LUNG ULTRASOUND CHARACTERISTICS IN COMMUNITY-ACQUIRED PNEUMONIA PATIENTS AT CAN THO UNIVERSITY OF MEDICINE AND PHARMACY HOSPITAL

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Semi-quantitative lung ultrasound has increasingly emerged as a bedside tool for evaluating pulmonary parenchymal involvement, yet evidence in community-acquired pneumonia remains limited. This analytical cross-sectional study investigated lung ultrasound features and their associations with selected severity assessment tools and inflammatory markers in 85 patients with community-acquired pneumonia admitted to the Department of General Internal Medicine, Can Tho University of Medicine and Pharmacy Hospital, from June 2025 to January 2026. The median age was 73.0 years old, and 55.3% were men. B-lines/lung rockets were the most common ultrasound finding (98.8%), followed by the shred sign (58.8%), air bronchograms (47.1%), and pleural effusion (17.6%). Consolidation with or without interstitial syndrome was the predominant lesion pattern (64.7%), whereas isolated interstitial syndrome accounted for 34.1%. Spline analysis showed that CRP and WBC increased with higher total lung ultrasound scores, with significant overall associations ($p<0.001$ and $p=0.032$, respectively). The total lung ultrasound score also increased progressively with pneumonia severity according to both CURB-65 and PSI/PORT ($p<0.05$). In multivariable analysis, CRP and severity assessed by CURB-65 and PSI/PORT were independently associated with the total lung ultrasound score. Lung ultrasound may therefore support assessment of inflammatory burden, severity stratification, follow-up, and prognostication in community-acquired pneumonia.

Keywords: Lung ultrasound (LUS), LUS score, community-acquired pneumonia.

I. INTRODUCTION

Pneumonia is one of the most common and serious infectious diseases in clinical practice and continues to impose a substantial burden on global health systems. According to the World Health Organization, pneumonia ranks among the 10 leading causes of death worldwide, numbering nearly 2.5 million deaths annually.[1] The disease presents with a broad clinical spectrum, ranging from mild to severe, and may progress rapidly with numerous life-threatening complications, particularly in children, older adults, and immunocompromised individuals. Therefore, early diagnosis, accurate assessment of the extent of lung involvement, and prognostication of disease severity are of paramount importance for guiding treatment decisions and ensuring timely intervention.[2] In this context, imaging modalities play an especially essential role.

In recent years, lung ultrasound (LUS) has emerged as a promising tool because of its noninvasive nature, its ability to provide direct bedside imaging, and its lack of ionizing radiation exposure, unlike chest radiography

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or computed tomography.[3] Numerous studies have demonstrated that lung ultrasound has high sensitivity and specificity for the diagnosis of pneumonia, even outperforming chest radiography and, in certain settings, showing diagnostic value comparable to chest computed tomography. Beyond lesion detection, semi-quantitative lung ultrasound has also shown associations with inflammatory burden and disease severity, suggesting a role in initial assessment and prognostication.[4,5] In Vietnam, lung ultrasound has gradually been applied in the evaluation of pulmonary involvement, mainly in children, critically ill patients, or patients with COVID-19; however, studies investigating the role of this modality in patients with community-acquired pneumonia, a highly common condition in routine clinical practice, remain limited. On this basis, the present study was conducted to investigate lung ultrasound characteristics and analyze their associations with selected severity assessment tools and inflammatory markers in patients with community-acquired pneumonia at Can Tho University of Medicine and Pharmacy Hospital.

II. MATERIALS AND METHOD

1. Study population and settings

All patients with suspected community-acquired pneumonia who were admitted for inpatient treatment to the Department of General Internal Medicine, Can Tho University of Medicine and Pharmacy Hospital, from June 2025 to January 2026, and were definitively diagnosed with pneumonia based on chest radiography or lung ultrasound, were considered for inclusion.

Inclusion criteria

Patients aged >18 years old who agreed to participate in the study and fulfilled the diagnostic criteria for community-acquired pneumonia according to the 2025 Vietnamese Respiratory Society guidelines, based on clinical features, blood tests, and pulmonary lesions identified on imaging.[6] Pulmonary lesions suggestive of pneumonia on chest radiography were defined as alveolar, bronchopulmonary, or interstitial abnormalities.[6] On lung ultrasound, imaging findings suggestive of pneumonia included the presence of multiple B-lines (≥3 B-lines), lung consolidation, air bronchograms, and pleural effusion.[2,6]

Exclusion criteria

Patients who could not undergo both lung ultrasound and chest radiography before antibiotic administration. Patients with acquired immunodeficiency, a neutrophil count <1000/mm³, those undergoing chemotherapy or radiotherapy for cancer, or those who were pregnant. Patients with pulmonary tuberculosis or pulmonary embolism. Patients with congestive heart failure, severe kidney failure, or those receiving dialysis. Patients with chronic inflammatory diseases or autoimmune disorders, such as rheumatoid arthritis, systemic lupus erythematosus, and others.

2. Study design and variables

Study design

This was an analytical cross-sectional study.

Sample size

Convenience sampling was used to recruit patients who met the eligibility criteria during the study period. In practice, the study enrolled 85 patients with community-acquired pneumonia who met the inclusion criteria, had no exclusion criteria, and agreed to participate in the study.

Study procedures and variables

Lung ultrasound was performed before the administration of antibiotics, together with assessment of inflammatory biomarkers, including white blood cell count [WBC] (G/L),

neutrophil-to-lymphocyte ratio [NLR] derived from the peripheral blood cell count, and C-reactive protein [CRP] concentration (mg/L) obtained from blood biochemistry testing. Pneumonia severity assessment tools, including CURB-65 and PSI/PORT, were evaluated at the time of hospital admission, and laboratory-related components were supplemented once the test results became available. CURB-65 was subsequently categorized into three groups: group 1 (0–1 points), group 2 (2 points), and group 3 (3–5 points). PSI/PORT was categorized into four groups: group I–II (PSI ≤70 points), group III (PSI 71–90 points), group IV (PSI 91–130 points), and group V (PSI >130 points).[6]

According to the hospital's routine workflow, patients admitted to the Emergency Department undergo chest radiography for initial assessment before transfer to the ward, whereas lung ultrasound is usually performed thereafter. In this study, lung ultrasound examinations in patients with pneumonia were assessed by the same experienced radiologist. The physician performing lung ultrasound was blinded to the patient's prior chest radiographic findings. Lung ultrasound was performed using a Philips ultrasound system (Netherlands) with a linear transducer. Patients were examined in the supine position. In patients without mobility limitation, posterior lung regions could also be examined in the sitting position. The lung ultrasound protocol was conducted in accordance with the American Thoracic Society guidelines using a 12-zone approach, corresponding to 6 lung regions on each side (anterior upper, anterior lower, lateral upper, lateral lower, posterior upper, and posterior lower). In each zone, the probe was placed longitudinally within the intercostal space to obtain a clear view of the pleural line between two adjacent ribs, and was then gently tilted and slid across adjacent intercostal spaces within the same zone to broaden the survey area. For each zone, the most severe aeration-loss pattern identified during scanning was recorded as the representative score. Each zone was scored from 0 to 3 (Figure 1) according to the degree of aeration and ultrasound findings in that region (score 0: normal aeration, with visible A-lines and pleural line, or <3 B-lines; score 1: moderate loss of aeration with ≥3 B-lines [lung rockets] or B-lines occupying <50% of the examined region; score 2: severe loss of aeration with multiple coalescent B-lines or B-lines occupying >50% of the examined region; score 3: complete loss of aeration with lung consolidation).[7] The total lung ultrasound score was calculated as the sum of the scores across the 12 lung regions (maximum, 36 points). Ultrasonographic signs of consolidation included the shred sign and tissue-like sign. The posterolateral alveolar and/or pleural syndrome (PLAPS) included consolidation and pleural effusion.

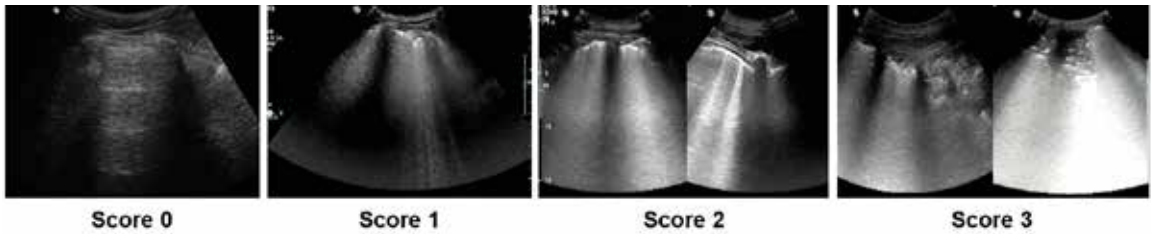

Figure 1. Illustration of lung ultrasound score calculation (images obtained from study patients)

Data analysis and processing

Data were entered using Microsoft Excel 365 and analyzed using R 4.5.0 and RStudio. The associations between the total lung ultrasound score and inflammatory markers were examined using restricted cubic spline (RCS) regression models and were visualized graphically to assess both the overall trend and the potential presence of nonlinear relationships. The overall p value was used to assess the statistical significance of the overall association, whereas the p for non-linearity was used to test the nonlinear component of the model. In addition, the distribution of total lung ultrasound scores across pneumonia severity subgroups based on the CURB-65 and PSI/PORT scores was illustrated using violin plots. Differences in the median total lung ultrasound score between groups were compared using the Kruskal–Wallis test. Furthermore, the associations of inflammatory markers and pneumonia severity with the total lung ultrasound score were investigated using multivariable linear regression models. Because CURB-65 and PSI/PORT are both severity scoring systems and share overlapping components, two separate models were constructed to minimize multicollinearity. Specifically, model 1 included BMI, CRP, WBC, and CURB-65, whereas model 2 included BMI, CRP, WBC, and PSI/PORT. Results were presented as regression coefficients (β), 95% confidence intervals, and p values; $p < 0.05$ was considered statistically significant.

3. Ethics approval

The study was approved by the Scientific Research Council and the Biomedical Research Ethics Committee of Can Tho University of Medicine and Pharmacy (No. 24.216.HV/PCT-HĐĐĐ) ngày 28/06/2024.

III. RESULTS

During the study period from May 2025 to January 2026, a total of 85 patients with community-acquired pneumonia who met the eligibility criteria were included in the final analysis. Selected general characteristics of the study population are presented in Table 1.

Table 1. Baseline characteristics of participants

Characteristics		n	%
Age	Median (IQR) [Min, Max]	73.0 (16.0) [25.0, 95.0]	
	Age < 65 years old	23	27.1
	Age ≥ 65 years old	62	72.9

Characteristics		n	%
Gender	Male	47	55.3
	Female	38	44.7
Comorbidities	COPD	11	12.9
	Sequelae of tuberculosis	6	7.1
	CKD	13	15.3
	Hypertension	47	55.3
	Diabetes	25	29.4
	Drug-induced Cushing syndrome	13	15.3
Body mass index	Median (IQR), [Max, Min]	21.7 (5.0) [14.8, 27.4]	
	Underweight	10	11.8
	Normal	47	55.3
	Overweight	18	21.2
	Obesity	10	11.8
CURB-65 classification	Class 1	16	16.8
	Class 2	54	63.5
	Class 3	15	17.6
PSI/PORT classification	Class I-II	11	12.9
	Class III	55	64.7
	Classs IV	14	16.5
	Classs V	5	5.9
Investigations	CRP (mg/L), Median (IQR)	68.2 (102.9)	
	WBC (G/L), Median (IQR)	9.35 (5.92)	
	NLR, Median (IQR)	6.3 (6.7)	

Table 1 shows that the median age of the patients was 73.0 years old, with most patients aged ≥65 years old (72.9%). The proportions of patients who were overweight and obese were 21.2% and 11.8%, respectively. Most patients were classified as CURB-65 group 2 (63.5%) and PSI/PORT group III (64.7%).

Table 2. Lung ultrasound characteristics in CAP patients

Characteristics		n	%
LUS signs n (%)	B-lines/Lung rocket	84	98.8
	Shred sign	50	58.8
	Tissue-like sign	5	5.8
	Air bronchogram	40	47.1
	Pleural effusion	15	17.6
	PLAPS	45	52.9
LUS patterns n (%)	Consolidation ± interstitial syndrome	55	64.7
	Interstitial syndrome	29	34,1
	Pleural effusion	15	17.6
LUS score of each region Median (IQR)	Left anterior	2.0 (2.0)	
	Right anterior	2.0 (2.0)	
	Left lateral	1.0 (2.0)	
	Right lateral	1.0 (2.0)	
	Left posterior	2.0 (2.0)	
	Right posterior	2.0 (3.0)	
Total LUS score, Median (IQR)		10.0 (10.0)	

The most frequently observed finding in patients with pneumonia was B-lines/lung rockets (98.8%), followed by consolidative lesions identified by the shred sign, which accounted for 58.8%, while 5.8% showed a tissue-like sign (5.8%). Pleural effusion was documented in 17.6% of cases. The prevalence of PLAPS was 52.9%. Regarding LUS patterns, consolidation with or without interstitial syndrome was the predominant pattern, accounting for 64.7%, and the median total lung ultrasound score was 10.0.

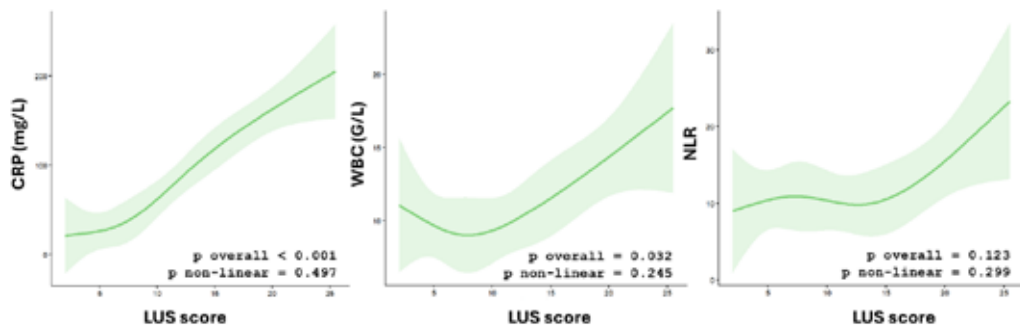

Figure 2. Restricted cubic spline curves showing the associations between LUS score and inflammatory markers

Figure 2 shows that CRP and WBC increased with increasing total lung ultrasound score, with statistically significant associations across the entire range of values (overall p < 0.001 and 0.032, respectively), and no evidence of a nonlinear relationship (p non-linearity > 0.05).

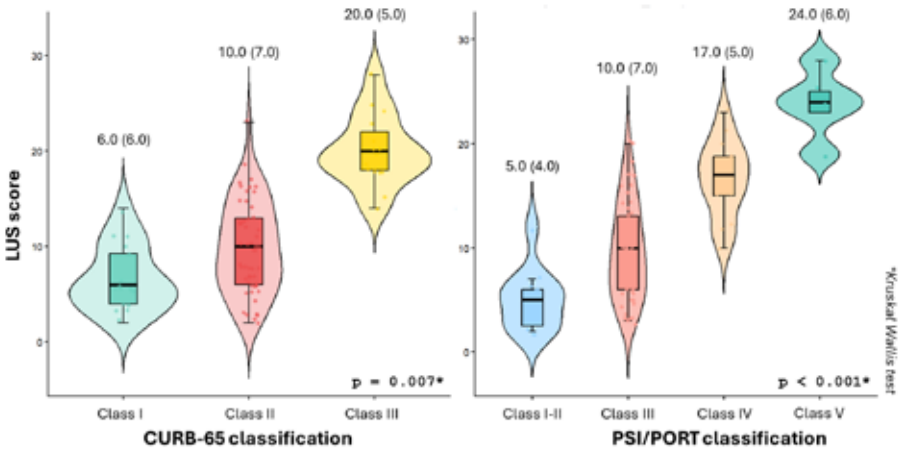

Figure 3. Distribution of LUS score according to CURB-65 and PSI/PORT severity classifications

Figure 3 shows that the total lung ultrasound score increased progressively with increasing pneumonia severity according to both the CURB-65 and PSI/PORT scoring systems (p < 0.05).

Table 3. Multivariable linear regression analysis of factors associated with LUS score

Model 1			Model 2		
Variables	**β (95% CI)**	**p**	**Variables**	**β (95% CI)**	**p**
BMI	-0.25 (-0.54. 0.04)	0.087	BMI	-0.02 (-0.33. 0.27)	0.858
CRP	0.03 (0.02. 0.05)	**<0.001**	CRP	0.03 (0.02. 0.04)	**<0.001**
WBC	0.03 (-0.13. 0.18)	0.719	WBC	-0.07 (-0.22. 0.08)	0.379
CURB-65			PSI/PORT		
Class 1	1 (Reference)	-	Class 0 – I	1 (Reference)	-
Class 2	3.12 (0.97. 5.26)	**0.005**	Class II	3.66 (1.16. 6.15)	**0.004**
Class 3	9.54 (6.57. 12.50)	**<0.001**	Class III	9.33 (6.13. 12.52)	**<0.001**
			Class IV	12.30 (7.26. 17.24)	**<0.001**

Table 3 shows that, in both multivariable linear regression models, CRP was positively and significantly associated with the total lung ultrasound score. In contrast, WBC was not significantly associated with the total lung ultrasound score after adjustment. Regarding pneumonia severity, stratification by either CURB-65 or PSI/PORT remained significantly associated with the total lung ultrasound score (p < 0.05).

IV. DISCUSSION

Our study showed that consolidation ± interstitial syndrome was the most common LUS pattern in patients with community-acquired pneumonia. More importantly, after adjustment for relevant factors, the total lung ultrasound score remained independently associated with the levels of inflammatory markers, particularly CRP, as well as with disease severity. These findings suggest that lung ultrasound not only reflects the characteristics of pulmonary parenchymal involvement at the time of examination but may also provide additional information regarding inflammatory burden and clinical severity in patients with community-acquired pneumonia.

With regard to lung ultrasound findings, our results were generally consistent with previous reports in that B-lines were the most frequently observed sign when each individual finding was considered separately.[8] However, when analyzed at the level of imaging combinations, lung consolidation with or without interstitial syndrome was more common than isolated interstitial syndrome. This finding is in agreement with the study by Tran Le et al. (2025), in which lung consolidation with or without interstitial syndrome was overwhelmingly predominant, accounting for 88.4%, whereas isolated interstitial syndrome represented only 11.6%.[9] These data suggest that, although B-lines are a very common manifestation in community-acquired pneumonia, the clinical interpretive value of lung ultrasound should not be limited to individual signs alone but should instead be considered within the broader context of combined pulmonary parenchymal abnormalities. This interpretation is further supported by the report of Sezgin et al. (2020), in which the authors proposed that even in the absence of consolidation, pneumonia may still be suggested on ultrasound when there are at least three B-lines or diffuse interstitial involvement.[8] In other words, B-lines and their combinations are not merely accompanying findings but may also serve a diagnostic role in certain pneumonia phenotypes. Recent studies have also shown that ultrasound imaging features may vary according to the underlying pathogen. For example, viral pneumonia is more commonly associated with interstitial syndrome and small subpleural consolidations, whereas bacterial pneumonia more often manifests as consolidation and pleural effusion, particularly in the posterior and basal lung regions.[10] Therefore, differences in causative pathogens may represent a plausible explanation for the heterogeneity across studies, in addition to differences in study populations, timing of assessment, and operator experience. In our study, microbial etiology was not analyzed in depth; therefore, the extent to which individual pathogens contributed to the observed ultrasound patterns could not be determined. Nevertheless, other conditions that may also produce B-lines, such as pulmonary edema or interstitial lung disease, were excluded from the study population. Therefore, the presence of B-lines in this cohort most likely reflected interstitial involvement related to pneumonia rather than confounding from other pulmonary or cardiovascular diseases, thereby increasing the reliability of our interpretation.

Our study found that the total lung ultrasound score was associated with the levels of inflammatory markers, particularly CRP, and that this association remained significant after adjustment for relevant factors. These findings suggest that the extent of abnormalities detected on lung ultrasound not only reflects morphological changes within the pulmonary

parenchyma but also, to some extent, parallels the intensity of the systemic inflammatory response in patients with community-acquired pneumonia. This interpretation is consistent with the study by Fu et al. (2023), in which the LUS score increased progressively with pneumonia severity and was simultaneously associated with several serum inflammatory indices, including interleukin-6, interleukin-10, TNF-α, CRP, and NLR.[4] From this perspective, some recent trials, such as PLUS-IS-LESS, have even proposed the use of lung ultrasound as an adjunctive marker to help guide antibiotic therapy in patients with community-acquired pneumonia, in combination with biomarkers such as procalcitonin.[11] However, the currently available evidence remains not entirely consistent. For example, the trial by Lhopitallier et al. (2021) showed that LUS has value as an adjunctive tool in patient assessment, but did not demonstrate that lung ultrasound could replace inflammatory biomarkers in clinical practice.[12] This suggests that LUS should more likely be regarded as a complementary component within a comprehensive assessment model, rather than as a standalone tool capable of fully replacing laboratory biomarkers. In other words, the principal value of lung ultrasound may lie in its ability to provide an immediate bedside imaging marker that reflects the burden of pulmonary involvement, whereas inflammatory markers continue to play an important role in evaluating systemic inflammatory activity and supporting therapeutic decision-making.

In addition, our analysis showed that the total lung ultrasound score was associated with commonly used severity assessment tools, including CURB-65 and PSI/PORT. This finding is consistent with the study by Rennis et al. (2017), in which the lung ultrasound score correlated with the PSI.[5] This suggests that the extent and severity of abnormalities detected on lung ultrasound tend to parallel the clinical severity of community-acquired pneumonia. Notably, some recent studies have even shown that lung ultrasound may outperform traditional scoring systems such as CURB-65 in prognostication and risk stratification, indicating that lung ultrasound is not only complementary but, in certain contexts, may also compete with conventional tools in the assessment of disease severity.[3] Furthermore, our results also showed that the total lung ultrasound score was associated with inflammatory markers. This finding is important because it indicates that the lung ultrasound score not only reflects the morphological burden of pulmonary involvement but also, to some extent, mirrors the degree of systemic inflammatory activation. In other words, when the total lung ultrasound score increases, this may correspond to more extensive pulmonary parenchymal involvement, a more intense inflammatory response, and a more severe clinical presentation. This interpretation is further supported by the fact that patients with pulmonary tuberculosis were excluded from the study; therefore, the parallel relationship among the burden of pulmonary lesions, inflammatory markers, and clinical severity more likely reflects the pathophysiological characteristics of acute pneumonia rather than being influenced by other chronic infectious lung diseases. This is consistent with the pathogenesis of acute pneumonia, in which more extensive pulmonary parenchymal involvement is generally accompanied by a stronger local and systemic inflammatory response.[13] In contrast, in pulmonary tuberculosis, the relationship between imaging burden and clinical manifestations or inflammatory markers is not always concordant, particularly in subclinical tuberculosis, in which patients may have relatively evident imaging abnormalities despite

minimal symptoms and a less prominent systemic inflammatory response.[14] From a practical perspective, these findings reinforce the value of lung ultrasound as a bedside tool that can simultaneously support the identification of pulmonary lesions, estimation of inflammatory burden, and contribution to risk stratification in patients with community-acquired pneumonia.

To our knowledge, this is the first study in Can Tho to apply lung ultrasound for the assessment of pulmonary involvement in patients with lower respiratory tract infection in general and community-acquired pneumonia in particular. One notable strength of the study lies in the relatively rigorous participant selection process, which improve the homogeneity of the study population. In addition, lung ultrasound was performed according to a standardized assessment protocol before the incorporation of biological test results into the analysis, thereby reduce information bias and allowing a more objective evaluation of the associations between ultrasound findings, inflammatory burden, and disease severity. Furthermore, conditions that could interfere with the interpretation of lung ultrasound findings, particularly those capable of generating B-lines, such as pulmonary edema or interstitial lung disease, were excluded from the study. This facilitated the attribution of the recorded ultrasound abnormalities, especially interstitial syndrome, to the acute pneumonic process rather than to underlying comorbid conditions. Nevertheless, several important limitations should be considered when interpreting the findings. First, convenience sampling was used; therefore, the possibility of selection bias cannot be completely excluded. In addition, the sample size was relatively small, with only 85 patients, and the study was conducted at a single center; accordingly, the generalizability of the findings to other populations remains limited. Second, all ultrasound examinations were performed by a single operator, and thus the study was unable to assess inter-operator reproducibility or inter-observer agreement. Third, the study did not include a systematic comparison with a reference imaging standard, particularly chest computed tomography. Therefore, some cases with pulmonary lesions may have been missed, especially deep lesions or lesions located in the apical regions, which are known to be less well assessed by lung ultrasound. Finally, given its analytical cross-sectional design, the study primarily reflects associations at a single time point and therefore does not provide a sufficient basis for causal inference or for evaluating prognostic value over time.

V. CONCLUSION

In patients with community-acquired pneumonia, consolidation, with or without interstitial syndrome, represents the most common pattern of lung ultrasound abnormalities. Lung ultrasound not only has value in detecting pulmonary parenchymal lesions but also shows potential in supporting the assessment of inflammatory burden, severity stratification, and the guidance of follow-up and prognostication in patients with community-acquired pneumonia in clinical practice.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest related to this study.

REFERENCES

1. Global Burden of Disease. Global burden of 292 causes of death in 204 countries and territories and 660 subnational locations, 1990-2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet*. Oct 18 2025; 406(10513): 1811-1872. doi:10.1016/s0140-6736(25)01917-8.

2. Jones BE, Ramirez JA, Oren E, et al. Diagnosis and Management of Community-acquired Pneumonia: An Official American Thoracic Society Clinical Practice Guideline. *Am J Respir Crit Care Med*. Jan 1 2026; 212(1): 24-44. doi:10.1164/rccm.202507-1692ST.

3. Shao L, Liang Y. Predictive value of bedside lung ultrasound, quantitative chest CT, and frailty assessment for short-term outcomes in elderly patients with severe pneumonia: a pilot study. *BMC Pulm Med*. Oct 15 2025; 25(1): 474. doi:10.1186/s12890-025-03950-0.

4. Fu B, Zhang P, Zhang J. Diagnosis and Prognosis Evaluation of Severe Pneumonia by Lung Ultrasound Score Combined with Serum Inflammatory Markers. *Mediterr J Hematol Infect Dis*. 2023; 15(1): e2023057. doi:10.4084/mjhid.2023.057.

5. Rennis KD, Anaz M, Krishnakumar EV, et al. Role of chest ultrasonography in the prognostic evaluation of patients with community acquired pneumonia: a prospective study. *Int J Res Med Sci*. 2017; 5: 25-30. doi:10.18203/2320-6012.ijrms20164510.

6. Hội hô hấp Việt Nam. *Hướng dẫn Chẩn đoán và Điều trị viêm phổi mắc phải cộng đồng ở người lớn (Bản cập nhật năm 2025)*. Nhà Xuất bản Y học; 2025.

7. Rouby JJ, Arbelot C, Gao Y, et al. Training for Lung Ultrasound Score Measurement in Critically Ill Patients. *Am J Respir Crit Care Med*. Aug 1 2018; 198(3): 398-401. doi:10.1164/rccm.201802-0227LE.

8. Sezgin C, Gunalp M, Genc S, et al. Diagnostic Value of Bedside Lung Ultrasonography in Pneumonia. *Ultrasound Med Biol*. May 2020;46(5): 1189-1196. doi:10.1016/j.ultrasmedbio.2020.01.014.

9. Tran-Le QK, Thai TT, Tran-Ngoc N, et al. Lung ultrasound for the diagnosis and monitoring of pneumonia in a tuberculosis-endemic setting: a prospective study. *BMJ Open*. Apr 7 2025; 15(4): e094799. doi:10.1136/bmjopen-2024-094799.

10. Pelagatti L, Vannini I, Mangani F, et al. Lung ultrasound for etiological diagnosis of pneumonia in the emergency department: correlation with bronchoalveolar lavage results. *Ultrasound J*. Nov 27 2025; 17(1): 63. doi:10.1186/s13089-025-00470-0.

11. Bessat C, Bingisser R, Schwendinger M, et al. PLUS-IS-LESS project: Procalcitonin and Lung UltraSonography-based antibiotherapy in patients with Lower rESpiratory tract infection in Swiss Emergency Departments: study protocol for a pragmatic stepped-wedge cluster-randomized trial. *Trials*. Jan 25 2024; 25(1): 86. doi:10.1186/s13063-023-07795-y.

12. Lhopitallier L, Kronenberg A, Meuwly JY, et al. Procalcitonin and lung ultrasonography point-of-care testing to determine antibiotic prescription in patients with lower respiratory tract infection in primary care: pragmatic cluster randomised trial. *Bmj*. Sep 21 2021; 374: n2132. doi:10.1136/bmj.n2132.

13. Tamayose M, Fujita J, Parrott G, et al. Correlations between extent of X-ray infiltration and levels of serum C-reactive protein in adult non-severe community-acquired pneumonia. *J Infect Chemother*. Jun 2015; 21(6): 456-63. doi:10.1016/j.jiac.2015.02.009.

14. Min J, Chung C, Jung SS, et al. Clinical profiles of subclinical disease among pulmonary tuberculosis patients: a prospective cohort study in South Korea. *BMC Pulm Med*. Dec 2 2020; 20(1): 316. doi:10.1186/s12890-020-01351-z.