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EFFICACY OF LUNG ULTRASOUND AS A DIAGNOSTIC MODALITY IN VARIOUS LUNG DISEASES

Radio-Diagnosis

Dr. Bhupesh Goyal PG JR 3 Department Of Radiadignosis Heritage Institute Of Medical Sciences Varanasi

Prof. (Dr.) Gaurav Sharma* DNB , FIVR Professor & Unit Head Department Of Radiadignosis Heritage Institute Of Medical Sciences Varanasi *Corresponding Author

Dr. Samarpan Raheja PG JR-3 Department Of Radiadignosis Heritage Institute Of Medical Sciences

ABSTRACT

Background: Chest X-rays and High-Resolution Computed Tomography (HRCT) scans are pivotal in diagnosing various lung diseases. However, limitations such as patient immobility, radiation exposure, and equipment sensitivity call for more adaptable, accurate, and safer methods. Lung Ultrasound (USG) emerges as a promising, quick non-invasive, radiation free alternative, offering substantial benefits, especially in critical care settings where traditional methods pose risks or are impractical. **Objectives:** To evaluate the sensitivity of lung ultrasound (USG) in detecting lung diseases in comparison to chest X-ray and CT chest findings. **Materials:** This is an observational cross-sectional study conducted at the Department of Radiodiagnosis, Heritage Institute of Medical Sciences, Varanasi, from July 2023 to January 2025. The study included patients referred for chest imaging due to respiratory complaints. Exclusions include non-consent, pregnancy, and extensive subcutaneous emphysema. Imaging techniques utilized are chest X-ray, CT chest, and lung USG, with equipment tailored to the depth and nature of suspected pathology. **Results:** Findings indicate lung USG's high sensitivity in detecting conditions like pneumothorax, pleural effusion, pneumonia, pulmonary edema, and ARDS compared to traditional methods. Notably, USG shows a sensitivity of 85% in pneumothorax, 92.5% in pleural effusion, and 90% in pneumonia detection, surpassing Chest X-ray significantly and sensitivity of 96.6 % in pulmonary edema 96.6% that is nearing CT performance. The convenience and safety of USG make it particularly effective in emergency and ICU settings. **Conclusion:** Lung ultrasound presents a viable diagnostic alternative to traditional methods, with high sensitivity and the added advantages of being non-invasive and radiation-free. Its efficacy in emergency and critical settings, combined with portability and cost-effectiveness, supports broader adoption, especially where traditional imaging poses risks or feasibility issues.

KEYWORDS

INTRODUCTION

Chest X-rays and High-Resolution CT (HRCT) scans are widely used for the early detection and evaluation of lung diseases, with X-rays being the first-line imaging method for a quick assessment of lung health and HRCT providing high-resolution images for more detailed examination of conditions such as interstitial lung disease, chronic obstructive pulmonary disease (COPD), and lung infections(1). These imaging techniques allow healthcare providers to identify abnormalities, diagnose conditions, and monitor disease progression or treatment responses effectively. However, they come with limitations, such as the need for accurate patient positioning, difficulties with immobile patients, and risks associated with repeated radiation exposure. Additionally, the image quality can be compromised with portable systems, and adjustments may be needed due to patient and machine-related conditions(2).To overcome these challenges, there has been growing interest in using lung ultrasound (USG) as an alternative diagnostic tool. USG is non-invasive, radiation-free, cost-effective, and portable, making it an attractive option for assessing lung diseases, especially in emergency and intensive care settings(3). Although ultrasound imaging of the lungs has been difficult due to air interference, advancements in understanding lung pathology have enabled better use of USG, particularly when fluid, consolidation, or lesions are present in the lung parenchyma. USG can detect conditions like pleural effusions, pneumothorax, and interstitial lung disease with high sensitivity(4,5). Moreover, it offers real-time imaging, is easily reproducible, and can be performed without moving non-ambulatory patients, making it highly beneficial in resource-limited settings(6-7).This study aims to validate lung USG as a primary diagnostic tool for various lung diseases, comparing its sensitivity to that of traditional X-ray and CT scans. By addressing the limitations of conventional imaging, USG provides a radiation-free, repeatable, reliable, and mobile solution, offering a promising alternative in modern diagnostic practice.

MATERIALS AND METHODS

A prospective observational cross sectional study was conducted over 18 months (July 2023 to January 2025) at the Department of Radiodiagnosis, Heritage Institute of Medical Sciences, Varanasi .A total of 200 patients presenting to the Radiology Department with clinical symptoms suggestive of various lung diseases and advised chest X-ray and/or CT scan were included in the study. Following a brief clinical history, each patient underwent lung ultrasonography. After completing the lung USG, patients were then evaluated with the prescribed diagnostic methods, including chest X-ray and/or CT chest. The sensitivity and specificity of each imaging modality (chest X-ray, lung USG, and CT) were compared in detecting various lung diseases. The 6-point evaluation (3 on each side of the chest) was performed as defined in the BLUE-protocol(Fig 1). The three standardized points were the upper BLUE-point, lower BLUE-point, and PLAPS-point, along with the bilateral Costo-Phrenic angles.

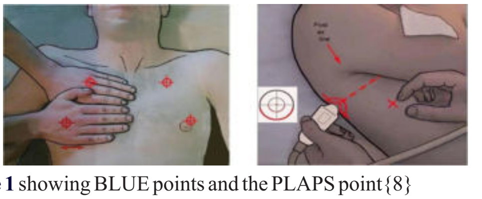


Figure 1 showing BLUE points and the PLAPS point{8}

Various diseases evaluated in this study and the findings that will be identified are enumerated below.

1. **Pneumothorax**
- **Chest X-ray:** Pleural line visibility, increased translucency, absence of lung markings, deep sulcus sign.
- **Lung Ultrasound:** Absence of lung sliding, B-lines disappearance, barcode sign, lung point.(Fig 2)
- **CT Scan:** Detection of small air collections, precise location/size, and associated injuries.

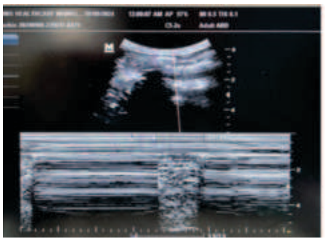
2. **Pleural Effusion**
- **Chest X-ray:** Blunting of costophrenic angle, meniscus sign, homogeneous opacity.
- **Lung Ultrasound:** Anechoic area, absent lung sliding, plankton sign, jellyfish sign , Quad sign . (Fig 3)
- **CT Scan:** Fluid density characterization, enhancing pleura, loculated effusions.

3. **Pneumonia**
- **Chest X-ray:** Infiltrates, air bronchogram, possible pleural effusion.
- **Lung Ultrasound:** B-lines, consolidations (Fig 4), pleural line

abnormalities, effusion.
- **CT Scan:** Ground-glass opacities, well-defined consolidations, interstitial changes, lymphadenopathy.

4. Pulmonary Edema
- **Chest X-ray:** Kerley B lines, bat-wing pattern, increased vascular markings, cardiomegaly.
- **Lung Ultrasound:** Multiple B-lines(Fig 5), homogeneous pleural line, pleural effusion.
- **CT Scan:** Ground-glass opacities, interlobular septal thickening, pleural effusion, cardiomegaly.

5. Acute Respiratory Distress Syndrome (ARDS)
- **Chest X-ray:** Diffuse bilateral opacities, air bronchogram, no cardiomegaly.
- **Lung Ultrasound:** Multiple B-lines, consolidations, pleural line abnormalities,(Fig 6) aeration loss.
- **CT Scan:** Ground-glass opacities, consolidations, traction bronchiectasis, honeycombing.



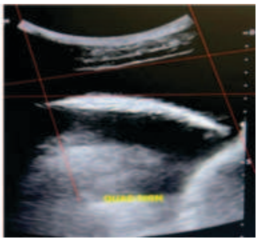
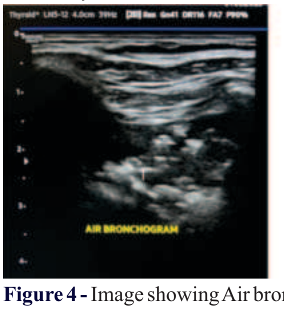


Figure 2 - Lung point – indicates transition point of normal lung with pneumothorax
Figure 3 - Quad Sign –Seen in pleural effusion with boundaries marked by red lines.



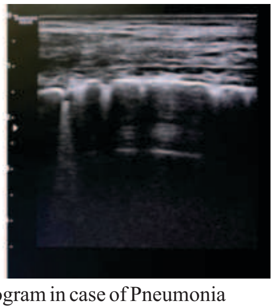


Figure 4 - Image showing Air bronchogram in case of Pneumonia
Figure 5 - Image showing multiple coalescent B lines in pulmonary edema

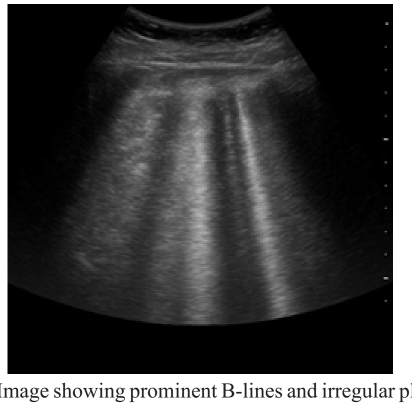


Figure 6 - Image showing prominent B-lines and irregular pleural line in ARDS

RESULT

A total of 200 patients were included in the study the most common clinical symptoms among participants were breathlessness (72.5 %), followed by fever (65%), and cough (45.%). The least reported symptom was chest pain (20%).The disease spectrum was primarily dominated by pleural effusion and pneumonia, each affecting 30% of the participants. This was followed by ARDS and pulmonary edema, both affecting 15%, while pneumothorax was observed in 10% of the patients.Lung ultrasound (USG) demonstrated high sensitivity in detecting pneumothorax, pleural effusion, pneumonia, ARDS and pulmonary edema when compared to chest X-ray. Lung USG detected pneumothorax with 85% sensitivity, significantly outperforming chest X-ray (70%), and pleural effusion with 92.5% sensitivity, again surpassing chest X-ray's 80%. For pneumonia, lung USG exhibited a sensitivity of 90%, compared to chest X-ray's 75%. Pulmonary edema was diagnosed with 96.6% sensitivity by lung USG, in contrast to chest X-ray's 66%.The study also assessed the role of lung ultrasound in diagnosing Acute Respiratory Distress Syndrome (ARDS). Lung USG demonstrated a sensitivity of 70% for ARDS, while chest X-ray had a sensitivity of 63% . CT scan provided 100% sensitivity for all conditions. The findings reveal a consistent pattern across various lung diseases, with CT scans showing the highest diagnostic sensitivity. Lung ultrasonography closely followed, performing comparably in many cases. Notably, lung USG showed significantly higher sensitivity than chest X-rays across all evaluated conditions.

Distribution according to Disease Spectrum

Disease	Number of Cases	Percentage
Pneumothorax	20	10.00%
Pleural Effusion	60	30.00%
Pneumonia	60	30.00%
Pulmonary Edema	30	15.00%
ARDS	30	15.00%

Senstivity comparison of various diagnostic modality

Disease	Sensitivity on LUS	Sensitivity on CXR	Sensitivity on CT
Pneumothorax	85 %	70 %	100 %
Pleural Effusion	92.5%	80%	100 %
Pneumonia	90 %	75 %	100 %
Pulmonary Edema	96.6 %	66.00%	100 %
ARDS	70 %	63 %	100 %

DISCUSSION

This study evaluated the diagnostic performance of lung ultrasound (LUS) in detecting common pulmonary pathologies and compared its accuracy with chest X-ray (CXR) and computed tomography (CT), which remains the current gold standard in thoracic imaging. Our findings underscore the growing role of LUS as a valuable diagnostic tool in respiratory medicine, particularly in resource-limited or point-of-care settings. LUS showed higher sensitivity than CXR across most conditions. For pneumothorax, LUS identified 85% of cases compared to 70% by CXR. For pleural effusion, the detection rate was 93.3% with LUS versus 80% by CXR. LUS also outperformed CXR in pneumonia (90% vs. 75%) and pulmonary edema (96.6% vs. 66%). These results align with previous studies; for instance, Lichtenstein et al. and Volpicelli et al. demonstrated similarly high diagnostic accuracy of LUS for pleural effusion and pneumonia, with LUS outperforming chest X-ray in both sensitivity and specificity. In this study, LUS outperformed chest X-ray in all the evaluated conditions.LUS showed high sensitivity in detecting various pulmonary conditions .Sensitivity was slightly lower in acute respiratory distress syndrome (ARDS) at 70%, likely due to the heterogeneous and diffuse nature of lung involvement in ARDS, which can challenge LUS interpretation.While CT remains the most sensitive imaging modality, especially for diffuse parenchymal diseases such as ARDS or early interstitial lung disease, its limitations—including radiation exposure, cost, and limited accessibility in emergency settings—make it less practical for serial assessments. LUS, in contrast, offers a repeatable, radiation-free, and cost-effective alternative that can be performed at the bedside with minimal preparation. These advantages are particularly relevant in intensive care units (ICUs), emergency departments, and during pandemics, where imaging access may be constrained.

Limitations

The study had several limitations. It was conducted at a single institution (Heritage Institute of Medical Sciences), limiting the generalizability of the results to other settings or regions. The sample size may have been insufficient to detect all lung diseases with confidence. Pregnant women were excluded, reducing the applicability of the findings to this group. Additionally, the inclusion of only patients referred for chest X-ray or CT chest may have introduced selection bias, as those with more severe conditions were more likely to participate. The observational cross-sectional design limits the ability to establish causal relationships. The reliance on existing diagnostic methods (chest X-ray, CT chest) may have introduced inherent limitations related to their sensitivity and specificity. Finally, variations in ultrasound equipment and operator skill may have affected the consistency of lung ultrasound results.

CONCLUSION

The study results clearly demonstrate the varied sensitivity and diagnostic utility of different imaging modalities—Chest X-ray, Lung Ultrasound (USG), and Computed Tomography (CT)—in the detection of common lung conditions. The findings indicate a consistent pattern across different conditions, with CT scans generally showing the highest sensitivity, which is closely followed by Lung USG. This indicates that lung USG is effective tool and can be used instead of CT especially in pleural effusion, pneumothorax, pneumonia with near same effectiveness in diagnosing pulmonary edema, with the added benefits of being quick, cost-effective, radiation-free, and easily accessible. In contrast, Chest X-ray shows lower sensitivity across all conditions. The findings emphasize the importance of selecting the most appropriate imaging modality based on the clinical scenario and the need for timely diagnosis. Lung USG is especially valuable in emergency and critical care settings, where rapid decision-making is crucial. This study highlights the potential of refining diagnostic protocols and enhancing training to ensure the optimal use of imaging tools in diverse clinical settings.

REFERENCES

1. Esposito S, Papa SS, Borzani I, Pinzani R, Giannitto C, Consonni D. Performance of lung ultrasonography in children with community-acquired pneumonia. Ital J Pediatr. 2014;40(1):1-6.
2. Hansell DM. High-resolution CT of diffuse lung disease: value and limitations. Radiol Clin North Am. 2001 Nov 1; 39(6):1091–113.
3. Shah VP, Tunik MG, Tsung JW. Prospective evaluation of point-of-care ultrasonography for the diagnosis of pneumonia in children and young adults. JAMA pediatr. 2013 1;167(2):119-25.
4. Mento F. Development of lung ultrasound quantitative approaches and automatic semi-quantitative strategies: in silico, in vitro, and clinical studies. 2022.
5. Gargani L, Volpicelli G. How I do it: lung ultrasound. Cardiovasc Ultrasound. 2014 Dec;12:25.
6. Berry L, Rehnberg L, Groves P, Knight M, Stewart M, Dushianthan A. Lung ultrasound in critical care: a narrative review. Diagnostics (Basel). 2025;15(6):755. doi:10.3390/diagnostics15060755.
7. Sivaramakrishnan A, Patel P, Chong WH, Kalra A. Lung ultrasound has greater accuracy than conventional respiratory assessment tools for the diagnosis of pleural effusion, lung consolidation and collapse: a systematic review. J Physiother. 2021;67(1):41–8.
8. Lichtenstein D, Mezière G. Lung ultrasonography in the critically ill. Intensive Care Med. 2008;34(4):554–60.