

Abnormal Lung Point-of-Care Ultrasound (POCUS) in Suspected Cases of COVID-19 pneumonia with Normal Plain Chest Radiographs – A Case Series

DO Mort, D Limbu, J Nunan & A Walden

Abstract

COVID-19 pneumonia produces a heterogeneous array of clinical, biochemical, and radiological findings. Over the last few months of global hurry to optimize a testing strategy, it has been suggested that bedside point-of-care lung ultrasound may have a diagnostic role. We present 3 patients with RT-PCR nasopharyngeal swab-confirmed COVID-19 pneumonia, who had an admission plain chest film reported to be normal by a consultant radiologist, but with significant sonographic abnormalities on bedside ultrasound performed within 24 hours of the chest radiograph. Lung ultrasound may better correlate with the oxygen requirement and overall condition of the patient than chest radiographs – a pertinent consideration given the imminent advance of the pandemic into resource-poor zones where timely access to roentgenological imaging may be sparse.

Keywords

COVID-19; point-of-care ultrasound (POCUS)

Teaching point

- Compared to plain chest films, bedside lung ultrasound may be more sensitive, and may better correlate with the clinical status of the patient, in the diagnosis and ongoing management of patients with COVID-19 pneumonia.

Introduction

Following the discovery of SARS-CoV-2 in December 2019 in Wuhan, Hubei province in China, healthcare systems have become overwhelmed with patients presenting with COVID-19 pneumonia. Current testing for SARS-CoV-2 in patients suspected of COVID-19 pneumonia is of limited value: despite the high analytic sensitivity of reverse-transcriptase polymerase chain reaction (RT-PCR) nasopharyngeal (NP) swabs, the variation in sampling and the instability of NG swabs means that the clinical sensitivity may be as low as 63%.¹ Whilst computed tomography (CT) scanning may be an earlier and more reliable way of detecting COVID-19 pneumonia,² there are implications in terms of resource and exposure to ionising radiation which make this impractical in all patients. Current studies demonstrate that plain chest X-rays (CXRs) have a significantly lower sensitivity than CT,³⁻⁵ with case studies demonstrating pathological changes on chest CT performed soon after an unremarkable CXR.⁶⁻⁷

Lung point-of-care ultrasound (POCUS) may aid in the initial triage, prognostication, management, and recovery of patients with COVID-19 pneumonia.⁸ Here, we document 3 cases of RT-

PCR swab-confirmed COVID-19 pneumonia, in whom the admission plain chest radiograph (CXR) was reported normal by a consultant radiologist, but bedside lung POCUS performed within 24 hours of CXR revealed sonographic signs consistent with COVID-19 pneumonia.

Methods

12-point scans were performed independently by two acute medicine junior doctors (DOM and DL), and then reviewed by the hospital's ultrasound fellow (JN) and Intensive Care POCUS lead (AW). The 12-point scans comprised the anterior Bedside Lung Ultrasound in Emergency (BLUE) protocol points, corresponding posterior points, PLAPS (postero-lateral alveolar-pleural syndrome) points, and anterolateral points (Figure 1). Scans were performed using the Butterfly iQ handheld device, displayed on an Apple iPhone 7s Plus. We used the scoring criteria for 12-point scans in the context of suspected COVID-19 which is currently proposed by the Society of Acute Medicine (SAM⁹):

- 0 = A lines or <2 B-lines
- 1 = 2 or more well-spaced B lines
- 2 = Coalescent B-lines +/- small consolidations <1cm

Daniel Owen Mort
BMBCh¹

Dipraj Limbu
MBBS¹

Joseph Nunan
MBBS¹

Andrew Walden
MBBS^{1,2}

¹ Acute Medical Unit, Royal Berkshire Hospital, Reading, UK

² Intensive Care Unit, Royal Berkshire Hospital, Reading, UK

Correspondence

Andrew Walden
Royal Berkshire Hospital,
London Road, Reading, UK,
RG1 5AN
Email: andrew.walden@nhs.net

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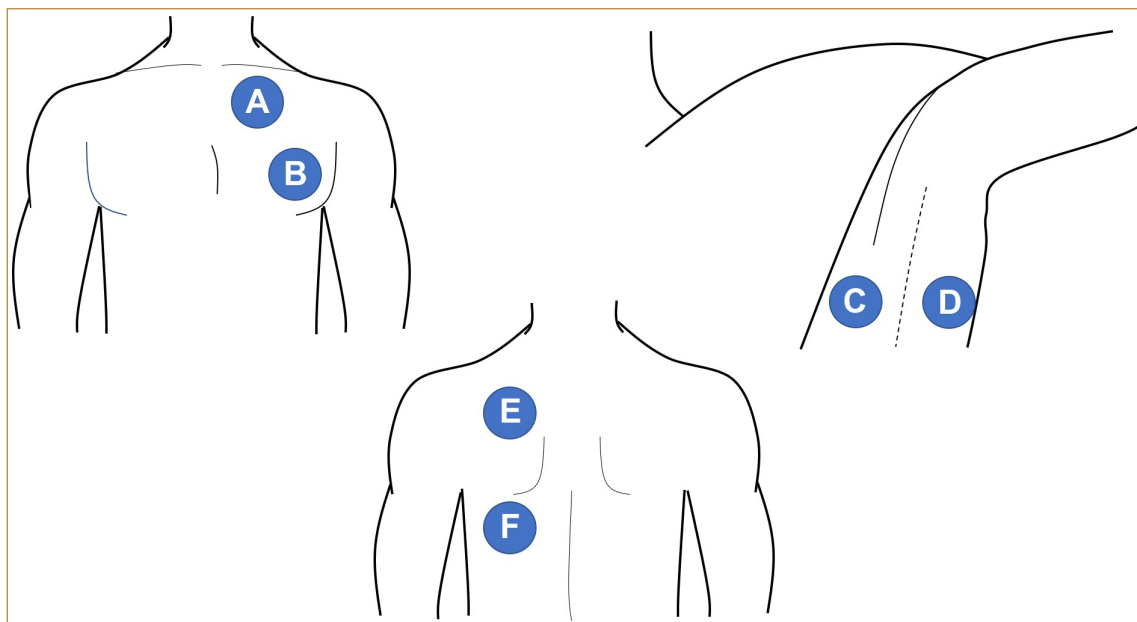


Figure 1. The 12-point bedside lung POCUS scan (left side only demonstrated here): A – upper anterior BLUE point; B – lower anterior BLUE point; C – anterolateral point; D – posterolateral/“PLAPS” point (dotted line = mid-axillary line); E – upper posterior point; F – lower posterior point. Exact points necessarily vary slightly with the patient’s body habitus and position of optimal intercostal views. A slight modification was made in Case 3 – where upper and lower lateral points were scanned instead of anterolateral and PLAPS points.

- 3 = Tissue-like pattern +/- frank consolidation +/- small consolidations >1cm

Patients were selected as a convenience sample, and were consented using the British Medical Journal (BMJ) Image Consent Form.

Case 1

A 24-year-old woman with no medical co-morbidities presented to the Emergency Department (ED) with eight days of progressively worsening shortness of breath, dry cough, myalgia, fatigue, with four days of central pleuritic chest pain. Observations on admission were oxygen saturation (SpO_2) 92% on room air, heart rate (HR) 122 bpm, blood pressure

(BP) 105/74 mmHg, respiratory rate (RR) 20 bpm. On examination, she had mild accessory muscle use and was only able to speak in short sentences, with bilaterally reduced air entry. Bloods showed C-reactive protein (CRP) 87mg/l, ferritin 1448 micrograms/l, D-dimer 829microgramsFEU/l, with partial pressure oxygen (pO_2) 11.4kPa on arterial blood gas (ABG) on 2 litres of oxygen. Her admission CXR was reported normal by a consultant radiologist (Figure 2a). A RT-PCR NP swab taken at admission returned positive for SARS-CoV-2 infection.

She was admitted to the ward for observation and given 1g oral amoxicillin TDS. 24 hours after her normal CXR, 12-point bedside lung POCUS

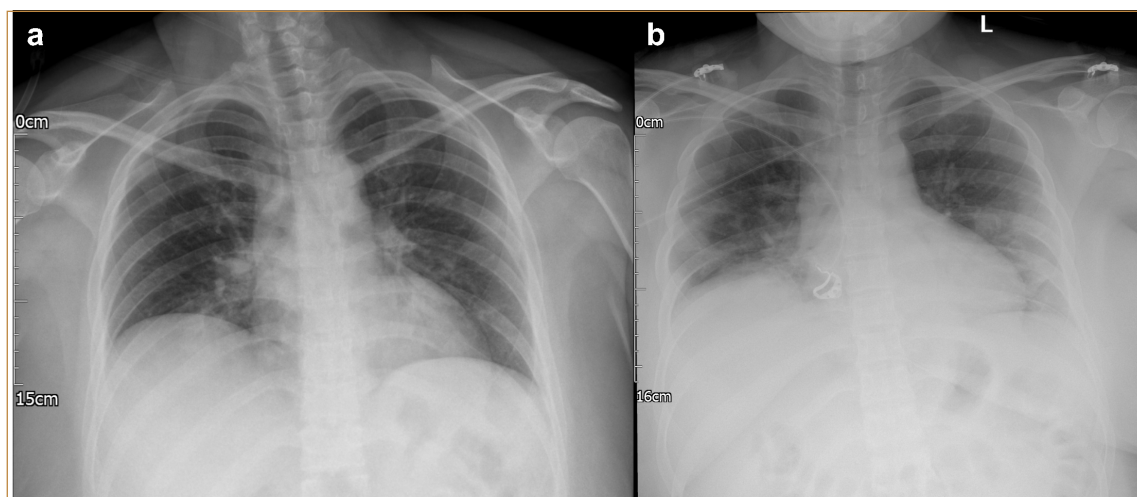


Figure 2. Case 1’s CXRs: day of admission – reported as normal by consultant radiologist
48 hours after admission – reported as patchy mid/lower zone consolidation by consultant radiologist

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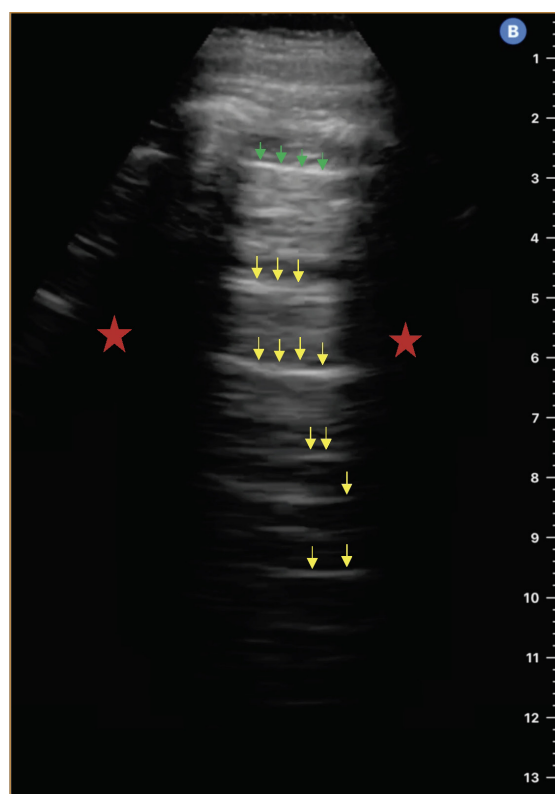


Figure 3. An example of normally-aerated lung, from the right posterior upper point of Case 1's 12-points POCUS scan. Note the undisturbed pleura (green arrows), well-defined A-lines (yellow arrows), with rib shadows on either side (red stars)

was performed. This showed bilaterally preserved anterior lung and upper posterior lung (Figure 3 – as a normal reference), with confluent B-lines and small <1cm consolidations in the right and left anterolateral (Figure 4a) and left PLAPS (Figure 4b) points, larger >1cm consolidation in the right posterior lower zone (Figure 4c), and a small consolidation with an associated small pleural effusion in the left posterior lower zone (Figure 4d). The total SAM score was 11/36. Her oxygen requirement at the time of bedside POCUS was the same as at the time of CXR – requiring 2l O₂ to maintain SpO₂ >94%.

Over the following 24 hours, she desaturated (pO₂ 11.4 on 4l O₂) with significantly increased work of breathing since admission, RR 35 bpm, BP 89/65 mmHg, HR 120 bpm, T 39.0°C, and so was escalated to our Higher Monitoring Unit (HMU) to trial continuous positive airways pressure (CPAP) ventilation, starting at 5 cmH₂O with 5l entrained O₂, with cautious intravenous fluid administration to manage her hypotension. A repeat CXR was performed, reported as patchy mid/lower zone consolidation (Figure 2b). Her work of breathing and hypoxia improved after 24hrs of CPAP. She was weaned off the CPAP and oxygen over the next 72 hours and discharged home.

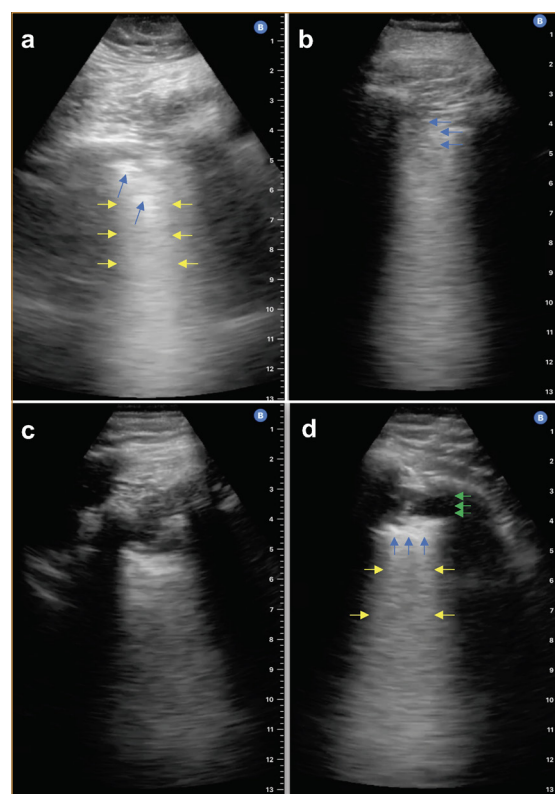


Figure 4. Case 1's Bedside Lung POCUS 24 hours after CXR. left anterolateral: large confluence of B-lines (yellow arrows) with superadded consolidative changes (blue arrows) left PLAPS point: consolidation (blue arrows) with poorly-aerated lung (absence of A-lines; confluent B lines – difficult to appreciate on static image, but note absence of A-lines with hyperechogenic texture throughout intercostal space, compared with normal lung in Figure 1) right posterior lower: frank consolidation with hepatization of lung (green arrows), small consolidation with air bronchograms (blue arrows), with underlying poorly aerated lung. left posterior lower: 2 poorly separated B-lines, becoming confluent (yellow arrows), small consolidation (blue arrows), and small pleural effusion (green arrows)

Case 2

A 58-year-old woman with hypertension and angina presented with 10 days of fever, myalgia, lethargy, shortness of breath worsening on exertion, coughing up white sputum, with one episode of diarrhoea, not improving with oral amoxicillin. Observations on admission were temperature 38.7°C, HR 91 bpm, BP 140/106 mmHg, SpO₂ 94% on room air, RR 24 bpm. On auscultation, she had some inspiratory crackles at the right base. Bloods were unremarkable. Her admission CXR was reported normal by a consultant radiologist (Figure 5a). A RT-PCR NP swab taken at admission returned positive for SARS-CoV-2 infection.

She was admitted to the Acute Medical Unit for observation and given intravenous ceftriaxone 2g OD. Over the following 24 hours, she developed a significant oxygen requirement, needing 4l O₂ to

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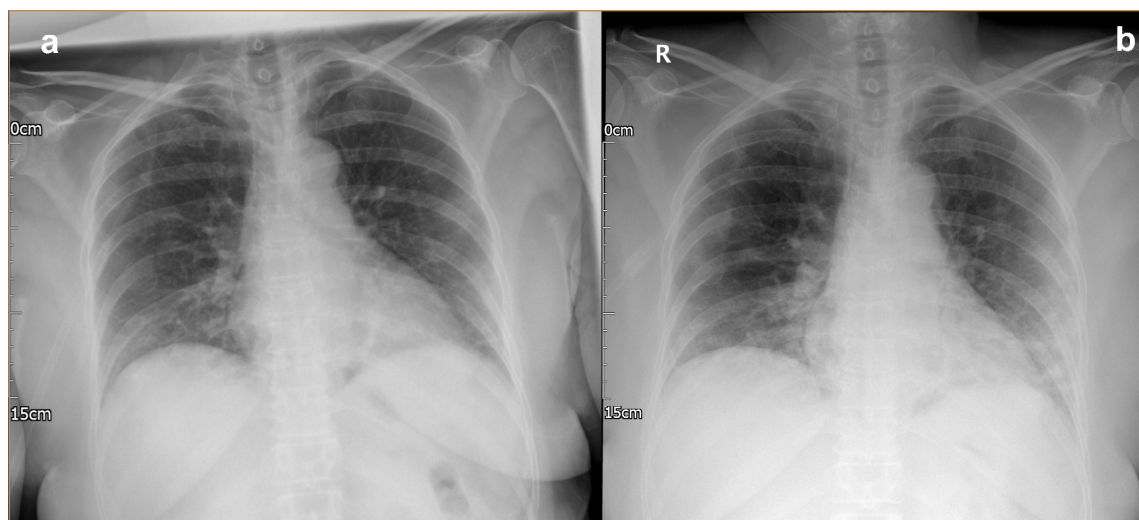


Figure 5. Case 2's CXRs: day of admission - reported normal by consultant radiologist 116 hours after admission – reported as subtle bilateral infective changes by consultant radiologist

maintain SpO₂ > 94%, and was persistently febrile. 19.5 hours after her reported-normal CXR, a bedside lung POCUS was performed (Figure 6a-d). This showed confluent B-lines, with occasional small <1cm consolidations, bilaterally throughout most of the posterior and posterolateral lung (Figure 6b-c), and also interstitial oedema in the left anterolateral (Figure 6a) and right upper anterior BLUE point (Figure 6d), with the rest of the anterior chest being relatively spared. The total SAM score was 14/36. A repeat CXR four days later only showed subtle bilateral infective changes, as reported by the consultant radiologist. (Figure 5b)

She completed 5 days of i.v. ceftriaxone, and her oxygen was gradually weaned over the following 10 days, after which she was successfully discharged.

Case 3

A 71-year-old woman with hypothyroidism, chronic lymphedema, chronic back pain, osteoporosis, and mild cognitive impairment presented with worsening shortness of breath, dry cough and mild confusion. She had been discharged from hospital two days previously after a 7 day course of intravenous antibiotics (benzylpenicillin and clindamycin) for a beta-haemolytic streptococcus group G bacteraemia. During that admission, she had a CXR reported normal by a consultant radiologist, and an RT-PCR NP swab was negative for SARS-CoV-2. Observations on admission were RR 22 bpm and SpO₂ 91% on 4l O₂. On examination she appeared flushed, delirious and had bilateral crackles and wheeze on chest auscultation. She was lymphopenic (0.70), with a CRP of 29 and an acute kidney injury (estimated glomerular filtration rate of 34 on a baseline of 70). Her admission CXR was reported normal by a consultant radiologist (Figure 7). A RT-

PCR NP swab taken at admission returned positive for SARS-CoV-2 infection.

6 hours after the CXR, bedside lung POCUS was performed (Figure 8a-d). This showed an irregular

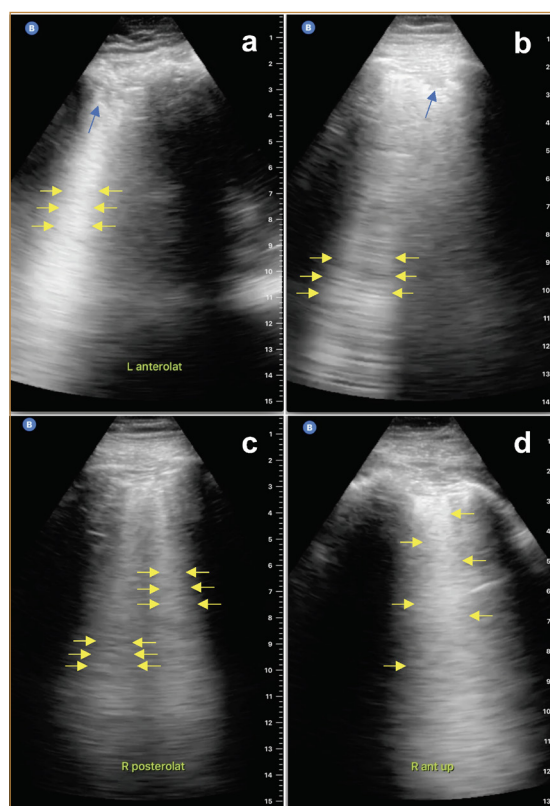


Figure 6. Case 2's Bedside Lung POCUS 19.5 hours after CXR. left anterolateral zone: confluent B-lines (yellow arrows) and small consolidation with air bronchograms (blue arrow) left posterior lower zone: 2 poorly separated B-lines (yellow arrows) with significant pleural disruption (blue line) right PLAPS zone: 2 well-separated B-lines - each of which probably is comprised of confluent B lines (yellow arrows) right anterior upper zone – large confluence of B lines (yellow arrows)

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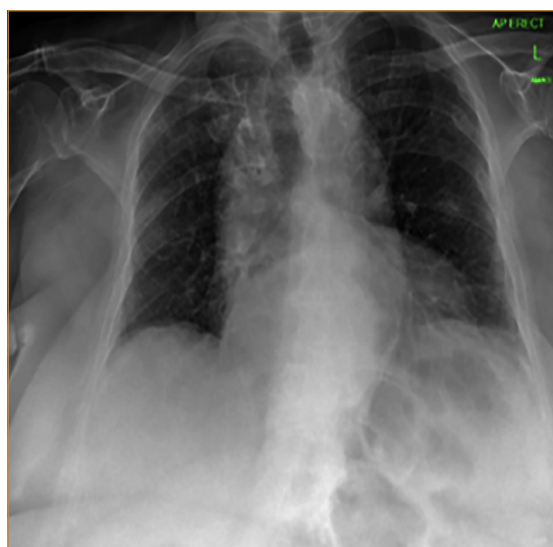


Figure 7. Case 3's CXR on day of admission – reported normal by a consultant radiologist

pleural line with consolidation (>1 cm) at the right anterior lower point (Figure 8a), and irregular, thickened pleural lines at the right PLAPS point. There were confluent B-lines with irregular and thickened pleural lines (small subpleural consolidation <1 cm) in the left and right posterior upper and lower zones (Figure 8d), scattered B-lines in the left posterior lower zone, with thickened and irregular pleural lines and confluent B-lines on the left lateral upper point (Figure 8c). The total SAM score was 11/36.

Since she had a raised D-dimer, a CT pulmonary angiogram was done within 24 hours of admission (Figure 9), which showed patchy ground-glass opacity in the right upper lobe, left upper lobe and lingula, consistent with COVID-19 pneumonia.

During her stay as an inpatient she clinically improved with supportive management and a course of oral co-amoxiclav. She was discharged from hospital after 7 days of admission.

Discussion

Five months after the initial emergence of SARS-CoV-2, the optimal imaging strategy for suspected cases is not yet clear. One study found that 31% of patients hospitalized with suspected (later swab-confirmed) COVID-19 had a normal admission CXR,³ and amongst 636 ambulatory patients with swab-confirmed COVID-19, 58.3% had CXRs reported normal by consultant radiologists aware of the swab results.⁴ CT chest is a more sensitive tool, with one study⁵ reporting 97% sensitivity amongst swab-positive hospitalized patients, but CT is clearly limited by reduced availability and increased cost compared with other imaging modalities, as well as by the time taken to decontaminate the CT facility after each scan. Over the coming months,

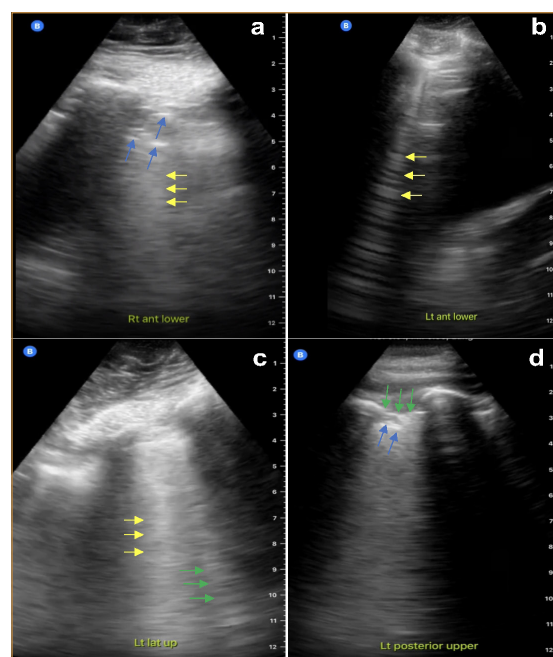


Figure 8. Case 3's Bedside Lung POCUS 6 hours after CXR. right anterior lower zone: confluent B-lines (yellow arrows) and irregular pleural line with subpleural consolidations (blue arrows) left anterior lower zone: B-line (yellow arrows) left upper lateral zone: 1 confluence of B-lines (yellow arrows) poorly-spaced from a separate B-line (green arrows) right posterior upper zone: confluent B-lines (difficult to appreciate on static image – but note absence of A-lines with hyperechogenic texture throughout intercostal space, compared with normal lung in Figure 1) and irregular pleural line (green arrows) with small subpleural <1 cm consolidation (blue arrows)

relying on a CT-based approach to diagnosis and ongoing evaluation would also expose a significant proportion of the population to ionizing radiation – which is of particular relevance amongst the young adult demographic hospitalized with COVID-19 pneumonia. Both CXR and CT findings tend to be most pronounced at around day 10 of symptoms.^{3,10}

Lung POCUS is cheap, quick, and does not expose the patient to ionizing radiation. It may be more readily available in low-resource settings where CT and adequate numbers of RT-PCR tests are not available. It is also easily repeatable at the bedside in the face of a changing clinical picture. However, currently, there is a lack of high-quality evidence from a range of different authorship groups to definitively support the use of bedside lung POCUS in the assessment and management of COVID-19 pneumonia¹¹ as expected given the relatively recent emergence of the pandemic. Case series^{8,12-13} have demonstrated findings of multifocal B-lines and consolidations with pleural line irregularity and thickening, most concentrated in the lower posterior zones. However, these findings are not specific for COVID-19, so must be taken in the context of the clinical history, examination, and laboratory findings.

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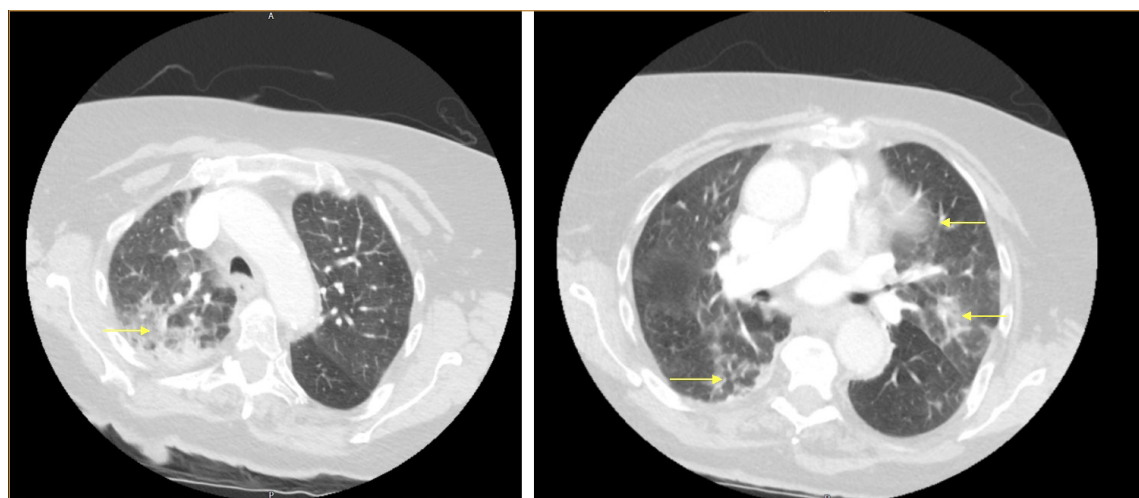


Figure 9. Case 3's CTPA – performed within 24 hours of admission – showing bilateral patchy ground-glass opacities (yellow arrows)

This case series raises 2 questions which merit further study. Firstly, lung POCUS may be a more sensitive imaging modality, and may better correlate with CT imaging, than consultant-reported CXRs for suspected cases of COVID-19 at the time of initial hospitalization. Secondly, lung POCUS may correlate more closely with oxygen requirement, severity of respiratory distress, and overall clinical picture than CXRs, for said cases. It may therefore be a more suitable test to repeat in the face of a clinically deteriorating patient, rather than sending the patient for repeat plain films, or ordering portable films that put further hospital personnel at risk of infection.

There is therefore good rationale to conduct a larger prospective observational study to accurately

determine the test characteristics of bedside POCUS, compared with CXR and CT chest. A formal investigation of the amount of time and training required to suspect COVID-19 on lung ultrasound would also be warranted – especially given the potential utility of POCUS in the low-resource settings of the predicted pandemic epicentres of Latin America and sub-Saharan Africa over the coming months.

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none

Conflicts of Interests

No conflicts of interest declared.

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