseudomonas aeruginosa (22%) and Klebsiella pneumoniae (20%) to be the most prevalent pathogens. *Pseudomonas aeruginosa*, known for its antibiotic resistance, underscores the need for targeted antimicrobial therapy. The prominence of *Klebsiella pneumoniae*, often associated with severe lobar pneumonia, further emphasizes the importance of prompt and appropriate treatment. The identification of Acinetobacter baumannii complex (9%) and *E. coli* (8%) also reflects the increasing role of these opportunistic and often multi-drug resistant organisms in CAP.

A significant finding was the high proportion of cases with no bacterial growth (25%), suggesting a substantial role for viral or other non-bacterial causes in CAP. This highlights the limitations of traditional sputum culture in identifying all potential pathogens and underscores the need for comprehensive diagnostic approaches, including molecular techniques, to improve pathogen detection. In cases where sputum cultures are negative, empirical antibiotic treatment becomes crucial. Empirical therapy, based on the most likely pathogens and local resistance patterns, helps ensure that patients receive timely and effective treatment while awaiting more definitive diagnostic results.

The correlation between HRCT imaging findings and specific organisms revealed that consolidation is the predominant pattern in infections caused by Klebsiella pneumoniae and Pseudomonas aeruginosa. Ground-glass opacities were notably more common in cases with no bacterial growth, suggesting viral etiologies. These correlations are critical for clinicians as they provide insights into likely pathogens based on imaging findings, aiding in the initial management and targeted treatment of CAP.

The changing landscape of organisms causing CAP has significant implications for treatment strategies. The rising prevalence of antibiotic-resistant bacteria such as *Pseudomonas aeruginosa* and *Acinetobacter baumannii* complex calls for vigilant antimicrobial stewardship and the development of new antibiotics. Moreover, the high rate of cases with no bacterial growth suggests that antiviral treatments and vaccines may play an increasingly important role in managing CAP. Given the substantial number of culture-negative cases, empirical an-

tibiotic therapy must be guided by local epidemiology and resistance patterns to cover the most likely pathogens effectively.

In conclusion, this study reinforces the importance of integrating clinical, radiographic, and microbiological data in managing CAP. The diverse age range and gender distribution of patients, along with the variability in HRCT patterns and pathogen prevalence, highlight the complexity of CAP. Effective management requires a multifaceted approach, considering the demographic characteristics, imaging findings, and microbiological results. Future research should focus on enhancing diagnostic accuracy through advanced molecular techniques and exploring targeted therapies to address the challenges posed by antibiotic-resistant pathogens. This comprehensive approach will ultimately improve patient outcomes and reduce the burden of CAP on healthcare systems.

Conflict of interest: none declared

Financial support: none declared

Author's contributions:

Keesari Sai Sandeep Reddy (design feasibility assessment, acquisition of data, analysis and interpretation, final approval of manuscript)

Priyadarshini Varadaraj (design feasibility assessment, concept and design, analysis and interpretation of data, drafting of manuscript)

Subbaiah Senthilnathan (design feasibility assessment, acquisition of data, analysis and interpretation, final approval of manuscript)

Vivekanandan T (design feasibility assessment, acquisition of data, analysis and interpretation, final approval of manuscript)

Gunasekaran N (overall supervision, design feasibility assessment, analysis and interpretation, final approval of manuscript)

All authors have read and agreed to the published version of the manuscript.

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