“ LUS helps estimate the severity of peripheral lung involvement in COVID-19, contributing to quicker and more solid patient management.”

LUS

Covid-19 Pneumonia
Lung Ultrasound (LUS) assessment of severity of involvement

Case studies courtesy of

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Score 0

Normal A pattern

Non significant vertical artifacts; < 3 B lines

Score 1

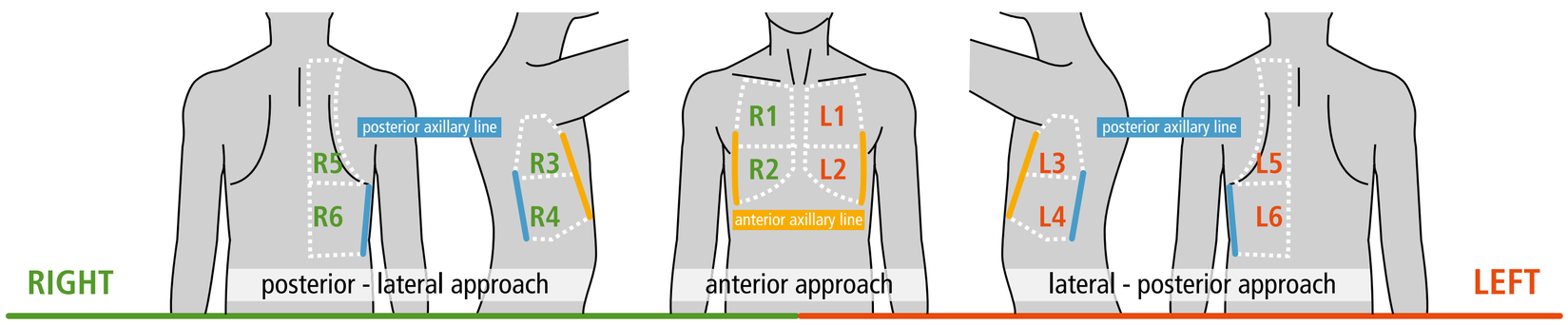
≥ 3 Distinct B lines and/or small pleural irregularities and/or microconsolidations

Score 2

Confluent or wide and dense bundles of B lines interspersed with spared areas ± pleural line thickening/fragmentation ± small consolidations

Score 3

White lung pattern - Confluent/larger consolidations



Machine settings

- Start with a standard adult multi-frequency convex probe; a linear probe could be useful to further analyze pleural line details but it is usually not needed.
- Start with a depth of view of at least 10 cm in each zone; if needed, details can then be magnified and analyzed by reducing the depth.
- Start with the highest frequency and then reduce it until the image is optimized depending on patient’s chest wall thickness.
- Use single point focusing, setting the focus depth at pleural line level.
- Keep the mechanical index as low as possible (≤ 0.7).
- Achieve the highest frame rate possible (ex. no persistence/compounding).
- Reduce cosmetic filters and try deactivating harmonic imaging.

Examination – 12 zones approach

Patients should ideally be scanned in sitting position; if the patient is bedridden efforts should nonetheless be made to obtain satisfactory scans of the posterior zones. Each hemithorax is virtually and grossly divided in 3 different longitudinal zones (anterior, lateral, and posterior), each of these further divided in two (upper and lower). The resulting 12 zones are labeled as shown in the figure. Each zone is assessed individually for signs of involvement of the disease. Longitudinal scans may be useful to navigate the chest but intercostal scans should be used to look for signs of disease and for scoring purposes. Each zone is thoroughly examined for signs and extension of interstitial syndrome, interstitial-alveolar syndrome, consolidations, pleural effusions, and any other ancillary findings. The involvement could be expressed with a score. Different scoring proposals have been put forward. The most utilized classification includes levels of severity ranging from 0 (normal) to 3 (severe) that are applied to each of the 12 zones and that may be added together to define a general LUS score (min 0, max 36).

LUS scoring system

Score 0: presence of a smooth and uninterrupted pleural line and of clear horizontal A lines; some punctiform asperities and few (up to 2†) narrow B lines* per field of view might be visible;
Score 1: presence of ≥ 3† B lines or of any B line originating from distinct irregularities of the pleural line or from isolated subpleural micro-consolidations (both width and height < 10 mm†); B lines are distinct and separated;
Score 2: presence of confluent or wide and dense bundles of B lines interspersed with “spared areas” (smooth pleural line and A lines); the pleural line frequently appears “thickened” and “fragmented” with some small sized consolidations (height < 1 cm†);
Score 3: presence of coalescent B lines across the whole width of the field (“white lung” pattern) abolishing all A lines and/or larger (both width and height > 1 cm†) or confluent consolidations.

NB

* With the term “B line” we refer for simplicity to “any hyperechoic vertical artifact arising from the pleural line or from subpleural consolidations that reaches the bottom of the image abolishing A lines and other horizontal artifacts”. Vertical artifacts that do not fulfill these criteria should be ignored.

† The reported cut-off values are indicative and should always be interpreted with caution by the operator since quantitative measures in lung ultrasound may not be highly reliable (especially when derived from artifacts) and are influenced by the hardware and the settings of the equipment.

For each zone, the score of the most abnormal intercostal scan should be reported. In case of uncertainty (i.e. between score 1 and 2 or between 2 and 3), the extension of abnormalities across multiple scans of the investigated zone could be taken into account. For example: an isolated bundle of B lines seen in an otherwise completely normal zone could be scored 1 instead of 2.

Current evidence on the clinical impact of lung ultrasound scoring systems

As of today, no standardization exists for the use of LUS score in COVID-19 pneumonia[1,2]. Studies significantly differ in scanning protocols, grading systems and cut-off values. No score has been adequately validated in COVID-19 patients.
We have recently proposed a slightly more granular scoring system primarily oriented to the screening of non or poorly symptomatic subjects at risk for COVID-19[3]. This score includes a more separated distribution of the classes (ranging 0-3) especially in the instance of mild abnormalities (Raiteri et al, 2021)[3] but its prognostic value in patients admitted for COVID-19 has never been investigated so far.

Present evidence

- LUS score may be categorized in severity classes. According to the existing studies in ARDS and other attempts of standardization in COVID-19, the following cut-off could be used for the total lung ultrasound score:
  0 = “normal”; 1-5 = mild involvement; 6-15 = moderate; > 15 = severe[4].
- One study found an optimal LUS score cut-off of 12.5 to predict SARS-CoV2 positivity (assessed by RT-PCR) in a population of hospitalized patients with high clinical suspicion for the disease (Se 73%, Sp 89%)[5].
- The extension of lung involvement (assessed as number of abnormal zones, i.e. those with score > 0) and/or the total LUS score appear to be positively related to the clinical severity (usually expressed as P/F), the need for hospitalization and the need for ventilatory support/mortality[5-8].
- One study found an optimal LUS score cut-off of > 18 to predict mortality of hospitalized positive patients[9].
- A very low score (< 2 in one study[10]) virtually excludes any severe lung involvement by COVID-19, especially in patients with no history of cardiopulmonary disease[9,10]. A low score in presence of severe respiratory distress should prompt further investigations of a different/adjunctive cause to COVID-19[11].
- LUS ultrasound findings and scoring showed a good to excellent interobserver reproducibility[5,9].
- LUS findings were found to show consistency with CT (gold standard technique). One study found that a LUS score of 23 predicted severe pneumonia at CT scan with a Sp > 90% and a PPV of 70%; LUS score < 13 excluded it with a Se > 90% and an NPV of 92%[7].

References 1. Soldati et al. *Proposal for international standardization of the use of lung ultrasound for COVID-19 patients; a simple, quantitative, reproducible method.* J. Ultrasound Med. 39, 1413-1419 (2020). **2.** Volpicelli et al. *What’s new in lung ultra- sound during the COVID-19 pandemic.* Intensive Care Med. 46, 1445–1448 (2020). **3.** Raiteri A, et al. *Lung Ultrasound is often, but not always, normal in healthy subjects: Considerations for COVID-19 pandemic.* Diagnostics. 82, 11 (2021) **4.** Manivel et al. *T. CLUE: COVID-19 lung ultrasound in emergency department.* EMA - Emerg. Med. Australas. 32, 694-696 (2020). **5.** Bosso et al. *Lung ultrasound as diagnostic tool for SARS-CoV-2 infection.* Intern. Emerg. Med. 1–6 (2020). **6.** Brahier et al. *Lung Ultrasonography features and risk stratification in 80 patients with COVID-19: A prospective observational cohort study.* Clin Infect Dis. 1408 (2020). **7.** Zieleskiewicz et al. *Comparative study of lung ultrasound and chest computed tomography scan in the assessment of severity of confirmed COVID-19 pneumonia.* Intensive Care Med. 46, 1707–1713 (2020). **8.** Perrone, T. et al. *A New Lung Ultrasound protocol able to predict worsening in patients affected by severe Acute Respiratory Syndrome Coronavirus 2 pneumonia.* J. Ultrasound Med. 2, 1–9 (2020). **9.** Lichter et al. *Lung ultrasound predicts clinical course and outcomes in COVID-19 patients.* Intensive Care Med. 46, 1873–1883 (2020). **10.** Haak et al. *Diagnostic accuracy of point-of-care lung ultrasound in COVID-19.* Emerg. Med. J. emermed-2020-210125 (2020). **11.** Millington et al. *Lung Ultrasound for patients with coronavirus disease 2019 pulmonary disease.* Chest 159, 205-211 (2021).

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