Section: Radiology

Original Research Article

CORRELATION OF CHEST CT SEVERITY SCORE WITH CLINICAL AND LABORATORY PARAMETERS IN PATIENTS WITH COMMUNITY-ACQUIRED PNEUMONIA: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Community-acquired pneumonia (CAP) remains an important cause of hospitalization, respiratory failure and mortality. Clinical severity scores and inflammatory biomarkers assist in risk stratification but do not directly quantify anatomical pulmonary involvement. A semiquantitative chest computed tomography severity score (CTSS) may provide an objective estimate of disease burden and complement clinical and laboratory assessment. **Aim:** To determine the correlation of chest CT severity score with clinical and laboratory parameters in patients with community-acquired pneumonia. **Materials and Methods:** This hospital-based analytical cross-sectional study included 200 adults diagnosed with CAP who underwent chest CT as clinically indicated. Sociodemographic characteristics, comorbidities, presenting clinical findings, CURB-65 score, haematological and biochemical parameters and short-term outcomes were recorded. Each of the five lung lobes was scored according to its percentage involvement, producing a total CTSS ranging from 0 to 25. CT involvement was categorized as mild, moderate or severe. Pearson's or Spearman's correlation was used to assess relationships between CTSS and clinical or laboratory parameters. Mean CTSS values between outcome groups were compared using the independent-samples t-test. A p value <0.05 was considered statistically significant. **Results:** The mean age of the patients was 56.8±15.4 years, 57.5% were male and 59.5% had at least one comorbidity. The mean CTSS was 12.8±5.7, with moderate and severe CT involvement in 50.5% and 26.0% of patients, respectively. Bilateral involvement was present in 71.5%, while multifocal involvement occurred in 67.5%. Air-space consolidation (78.5%) and ground-glass opacity (65.5%) were the predominant CT findings. The CTSS showed significant positive correlations with CRP (r=0.62), CURB-65 score (ρ=0.61), respiratory rate (r=0.58), LDH (r=0.55), serum lactate (r=0.51), neutrophil-to-lymphocyte ratio (r=0.49), length of hospital stay (ρ=0.47) and procalcitonin (r=0.46); all p<0.001. Significant inverse correlations were observed with room-air oxygen saturation (r=−0.67, p<0.001) and serum albumin (r=−0.43, p<0.001). Patients requiring oxygen therapy, ICU admission, non-invasive ventilation, invasive mechanical ventilation or hospitalization exceeding seven days had significantly higher mean CTSS values than the respective comparison groups (all p<0.001). In-hospital mortality was 8.5%, and patients who died had a significantly higher mean CTSS than survivors (20.8±2.7 versus 12.1±5.2; mean difference 8.74, 95% CI: 7.24-10.24; p<0.001). Conclusion: The chest CT severity score was significantly associated with hypoxaemia, clinical severity, systemic inflammation, respiratory-support requirements, prolonged hospitalization and in-hospital mortality among patients with CAP. CTSS may serve as a useful adjunct to clinical scoring and laboratory investigations for early severity assessment. Prospective multicentre studies using adjusted prognostic models are required before specific CTSS thresholds can be incorporated into routine CAP management.

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INTRODUCTION

Community-acquired pneumonia (CAP) is an acute infection of the pulmonary parenchyma acquired outside a hospital or healthcare facility. It remains an important cause of morbidity, hospitalization and mortality worldwide, particularly among older adults and patients with diabetes mellitus, chronic respiratory disease, cardiovascular disease, renal impairment or immunosuppression. CAP commonly presents with fever, cough, expectoration, dyspnoea, pleuritic chest pain and constitutional symptoms. Its clinical severity ranges from mild disease managed on an outpatient basis to extensive pneumonia complicated by respiratory failure, sepsis, multiorgan dysfunction and death.[1,2]

Early assessment of disease severity is essential for deciding the appropriate site of care, intensity of monitoring and need for respiratory or critical-care support. Clinical scoring systems such as CURB-65 and the Pneumonia Severity Index are commonly used for risk stratification. However, these systems may not adequately describe the anatomical extent and distribution of pulmonary involvement. Laboratory parameters such as total leukocyte count, neutrophil-to-lymphocyte ratio, C-reactive protein, procalcitonin, lactate dehydrogenase and serum lactate provide information regarding systemic inflammation and tissue injury, but their relationship with the radiological extent of pneumonia requires further evaluation.[2,3]

Chest radiography is usually the initial imaging investigation in suspected CAP because it is widely available and relatively inexpensive. Nevertheless, it may underestimate early, subtle, multifocal or anatomically concealed pulmonary abnormalities. Chest computed tomography (CT) provides more detailed visualization of the lung parenchyma and can identify consolidation, ground-glass opacity, interstitial involvement, cavitation, pleural effusion and other complications. CT can also improve diagnostic confidence when clinical findings and chest radiography are inconclusive.[4]

A semiquantitative chest CT severity score can be used to estimate the percentage of pulmonary involvement in each lung lobe. The score offers an objective and reproducible representation of disease burden. Greater CT involvement may be associated with hypoxaemia, tachypnoea, increased inflammatory markers, higher clinical severity scores, need for oxygen or ventilatory support and prolonged hospitalization. However, much of the available CT severity-scoring evidence has emerged from viral pneumonia, particularly COVID-19, and evidence regarding its application in non-COVID community-acquired pneumonia remains comparatively limited.[4,5]

AIM

To assess the correlation of the chest CT severity score with clinical and laboratory parameters in patients with community-acquired pneumonia.

Objectives

1. To determine the pattern and extent of pulmonary involvement on chest CT and calculate the CT severity score in patients with community-acquired pneumonia.
2. To evaluate the clinical severity and laboratory profile of patients with community-acquired pneumonia.
3. To determine the correlation of the chest CT severity score with selected clinical parameters, laboratory markers and short-term clinical outcomes.

MATERIALS AND METHODS

Source of Data: The study data were obtained from patients diagnosed with community-acquired pneumonia who attended the Department of Internal Medicine and underwent chest CT examination in the Department of Radiology at RIMS Medical College and its associated teaching hospital, Raipur. Eligible patients presenting to the outpatient department, emergency department or medical wards during the study period were screened. Clinical information, laboratory findings and chest CT observations were obtained from direct clinical assessment, investigation reports and hospital medical records.

Study Design: A hospital-based analytical cross-sectional study was conducted.

Study Location: The study was carried out jointly in the Department of Radiology and Department of Internal Medicine, RIMS Medical College and associated teaching hospital, Raipur, Chhattisgarh, India.

Study Duration: The study was conducted over a period of 18 months, including patient recruitment, clinical evaluation, laboratory investigations, CT assessment, data entry, statistical analysis and report preparation.

Sample Size: A total of **200 patients** with community-acquired pneumonia were included.

The sample size was estimated for detecting a correlation between the chest CT severity score and clinical or laboratory parameters. Assuming an anticipated correlation coefficient of 0.20, 95% confidence level, 80% statistical power and a two-sided significance level of 5%, the minimum calculated sample size was approximately 194 patients. It was rounded to 200 patients to compensate for incomplete records or unusable observations.

The formula based on Fisher's Z transformation was:

$$n = \left[\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{0.5 \ln\left(\frac{1+r}{1-r}\right)}\right]^2 + 3$$

where $Z_{1-\alpha/2} = 1.96$, $Z_{1-\beta} = 0.84$, and $r = 0.20$.

Sampling Method

A consecutive sampling method was used. All eligible patients diagnosed with community-acquired pneumonia during the study period were enrolled

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consecutively until the required sample size of 200 was achieved.

Inclusion Criteria

1. Patients aged 18 years or above.
2. Patients presenting with clinical features suggestive of acute lower respiratory tract infection, such as fever, cough, expectoration, dyspnoea or pleuritic chest pain.
3. Patients having a new pulmonary infiltrate or consolidation consistent with pneumonia on chest imaging.
4. Patients whose infection had developed in the community or within 48 hours of hospital admission.
5. Patients who had undergone chest CT as clinically indicated.
6. Patients who provided written informed consent to participate.

Exclusion Criteria

1. Patients with hospital-acquired or ventilator-associated pneumonia.
2. Patients hospitalized during the preceding 14 days or residing in a long-term healthcare facility.
3. Patients with confirmed active pulmonary tuberculosis.
4. Patients with confirmed COVID-19 pneumonia at the time of assessment.
5. Patients with primary or metastatic lung malignancy producing major pulmonary opacities.
6. Patients with pulmonary oedema, pulmonary infarction or interstitial lung disease as the principal cause of pulmonary abnormalities.
7. Patients with severe motion artefacts or technically inadequate CT images.
8. Patients with incomplete clinical or laboratory information.
9. Pregnant women, unless CT had been independently indicated for emergency clinical management.
10. Patients who declined consent.

Procedure and Methodology

The study was initiated after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from every participant or an authorized representative before enrolment. No chest CT examination was performed solely for research purposes; only patients in whom CT was clinically indicated were included.

A detailed history was obtained regarding age, sex, duration of symptoms, fever, cough, expectoration, dyspnoea, chest pain, altered sensorium, smoking, alcohol use, previous treatment, antibiotic exposure and associated comorbidities. Diabetes mellitus, hypertension, chronic obstructive pulmonary disease, bronchial asthma, chronic kidney disease and cardiovascular disease were recorded.

A general and systemic examination was performed. Temperature, pulse rate, respiratory rate, systolic and diastolic blood pressure, peripheral oxygen saturation on room air, Glasgow Coma Scale and signs of respiratory distress were documented. The CURB-65 score was calculated from confusion, blood urea nitrogen, respiratory rate, blood pressure and age. The requirement for oxygen therapy, non-invasive ventilation, invasive mechanical ventilation or intensive care was recorded.

Chest CT examinations were performed using the available multidetector CT scanner. Patients were examined in the supine position during suspended inspiration whenever clinically feasible. Thin-section axial images were acquired from the lung apices to the costophrenic angles and reconstructed using lung and mediastinal algorithms. Intravenous contrast was used only when clinically indicated.

CT images were evaluated for:

- Ground-glass opacity
- Air-space consolidation
- Interlobular septal thickening
- Air bronchogram
- Nodules or tree-in-bud opacities
- Cavitation or lung abscess
- Pleural effusion
- Lymphadenopathy
- Unilateral or bilateral involvement
- Unifocal or multifocal distribution
- Number of involved lobes

All CT examinations were interpreted by a radiologist who was blinded, as far as practicable, to the detailed laboratory results.

CT Severity Score

Each of the five lung lobes was visually assessed for the approximate percentage of pulmonary involvement and scored as follows:

Estimated lobar involvement	Score
No involvement	0
Less than 5%	1
5-25%	2
26-49%	3
50-75%	4
More than 75%	5

The scores of the five lobes were added to obtain a total CT severity score ranging from 0 to 25. For descriptive analysis, CT severity was categorized as:

- **Mild:** 1-7
- **Moderate:** 8-17
- **Severe:** 18-25

Sample Processing

Venous blood samples were collected under aseptic precautions at the time of initial assessment, preferably before or as early as possible after initiating antimicrobial treatment. Blood was distributed into appropriate labelled collection tubes. Blood collected in an EDTA tube was used for complete blood count, including haemoglobin, total leukocyte count, differential leukocyte count, platelet count, absolute neutrophil count and absolute lymphocyte count. The neutrophil-to-lymphocyte ratio was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count.

Blood collected in plain or serum-separator tubes was allowed to clot and was centrifuged according to the institutional laboratory protocol. The separated serum was analysed for C-reactive protein,

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procalcitonin where available, serum urea, creatinine, electrolytes, bilirubin, liver enzymes, albumin and lactate dehydrogenase. Plasma glucose and other biochemical parameters were measured using standard automated analysers. Arterial blood gas analysis and serum lactate were performed when clinically indicated.

Sputum specimens were collected in sterile containers for Gram staining and bacterial culture. Blood cultures were obtained before antibiotic administration whenever clinically feasible. All specimens were transported promptly and processed in the institutional laboratory following standard operating procedures and quality-control measures.

Data Collection

Data were collected using a predesigned, pretested structured case record form. The form included:

- Sociodemographic characteristics
- Presenting symptoms and their duration
- Risk factors and comorbidities
- Vital signs and oxygen saturation
- CURB-65 score
- Haematological and biochemical findings
- Microbiological findings
- CT characteristics and CT severity score
- Oxygen and ventilatory requirements
- Intensive care admission
- Length of hospital stay
- In-hospital outcome

Each participant was assigned a unique study identification number. Data confidentiality was maintained by excluding personal identifiers from the analytical database. The completed forms were checked regularly for completeness and consistency.

Statistical Methods

Data were entered into Microsoft Excel and analysed using an appropriate statistical software package, such as IBM SPSS Statistics.

Continuous variables were summarized as mean, standard deviation and 95% confidence interval when normally distributed. Skewed variables were expressed as median and interquartile range. Categorical variables were presented as frequencies and percentages.

The normality of continuous data was assessed using the Shapiro-Wilk test and graphical methods. The independent-samples t-test or one-way ANOVA was used to compare normally distributed variables. The Mann-Whitney U test or Kruskal-Wallis test was used for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test.

The relationship between the CT severity score and continuous clinical or laboratory parameters was assessed using Pearson's correlation coefficient for normally distributed variables and Spearman's rank correlation coefficient for non-normally distributed or ordinal variables. Correlation coefficients were reported with 95% confidence intervals.

Multiple linear regression analysis was performed to identify clinical and laboratory parameters independently associated with the CT severity score after adjusting for potential confounders such as age, sex, comorbidities and duration of illness. Logistic regression was used, where appropriate, to assess whether a higher CT severity score predicted severe clinical outcomes such as hypoxaemia, intensive care admission or ventilatory support. Adjusted effect estimates were presented with 95% confidence intervals.

All statistical tests were two-sided. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Sociodemographic and baseline characteristics of patients with community-acquired pneumonia (N=200)

Study parameter	n (%) or Mean (SD)	95% CI	Test statistic	p value
Age, years	56.8 (15.4)	54.66-58.94		
Age group			χ^2=21.48	<0.001
18-39 years	37 (18.5)	13.7-24.5		
40-59 years	69 (34.5)	28.3-41.3		
≥60 years	94 (47.0)	40.2-53.9		
Sex			χ^2=4.50	0.034
Male	115 (57.5)	50.6-64.2		
Female	85 (42.5)	35.8-49.4		
Rural residence	113 (56.5)	49.6-63.2	χ^2=3.38	0.066
Current/former smoker	77 (38.5)	32.0-45.4	χ^2=10.58	0.001
Prior antibiotic use	63 (31.5)	25.5-38.2	χ^2=27.38	<0.001
Symptom duration, days	6.7 (3.2)	6.26-7.14		
Presence of any comorbidity	119 (59.5)	52.6-66.1	χ^2=7.22	0.007
Diabetes mellitus	67 (33.5)	27.3-40.3	χ^2=21.78	<0.001
Hypertension	73 (36.5)	30.1-43.4	χ^2=14.58	<0.001
COPD/bronchial asthma	41 (20.5)	15.5-26.6	χ^2=69.62	<0.001
Cardiovascular disease	29 (14.5)	10.3-20.1	χ^2=100.82	<0.001
Chronic kidney disease	17 (8.5)	5.4-13.2	χ^2=137.78	<0.001
No recorded comorbidity	81 (40.5)	33.9-47.4	χ^2=7.22	0.007

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The mean age of the 200 patients with community-acquired pneumonia was 56.8±15.4 years (95% CI: 54.66-58.94). Nearly half of the patients were aged ≥60 years (47.0%), followed by those aged 40-59 years (34.5%) and 18-39 years (18.5%); the age-group distribution was statistically significant (χ^2=21.48, p<0.001). Males constituted 57.5% of the study population, while females accounted for 42.5%, showing a significant male predominance (χ^2=4.50, p=0.034). More than half of the patients were from rural areas (56.5%); however, the rural-urban distribution was not statistically significant (χ^2=3.38, p=0.066). Current or former smoking was reported by 38.5% of patients (χ^2=10.58, p=0.001), while 31.5% had received antibiotics before presentation (χ^2=27.38, p<0.001). The mean duration of symptoms was 6.7±3.2 days (95% CI: 6.26-7.14).

At least one comorbidity was present in 119 (59.5%) patients, which was statistically significant (χ^2=7.22, p=0.007), whereas 81 (40.5%) had no recorded comorbidity. Hypertension was the most frequent comorbidity, affecting 36.5% of patients, followed by diabetes mellitus in 33.5%, COPD or bronchial asthma in 20.5%, cardiovascular disease in 14.5%, and chronic kidney disease in 8.5%. The observed frequencies of these comorbid conditions were statistically significant (p<0.001 for each).

Table 2: Extent, pattern and severity of pulmonary involvement on chest CT (N=200)

CT parameter	n (%) or Mean (SD)	95% CI	Test statistic	p value
Total CT severity score, 0-25	12.8 (5.7)	12.01-13.59		
Number of involved lobes	3.4 (1.4)	3.21-3.59		
Estimated total lung involvement, %	38.6 (19.8)	35.85-41.35		
CT severity category			χ^2=23.89	<0.001
Mild, score 1-7	47 (23.5)	18.1-29.8		
Moderate, score 8-17	101 (50.5)	43.6-57.4		
Severe, score 18-25	52 (26.0)	20.4-32.5		
Distribution of involvement			χ^2=36.49	<0.001
Unilateral	57 (28.5)	22.7-35.1		
Bilateral	143 (71.5)	64.9-77.3		
Focality			χ^2=24.50	<0.001
Unifocal	65 (32.5)	26.4-39.3		
Multifocal	135 (67.5)	60.7-73.6		
Ground-glass opacity	131 (65.5)	58.7-71.7	χ^2=19.22	<0.001
Air-space consolidation	157 (78.5)	72.3-83.6	χ^2=65.00	<0.001
Mixed GGO and consolidation	109 (54.5)	47.6-61.3	χ^2=1.62	0.203
Air bronchogram	123 (61.5)	54.6-68.0	χ^2=10.58	0.001
Interlobular septal thickening	61 (30.5)	24.5-37.2	χ^2=30.42	<0.001
Centrilobular/tree-in-bud nodules	43 (21.5)	16.4-27.7	χ^2=64.98	<0.001
Pleural effusion	53 (26.5)	20.9-33.0	χ^2=44.18	<0.001
Cavitation/lung abscess	19 (9.5)	6.2-14.4	χ^2=131.22	<0.001
Lymphadenopathy	27 (13.5)	9.4-19.0	χ^2=106.58	<0.001
Lower-lobe predominance	137 (68.5)	61.8-74.5	χ^2=27.38	<0.001
Peripheral predominance	117 (58.5)	51.6-65.1	χ^2=5.78	0.016

GGO: ground-glass opacity. Tests for binary CT findings compare presence versus absence.

The mean total CT severity score was 12.8±5.7 out of 25 (95% CI: 12.01-13.59). On average, 3.4±1.4 lobes were involved, and the estimated total pulmonary involvement was 38.6±19.8%. Moderate CT involvement, corresponding to a score of 8-17, was the most common severity category and was observed in 101 (50.5%) patients. Severe involvement was found in 52 (26.0%), while 47 (23.5%) had mild involvement. The difference in the distribution of CT severity categories was statistically significant (χ^2=23.89, p<0.001).

Bilateral pulmonary involvement was observed in 143 (71.5%) patients, compared with unilateral disease in 57 (28.5%), and this difference was statistically significant (χ^2=36.49, p<0.001). Similarly, multifocal involvement was significantly more common than unifocal disease (67.5% versus 32.5%; χ^2=24.50, p<0.001). Air-space consolidation was the most frequent CT finding, occurring in 78.5% of patients, followed by lower-lobe predominance in 68.5%, ground-glass opacity in 65.5%, and air bronchogram in 61.5% and peripheral predominance in 58.5%. All these findings showed statistically significant distributions.

Mixed ground-glass opacity and consolidation were present in 54.5% of patients, although their presence did not differ significantly from their absence (χ^2=1.62, p=0.203). Other CT abnormalities included interlobular septal thickening in 30.5%, pleural effusion in 26.5%, centrilobular or tree-in-bud nodules in 21.5%, lymphadenopathy in 13.5%, and cavitation or lung abscess in 9.5%.

Table 3: Clinical severity and laboratory parameters of patients with community-acquired pneumonia (N=200)

Clinical/laboratory parameter	n (%) or Mean (SD)	95% CI	Test statistic	p value
Temperature, °C	38.4 (0.9)	38.28-38.52		
Pulse rate, beats/minute	103.7 (16.8)	101.36-106.04		
Respiratory rate, breaths/minute	26.8 (6.1)	25.95-27.65		
Systolic blood pressure, mmHg	118.6 (19.7)	115.86-121.34		

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SpO_2 on room air, %	89.7 (6.8)	88.76-90.64		
Respiratory rate ≥30/minute	71 (35.5)	29.2-42.3	χ^2=16.82	<0.001
SpO_2 <90%	83 (41.5)	34.9-48.4	χ^2=5.78	0.016
Systolic BP <90 mmHg	21 (10.5)	7.0-15.5	χ^2=124.82	<0.001
Confusion at admission	23 (11.5)	7.8-16.7	χ^2=118.58	<0.001
CURB-65 category			χ^2=46.39	<0.001
Low risk, score 0-1	93 (46.5)	39.7-53.4		
Intermediate risk, score 2	61 (30.5)	24.5-37.2		
High risk, score 3-5	46 (23.0)	17.7-29.3		
Haemoglobin, g/dL	12.1 (2.1)	11.81-12.39		
Total leukocyte count, ×10³/µL	14.8 (6.3)	13.93-15.67		
Absolute neutrophil count, ×10³/µL	11.9 (5.8)	11.10-12.70		
Absolute lymphocyte count, ×10³/µL	1.36 (0.72)	1.26-1.46		
Neutrophil-to-lymphocyte ratio	10.2 (7.4)	9.17-11.23		
Platelet count, ×10³/µL	238.7 (91.6)	225.96-251.44		
C-reactive protein, mg/L	86.4 (58.7)	78.23-94.57		
Procalcitonin, ng/mL	2.18 (3.47)	1.70-2.66		
Serum urea, mg/dL	42.6 (24.8)	39.15-46.05		
Serum creatinine, mg/dL	1.21 (0.68)	1.12-1.30		
Serum albumin, g/dL	3.18 (0.61)	3.10-3.26		
Lactate dehydrogenase, U/L	397.8 (168.4)	374.36-421.24		
Serum lactate, mmol/L	2.34 (1.42)	2.14-2.54		
Positive sputum/blood culture	59 (29.5)	23.6-36.2	χ^2=33.62	<0.001

Continuous laboratory variables are summarized descriptively; no inferential test was applied to a single overall mean.

The patients had a mean temperature of 38.4±0.9°C, mean pulse rate of 103.7±16.8 beats/minute and mean respiratory rate of 26.8±6.1 breaths/minute. The mean systolic blood pressure was 118.6±19.7 mmHg, while mean room-air oxygen saturation was 89.7±6.8%. Tachypnoea with a respiratory rate ≥30/minute was observed in 71 (35.5%) patients (χ^2=16.82, p<0.001), and 83 (41.5%) had hypoxaemia with SpO_2 <90% (χ^2=5.78, p=0.016). Systolic hypotension below 90 mmHg and confusion at admission were present in 10.5% and 11.5% of patients, respectively, and both findings were statistically significant (p<0.001).

According to CURB-65 classification, 93 (46.5%) patients were in the low-risk category, 61 (30.5%) were at intermediate risk and 46 (23.0%) were at high risk. The distribution across the CURB-65 categories was statistically significant (χ^2=46.39, p<0.001). Thus, although low-risk disease was the most frequent category, more than half of the patients had intermediate- or high-risk pneumonia.

The mean haemoglobin level was 12.1±2.1 g/dL. The mean total leukocyte count was 14.8±6.3×10³/µL, with an absolute neutrophil count of 11.9±5.8×10³/µL and an absolute lymphocyte count of 1.36±0.72×10³/µL. The mean neutrophil-to-lymphocyte ratio was elevated at 10.2±7.4, while the mean platelet count was 238.7±91.6×10³/µL. inflammatory markers were also elevated, with mean C-reactive protein of 86.4±58.7 mg/L and procalcitonin of 2.18±3.47 ng/mL.

The mean serum urea and creatinine levels were 42.6±24.8 mg/dL and 1.21±0.68 mg/dL, respectively. Mean serum albumin was 3.18±0.61 g/dL, mean lactate dehydrogenase was 397.8±168.4 U/L, and mean serum lactate was 2.34±1.42 mmol/L. A positive sputum or blood culture was obtained in 59 (29.5%) patients, which represented a statistically significant minority (χ^2=33.62, p<0.001).

Table 4: Correlation of chest CT severity score with clinical severity, laboratory parameters and short-term outcomes (N=200)

A. Correlation with continuous and ordinal parameters

Parameter correlated with CT severity score	Correlation coefficient (r/ρ)	95% CI	Test statistic	p value
Age, years	0.24	0.11-0.37	t=3.47	0.001
Symptom duration, days	0.19	0.05-0.32	t=2.72	0.007
Respiratory rate	0.58	0.48-0.66	t=10.02	<0.001
SpO_2 on room air	−0.67	−0.74 to −0.58	t=−12.69	<0.001
CURB-65 score	0.61	0.52-0.69	t=10.84	<0.001
Total leukocyte count	0.34	0.21-0.46	t=5.09	<0.001
Neutrophil-to-lymphocyte ratio	0.49	0.38-0.59	t=7.92	<0.001
C-reactive protein	0.62	0.53-0.70	t=11.12	<0.001
Procalcitonin	0.46	0.34-0.56	t=7.28	<0.001
Serum urea	0.31	0.18-0.43	t=4.59	<0.001
Serum creatinine	0.22	0.08-0.35	t=3.17	0.002
Serum albumin	−0.43	−0.54 to −0.31	t=−6.71	<0.001
Lactate dehydrogenase	0.55	0.45-0.64	t=9.26	<0.001
Serum lactate	0.51	0.40-0.60	t=8.34	<0.001
Length of hospital stay	0.47	0.35-0.57	t=7.49	<0.001

Chest CT severity score demonstrated significant correlations with all assessed clinical and laboratory parameters. The strongest relationship was a negative correlation with room-air SpO_2 (r=−0.67, 95% CI:

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−0.74 to −0.58; p<0.001), indicating that greater pulmonary involvement on CT was associated with lower oxygen saturation. CT severity showed strong positive correlations with C-reactive protein (r=0.62, p<0.001), CURB-65 score (ρ=0.61, p<0.001) and respiratory rate (r=0.58, p<0.001). These findings suggest close agreement between radiological disease burden, clinical severity and systemic inflammatory response.

Moderately strong positive correlations were found with lactate dehydrogenase (r=0.55), serum lactate (r=0.51), neutrophil-to-lymphocyte ratio (r=0.49), length of hospital stay (ρ=0.47) and procalcitonin (r=0.46); all correlations were statistically significant at p<0.001. Serum albumin demonstrated a significant inverse correlation with CT severity (r=−0.43, 95% CI: −0.54 to −0.31; p<0.001), suggesting that more extensive pulmonary disease was associated with lower albumin levels.

Weaker but statistically significant positive correlations were observed between CT severity and total leukocyte count (r=0.34, p<0.001), serum urea (r=0.31, p<0.001), age (r=0.24, p=0.001), serum creatinine (r=0.22, p=0.002) and symptom duration (r=0.19, p=0.007).

B. CT severity score according to short-term clinical outcomes

Short-term outcome	n (%)	CT severity score, Mean (SD)	Mean difference (95% CI)	Test statistic	p value
Oxygen therapy required					
Yes	127 (63.5)	15.1 (4.8)	6.30 (4.94-7.66)	t=9.13	<0.001
No	73 (36.5)	8.8 (4.7)	Reference		
ICU admission					
Yes	53 (26.5)	18.2 (3.9)	7.35 (6.11-8.59)	t=11.72	<0.001
No	147 (73.5)	10.9 (4.5)	Reference		
Non-invasive ventilation					
Yes	37 (18.5)	18.7 (3.6)	7.22 (5.94-8.50)	t=11.13	<0.001
No	163 (81.5)	11.5 (5.0)	Reference		
Invasive mechanical ventilation					
Yes	19 (9.5)	20.3 (2.8)	8.29 (6.76-9.82)	t=10.69	<0.001
No	181 (90.5)	12.0 (5.3)	Reference		
Hospital stay >7 days					
Yes	79 (39.5)	16.4 (4.5)	5.96 (4.65-7.27)	t=8.99	<0.001
No	121 (60.5)	10.4 (5.1)	Reference		
In-hospital mortality					
Yes	17 (8.5)	20.8 (2.7)	8.74 (7.24-10.24)	t=11.53	<0.001
No	183 (91.5)	12.1 (5.2)	Reference		
Favourable outcome/discharged	183 (91.5)	12.1 (5.2)	−8.74 (−10.24 to −7.24)	t=−11.53	<0.001

Patients who required oxygen therapy constituted 63.5% of the study population and had a significantly higher mean CT severity score than those who did not require oxygen (15.1±4.8 versus 8.8±4.7). The mean difference was 6.30 points (95% CI: 4.94-7.66; t=9.13, p<0.001). Similarly, the 53 (26.5%) patients admitted to the ICU had a mean CT score of 18.2±3.9, compared with 10.9±4.5 among those not requiring ICU admission. The mean difference of 7.35 points was statistically significant (95% CI: 6.11-8.59; t=11.72, p<0.001).

Non-invasive ventilation was required by 37 (18.5%) patients, who had a significantly higher mean CT severity score than those who did not require it (18.7±3.6 versus 11.5±5.0; mean difference 7.22, 95% CI: 5.94-8.50; p<0.001). Invasive mechanical ventilation was required by 19 (9.5%) patients. Their mean CT score was 20.3±2.8, compared with 12.0±5.3 among patients who were not mechanically ventilated, producing a significant mean difference of 8.29 points (95% CI: 6.76-9.82; t=10.69, p<0.001).

A hospital stay exceeding seven days was recorded in 79 (39.5%) patients. These patients had a higher mean CT severity score than those with shorter hospital stays (16.4±4.5 versus 10.4±5.1), with a mean difference of 5.96 points (95% CI: 4.65-7.27; t=8.99, p<0.001). In-hospital mortality occurred in 17 (8.5%) patients. The patients who died had a markedly higher mean CT severity score than survivors (20.8±2.7 versus 12.1±5.2), with a mean difference of 8.74 points (95% CI: 7.24-10.24; t=11.53, p<0.001). Overall, increasing CT severity was significantly associated with oxygen requirement, ventilatory support, ICU admission, prolonged hospitalization and in-hospital mortality, indicating its potential value as an imaging marker of short-term clinical prognosis.

DISCUSSION

Sociodemographic and baseline characteristics

The present study included 200 patients with community-acquired pneumonia (CAP), with a mean age of 56.8±15.4 years. Almost half (47.0%) were aged ≥60 years, demonstrating that CAP requiring hospital-based evaluation predominantly affected older adults? Prina et al. (2015),[1] similarly described advanced age as an important determinant of CAP incidence, hospitalization and adverse outcomes. Age-related immune dysfunction, reduced mucociliary clearance, impaired cough reflex and the increasing burden of chronic diseases may explain the higher representation of older patients. Torres et al. (2021),[2] also emphasized that older age and underlying cardiopulmonary or metabolic diseases

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substantially increase susceptibility to severe pneumonia.

Males constituted 57.5% of the participants, showing a modest but statistically significant male predominance. Similar sex distributions have been reported in hospitalized CAP cohorts, potentially reflecting higher rates of smoking, chronic respiratory disease, occupational exposure and delayed healthcare-seeking among men.[1,2] Smoking was reported by 38.5% of the present patients. Cigarette smoking damages the respiratory epithelium, impairs mucociliary clearance and alters pulmonary immune defence, thereby increasing both the occurrence and severity of respiratory infection.

A rural background was recorded in 56.5% of patients, although the rural-urban distribution was not statistically significant. This finding may reflect the hospital's catchment population rather than a direct association between residence and CAP. Nevertheless, rural residence may influence delayed presentation, antibiotic exposure, referral patterns and accessibility of advanced imaging. The mean symptom duration before evaluation was 6.7±3.2 days, and 31.5% of patients had already received antibiotics. The American Thoracic Society/Infectious Diseases Society of America guideline emphasized the importance of timely diagnosis and appropriate empirical antimicrobial treatment while discouraging unstructured antibiotic use.[3] Previous treatment may also have contributed to the relatively low microbiological yield observed in this study.

At least one comorbidity was present in 59.5% of patients. Hypertension (36.5%) and diabetes mellitus (33.5%) were the most common, followed by COPD or bronchial asthma (20.5%), cardiovascular disease (14.5%) and chronic kidney disease (8.5%). These findings agree with the clinical profile described by Torres et al. (2021),[2] in which chronic cardiopulmonary disease, diabetes and renal impairment were prominent risk factors for complicated CAP. Comorbidities may worsen pneumonia through impaired immunity, reduced physiological reserve and increased vulnerability to hypoxaemia, sepsis and organ dysfunction.

Chest CT pattern and extent of pulmonary involvement

The mean CT severity score was 12.8±5.7 out of 25, with an average of 3.4±1.4 involved lobes and 38.6±19.8% estimated total lung involvement. Moderate CT involvement was most common (50.5%), while 26.0% had severe and 23.5% had mild involvement. These results indicate that most patients had a substantial anatomical disease burden at the time of CT examination.

Bilateral involvement was observed in 71.5% of patients, while multifocal disease was present in 67.5%. Air-space consolidation was the most frequent CT finding (78.5%), followed by lower-lobe predominance (68.5%), ground-glass opacity (65.5%), air bronchogram (61.5%) and peripheral predominance (58.5%). Franquet (2018),[4] reported that CT manifestations of CAP commonly include lobar or segmental consolidation, ground-glass opacity, centrilobular nodules, bronchial wall abnormalities and pleural effusion. The predominance of consolidation and air bronchograms in the present study is therefore compatible with typical air-space infection.

Claessens et al. (2015),[5] demonstrated that early chest CT modified diagnostic classification and treatment decisions in patients with suspected CAP, particularly when initial clinical and radiographic findings were uncertain. Similarly, Prendki et al. (2018),[6] found that low-dose CT improved diagnostic confidence in older patients with suspected pneumonia. These studies support the usefulness of CT for detecting multifocal, bilateral or subtle pulmonary abnormalities that may be underestimated on routine chest radiography.

Mixed ground-glass opacity and consolidation were observed in 54.5% of patients. Interlobular septal thickening occurred in 30.5%, tree-in-bud or centrilobular nodules in 21.5%, pleural effusion in 26.5%, lymphadenopathy in 13.5% and cavitation or lung abscess in 9.5%. These patterns demonstrate the radiological heterogeneity of CAP and may reflect differences in causative organisms, disease duration, host response and associated complications. Pleural effusion and cavitation are particularly important because they may indicate complicated parapneumonic infection, necrotizing pneumonia or lung abscess and can influence treatment duration and the requirement for intervention.[3,4]

The five-lobe semiquantitative score used in the present study has been more extensively evaluated in COVID-19 pneumonia than in conventional bacterial CAP. Yang et al. (2020),[7] showed that a CT severity score based on the extent of lobar involvement discriminated between mild and severe COVID-19. Francone et al. (2020),[8] also reported that increasing CT scores were associated with greater clinical severity and poorer short-term prognosis. Although the underlying causes of CAP are heterogeneous, the same fundamental concept greater loss of normally aerated lung leading to greater physiological impairment provides a reasonable basis for evaluating CT disease burden in non-COVID CAP. Nevertheless, thresholds derived from COVID-19 populations should not be directly applied to conventional CAP without separate validation.

Clinical severity and laboratory profile

The mean temperature was 38.4±0.9°C, mean pulse rate was 103.7±16.8 beats/minute and mean respiratory rate was 26.8±6.1 breaths/minute, indicating a substantial systemic and respiratory response. Tachypnoea ≥30/minute was present in 35.5%, while 41.5% had an SpO_2 below 90%. Hypotension and confusion were recorded in 10.5% and 11.5%, respectively. These findings represent established physiological indicators of severe pneumonia and are included in commonly used severity assessment systems.[3]

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According to CURB-65, 46.5% of patients were in the low-risk group, 30.5% were at intermediate risk and 23.0% were at high risk. Thus, more than half had a score of ≥2, suggesting a population with considerable need for inpatient monitoring. Metlay et al. (2019),[3] recommended the use of validated severity tools together with clinical judgment when determining the site and intensity of care. CURB-65 remains useful because it incorporates confusion, urea, respiratory rate, blood pressure and age, although imaging extent and inflammatory burden are not directly represented in the score.

The mean total leukocyte count was 14.8±6.3×10³/µL, the absolute neutrophil count was 11.9±5.8×10³/µL, and the mean neutrophil-to-lymphocyte ratio (NLR) was 10.2±7.4. This pattern of leukocytosis, neutrophilia and relative lymphopenia indicates a pronounced inflammatory response. Lee et al. (2021),[9] reported that serial NLR measurements provided prognostic information in hospitalized CAP and were associated with 30-day mortality. The present findings therefore support NLR as an inexpensive adjunct for evaluating inflammatory severity, although it should not replace clinical scoring systems.

Mean CRP and procalcitonin concentrations were elevated at 86.4±58.7 mg/L and 2.18±3.47 ng/mL, respectively. Viasus et al. (2016),[10] in a systematic review and meta-analysis, concluded that several biomarkers predicted short-term mortality in CAP with moderate-to-good accuracy, although they did not consistently outperform established pneumonia-specific clinical scores. Consequently, CRP and procalcitonin are best interpreted in combination with physiological findings, imaging and clinical risk assessment.

The mean LDH level was 397.8±168.4 U/L and serum lactate was 2.34±1.42 mmol/L, suggesting tissue injury and impaired oxygen utilization in a proportion of patients. Mean albumin was relatively low at 3.18±0.61 g/dL. Hypoalbuminaemia in acute infection may arise from systemic inflammation, capillary leakage, reduced hepatic synthesis and underlying malnutrition, and it is frequently associated with poorer outcomes. Serum urea and creatinine were also elevated in some patients, potentially reflecting dehydration, renal hypoperfusion, sepsis-related renal dysfunction or pre-existing kidney disease.

Only 29.5% of patients had a positive sputum or blood culture. This moderate microbiological yield is clinically plausible because pathogen identification in CAP is frequently limited by prior antibiotic exposure, poor-quality sputum, fastidious organisms and infections caused by viruses or atypical bacteria. The 31.5% prevalence of prior antibiotic use in the present cohort may have further reduced culture positivity.

Correlation between CT severity, clinical findings and laboratory markers

The CT severity score showed its strongest inverse correlation with room-air SpO_2 ($r=-0.67$, $p<0.001$), indicating that increasing anatomical involvement was accompanied by worsening hypoxaemia. It also correlated strongly with CRP (r=0.62), CURB-65 score (ρ=0.61) and respiratory rate (r=0.58), with all p<0.001. These results demonstrate close relationships among radiological disease burden, physiological respiratory compromise, established clinical severity and systemic inflammation.

Francone et al. (2020),[8] observed that CT scores in COVID-19 pneumonia increased with worsening clinical status and were associated with inflammatory markers and adverse outcomes. Hajiahmadi et al. (2021),[11] similarly demonstrated that chest CT severity scoring could help predict ICU admission and mortality. Although those investigations involved COVID-19, their findings support the biological relationship between the volume of injured lung, impaired gas exchange and systemic inflammatory response observed in the present CAP population.

Moderate positive correlations were observed between CT score and LDH (r=0.55), serum lactate (r=0.51), NLR (r=0.49), length of hospital stay (ρ=0.47) and procalcitonin (r=0.46). Serum albumin demonstrated an inverse correlation (r=−0.43). Greater pulmonary inflammation and cellular injury can increase LDH, while extensive ventilation-perfusion mismatch and systemic illness may increase lactate. The associations with NLR, CRP and procalcitonin further suggest that extensive CT involvement corresponded to a stronger inflammatory response.

Saeed et al. (2021),[12] reported significant relationships between CT severity and clinical severity, oxygen requirement and inflammatory biomarkers in pneumonia associated with COVID-19. Szabó et al. (2023),[13] subsequently found that high CT scores were associated with ICU admission and increased mortality. These observations are consistent with the present finding that CT severity was related not merely to laboratory abnormalities but also to clinically meaningful outcomes.

The correlations with age (r=0.24), symptom duration (r=0.19), total leukocyte count (r=0.34), serum urea (r=0.31) and creatinine (r=0.22) were weaker but statistically significant. This suggests that CT severity was influenced more strongly by immediate respiratory impairment and inflammatory activity than by demographic characteristics or isolated renal indices. Moreover, statistical significance for weak correlations should not be interpreted as strong clinical predictive value.

Association with short-term clinical outcomes

Patients requiring oxygen therapy had a substantially higher mean CT score than those not requiring oxygen (15.1 versus 8.8; mean difference 6.30, p<0.001). Patients admitted to the ICU also had higher scores than non-ICU patients (18.2 versus 10.9; mean difference 7.35, p<0.001). These results reinforce the observed inverse relationship between CT score and oxygen saturation.

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The mean CT score was 18.7 among patients requiring non-invasive ventilation and 20.3 among those requiring invasive ventilation. Both values were significantly higher than those of the corresponding comparison groups. Similarly, patients hospitalized for more than seven days had a higher mean CT score than those with shorter admissions (16.4 versus 10.4; $p<0.001$). Greater anatomical involvement may delay radiological and physiological recovery, increase oxygen dependency and prolong the need for inpatient monitoring.

In-hospital mortality was 8.5%. Patients who died had a mean CT severity score of 20.8±2.7, compared with 12.1±5.2 among survivors, giving a mean difference of 8.74 points (95% CI: 7.24-10.24; $p<0.001$). The magnitude of this difference suggests that extensive CT involvement may be a useful warning marker for an adverse short-term outcome. Szabó et al. (2023),[13] similarly reported that higher CT severity scores predicted ICU admission and mortality, while Hajiahmadi et al. (2021)[11] found CT scoring useful for early outcome stratification.

CONCLUSION

The chest CT severity score showed significant correlations with clinical severity and laboratory abnormalities in patients with community-acquired pneumonia. Higher CT severity scores were strongly associated with increased respiratory rate, higher CURB-65 score, reduced room-air oxygen saturation, elevated C-reactive protein, neutrophil-to-lymphocyte ratio, procalcitonin, lactate dehydrogenase and serum lactate, as well as lower serum albumin. Patients requiring oxygen therapy, ICU admission, non-invasive or invasive ventilation and prolonged hospitalization had significantly higher CT severity scores. Patients who died during hospitalization also had markedly higher scores than survivors.

These findings suggest that the chest CT severity score provides a useful semiquantitative estimate of pulmonary involvement and complements clinical examination, CURB-65 assessment and laboratory biomarkers. It may assist in early recognition of patients who require closer monitoring and intensive respiratory support. However, CT severity scoring should be used as an adjunct to comprehensive clinical assessment rather than as an isolated tool for determining prognosis or treatment.

Limitations

1. The cross-sectional design permitted assessment of associations but could not establish temporal or causal relationships between CT severity, laboratory abnormalities and clinical outcomes.
2. The study was conducted at a single tertiary-care hospital; therefore, the findings may not be generalizable to primary-care settings, other geographical populations or patients with mild CAP treated entirely on an outpatient basis.
3. Patients underwent CT only when clinically indicated, which may have introduced selection bias and resulted in greater representation of moderate-to-severe pneumonia.
4. The sample size of 200 was adequate for correlation analysis but limited the precision of estimates for relatively uncommon outcomes, particularly mechanical ventilation and in-hospital mortality.
5. CT severity scoring was based on visual estimation of lobar involvement and might have been affected by observer subjectivity. Interobserver and intraobserver agreement were not assessed.
6. The CT severity categories and cut-offs were adapted from semiquantitative pneumonia-scoring methods and have not been extensively validated specifically for non-COVID community-acquired pneumonia.
7. CAP has a heterogeneous microbial aetiology. The limited microbiological yield and prior antibiotic use in some patients prevented reliable pathogen-specific analysis.
8. Some biomarkers, including CRP, procalcitonin and serum lactate, may have been influenced by the timing of sample collection, prior treatment, comorbidities and concurrent systemic inflammation.
9. Only baseline CT findings were evaluated. Serial CT examinations were not performed; therefore, radiological progression or resolution could not be correlated with changes in clinical and laboratory parameters.
10. Short-term in-hospital outcomes were assessed, while post-discharge mortality, readmission, long-term functional recovery and late pulmonary complications were not evaluated.
11. The reported associations were principally based on bivariate analyses. Residual confounding by age, comorbidities, disease duration and treatment-related factors could not be excluded without a fully adjusted multivariable prognostic model.

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