TITLE: CLUE: COVID-19 Lung Ultrasound in Emergency Department.

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o All authors contributed to protocol development, manuscript writing, approval of final version

and agree to be accountable for all aspects of the work.

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o Author SS drafted figure 1.

Lung Ultrasound in COVID-19: Current evidence

Lung ultrasound (LUS) is a vital part of critical care evaluation of multiple lung pathologies, like pneumothorax, acute respiratory distress syndrome (ARDS), pulmonary oedema, interstitial lung disease (ILD) and pneumonia(1). As SARS-CoV-2 infection causes interstitial pneumonitis, there is an extensive use of LUS in COVID-19 patients in China(2) and Italy(3). Detection of COVID-19 by RT-PCR testing of nasopharyngeal swabs, considered as the gold-standard test, lacks sensitivity compared to CT chest, 59% vs 88% respectively(4). Ultrasound has an excellent correlation to CT chest findings (2) and could be an alternative to ionising radiation imaging(3). Poor sensitivity of 59% for CXR to detect COVID-19 changes(5) and superiority of ultrasound in similar ILD (6), makes it an attractive imaging option. Performance of LUS at bedside also allows concurrent execution of clinical examination and lung imaging by the same clinician, expedites clinical decision making(7).

Technical aspects of LUS in COVID-19

A step-by-step approach to safely performing LUS in Table 1. We recommend chest be scanned systematically as 12 zones, six zones for the right lung (R1 to R6) and six zones for the left lung (L1 to L6, Figure 1). Scanning the posterior lung zones (R5, R6, L5, L6) will improve the sensitivity of LUS, as most changes are in the posterior lung(8). For safe scanning, the patient to sit facing away from the clinician and posterior, lateral (R3, R4, L3, L4) and even anterior (R1, R2, L1, L2) zones scanned by the clinician positioned behind the patient. If the patient is in the supine position (unwell to move or sedated), the posterior lung zones replaced by scanning areas slightly posterior to the posterior axillary line. In our limited experience with COVID-19 patients, it takes less than 10 minutes to perform LUS, excluding cleaning time.

Coronavirus being a lipid-based enveloped virus, is susceptible to low-level alcohol based disinfectant wipes (9) but strongly recommend involvement of the infection-control department and the ultrasound manufacturer in disinfection planning and guideline development.

Sonographic features in COVID-19

An appropriately optimised image of a normal LUS will feature A-lines and few B-lines (<3 B-lines per intercostal space) and smooth thin pleural line(1). Sonographic features of COVID-19 pneumonitis are(2),

- increased number of B-lines (discrete or confluent, multifocal and usually bilateral),

- thickening of pleura with pleural line irregularities,

- subpleural small consolidations (<1cm height), which progress to large poorly vascularised or avascular consolidations(8) (>1cm height), with occasional air bronchograms and

- pleural effusions are uncommon.

CLUE protocol: COVID-19 Lung Ultrasound in Emergency protocol.

CLUE protocol (Figure 2) involves an anatomical parameter, lung ultrasound scoring system (LUSS) and a physiological parameter, oxygen requirement at the time of examination, to aid emergency clinician make disposition decision.

LUSS is a valid tool to assess regional and global lung aeration in ARDS (10, 11) and can be used in COVID-19 pneumonitis with several similar sonographic features(2). At each zone, LUSS points range from 0 to 3, with higher points allocated to severe lung changes (Figure 2). Based on the total score from 12 lung zones, the severity classified as mild (score 1-5), moderate (>5-15) and severe (>15). A normal lung will have a total score of 0.

A clinician's decision on the need for supplemental oxygen is a complex process, involving factors like oxygen saturation, work of breathing, respiratory rate and pre-existing medical conditions (i.e. COPD, heart disease). A single parameter like oxygen saturation or respiratory rate, may not represent real-time clinical practice.

CLUE protocol only provides a foundation, which is easy to use and flexible to accommodate complex clinical presentations. Some of the patients in the mild and moderate severity group could safely go home from the ED, provided a proper self-isolation facility, and adequate community follow-up ensured. In patients, who are depicted in cells with dotted borders in the table "CLUE protocol" in Figure 2, consider in-hospital management if no pulse-oximetry monitoring or home-oxygen support provided.

Why CLUE protocol?

While Australia and New Zealand prepare for a figurative tsunami of highly infectious patients, we anticipate that a protocolised use of bedside LUS by emergency clinicians in COVID-19 patients could alleviate some of the radiological resource burden expected.

Existing evidence supports LUS in COVID-19, but none has a clear objective scoring system or incorporates clinician's assessment in decision making. CLUE protocol aims to addresses this gap and provide the emergency clinician with an appropriate disposition plan. CLUE protocol will provide instant, objective information of the severity of the disease and may avoid further imaging like CXR and CT chest. Absence of ionising radiation with ultrasound makes it an ideal imaging modality for serial assessments, providing an objective measure of disease progression. Ultrasound performed by the treating clinician during the clinical examination may minimise the number of staff encounters, potentially minimise healthcare worker infection rate and cross-contamination among patients.

We anticipate several limitations. Firstly, LUSS and CLUE protocol has never been tested for use in COVID-19 viral pneumonitis and currently a multicentre trial in Australia and New Zealand EDs in progress, to evaluate this scoring system. Secondly, LUS findings are not specific to COVID-19 and may not correlate to clinical outcome. Thirdly, using ultrasound in COVID-19 involves meticulous infection control practice. Finally, LUS requires an operator with a certain degree of training, and we strongly emphasise that beginners to LUS are not to train on these highly infectious patients.

CONCLUSION

CLUE protocol which incorporates lung ultrasound scoring system and supplemental oxygen requirement at the time of examination, when performed by a trained emergency clinician, can help risk-stratify suspected COVID-19 patients. This protocol will aid the clinician to make rapid and appropriate bedside clinical decisions, potentially decrease reliance on chest X-rays or CT chest and aid disposition planning from the emergency department.
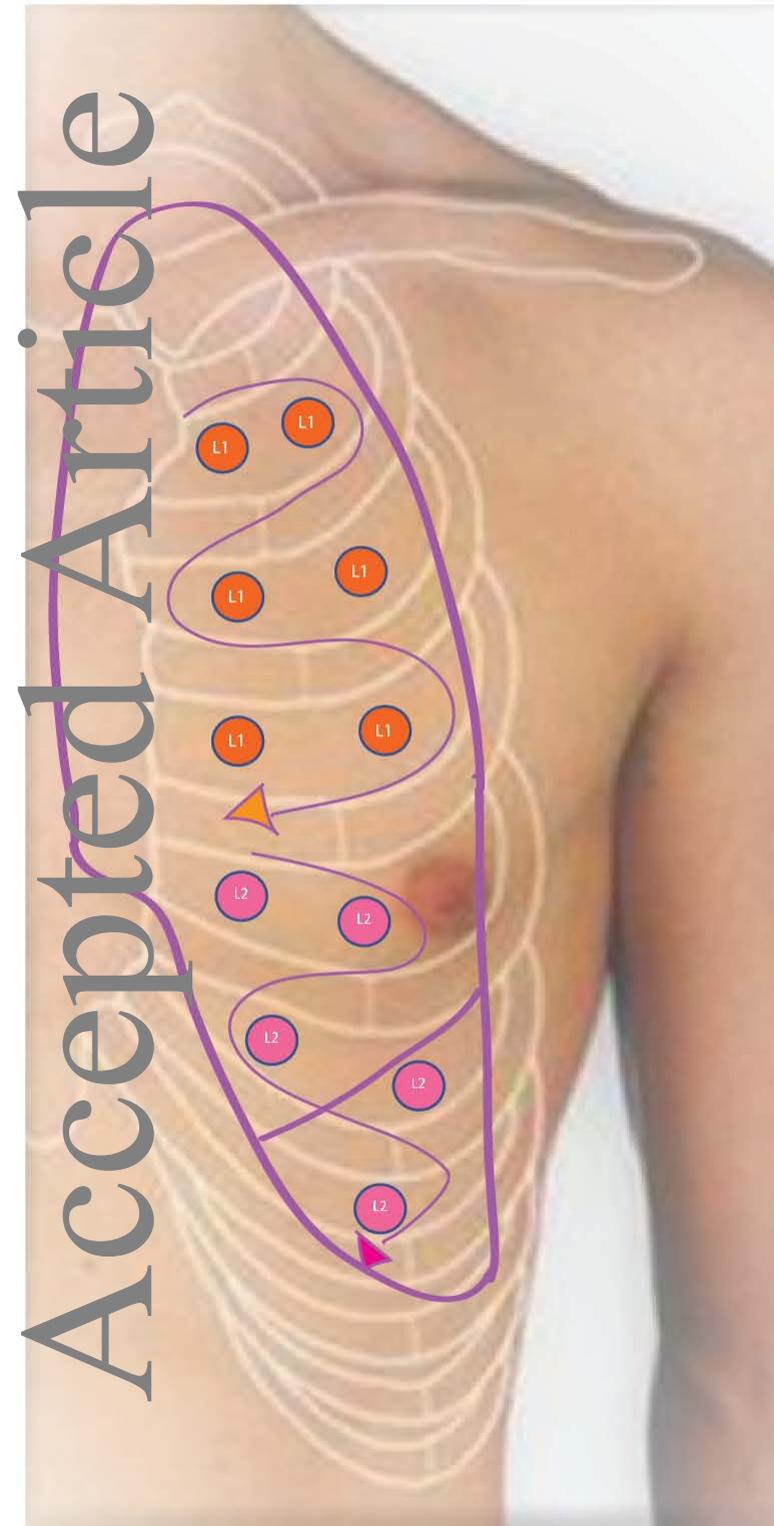
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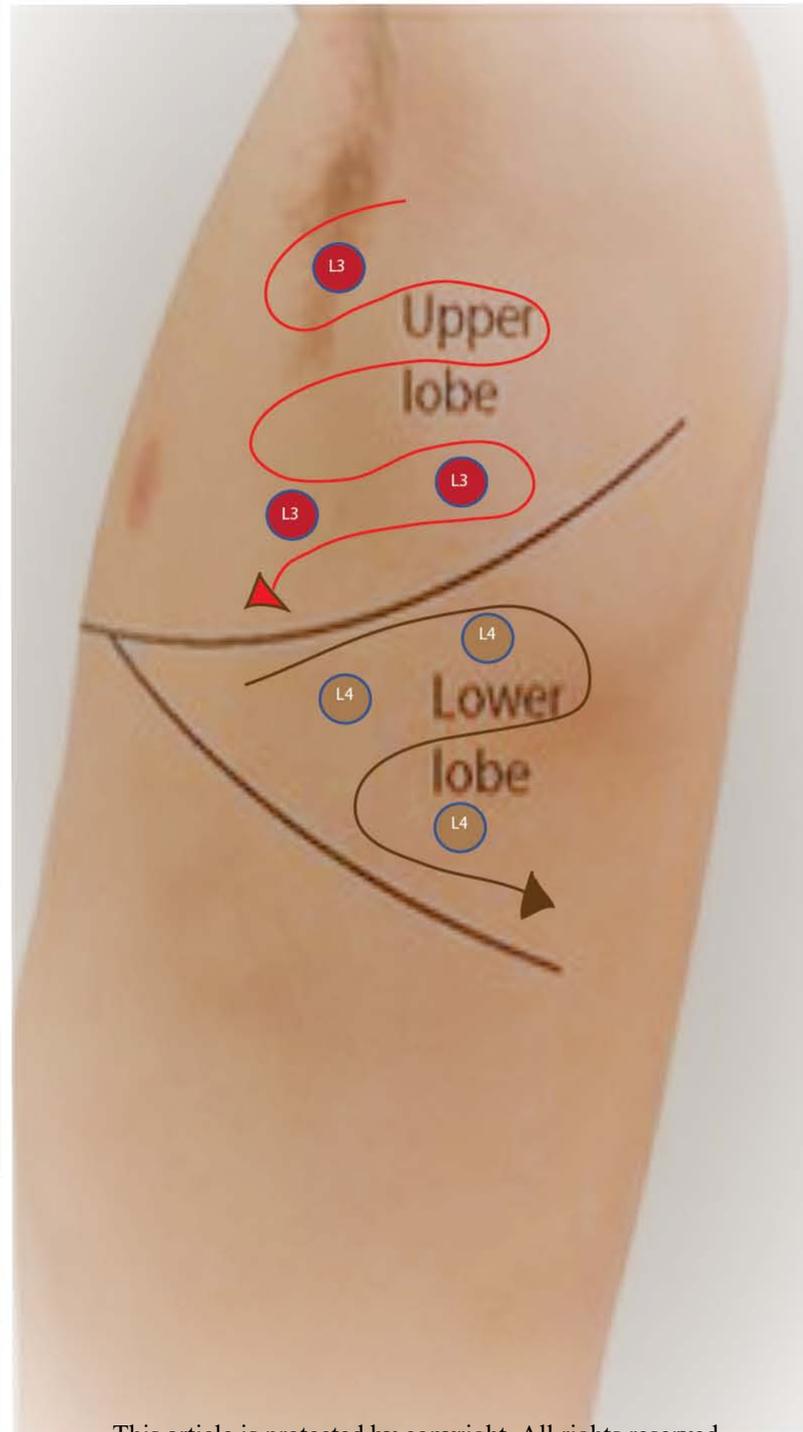
Table 1.Step by Step approach on scanning COVID-19

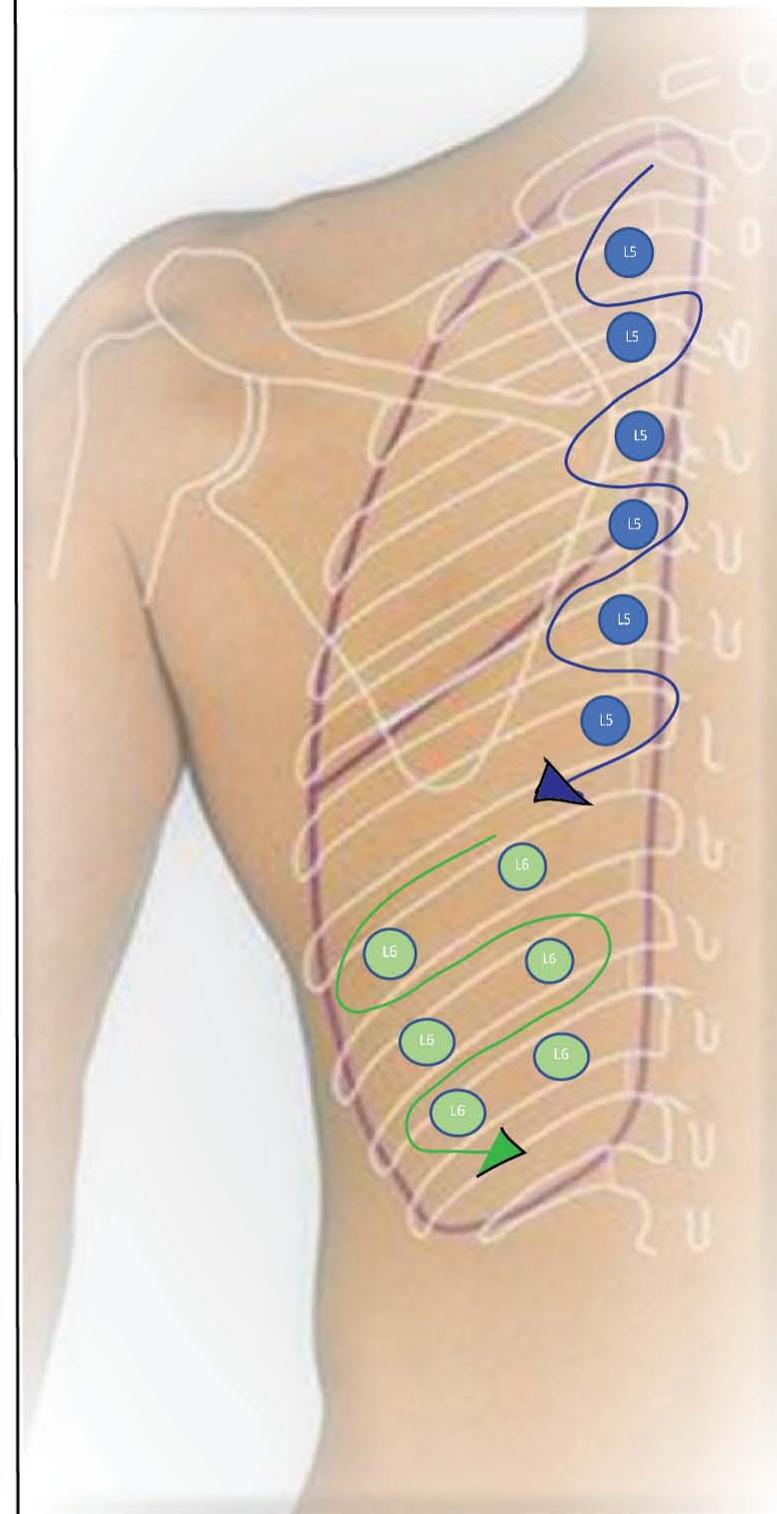| |
|---|
| Don PPE and double gloves. |
| Perform ultrasound only if needed & preferably along with clinical examination. |
| Handheld US device (cover entire device) or Cartwheel US device (transparent plastic drape and transducer cover). |
| Use small disposable packets of gel. |
| Position patient facing away from the sonographer (if possible). |
| Scan posterior lung zones (R5, R6, L5, L6), then lateral zones (R3, R4, L3, L4) and finally anterior zones (R1, R2, L1, L2). |
| Acquire video clips and label presets to minimise keyboard handling. |
| After scanning, remove transducer cover, plastic drape and outer pair of gloves. |
| Wearing the inner pair of gloves, wipe-clean entire machine. |
| Doff PPE, wear new gloves and wipe-clean entire machine again. |

A. Anterior Chest Wall

L1 L1

L1 L1

L1 L1

L2 L2

L2 L2

L2

| L1 | Left upper anterior | | L2 | Left lower anterior |

B. Lateral Chest Wall

L3

Upper lobe

L3 L3

L4

L4 Lower lobe

L4

| L3 | Left upper lateral | | L4 | Left lower lateral |

C. Posterior Chest Wall

L5

L5
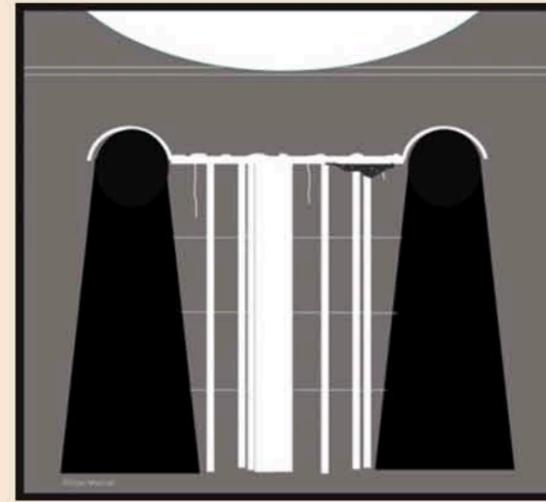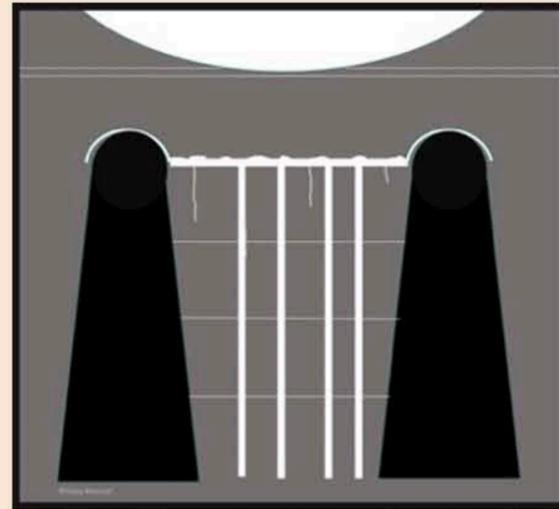
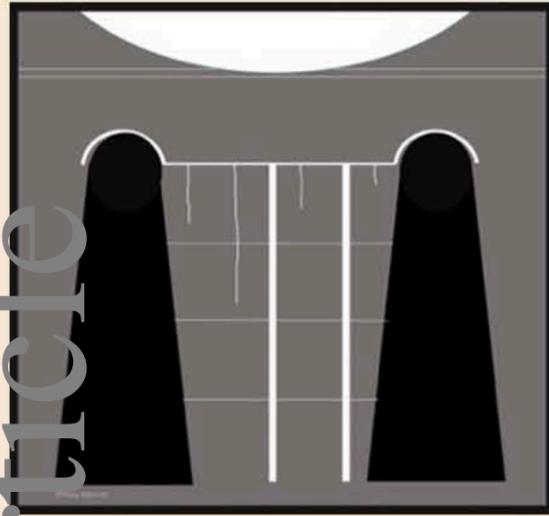L5

L5

L5

L5

L6

L6 L6

L6 L6

L6

| L5 | Left upper posterior | | L6 | Left lower posterior |

CLUE PROTOCOL

COVID19 Lung Ultrasound in Emergency Department

Lung Ultrasound Scoring System (LUSS)

LUSS 0
A lines, 1or2 B-lines, Smooth thin pleural line

LUSS 1
>2 B-lines but discrete, Irregular/ thickened pleura

LUSS 2
Confluent B-lines, subpleural consolidations (height <1cm)

LUSS 3
Large consolidations (height >1cm) +/- air bronchogram +/- vascularity

CLUE protocol

Classification	Total LUSS Score from 12 zones	Clinician's decision to supplement oxygen?	Disposition from Emergency Department	
Normal	0	No	Home	
		Yes	Consider alternate cause & appropriate disposition	
Mild	1-5	No	Home + follow-up monitoring	
		Yes	Home with SPO$_2$ monitoring +/- Oxygen (or) Consider admission to ward	Involve Respiratory / ICU Physician
Moderate	>5 - 15	No		
		Yes	Admit to Ward/ Consider ICU	
Severe	>15	No	Admit to Ward	
		Yes	Admit to ICU	

LUSS= Lung Ultrasound Scoring System, Ward = Respiratory or other appropriate ward, ICU = Intensive care unit, SPO$_2$ = Pulse Oximetry.