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Case report

Thoracic ultrasonic narration of Covid-19 pneumonia

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ABSTRACT

Covid-19 (SARS-CoV-2) is a new coronavirus. Since the declaration of a global pandemic, a lot has been learnt about its spread, disease pattern, diagnosis and management. The lungs remain the prime organs to incur serious insult and when lung complications embark, significant morbidity and mortality is observed. Predominantly, patchy and peripheral lung distribution in the Covid-19 pneumonia has been described in the radiology experience and literature. There are a range of imaging modes useable in diagnosis, prognosis, monitoring, and therapy of Covid-19. However, when it comes to the appropriateness and the potential benefits of imaging, resource utilization and infectious risk must be considered. The use of ultrasound during this pandemic has provided us with an alternate imaging modality that is easily performed at the bedside, with real time images available to the clinician. This case highlights the role played by the thoracic ultrasound in the diagnosis and progression of Covid-19 pneumonia.

A 68-year-old Caucasian lady presented, feeling generally unwell, to the Accident and Emergency (A&E) department at Antrim Area Hospital, Northern Ireland. She described a one-week history of cough, lethargy and high-grade temperature, with gradual worsening of symptoms over that period. She noticed a rapid deterioration in her exercise tolerance and progressive shortness of breath. Her past medical history included controlled hypertension, asthma, seronegative arthritis and diverticulitis. She was not on any immunosuppressive medications. A week prior to admission, this lady was independent with her activities of daily living.

On admission her respiratory rate was 30 breaths per minute, blood pressure 134/88 mmHg, heart rate was 108 beats per minute, with a regular rhythm and temperature was 39.9 °C. Her oxygen saturations on room air were 84% and an arterial blood gas showed pH 7.49, PaO_2 6.9 KPa, $PaCO_2$ 4.3 KPa, HCO_3 24.7 mmol/Litres and arterial blood saturations of 85.1%. She was given 4 L oxygen via nasal cannula and her saturations increased to 98% and respiratory rate lowered to 24. The total white cell count was 5.7×10^9/Litres but lymphocytes of 0.31×10^9/Litre (1–3 10^9/Litre) were seen on differential cell count. D-Dimer was 2140.0 ng/mL (0–250 ng/mL). Serum C reactive protein was 182 mg/Litre, but liver function tests, electrolytes, and bone profile were unremarkable. She was admitted to a dedicated ward for Covid-19 positive patients. Oral antibiotics were started to cover any potential bacterial chest infection. The physician-led chest ultrasound showed thick, ragged and rough pleural surfaces due to increased fluid content in the lungs (pulmonary and pleural oedema). There was some pleural sparing and more than three variable density B-lines, originating randomly from the pleural surface in an individual intercostal space were evident. Few A-lines were still preserved, but the B-lines were heterogeneous and asymmetrical in their distribution (Image-1a, 1b, 1c, 1d, 1e & 1f). Her chest x-ray showed bilateral and dominantly peripheral patchy air space opacities in the left midzone (Image-1g). Later that day, her swabs returned positive for Covid-19 virus.

She initially remained stable on 4 L of oxygen but deteriorated with temperature spike of 40 °C on day six. Her oxygen demand increased to 15 L, respiratory rate increased to 38 breaths per minute and CRP to 307 mg/Litres. High flow nasal AIRVO oxygenation (HFNO) therapy was commenced. Antibiotics were escalated and were changed to the intravenous route. Repeat thoracic ultrasound revealed notching and roughness of pleural surface. The B-lines spread bilaterally and were more frequent, variable, dense, coarse and intense in nature. The confluent B-lines generated an impression of a search light ("search light sign") emitting from the pleural surface with respiration. Compressed B-lines extended over an individual intercostal space created the impression of waterfalls ("waterfalls sign"). C-lines originated from the ragged pleural surface (line) bilaterally, suggesting emergence of early micro-consolidations (Image-2a, 2b, 2c, 2d, 2e & 2f). Chest x-ray showed worsening in the number and intensity of airspace opacities bilaterally

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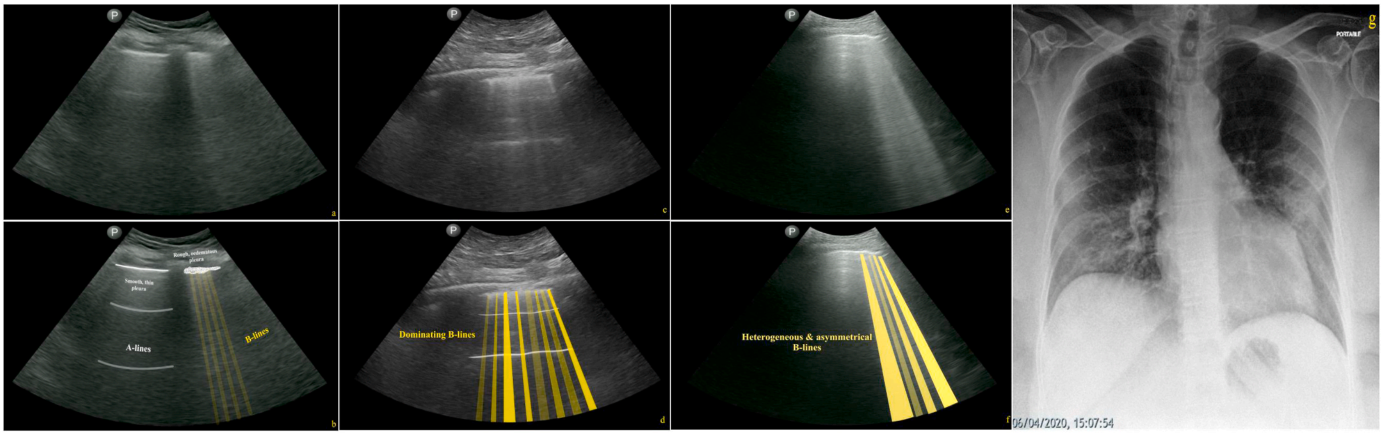

Fig. 1. 1a & 1b- Pleural oedema with relative sparing and preserved A-lines. **1c & 1d-** Pleural oedema and overpowering B-lines with few A-lines. **1e & 1f-** Heterogeneous B-lines in an intercostal space. **1g-** Bilateral but dominantly unilateral shadowing (Mild Covid pneumonia).

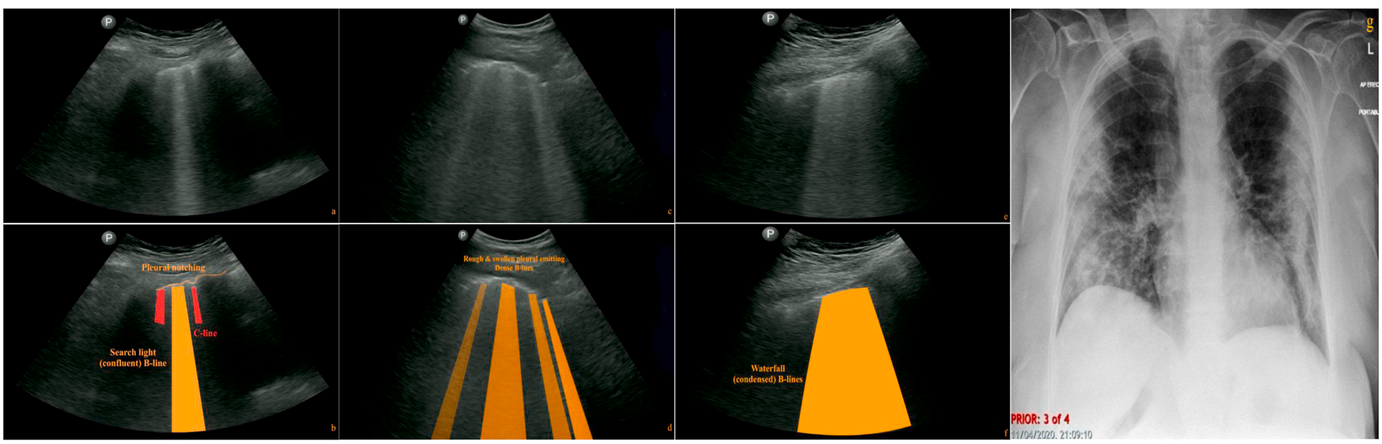

Fig. 2. 2a & 2b- Notched pleura, confluent B-lines (search lights) and C-lines. **1c & 2d-** Rough and ragged pleura and dense B-lines. **2e & 2f-** Condensed B-lines (waterfalls) and emerging C-lines. **2g-** Dense & bilateral air space shadowing (Moderate Covid pneumonia).

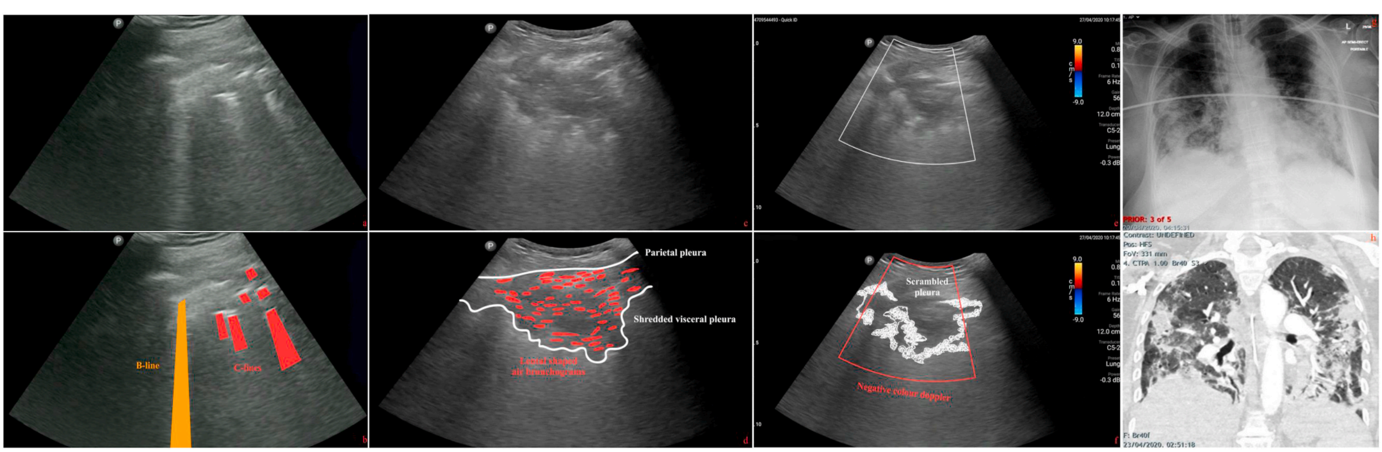

Fig. 3. 3a & 3b- Distorted pleural surface and dominant C-lines. **3c & 3d- P**arietal & visceral pleural separation (Shred sign) and air bronchograms. **3e & 3f-** Distorted (scrambled pleura) and negative colour dopplers. **3g & 3h-** Dense airspace shadowing (severe Covid pneumonia). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

(Image-2g). These changes were indicative of worsening Covid-19 pneumonia due to advancing lung oedema.

The patient started feeling increasingly tired on AIRVO and was intubated and transferred to the intensive care unit (ICU). Portable chest x-ray revealed bilateral confluent and denser airspace consolidations. On thoracic ultrasound, the C-lines (consolidation) pattern became dominant. The consolidations of variable size and shape containing air-bronchograms were visible. Visceral and parietal pleurae were separated (shredded), hence, creating the “shred sign”. The pleural visceral pleural surface became fuzzy due to increased oedema, creating the impression

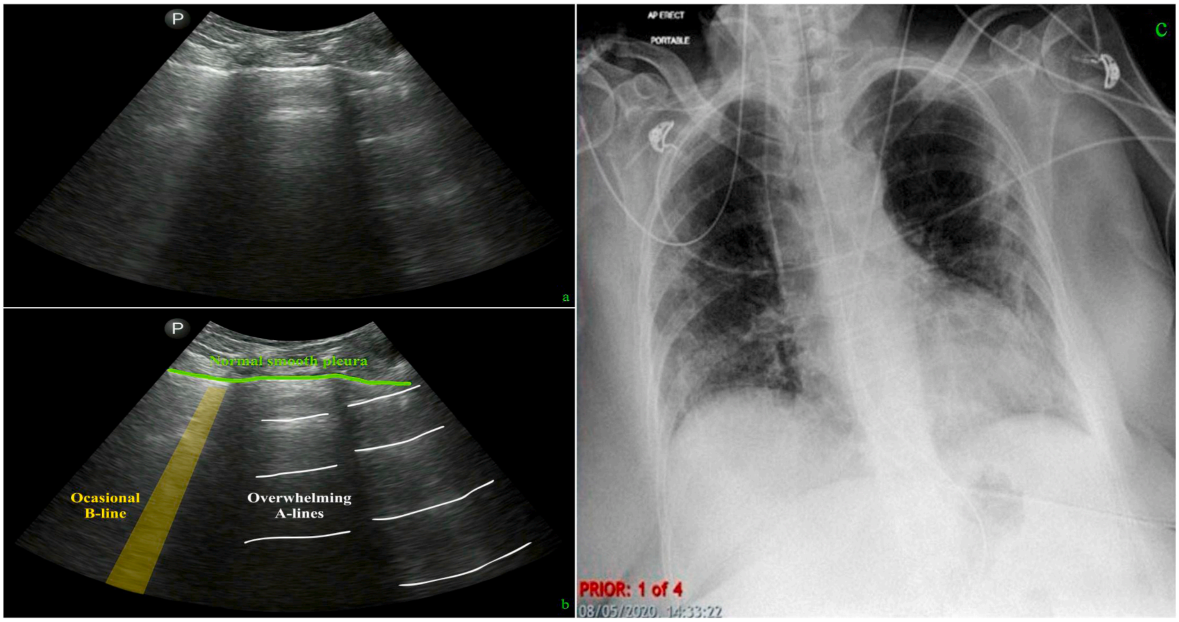

Fig. 4. 4a & 4b- Smooth pleural surface, overwhelming A-lines and occasional B-lines. **4c-** Minimal air space shadowing (resolving Covid pneumonia).

of scrambled pleura ("scrambled pleural sign"). The lungs remained boggy but were devoid of overt pleural fluid. Therefore, the colour Doppler uptake was negative signifying a negative "fluid colour sign" (Image-3a, 3b, 3c, 3d, 3e & 3f). Portable chest x-ray revealed bilateral confluent and denser airspace consolidations. Computed tomography pulmonary angiogram (CTPA) was negative for embolism but confirmed bilateral, peripheral ground glass shadows. Confluent basal consolidations and multifocal and multiscale airspace shadows suggested severe and critical pneumonia (Image- 3g & 3h).

This lady remained in the intensive care unit on ventilation support for 32 days and made an excellent recovery. Thoracic ultrasound showed resurgence of the normal smooth pleural surfaces, A-lines dominance, less than three B-lines in an intercostal space and occasional activity of Z-lines on normal breathing (Image- 4a & 4b). Her CXR showed resolution of the pneumonia (Image-4c). She was discharged home after a week and remains clinically stable as per most recent clinic review.

Discussion

Covid-19 (SARS-CoV-2) is a new coronavirus. Since the declaration of a global pandemic, a lot has been learnt about its spread, disease pattern, diagnosis and management. However, it remains a mysterious illness due to its erratic spread, unpredictable clinical course and uncertainty of outcome [1]. Although various organs of the human body are affected by Covid-19 (SARS-CoV-2), the lungs remain the prime organs to incur serious insult and when lung complications embark, significant morbidity and mortality is observed [2]. Pneumonia with Covid-19 (SARS-CoV-2) virus leads to a stormy illness and rapid clinical deterioration can be a real possibility. Prolonged hospitalisation may be required for improvement in patients with Covid-19 pneumonia [3].

Prior to establishing a definite diagnosis of Covid-19 pneumonia, clinical suspicion and radiological judgment is required to ensure timely management of this illness. Radiological changes may be non-existing at the time of presentation and may evolve later but rapidly [4]. Globally, a delay in nasopharyngeal and sputum swab results caused a sluggish response in decision making, appropriate triage and suitable bed allocation for patients with high suspicion of Covid-19 illness [5]. The diverse radiological findings have been reported by various studies [6]. Predominantly, patchy and peripheral lung distribution in the Covid-19 pneumonia has been described in the radiology experience and literature. Overall, there are heterogeneous, reticular, airspace consolidation patterns which become confluent and dense with disease progression. However, the classical lobar or segment involvement is absent which is common in bacterial pneumonias [7]. There is minimal or no pleural effusion in Covid-19 (SARS-CoV-2) pneumonia radiology.

There are a range of imaging modes useable in diagnosis, prognosis, monitoring, and therapy of Covid-19. However, when it comes to the appropriateness and the potential benefits of imaging, resource utilization and infectious risk must be considered [8]. Many learned societies and health services have created recommendations and guidelines for the professionals locally and globally. Chest radiograph is generally used as the first diagnostic imaging mode, followed by chest tomography. The initial findings can be non-specific [9]. The threshold for radiological imaging can vary depending on resources, infection control, clinical governance, sociocultural norms and guidelines and the clinical setting. When a Covid −19 patient is seriously ill or suddenly deteriorates, a timely radiograph or CT chest is needed which can be limited by the crucial factors like infection control, personal protection equipment (PPE), logistic arrangements, staff availability, patient positioning, ventilation and dependence on high oxygen [10].

The use of ultrasound during this pandemic has provided us with an alternate imaging [11] modality that is easily performed at the bedside, with real time images available to the clinician. This can be reproduced daily and help guide the patients' clinical course. Minimising other contact with this highly contagious disease is preferable and if ultrasound scanning is carried out at the bedside, this exposure can be limited to the operator [12]. This can help avoid further staff exposure and the need for patient transfer within the hospital, as would be required for other forms of imaging. It is of course operator dependent but could be used throughout admission for triaging severity of disease, from emergency room admission, through to ward level management and in an intensive care setting. The lack of radiation and subsequent risk to patient is a further positive to this modality of imaging [13].

This case highlights the role played by the thoracic ultrasound in the diagnosis and progression of Covid-19 pneumonia. It demonstrates that thoracic ultrasound imaging is extremely sensitive to discriminate between an aerated and unaerated lung [14]. The normal lung is stacked with horizontal A-lines and vertical B-lines start to populate as it loses oxygen due to oedema. B-lines reach the whole length of an ultrasound image and differ from Z-lines normally seen on the surface of pleura as minute vertical artefacts of no clinical significance. As the pneumonia progresses, the lung becomes laden with B-lines [15]. The commotion of B-lines creates artefacts like "search light sign" or "waterfall sign". The C-lines originate from pleural erosion, terminate before reaching the full length of the ultrasound image and are pathognomonic of lung consolidation [16]. In bacterial pneumonia, consolidations are segmental, sub-segmental or lobar with air and fluid bronchograms within. However, the consolidations of Covid-19 are geographical, patchy and peripheral. The severe Covid-19 pneumonia displays lentil shaped air bronchograms but are devoid of fluid bronchograms and hence the "fluid Doppler sign" is negative. The reversal of line patterns recommences, when pneumonia starts to subside [17].

Thoracic ultrasound is underused in pneumonias [18]. However, when dealing with this pandemic, it is vital to innovate, diversify, utilise this mode and share experiences. Our experience of thoracic ultrasound has created a positive impact on our practice. Changes in clinical condition, variation in oxygen demand, X-ray and CT images, requirement of ventilation support, and even the clinical improvement are clearly reflected with our series of ultrasound images [19]. It highlights that bedside clinical progress can be monitored closely and clinical care can be prioritised appropriately by using thoracic ultrasound as a decision-making tool kit for Covid-19 pneumonia patients. As our understanding has grown, it is felt that a focused chest ultrasound can play a vital role in patient triage, timely diagnosis, clinical course, severity evaluation, ventilation commencement and withdrawal [20]. As we endeavour to develop our acumen and service, we hope this case will generate interest among other clinicians and will provoke the desire to use chest ultrasound for rapid clinical judgement and patient and medical staff safety.

Declaration of competing interest

There is no conflict of interest as stated in the cover letter and signed authors statement.

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