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Lung Ultrasound Predictive Value in Patients with Acute Heart Failure

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Abstract

Acute heart failure (AHF) is a leading cause of hospitalization globally and is associated with high rates of early readmission and mortality [1]. Pulmonary congestion due to elevated cardiac filling pressures is a hallmark of AHF [2,6], and its timely assessment is critical for guiding therapy and improving outcomes.

Traditional tools such as physical examination and chest radiography often fall short in detecting pulmonary congestion early and accurately [2,7]. Lung ultrasound (LUS), particularly through the identification of B-lines—vertical reverberation artifacts indicating extravascular lung water—has emerged as a rapid, non-invasive, and reliable alternative [3,8].

While the diagnostic role of LUS in heart failure (HF) is well established [1,3,8], its prognostic utility, especially in the early phase of AHF, remains underexplored. This study aimed to evaluate whether early B-line assessment using LUS can predict short- and long-term outcomes in patients with acute HF.

Introduction

Acute heart failure (AHF) is a leading cause of hospitalization globally and is associated with high rates of early readmission and mortality [1]. Pulmonary congestion due to elevated cardiac filling pressures is a hallmark of AHF [2,6], and its timely assessment is critical for guiding therapy and improving outcomes.

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Methods

Study Design and Population: This prospective observational study enrolled 194 consecutive adult patients admitted with a diagnosis of acute HF [Table 1].

Inclusion and Exclusion Criteria: Patients aged ≥18 years with confirmed AHF (either de novo or decompensated chronic HF) were included if they underwent LUS within 6 hours of admission. Patients with significant

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Table 1: Baseline Characteristics.

Characteristic	Group 1 (<20 B-lines)	Group 2 (≥20 B-lines)	p-value
Age (years)	67.5 ± 12.6	66.4 ± 11.7	0.53
Hypertension (%)	62.2%	67.7%	0.42
Diabetes Mellitus (%)	30.6%	29.2%	0.83
Prior MI (%)	71.4%	71.9%	0.94
LVEF (%)	27.3 ± 5.2	26.8 ± 6.4	0.55
Atrial Fibrillation (%)	37.8%	36.5%	0.85
NT-proBNP (pg/mL)	3572.6 ± 672.6	3754.3 ± 853.6	0.10

chronic obstructive pulmonary disease (COPD), interstitial lung disease, or conditions impeding LUS imaging were excluded.

Lung Ultrasound Protocol: LUS was performed using a portable ultrasound machine with a convex or phased-array probe. An 8-zone scanning protocol was utilized, assessing anterior and lateral chest regions bilaterally. The total B-line count across all zones was recorded [3,4,8].

Patients were categorized into:
- Group 1: <20 B-lines
- Group 2: ≥20 B-lines

Clinical and Laboratory Data: Collected data included demographics, comorbidities (e.g., hypertension [AH], diabetes mellitus [DM], prior myocardial infarction [PMI]), left ventricular ejection fraction (LVEF), and presence of atrial fibrillation (AF). NT-proBNP levels were measured at admission and at 12-month follow-up using standardized immunoassays [6].

Outcomes

Primary Outcome:
- Change in NT-proBNP from baseline to 12 months

Secondary Outcomes:

- In-hospital mortality
- Requirement for endotracheal intubation

Statistical Analysis: Statistical analysis was conducted using SPSS v26.0. Categorical variables were compared using chi-square tests; continuous variables were analyzed with independent t-tests. A p-value <0.05 was considered statistically significant.

Results

Baseline Characteristics [Table 1]: Baseline demographics and comorbidities were comparable between groups. There was no significant difference in initial NT-proBNP levels (p = 0.10).

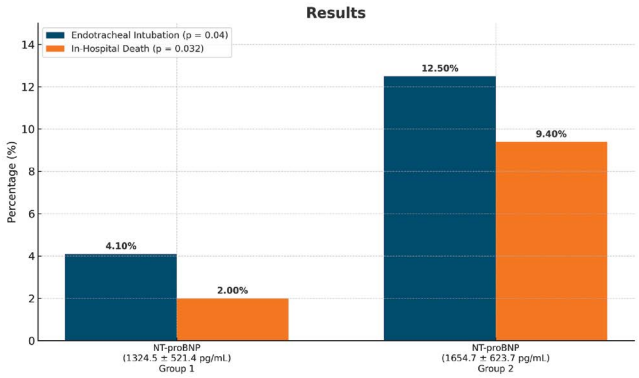
NT-proBNP at 12 Months: At 12 months, NT-proBNP levels were significantly lower in Group 1:

- Group 1: 1324.5 ± 521.4 pg/mL
- Group 2: 1654.7 ± 623.7 pg/mL
- p = 0.0004

In-Hospital Outcomes: - In-hospital mortality:

- Group 1: 2%
- Group 2: 9.4%
- p = 0.032

- Endotracheal intubation:
- Group 1: 4.1%
- Group 2: 12.5%
- p = 0.04



Discussion

This study demonstrates that early quantification of B-lines via LUS is a powerful predictor of adverse clinical outcomes in AHF. Patients presenting with ≥20 B-lines had significantly higher rates of in-hospital mortality, need for intubation, and persistently elevated NT-proBNP at one year.

These findings support earlier studies in stable HF populations that confirmed the prognostic value of LUS [1,4,9]. In the acute setting, B-line quantification can assist clinicians in identifying high-risk patients who may benefit from intensified decongestive therapy or closer monitoring [3,5].

B-lines reflect extravascular lung water and correlate closely with pulmonary capillary wedge pressure and natriuretic peptides [6,9], making LUS a physiologically relevant, bedside-available tool for real-time patient assessment [8,10].

Limitations

This single-center study may limit external generalizability. Although sonographers followed a standardized scanning protocol, inter-operator variability cannot be excluded. Additionally, echocardiographic parameters such as E/e' were not included to further validate pulmonary congestion.

Conclusion

Lung ultrasound, particularly B-line assessment, is a valuable tool for early risk stratification in AHF. A B-line

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count ≥20 on admission is associated with increased in-hospital mortality, higher need for mechanical ventilation, and less favorable biomarker trajectory at 12 months. Integrating LUS into early evaluation protocols may enhance outcome prediction and clinical decision-making in AHF management.

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