EDITORIAL

Lung Ultrasound Score for Prognosticating Ventilator-associated Pneumonia (VAP): Evidence and Wisdom

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Ventilator-associated pneumonia (VAP) is said to have occurred when new infiltrates in the lung, fever, and leukocytosis with increasing quantity and more purulence in tracheal aspirates, accompanied by a drop in PaO_2/FiO_2 ratio and bacterial growth in the lower respiratory secretions, are noted after 48 hours of invasive mechanical ventilation. Though its incidence varies but, it affects almost a third of intubated and ventilated patients and cure rate can be as low as 50–60% with high re-occurrence rate. As we know from pathology that, exudates fill up alveolar spaces and cause the appearance of "Hepatization" of the lungs in pneumonia.

Most pneumonias extend laterally to involve subpleural space and this forms the basis of detection by lung ultrasound.[1] Ultrasonic appearance of lung depends on air to fluid ratio of the lung underneath the probe and range from; nothing visible below pleura (air filled alveoli) to tissue like structure with air bronchogram (exudate filled alveoli, consolidation). This means air is replaced by thick liquids or even solids (very low air/fluid ratio) thus giving tissue like appearance. One needs to fulfill the following criteria for labelling a "tissue like structure" as consolidation, namely; it must be above diaphragm (to avoid liver and spleen), tissue like pattern arising from pleura and extending deeper, tissue like area surrounded by air filled alveoli and deeper edge of the tissue like area (consolidation to air filled lung interface) is irregular and presence of dynamic air bronchogram in tissue like area. Pleural effusion may be present in many cases and probably reflects synpneumonic effusion.[1–4]

Modified global lung ultrasound score (LUS) based on transverse scans of intercostal spaces (score 0: <3 B lines, score 1:3 or more B lines or consolidation below <50% pleural line; score 2:3 or more B lines or consolidation beneath >50% pleural line, score 3: Tissue like pattern or consolidation) was originally designed for detection of an increment in deaeration in the emergency department and showed a good correlation with extravascular lung water using pulse contour cardiac output analysis.[5,6] This deaeration can be due to edema (hydrostatic) or exudate (ARDS, pneumonia, blood or exudate in a contusion) or both.

Clinical pulmonary infection score (CPIS) is conventionally used to diagnose VAP in critically ill patients. Use of clinical and biochemical points of a CPIS score ≥6 showed only 68% sensitivity and 50% specificity for the diagnosis of VAP. Its specificity can be increased only by adding microbiological data (positive distal airway cultures), as other clinical and imaging findings can occur in many other clinical conditions besides pneumonia.[7,8] Similarly, one needs to add microbiological data to the global LUS for it to be specific to VAP diagnosis and monitoring. Mongodi et al., used the ventilator-associated pneumonia lung ultrasound score (VPLUS) score for diagnosis of ventilator-associated pneumonia in a study on 99 patients.[9] Adding gram stain of ET secretions increases sensitivity and specificity for diagnosis of VAP to 57 and 83%, and adding quantitative cultures increases it further to 77 and 71% in respectively. Use of LUS alone (tissue line pattern) has high 93% sensitivity but 0% specificity, thus confirming that loss of aeration in ventilated patients can be due to causes other than VAP (e.g. Contused or edematous lung). Air bronchogram has greater specificity 81% in this context. In one study that described lung reaeration score, increment of LUS score1, 2, 3 is given 1, 3, 5 points or -1, –3, –5 points on deaeration. About 5 point gain after antibiotics was found to have gained 400 mL lung volume on CT scan and –10 point loss equal to 400 mL loss.[10] Thus lung ultrasound can tell us progress or regress of aeration index, which may be due to a process other than VAP in ventilated patients if elements that show infection are not added to a scoring system.

VPLUS Score

Lung ultrasound score based detection of 2 or more subpleural consolidations (1 point) and more than 1 area with dynamic air bronchogram (2 points). It needs evidence of infection increased quantity and purulence (1 point) and microbial growth in these secretions (1 point). Inclusion of LUS + increased Endotracheal aspirate (VPLUS ≥2) makes it 70% specific and equally sensitive for diagnosis of VAP. Addition Microbiological growth, VPLUS = 4 makes it near 97% specific.[11]

Study published in this journal by Sagarika Panda has taken 120 of 600 patients on ventilators.[12] There are many strengths to this

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study. Follow-up was complete in 117 of these 120 patients up to 28 days. Investigators doing LUS, doing ABG and calculating static lung compliance were not involved in patient care, reducing the possibility of observer biases. Clinical pulmonary infection score score of ≥6 was used for the diagnosis of VAP, and these patients were followed up for 5 consecutive days by recording changes in LUS, PaO_2/FiO_2 ratio, and static lung compliance. The study could differentiate responders (drop in LUS score by 2) from non-responders by showing a statistically significant difference in mortality (responders 26.3% and non-responders 87.8%, $p < 0.001$) as primary outcome. They could show a significant correlation between LUS and PaO_2/FiO_2 ratio, LUS and Static compliance, and LUS with plateau pressure as a secondary outcome. This well-performed study showed that following up patients with VAP with LUS is commensurate with analyzing the trend of plateau pressure and PaO_2/FiO_2 ratio.

However, we need to clearly understand the following limitations. (1) Clinical pulmonary infection score can be more than 6 without microbiological data and thus is only 50% specific in diagnosis of VAP. (2) Lung ultrasound score is more to do with aeration index of the area scanned, irrespective of cause of deaeration. B lines can increase or decrease in an area depending on recruitment-derecruitment, extravascular lung water, PEEP withdrawal, pathologies other than pneumonia like fluid overload, mucus plugging associated to collapse in ventilated patients. (3) Doing scrupulous LUS count on multiple areas of lung, especially more relevant posterior ones, is difficult, time-consuming and subject to operator bias. Use of more specific LUS findings like, presence or disappearance of tissue like pattern and dynamic air bronchogram would have not only increased specificity but also relatively easier for performer. (4) Patients with less fluid overload (cumulative fluid balance) and thus less extravascular lung water (EVLW) will have lower mortality, irrespective of the presence or absence of VAP. Thus, change in LUS is more reflective of EVLW (infective or non-infective) rather than VAP progress or regress. (5) Lung ultrasound score EVLW will obviously have a correlation with static lung compliance and PaO_2/FiO_2 ratio, irrespective of VAP. (6) Lack of microbiological data in the patients make it non-specific for VAP, as shown in multiple other scores like VPLUS, lung ultrasound and pentraxin-3 pulmonary infection score (LUPPIS) which add quantitative culture results to LUS to make it specific for the study of VAP. This study could very well show clear demarcation between responders (lesser mortality) and nonresponders (higher mortality), but ascribing it to be due to VAP only as a pathology is questionable.

Thus, use of LUS is a reasonable tool to follow up on patients diagnosed with VAP using validated scores like VPLUS or LUPPIS but sole reliance on it for the diagnosis of VAP needs caution.[13–15] Rising competency and enthusiasm among Critical Care Specialist in doing point-of-care ultrasound (POCUS) need to be guarded on multiple fronts, as many findings lack specificity (e.g., B line index for VAP). One can generate evidences through well performed studies, but we need to keep questioning the relevance and significance of each conclusion, to influence change in clinical decisions and practice from now on, where wisdom is required.

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