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Lung Ultrasound B-lines and 30-Day Mortality in Older Adults Hospitalized With Heart Failure: A Prospective Cohort Study

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Abstract

Background

Lung ultrasound enables bedside assessment of pulmonary congestion through B-line quantification. However, evidence regarding the association between B-line burden and short-term mortality specifically in older adults hospitalized with heart failure remains limited.

Objective

To evaluate the association between the presence of six or more B-lines on lung ultrasound and 30-day all-cause mortality in older adults hospitalized with heart failure.

Methods

An observational, analytical, prospective cohort study was conducted at a secondary-care hospital in Torreón, Mexico. A total of 130 older adults hospitalized with heart failure underwent bedside lung ultrasound using an eight-zone protocol. Patients were classified according to the presence of <6 or ⩾6 B-lines and followed for 30 days. Demographic and clinical characteristics were compared between groups, and the association with mortality was estimated using the unadjusted relative risk (RR) with a 95% confidence interval (CI). An exploratory sensitivity analysis was performed using modified Poisson regression with robust standard errors, adjusting for age, sex, and chronic kidney disease.

Results

Of the 130 participants, 74 (56.9%) had ⩾6 B-lines and 56 (43.1%) had <6 B-lines. Overall, 28 patients (21.5%) died within 30 days. Mortality occurred in 24/74 (32.4%) patients with ⩾6 B-lines compared with 4/56 (7.1%) patients with <6 B-lines ($\chi^2 = 12.06$; $p < 0.001$), corresponding to an unadjusted RR of 4.54 (95% CI: 1.67-12.34). In the exploratory analysis of 127 patients, the association persisted after adjustment for age, sex, and chronic kidney disease (adjusted RR = 4.20; 95% CI: 1.54-11.42; p = 0.005). B-type natriuretic peptide (BNP) concentrations were higher in the ⩾6 B-line group than in the <6 B-line group (median (q25-q75): 8815 (3000-35000) versus 297 (122-533.75) pg/mL; n = 37 and n = 50, respectively; U = 132.5; $p < 0.001$). Chronic kidney disease was also more frequent in the ⩾6 B-line group (18/73 (24.7%) vs. 2/54 (3.7%); $\chi^2 = 10.27$; p = 0.001).

Conclusions

The presence of ⩾6 B-lines on lung ultrasound was associated with higher 30-day all-cause mortality among older adults hospitalized with heart failure. This association persisted after exploratory adjustment for age, sex, and chronic kidney disease. These findings suggest that B-line quantification may provide complementary information for short-term risk assessment, although larger studies with more comprehensive adjustment are needed to establish its independent prognostic value.

Categories: Geriatrics
Keywords: b-lines, heart failure, lung ultrasound, mortality, older adults, pulmonary congestion

Introduction

Heart failure is a major cause of hospitalization and mortality among older adults. Pulmonary congestion is a frequent manifestation of cardiac decompensation, and its identification is essential for clinical assessment and risk stratification. However, conventional physical examination may not adequately reflect the extent of pulmonary fluid accumulation. Lung ultrasound has emerged as a rapid, noninvasive bedside tool for assessing pulmonary congestion through the detection of B-lines, vertical ultrasound artifacts

associated with increased extravascular lung water. Their quantification provides an objective measure of pulmonary congestion that may complement conventional clinical evaluation [1].

Beyond its diagnostic applications, lung ultrasound has demonstrated potential prognostic value in patients with heart failure. In a pooled analysis of international cohorts, Rastogi et al. found that higher B-line counts were associated with an increased risk of heart failure hospitalization or all-cause mortality across different clinical settings, including hospital admission, discharge, and outpatient follow-up. These findings support the relevance of pulmonary congestion detected by ultrasound as a marker of adverse clinical outcomes [2].

The prognostic significance of specific B-line thresholds has also been investigated. Imanishi et al., in a prospective study involving 116 patients hospitalized with acute heart failure, used an eight-zone lung ultrasound protocol and identified the presence of six or more B-lines (⩾6) at hospital discharge as a threshold associated with residual pulmonary congestion and an increased risk of subsequent cardiac events. Nevertheless, evidence regarding the association between this threshold and short-term all-cause mortality specifically in older hospitalized patients remains limited [3].

Therefore, this study aimed to evaluate the association between the presence of ⩾6 B-lines on lung ultrasound and 30-day all-cause mortality in older adults hospitalized with heart failure at a secondary-care hospital in Mexico. The manuscript was prepared following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies, as recommended by the EQUATOR (Enhancing the QUAlity and Transparency Of health Research) Network [4].

Materials And Methods

Study design and population

An observational, analytical, prospective cohort study was conducted in the Geriatrics Department of the General Hospital of Zone with Family Medicine No. 16 of the Mexican Social Security Institute (IMSS), in Torreón, Coahuila, Mexico. The study included 130 older adults hospitalized with heart failure who were selected through consecutive nonprobability sampling. Given the exploratory nature of the study, the sample size was determined by feasibility without a formal confirmatory sample size calculation.

Eligible participants were adults aged 65 years or older with a diagnosis of heart failure who were hospitalized in the Geriatrics Department and provided written informed consent. Patients with a concomitant infection at the time of evaluation were excluded. Participants who withdrew consent or could not complete the lung ultrasound examination were excluded from the analysis. Eligible patients were enrolled immediately after providing written informed consent.

Clinical and ultrasound assessment

Following hospital admission, lung ultrasound and laboratory examinations were performed as part of the initial clinical assessment, before treatment initiation. Demographic and clinical information was collected at enrollment, including age, sex, medical history, comorbidities, and B-type natriuretic peptide (BNP) concentrations when available. The comorbidities assessed included hypertension, diabetes mellitus, chronic kidney disease, chronic obstructive pulmonary disease, and asthma.

Lung ultrasound was performed at the bedside by a pulmonology specialist using a portable Kosmos ultrasound system equipped with a Torso-One phased-array transducer (EchoNous, Inc., Redmond, WA, USA), running software version 5.1.2. Patients were examined in a supine or semirecumbent position according to respiratory tolerance. An eight-zone scanning protocol was applied, including upper and lower anterior zones and upper and lower lateral zones in each hemithorax. Anterior regions extended from the sternum to the anterior axillary line, while lateral regions extended from the anterior to the posterior axillary line.

B-lines were identified as vertical hyperechoic artifacts originating from the pleural line, extending to the bottom of the ultrasound image, and moving synchronously with respiration. Individual B-lines were counted separately in each examined zone. When B-lines were confluent, their number was estimated by dividing the percentage of the image below the pleural line occupied by these artifacts by 10, with a maximum of 10 B-lines per zone. The highest B-line count within each zone was recorded, and the values were summed across all eight zones to obtain the total B-line count, following standardized recommendations [1]. No operator blinding was implemented.

Patients were classified into two groups according to the total B-line count: those with fewer than six B-lines (<6) and those with six or more B-lines (⩾6). This threshold was supported by previous research evaluating pulmonary congestion and clinical outcomes in patients with heart failure [3].

Outcome assessment

The primary outcome was all-cause mortality within 30 days after enrollment. Vital status was assessed through outpatient follow-up visits. For patients who did not attend their scheduled appointments, vital status was verified by telephone contact. Follow-up was conducted by the principal investigator, a geriatrics resident. Mortality was recorded as a dichotomous outcome and compared between patients with <6 and ⩾6 B-lines.

Statistical analysis

Categorical variables were summarized as absolute frequencies and percentages. Continuous variables were expressed as mean and standard deviation or median (q25-q75), according to their distribution. Normality was assessed using the Shapiro-Wilk test. Comparisons between patients with <6 and ⩾6 B-lines were performed using Student's t-test for independent samples or the Mann-Whitney U test, as appropriate. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test, according to expected cell frequencies.

The association between ⩾6 B-lines and 30-day mortality was assessed by calculating the unadjusted relative risk (RR) with its 95% confidence interval (CI). Clinical characteristics and comorbidities were compared between groups to describe baseline differences and identify potential sources of confounding. All statistical tests were two-sided, with statistical significance established at $p < 0.05$. Analyses were performed using available observations for each variable, accounting for missing data through variable-specific denominators. As an exploratory sensitivity analysis, modified Poisson regression with robust standard errors was used to estimate the relative risk after adjustment for age, sex, and chronic kidney disease. This analysis included participants with complete data for the selected variables.

Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki and applicable Mexican regulations governing research involving human participants. The research protocol was registered with the Mexican Social Security Institute under number R-2025-502-050 and underwent institutional scientific and ethical review. The study was classified as minimal risk because it involved noninvasive diagnostic procedures and clinical data collection. Written informed consent was obtained from all participants before enrollment. Patient information was coded and handled confidentially, and participation was voluntary without affecting medical care.

Results

A total of 130 older adults hospitalized with heart failure were included, of whom 56 (43.1%) had <6 B-lines and 74 (56.9%) had ⩾6 B-lines. The median age was 72.5 (70-78) years and 75 (70-79) years, respectively ($p = 0.057$). Women represented 51.8% and 66.2% of the groups, without a statistically significant difference ($p = 0.096$).

Hypertension and diabetes mellitus were the most frequent comorbidities. Chronic kidney disease was more prevalent among patients with ⩾6 B-lines than among those with <6 B-lines (24.7% vs. 3.7%; $p = 0.001$). No statistically significant differences were observed in the remaining evaluated comorbidities (Table *1*).

Characteristic	<6 B-lines (n = 56)	≥6 B-lines (n = 74)	Test statistic	p-value
Age, years, median (q25-q75)	72.5 (70-78)	75 (70-79)	U = 1677.0	0.057
Female sex, n/N (%)	29/56 (51.8)	49/74 (66.2)	χ^2 = 2.766	0.096
Male sex, n/N (%)	27/56 (48.2)	25/74 (33.8)	—	—
Hypertension, n/N (%)	38/54 (70.4)	59/73 (80.8)	χ^2 = 1.879	0.170
Diabetes mellitus, n/N (%)	31/54 (57.4)	32/73 (43.8)	χ^2 = 2.287	0.130
Chronic kidney disease, n/N (%)	2/54 (3.7)	18/73 (24.7)	χ^2 = 10.271	0.001
Chronic obstructive pulmonary disease, n/N (%)	1/54 (1.9)	7/73 (9.6)	Fisher's exact test	0.137
Asthma, n/N (%)	0/54 (0.0)	0/73 (0.0)	—	—
BNP, pg/mL, median (q25-q75)	297 (122-533.75); n = 50	8815 (3000-35000); n = 37	U = 132.5	<0.001

TABLE 1: Demographic and clinical characteristics of the study population.

Values are presented as n/N (%) or median (q25-q75). Percentages were calculated using the number of available observations for each variable. Demographic information was available for all 130 participants, comorbidity information for 127 participants, and BNP measurements for 87 participants. Continuous variables were compared using the Mann-Whitney U test. Categorical variables were compared using Pearson's chi-square test (df = 1) or Fisher's exact test, as appropriate. All p-values are two-sided.

BNP: B-type natriuretic peptide.

B-type natriuretic peptide concentrations

BNP concentrations were significantly higher among patients with ⩾6 B-lines, with a median of 8815 (3000-35000) pg/mL compared with 297 (122-533.75) pg/mL among those with <6 B-lines ($p < 0.001$). BNP measurements were available for 87 patients (66.9% of the study population). The distribution showed considerable variability, particularly among patients with ⩾6 B-lines (Figure *1*).

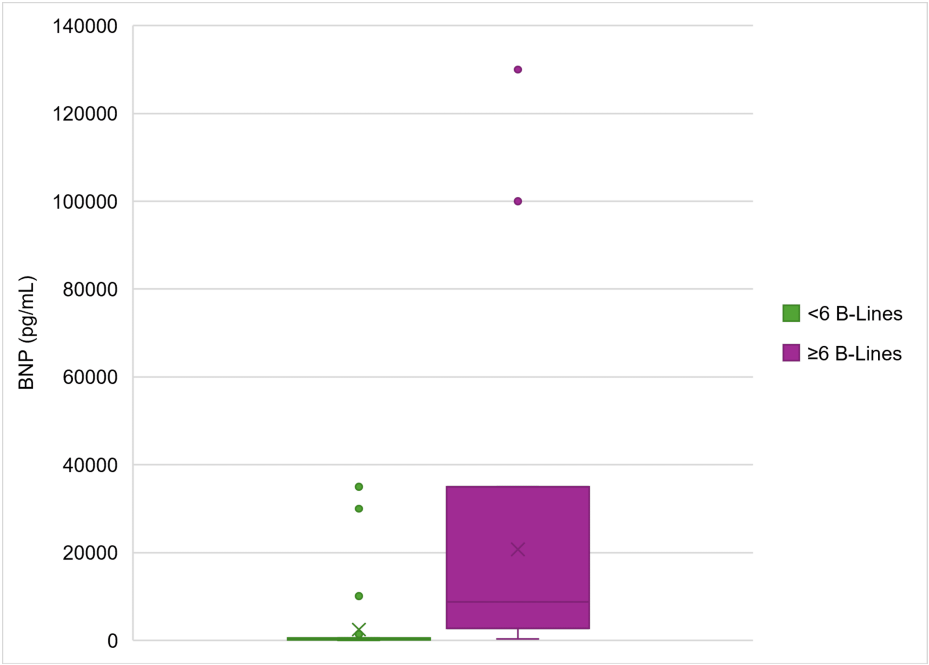


FIGURE 1: Distribution of B-type natriuretic peptide concentrations according to lung ultrasound B-line groups.

Boxes represent the interquartile range (q25-q75), horizontal lines indicate medians, and individual points represent outliers.

BNP: B-type natriuretic peptide.

Association between B-lines and 30-day mortality

During the 30-day follow-up, 28 patients (21.5%) died. Mortality occurred in 24 (32.4%) patients with ⩾6 B-lines compared with four (7.1%) patients with <6 B-lines. The presence of ⩾6 B-lines was associated with a higher risk of 30-day all-cause mortality (unadjusted RR = 4.54; 95% CI: 1.67-12.34; p < 0.001) (Table *2*). In an exploratory sensitivity analysis, including 127 patients with complete covariate data, the association persisted after adjustment for age, sex, and chronic kidney disease (adjusted RR = 4.20; 95% CI: 1.54-11.42; p = 0.005), with minimal change from the unadjusted estimate in the same subset (RR = 4.25).

Outcome	<6 B-lines (n = 56)	≥6 B-lines (n = 74)	RR (95% CI)	p-value
Survival at 30 days, n (%)	52 (92.9)	50 (67.6)	-	-
Death within 30 days, n (%)	4 (7.1)	24 (32.4)	4.54 (1.67-12.34)	<0.001

TABLE 2: Association between ≥6 B-lines and 30-day all-cause mortality.

The unadjusted RR represents the risk of 30-day mortality among patients with ≥6 B-lines compared with those with <6 B-lines. The p-value was calculated using Pearson's chi-square test.

RR: relative risk; CI: confidence interval.

Discussion

The principal finding of this study was the association between the presence of ⩾6 B-lines on lung ultrasound and increased 30-day all-cause mortality among older adults hospitalized with heart failure. Mortality was 32.4% in patients with ⩾6 B-lines compared with 7.1% in those with <6 B-lines, corresponding to an unadjusted relative risk of 4.54 (95% CI: 1.67-12.34; p < 0.001). These findings are consistent with those reported by Platz et al., who evaluated 349 patients hospitalized with acute heart failure and observed that the risk of adverse in-hospital events increased with higher B-line counts (OR = 1.82 per B-line tertile; 95% CI: 1.14-2.88). Furthermore, among patients assessed at discharge, a greater B-line burden was

associated with an increased risk of heart failure hospitalization or all-cause mortality at 60 days (HR = 3.30; 95% CI: 1.52-7.17). Although their study used a four-zone ultrasound protocol and different clinical outcomes, both investigations identified higher pulmonary congestion as a marker of adverse prognosis [5].

The relevance of the ⩾6 B-line threshold is supported by Imanishi et al., who conducted a prospective study involving 116 patients hospitalized with acute heart failure. Using an eight-zone ultrasound protocol, they identified ⩾6 B-lines at discharge as an indicator of residual pulmonary congestion and reported a greater risk of subsequent cardiac events (HR = 12.6; 95% CI: 4.71-33.7). Although their assessment was performed near discharge and outcomes were evaluated over one year, these findings support the clinical relevance of this threshold. Our results extend the investigation of this cutoff to 30-day all-cause mortality in older hospitalized patients, without establishing its independent prognostic performance [3].

The association observed in our cohort also agrees with the systematic review and meta-analysis by Suhardi et al., which included 15 studies evaluating residual pulmonary congestion in patients hospitalized with acute heart failure. The authors reported that persistent B-lines at discharge were associated with all-cause mortality (HR = 3.01; 95% CI: 1.91-4.73) and a combined outcome of mortality and heart failure rehospitalization (HR = 2.32; 95% CI: 1.91-2.82). Their findings reinforce the prognostic relevance of ultrasound-detected pulmonary congestion, although differences in the timing of assessment, B-line thresholds, and follow-up periods limit direct comparisons with our results [6].

BNP concentrations were significantly higher in patients with ⩾6 B-lines than in those with <6 B-lines (median 8815 vs. 297 pg/mL; $p < 0.001$). This finding is clinically consistent with the relationship between increased cardiac filling pressures, neurohormonal activation, and pulmonary congestion. Bajraktari et al. reported that persistently elevated BNP concentrations and the presence of ⩾15 B-lines were associated with adverse outcomes in ambulatory patients with heart failure. Although their study involved a different clinical setting and longer follow-up, the findings support the complementary information provided by biochemical and ultrasound markers of congestion. Nevertheless, BNP measurements were available for only 87 participants in our study, with greater missingness in the ⩾6 B-line group, which limits interpretation of the observed difference [7].

Chronic kidney disease was more frequent among patients with ⩾6 B-lines than among those with <6 B-lines (24.7% vs. 3.7%; $p = 0.001$). This difference is relevant because renal dysfunction may contribute to fluid retention and influence both pulmonary congestion and clinical outcomes. Alsaeed et al., in a study of 342 patients with chronic heart failure, observed that impaired renal function was associated with a greater prevalence of clinical congestion, although its relationship with individual ultrasound measurements was less consistent. They also found that combined clinical and ultrasound evidence of congestion was associated with higher natriuretic peptide concentrations and an increased risk of hospitalization or death [8]. In our cohort, the unequal distribution of chronic kidney disease represented a potential source of confounding; however, the association between ⩾6 B-lines and mortality persisted after adjustment for chronic kidney disease, age, and sex.

Several limitations should be considered when interpreting these findings. The study was conducted at a single center with a feasibility-based sample, which may limit generalizability. The exploratory adjusted analysis showed that the association between ⩾6 B-lines and 30-day mortality persisted after accounting for age, sex, and chronic kidney disease, with minimal change in the risk estimate. Nevertheless, the limited number of deaths and the inclusion of only three covariates in the adjusted model do not exclude residual confounding or establish independent prognostic value beyond other relevant clinical factors. Additionally, incomplete BNP measurements limited biochemical comparisons, while the lack of serial ultrasound assessments prevented evaluation of changes in pulmonary congestion during hospitalization. B-lines are not specific to cardiogenic pulmonary edema and may also occur in other pulmonary conditions. Nevertheless, the prospective design, bedside ultrasound examinations performed by a pulmonology specialist using a standardized eight-zone protocol, and assessment of a clinically relevant 30-day outcome constitute important strengths. These findings provide evidence from an older hospitalized population in Mexico and support further investigation of lung ultrasound as a complementary tool for short-term risk assessment in heart failure.

Conclusions

The presence of ⩾6 B-lines on lung ultrasound was associated with higher 30-day all-cause mortality among older adults hospitalized with heart failure, with an approximately 4.5-fold higher unadjusted risk compared with patients with <6 B-lines. This association persisted after exploratory adjustment for age, sex, and chronic kidney disease. Higher B-line counts were also associated with elevated BNP concentrations and a greater prevalence of chronic kidney disease. These findings suggest that bedside lung ultrasound may provide complementary information for short-term risk assessment in this population. Further studies with larger samples and more comprehensive adjustment are needed to determine the independent prognostic value of this ultrasound threshold.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Research Ethics Committee No. 5028 of the Mexican Social Security Institute issued approval R-2025-502-050. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Gargani L, Girerd N, Platz E, et al.: Lung ultrasound in acute and chronic heart failure: a clinical consensus statement of the European Association of Cardiovascular Imaging (EACVI). Eur Heart J Cardiovasc Imaging. 2023, 24:1569-82. 10.1093/ehjci/jead169
2. Rastogi T, Gargani L, Pellicori P, et al.: Prognostic implication of lung ultrasound in heart failure: a pooled analysis of international cohorts. Eur Heart J Cardiovasc Imaging. 2024, 25:1216-25. 10.1093/ehjci/jeae099
3. Imanishi J, Maeda T, Ujiro S, et al.: Association between B-lines on lung ultrasound, invasive haemodynamics, and prognosis in acute heart failure patients. Eur Heart J Acute Cardiovasc Care. 2023, 12:115-23. 10.1093/ehjacc/zuac158
4. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP: The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Intern Med. 2007, 147:573-7. 10.7326/0003-4819-147-8-200710160-00010
5. Platz E, Campbell RT, Claggett B, et al.: Lung ultrasound in acute heart failure: prevalence of pulmonary congestion and short- and long-term outcomes. JACC Heart Fail. 2019, 7:849-58. 10.1016/j.jchf.2019.07.008
6. Suhardi KF, Prasetyo A, Malik R, Pauliana, Viazelda AT: Quantification of residual pulmonary congestion defined by B-line findings on lung ultrasound to predict cardiovascular events in acute heart failure: a systematic review and meta analysis. Indian Heart J. 2025, 77:258-66. 10.1016/j.ihj.2025.05.003
7. Bajraktari G, Pugliese NR, D'Agostino A, et al.: Echo- and B-type natriuretic peptide-guided follow-up versus symptom-guided follow-up: comparison of the outcome in ambulatory heart failure patients. Cardiol Res Pract. 2018, 2018:3139861. 10.1155/2018/3139861
8. Alsaeed A, Khin HH, Caiazzo E, et al.: Congestion and renal function in patients with chronic heart failure . ESC Heart Fail. 2026, 13:xvag126. 10.1093/eschf/xvag126