Lung Ultrasound

Purpose & Preamble

This is not a standard operating procedure or a guideline it is a distillation of literature and available resources.

This document has the aim of aiding the potential scanning of lung during the COVID-19 pandemic. BMUS does not advocate now is the time to learn lung ultrasound if you are a complete beginner to chest ultrasound. Any training or undertaking of lung ultrasound should be with the support of Radiology Departments and/or Intensivists. Ultrasound Services should not feel pressured to deliver lung ultrasound services if they do not have adequately trained staff. Safety and competency – as always- is paramount.

This is a live document and will remain a live document due to increasing emerging information as the pandemic continues to unfold. It is a guidance document and not absolute.

It is advised that the video clip references given in this document are utilised for to allow better demonstration of the subject matter.

This document is not an extensive chest ultrasound document, nor by reading this does it denote competence in the examination. It is an aid to focus study in lung ultrasound during the Covid-19 pandemic.
Background

The high contagiousness of COVID-19 and the risk of transporting unstable patients with hypoxemia and hemodynamic failure may, in some cases, make chest CT a limited option for the patient with suspected or established COVID-19. Lung ultrasonography has been noted to have results that are similar to chest CT and superior to standard chest radiography for evaluation of pneumonia/pneumonitis and/or adult respiratory distress syndrome (ARDS) with the added advantage of ease of use at point of care, repeatability, absence of radiation exposure. The table below is taken from the WHO interim guidance produced March 2020.

<table>
<thead>
<tr>
<th>Acute respiratory distress syndrome (ARDS) (17-19)</th>
<th>Onset: within 1 week of a known clinical insult or new or worsening respiratory symptoms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest imaging (radiograph, CT scan, or lung ultrasound): bilateral opacities, not fully explained by volume overload, lobar or lung collapse, or nodules.</td>
<td></td>
</tr>
<tr>
<td>Origin of pulmonary infiltrates: respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment (e.g. echocardiography) to exclude hydrostatic cause of infiltrates/edema if no risk factor present.</td>
<td></td>
</tr>
<tr>
<td>Oxygenation impairment in adults (17, 19):</td>
<td></td>
</tr>
<tr>
<td>- Mild ARDS: 200 mmHg &lt; PaO₂/FI O₂ ≤ 300 mmHg (with PEEP or CPAP ≥ 5 cmH₂O, on non-ventilated)</td>
<td></td>
</tr>
<tr>
<td>- Moderate ARDS: 100 mmHg &lt; PaO₂/FI O₂ ≤ 200 mmHg (with PEEP ≥ 5 cmH₂O, or non-ventilated)</td>
<td></td>
</tr>
<tr>
<td>- Severe ARDS: PaO₂/FI O₂ ≤ 100 mmHg (with PEEP ≥ 5 cmH₂O, or non-ventilated)</td>
<td></td>
</tr>
<tr>
<td>- When PaO₂ is not available, PaO₂/FI O₂ ≤ 255 suggests ARDS (including in non-ventilated patients).</td>
<td></td>
</tr>
<tr>
<td>Oxygenation impairment in children: note CI = Oxygenation Index and OSI = Oxygenation Index using SpO₂. Use PaO₂ based metric when available. If PaO₂ not available, use FiO₂ to maintain SpO₂ ≥ 97% to calculate OSI or SpO₂/FI O₂ ratio:</td>
<td></td>
</tr>
<tr>
<td>- Blow-in (NIV or CPAP) &gt; 5 cmH₂O via full face mask: PaO₂/FI O₂ ≤ 300 mmHg or SpO₂/FI O₂ &lt; 264</td>
<td></td>
</tr>
<tr>
<td>- MId ARDS (invasively ventilated): 4 ≤ CI &lt; 8 or 5 ≤ OSI &lt; 7.5</td>
<td></td>
</tr>
<tr>
<td>- Moderate ARDS (invasively ventilated): 8 ≤ CI &lt; 16 or 7.5 ≤ OSI &lt; 12.3</td>
<td></td>
</tr>
<tr>
<td>- Severe ARDS (invasively ventilated): CI ≥ 16 or OSI ≥ 12.3</td>
<td></td>
</tr>
</tbody>
</table>

Anecdotal evidence from those who have working in units with multiple COVID-19 patients have indicated that imaging maybe more useful for problem solving i.e. looking for alternative diagnoses for chest symptoms such as pleural effusion.

Those who are experienced in Chest/Lung Ultrasound should be the team members who should be utilised. ANY Sonographer who feels that they absolutely cannot perform this type of examination with any degree of usefulness and produce an accurate report they should not be forced to do so and individuals should be professionally responsible to highlight this. This document has been created to allow a focus for study and professional development in the current crisis and a desire to aid medical colleagues where CT cannot be accessed or appropriate due to patient condition. It is not all encompassing for all chest ultrasound. Sonographers should also be reminded that medical management decisions will be made on issue of a lung ultrasound report and therefore consideration to a clear report is essential.
ALERT Imaging does NOT definitively diagnose COVID-19. It may define the extent of the disease or suggest and alternative/additional diagnosis.

**Policy**
Before commencement of the examination, the sonographer should enquire about;

- Suspected or Confirmed for COVID-19
- Be fully aware of the PPE required to perform the scan and how to decontaminate post procedure – including the machine.
- If on ITU be directed by the team in charge
- An ultrasound examination request should only be accepted where it will make a clear difference to the patient management pathway.
- The request for ultrasound examination should be vetted and performed when it is likely to affect patient management to avoid unnecessary exposure

To allow comparison to previous US scan it is important that as far as reasonably practicable, the examination should be standardised and images stored to a picture archiving computer system (PACS).

**Patient Consent.**
The sonographer is required to obtain valid consent for lung ultrasound scanning. If procedures are performed on ITU, the sonographer should be familiar with procedures when performing scan in the ‘best interests’ of patients when verbal consent cannot be given.

**Prior to the Examination**
It is important that all precautions are taken when scanning COVID-19 patients (confirmed and suspected). It is suggested that all removable items from the ultrasound cart are taken away prior to the examination commencing. The machine should be protected with regard to prevention of contamination as far as is practicable to enable use. Probe covers which drape along the wire and sterile drapes may be utilised.
Examination.

Standard Technique: where patient condition allows, acknowledging posterior chest will often be the most difficult if at all to obtain.

The standard zones for scanning:

- a) Anterior chest
- b) Lateral chest
- c) Posterior chest

This is the ‘mow the lawn’.

Move the probe relatively slowly to allow you to observe as the patient breathes. Pause intercostally.

Transducer should be held perpendicular to the thoracic cage as illustrated below.
Technical Factors to be considered:
- turn off harmonics, compound imaging
- set focus to pleural line
- Depth at 12 cm (3.5MHz). Abdominal Curvy Transducer
- low dynamic range

Findings of pathology are most likely in the lower posterior zones.

Normal Lung

- Thin pleural line, sliding (on dynamic live scanning)
- ‘Alines’
- Rib shadows

Taken from https://academic.oup.com/bjaed/article/16/2/39/2897763

Taken from https://www.youtube.com/watch?v=8pw9Sxli68A&feature=youtu.be
The bat wing sign

Seeing the bat wing sign (rib-pleural line-rib) can be used as a landmark of correct scanning plane. The artefacts that are produced by a normal pleural lines are described as ‘A’Lines (Horizontal lines below the pleura*).\textsuperscript{4,5} A-lines result from reverberation between the transducer and plural interface. They are equidistant and decrease in intensity.

Normal Lung right lower segment. In a normal patient, mirror image artefact of the liver is seen above the right hemidiaphragm.
B-lines are comet tail artefacts which extend from the pleural line to the depth of the image and extend backwards and forwards evenly on normal respiration.
Abnormal Findings Which Can be Associated with COVID-19

* B-lines appearances increases with interstitial oedema as the air / fluid interface causes reverberation.

Similar to the comet tail artefacts generated by bowel, B-lines extend deep into the patient and move with lung sliding (if present). Much easier to identify in a dynamic image.

Focal scattered B-lines are seen during the early stages of COVID-19.

(However, a few B-lines (<3/field of view) can be a normal finding in the elderly, particularly around the base of the lungs. Serial scans may be useful.

As seen below, multiple B-lines in a diffuse, non-homogeneous pattern indicate lung interstitial syndrome. This is seen in COVID-19 patients as the disease progresses.

B-lines may obliterate A-lines. Reappearance of A-lines seen in recovery patients.

Taken from https://academic.oup.com/bjaed/article/16/2/39/2897763
Sub pleural consolidation
Increased density in B Lines

Irregular pleural line
Patchy B Lines
More severe disease resulting in a large area of consolidation

It may be possible to see the spine continuing into the chest due to the consolidation. It is usually obscured due to air in the normal lungs.
Summary

COVID-19 is a **bilateral** pneumonitis

Signs include

- Pleural thickening
- Focal, patchy B-lines
- Subpleural lesions
- Most often found in the lower posterior zone of the lung

<table>
<thead>
<tr>
<th>Lung CT</th>
<th>Lung ultrasound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickened pleura</td>
<td>Thickened pleural line</td>
</tr>
<tr>
<td>Ground glass shadow and effusion</td>
<td>B lines (multifocal, discrete, or confluent)</td>
</tr>
<tr>
<td>Pulmonary infiltrating shadow</td>
<td>Confluent B lines</td>
</tr>
<tr>
<td>Subpleural consolidation</td>
<td>Small (centimetric) consolidations</td>
</tr>
<tr>
<td>Translobar consolidation</td>
<td>Both non-translobar and translobar consolidation</td>
</tr>
<tr>
<td>Pleural effusion is rare</td>
<td>Pleural effusion is rare</td>
</tr>
<tr>
<td>More than two lobes affected</td>
<td>Multilobar distribution of abnormalities</td>
</tr>
</tbody>
</table>

Negative or atypical in lung CT images in the super-early stage, then diffuse scattered or ground glass shadow with the progress of the disease, further lung consolidation.

Focal B lines is the main feature in the early stage and in mild infection; alveolar interstitial syndrome is the main feature in the progressive stage and in critically ill patients; A lines can be found in the convalescence; pleural line thickening with uneven B lines can be seen in patients with pulmonary fibrosis.

Alternative Diagnoses

There is emerging evidence to suggest that some patients, particularly in a younger age group demographic, are presenting with abdominal pelvic pain as the only symptom. It may be possible with this group of patients to note whilst scanning the upper abdomen, the normal lung or otherwise.

Reporting

**ALERT** Imaging does NOT definitively diagnose COVID-19. It may define the extent of the disease or suggest and alternative/additional diagnosis.

Report findings in a clear way. Bullet point reports may be useful.

Example Reports:

1) There is a unilateral large pleural effusion evident. Very rarely associated with COVID-19 patients

2) There is evidence of bilateral irregular pleural thickening, scattered b-lines and an absence of rib shadowing. These are ultrasound features which can be associated with COVID-19/ARDS/Pneumonitis

**Important Note:** Large pleural effusions have shown to be rare in COVID-19 patients

Empyema
Possible schema for imaging in patients with respiratory symptoms and suspected COVID-19

**Initial evaluation**
- Chest X-ray
- Lung ultrasound (thorough "lawn-mower" exam to look for focal B-lines)

- **CXR negative.**
  - Lung US negative.

- **CXR is normal or shows an equivocal abnormality.**
  - Lung US shows patchy B-lines

- **CXR shows patchy infiltrates or diffuse abnormality which is unequivocal.**
  - Lung US negative

- **CXR shows patchy infiltrates.**
  - Lung US shows patchy B-lines.

**No further imaging.**
- May repeat CXR and lung ultrasound if symptoms persist or worsen.

**Consider CT scan only if this would affect management.**

**Further imaging probably unnecessary.**
- Unlikely to affect management.
- Could be considered in immunocompromised patients if there is concern for other infections (e.g. fungal or pneumocystis pneumonia).

The optimal imaging strategy remains unknown. Chest X-ray and lung ultrasonography are a sensible place to start. CT scanning could have a role in some equivocal situations, but is generally unlikely to affect clinical management (since treatment for mild COVID-19 is supportive).
Further Reading & References

This document should not be used in isolation and therefore further reading is strongly advised.

You may need to familiarise yourself with the glossary of terminology in this document to understand the pathophysiology further with regard to pneumonitis etc.

The teaching tool which is the source documents of this guidance is:

https://www.youtube.com/watch?v=nx6eHINDveM&feature=emb_title

https://www.youtube.com/watch?v=8pw9Sxll68A&feature=youtu.be

https://www.ics.ac.uk/ICS/FUSIC/ICS/FUSIC/FUSIC_Accreditation.aspx?hkey=c88fa5cd-5c3f-4c22-b007-53e01a523ce8 – this document contains datasets to aid reporting and further standards on decontamination

Other online training resources include.

http://www.thepocusatlas.com/pulmonary

http://www.thepocusatlas.com/covid19


11. COVID-19 outbreak: less stethoscope, more ultrasound https://doi.org/10.1016/S2213-2600(20)30120-X

Cross-Reference

Departmental COVID-19 decontamination procedures
Departmental COVID-19 PPE for suspected and confirmed cases
Departmental COVID-19 Donning and Doffing procedures for ITU/aerosol generated environment
Contributors and Acknowledgements:
Adrian Wong. Consultant Intensive Care Medicine and Anaesthesia. Kings College Hospital, London
Catherine Kirkpatrick. Consultant Sonographer United Lincolnshire Hospitals NHS Trust
Andrew Longmead. Advanced Practitioner Sonographer. Royal Chesterfield Hospital.
Heather Venables. Senior Lecturer, Acting Assistant Discipline Lead (Diagnostic Imaging), University of Derby
Pamela Parker. Consultant Sonographer. Hull University Teaching Hospitals NHS Trust