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Prehospital lung ultrasound for acute dyspnoea: a narrative mini-review of diagnostic accuracy, feasibility, and B-line-focused training

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Key words: dyspnoea; emergency medical services; lung ultrasound; point-of-care ultrasonography; prehospital care.

Abstract

Lung Ultrasound (LUS) is increasingly used in prehospital emergency care for acute respiratory distress. By identifying artefacts such as B-lines, clinicians can rapidly differentiate “dry” from “wet” lung patterns to guide early treatment, although adoption in the field remains uneven. We conducted a narrative literature review to assess the usefulness of LUS for prehospital evaluation of respiratory distress. A secondary aim was to examine whether focused training on B-line detection improves patient management and limits early symptom progression. Sixteen articles were included. Overall, LUS showed high diagnostic performance for the differential diagnosis of dyspnoea. Using an eight-zone scan, the presence of ≥3 B-lines in at least two thoracic zones reached 94.2% sensitivity and 77.5% specificity for acute heart failure. LUS is rapid, non-invasive, and feasible in the field when performed by trained personnel; targeted education for paramedics and nurses improved diagnostic accuracy and shortened time to therapy in several studies. LUS is a useful, feasible tool for prehospital assessment and early management of acute respiratory distress. Structured theoretical–practical training and protocolised integration of LUS into prehospital pathways are recommended.

Highlights:

- Narrative review on prehospital lung ultrasound (LUS) for acute dyspnoea (16 studies, 2020–2025);
- LUS rapidly differentiates “wet” vs “dry” lung patterns, supporting early triage and therapy;
- Eight-zone scan; ≥3 B-lines in ≥2 zones → high accuracy for acute heart failure (sens 94.2%, spec 77.5%);
- Feasible in the field with portable devices when performed by trained personnel;
- Focused training (including paramedics) improves B-line recognition and consistency;
- Standardized protocols and outcome-oriented studies are needed to quantify patient-level impact.

Introduction

Lung Ultrasound (LUS) is an increasingly adopted point-of-care imaging modality in prehospital emergency care, particularly for patients with respiratory distress. Contrary to earlier assumptions, the air-filled lung can be evaluated sonographically by analysing characteristic artefacts. Thoracic ultrasound relies on recognising both physiological and pathological artefacts produced by the interaction of ultrasound waves with thoracic tissues. Three artefacts are particularly relevant: i) pleural sliding denotes the to-and-fro movement of the visceral against the parietal pleura during the respiratory cycle; its presence indicates pleural apposition and ventilation of the underlying lung, whereas its absence raises suspicion for pneumothorax (air in the pleural space); ii) A-lines are horizontal, hyperechoic, regularly spaced reverberation artefacts arising from the pleural line, they are typical of normally aerated lung and reflect the presence of intrapulmonary air; iii) B-lines are vertical, hyperechoic artefacts that originate at the pleural line and extend to the bottom of the screen; when ≥3 are present per intercostal space, they suggest increased pulmonary fluid content, as in pulmonary oedema or interstitial syndromes.

Because it is rapid, non-invasive, and portable, LUS is a key diagnostic adjunct in the prehospital management of respiratory distress. Accurate interpretation, however, requires a solid grasp of core principles and adequate training for clinicians.[1-4]

Respiratory distress is a critical, time-sensitive presentation requiring immediate intervention. Its diagnostic complexity reflects the breadth of possible aetiologies; understanding their relative frequency helps guide prompt treatment decisions. Among adults and older patients, acute AHF often manifesting as cardiogenic pulmonary oedema—is a leading cause of hospitalisation worldwide and a frequent consideration in prehospital dyspnoea. Exacerbations of Chronic Obstructive Pulmonary Disease (COPD) are also highly prevalent, particularly among smokers, and commonly precipitate respiratory failure requiring hospital care. Asthma exacerbations vary in severity but can be life-threatening. Pneumonia, an acute infection of the lung parenchyma, spans a wide severity spectrum depending on the pathogen and is especially hazardous for young children, older adults, and immunocompromised individuals. Finally, although less common, massive pneumothorax is a time-critical emergency that must be recognised without delay. Appreciating this epidemiological hierarchy is fundamental for emergency nurses.

Although comprehensive on-scene diagnosis is not always feasible due to time and resource constraints, recognising the most likely conditions and rapidly distinguishing a "wet lung" from a "dry lung" with focused LUS—within the broader framework of Point-Of-Care Ultrasonography (POCUS)-can meaningfully inform immediate supportive therapy and potentially improve outcomes before hospital arrival.

Through a review of the literature, our primary objective was to evaluate whether LUS is useful in prehospital emergency settings for patients presenting with respiratory distress. As a secondary objective, we examined whether training in, and performance of, a B-line-focused LUS approach can help prehospital nurses deliver more appropriate initial treatment to dyspnoeic patients, thereby limiting early clinical deterioration.

Materials and Methods

This study was conducted as a literature review. Source identification was performed by searching the MEDLINE databases, specifically via PubMed, Web of Science, and CINAHL, covering the period from November 2024 to January 2025. Our primary research question was: can lung thoracic ultrasound be a useful technique for assessment in the prehospital emergency setting for patients presenting with acute dyspnoea?

Following the insights gained from the primary objective and the selected articles, a secondary objective was established: can training and the performance of lung ultrasound, specifically focused on the evaluation of B-lines, assist prehospital healthcare professionals in administering more appropriate treatment to dyspnoeic patients, thereby mitigating symptom worsening?

The search strategy and eligibility considerations were structured using the PICO framework (Table 1). To build the search strings, we combined Medical Subject Headings (MeSH)—specifically "Emergency Medical Services" and "Dyspnoea"—with non-MeSH keywords ("point-of-care ultrasound", "lung ultrasound"). Boolean operators and database-specific syntax were applied for each source. The only filter applied was publication date: 2020–2025 (Table 2).

Results

The database search identified 155 records. Applying the 5-year time filter (2020–2025) yielded 44 records. After title/abstract screening, 18 articles were judged relevant to the use of LUS in dyspnoeic patients. Of these, 16 full-text articles were available and were included in the qualitative synthesis; two records were excluded due to unavailable full text. The list of included studies with concise summaries is reported below (Supplementary materials, Table 1).

Discussion

Dyspnoea requires timely diagnostic evaluation because several underlying conditions are life-threatening; diagnostic delay increases morbidity, length of hospital stay, and costs.[7] After history and physical examination raise specific clinical suspicions, these should be confirmed or refuted using biomarkers and imaging. Among the latter, LUS is gaining traction with emergency department physicians and, progressively, within the out-of-hospital emergency setting.

Across the included studies, LUS is increasingly recognised as a useful tool for evaluating acute dyspnoea in prehospital care.[17,1921] In the out-of-hospital environment, portable devices have enabled LUS to achieve a diagnostic accuracy of 75.8%.[17] This supports earlier and more accurate diagnosis and allows prompt initiation of treatment prior to hospital arrival.[19]

Nonetheless, prehospital LUS has practical constraints related to device characteristics (screen size, image quality), availability, and time pressure arising from patient severity. These context and equipment factors—distinct from operator skill—may degrade image quality and therefore the accuracy of the differential diagnosis.[6]

LUS shows high sensitivity and specificity for differentiating causes of dyspnoea, particularly congestive heart failure (CHF)/AHF.[6,14-16,20] Using an 8-zone scan (four zones per hemithorax), the presence of ≥3 B-lines in at least two thoracic zones yields a sensitivity of 94.2% and a specificity of 77.5% for CHF.[16] By contrast, Glockner *et al.* (2020) reported lower sensitivity (54.2%) because many patients had already received diuretics, reducing B-line counts and complicating AHF diagnosis; specificity remained high (97.6%), and sensitivity improved to 75% among patients not pre-treated with diuretics.[14] Overall, prehospital B-line assessment can help identify or exclude CHF and pulmonary oedema as causes of dyspnoea.

When compared with traditional approaches-clinical examination, chest radiography, and NT-proBNP-LUS performed by emergency physicians demonstrates superior sensitivity and specificity to chest radiography for suspected CHF or COPD in dyspnoeic patients.[15-10] Radiography typically captures a single, static image in a constrained patient position (often supine), whereas ultrasound provides dynamic, cycle-to-cycle information across multiple lung regions. In addition, chest radiography exhibits a higher false-negative rate (50%) than LUS, which attains 81% diagnostic accuracy for AHF.[16] Natriuretic peptides have lower diagnostic accuracy than LUS.[16] Importantly for emergency care, LUS expedites decision-making: average time to diagnosis falls from 79.33 minutes with routine assessment to 42.61 minutes with early ultrasound.[13]

Focusing LUS on B-line assessment is attractive because it is rapid, diagnostically informative, and supports earlier initiation of appropriate therapy.[11] Serial examinations can also track early response: in CHF cohorts, repeat LUS 1–2 hours after diuretic administration correlated with symptomatic improvement,[12] and 24–72 hours later with a reduction in B-lines.[14]

Operator background is another practical consideration. Beyond specialised sonographers, emergency physicians using LUS can deliver feasible, reliable, and specific diagnoses for dyspnoea differentials.[8] With targeted theoretical–practical training, both physicians and paramedics can perform thoracic ultrasound with excellent results.[4,9,18] Training often centres on B-line recognition to distinguish “wet” from “dry” lung patterns for AHF versus COPD exacerbations; paramedics correctly interpreted images in 90% of cases.[9] In one study, specific ultrasound training yielded image-quality correctness and diagnostic accuracy of 99.5%/94% for emergency physicians, 98.5%/88% for interns, and 98%/81.5% for paramedics.[18]

Taken together, LUS appears reliable, feasible, sensitive, and accurate in both prehospital and hospital emergency settings, and its use is recommended in undifferentiated dyspnoea. Multiple ultrasound algorithms exist to classify dyspnoeic patients; the BLUE Protocol proposed by Lichtenstein in 2008 is among the most established,[18] although some newer algorithms remain limited by small sample sizes. The literature overall reflects substantial and growing interest in this modality.

A notable gap concerns the prehospital context: only three studies specifically addressed prehospital ultrasound. Nevertheless, most other studies inferred that LUS would add value in out-of-hospital emergencies for undifferentiated respiratory distress. Another gap relates to the professional profile performing LUS. In many included studies-often from countries where paramedics lead prehospital care—nurses are not mentioned in training or practice pathways. In the Italian context, targeted diagnostic-validation studies are warranted to assess accuracy and reproducibility of nurse-performed LUS. Likewise, pre–post training designs could quantify whether theoretical–practical courses improve diagnostic performance, define optimal training duration to achieve competence comparable with experienced operators, and evaluate skill retention without regular updates. Methodologically, the choice of a gold standard is critical: lung status may change between the index LUS and the reference test, potentially biasing accuracy estimates. Finally, despite accumulating evidence for LUS by different professional groups, professional acceptance and scope-of-practice considerations may influence implementation.

Conclusions

Current evidence indicates that LUS is a valuable tool for improving the diagnostic assessment of patients with acute respiratory distress and can favourably influence therapy in prehospital settings. Given the time-critical nature of prehospital care, a simplified LUS approach is advisable, emphasising recognition of the most likely causes of dyspnoea. Practically, this can be framed as a "dry lung" pattern (few or no B-lines), aligning with COPD exacerbation, asthma, or secondary dyspnoea when consistent with the clinical picture, versus a "wet lung" pattern (numerous B-lines), suggestive of cardiac decompensation.

From this perspective, training for nursing staff could be deliberately focused on B-line identification alone. At present, teaching more complex sonographic patterns to emergency nurses appears to have limited added value in the prehospital phase, both because of the imperative for rapid, clinically driven decisions in unstable patients (e.g., tension pneumothorax) and the restricted range of therapies available in the field. Ultimately, LUS holds substantial potential-especially when applied in a targeted manner with role-specific training for prehospital personnel-but successful integration requires attention to environmental constraints and staff competencies (Figure 1). Another priority is to expand training as a core component of emergency preparedness. Training should be accessible to all involved professionals (e.g., nurses and physicians) and focus on the practical use of LUS, combining theoretical and hands-on components. Broader training can extend LUS use to other roles in prehospital emergency care, such as ambulance nurses. Technological innovation will also play a crucial role in improving the quality and reliability of portable devices used in emergency contexts. Optimizing thoracic ultrasound for challenging environments-such as prehospital settings or adverse weather conditions-will help overcome current technical limitations.

Finally, continued research is essential to refine LUS applications and to update protocols periodically based on real-world clinical data. This approach will optimize use of the technique and support the continuous improvement of emergency care.

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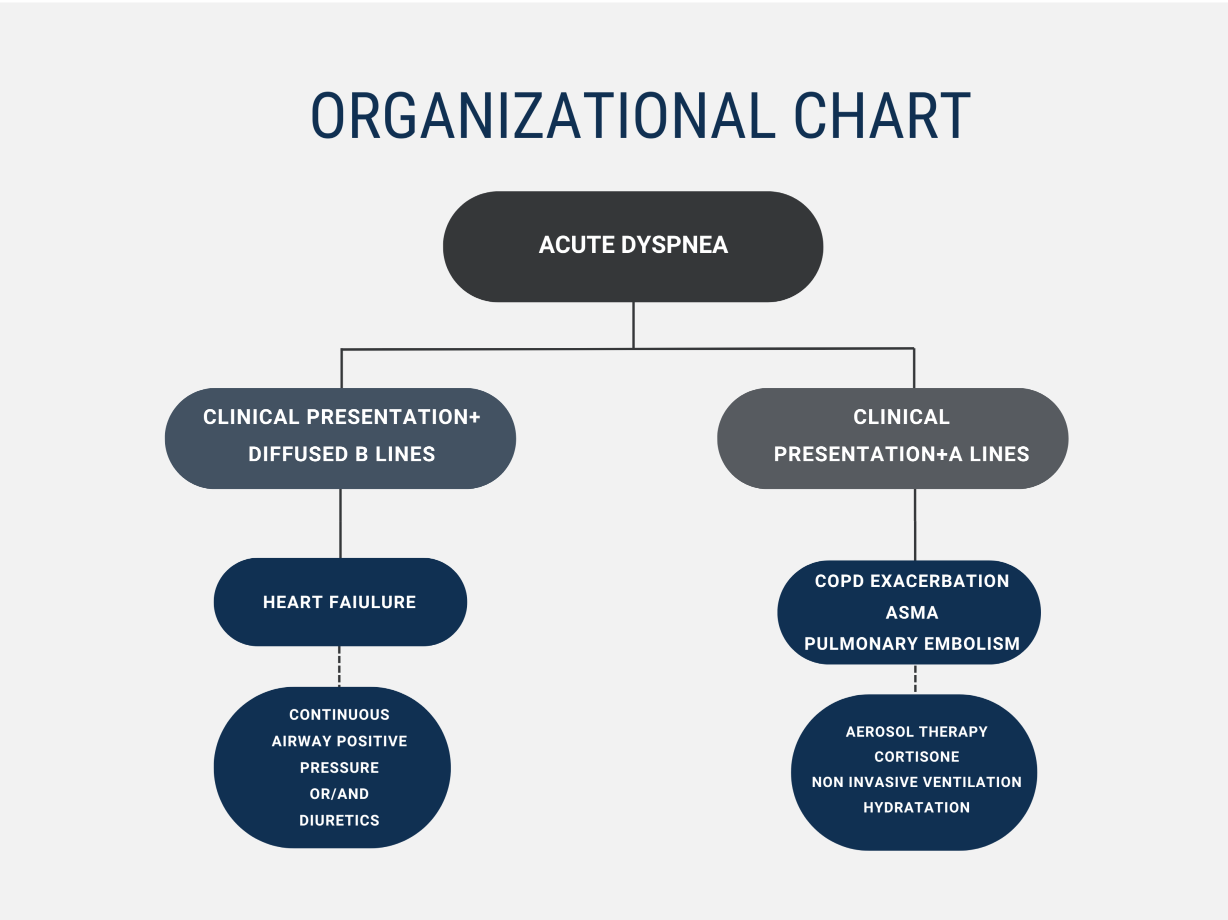
Table 1. PICO framework for the review.

Element	Definition used for the review
Population (P)	Adults with acute dyspnoea managed in the prehospital emergency setting
Intervention (I)	LUS in the prehospital setting; for the secondary question, B-line–focused LUS and related training.
Comparator (C)	Standard prehospital assessment without LUS and/or alternative initial diagnostic approaches.
Outcomes (O)	Diagnostic usefulness/feasibility of LUS; appropriateness of initial treatment; mitigation of early symptom worsening before hospital arrival.

Table 2: Database-specific search strategies.

PubMed	((("Emergency Medical Services"[Mesh]) AND (point of care ultrasound)) AND ("Dyspnea"[Mesh])) OR ((("Emergency Medical Services"[Mesh]) AND (lung ultrasound)) AND ("Dyspnea"[Mesh]))
Web of Science	(((TS=(emergency medical service))AND TS=(point of care ultrasound)) AND TS=(dyspnea)) OR TS=(((TS=(emergency medical service)) AND TS=(lung ultrasound)) AND TS=(dyspnea))
Cinahl	(((emergency medical services) AND (pocus) AND (dyspnea)) OR ((emergency medical services) AND (lung ultrasound) AND (dyspnea)))

Figure 1. Simplified algorithm for acute dyspnoea: prehospital therapy based on clinical assessment and LUS findings.



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Online supplementary materials

Table 1. Summary of studies included.