A direct comparison between five lung-US and chest-CT-scans in a patient infected by SARS-CoV-2

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Abstract

The gold standard for SARS-CoV-2 pneumonia diagnosis is chest Computed Tomography (CT), but Lung Ultrasound (LUS) is also useful in differential diagnosis and in-hospital monitoring of patients with infection by new Coronavirus 2019 disease (COVID-19). We present a case of a young man who was infected with SARS-CoV-2 pneumoniae and underwent five steps of chest imaging, including LUS aeration scorings and chest CT scans. Each decrease or increase in LUS scoring could accurately predict CT scan changes.

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Introduction

Chest Computed Tomography (CT) is the gold standard for identifying SARS-CoV-2 pneumonia.[1] Ground glass opacities, consolidation, reticular and crazy paving patterns are typical CT manifestations.[2] Instead, COVID19 pneumonia LUS patterns are irregular pleural lines, coalescent B lines with large "light beams", patchy distribution, and subpleural mantle consolidation areas.[3] These clinic-related patterns enable the identification of probability levels, which is extremely useful for making a diagnosis.[4,5] Despite the fact that LUS has inherent limitations (operator dependence, quantification difficulties), many studies have found a strong correlation between the two methods.[6,7]

Case Report

C.S., a forty-year-old man, was admitted to our Emergency Department (ED) on 03/17/20 with a cough, fever, fatigue, malaise, and diarrhoea that had begun eight days prior to the presentation.

He didn't smoke and had no comorbidities. Except for tachycardia, mild tachypnoea, and fever, his vital signs were normal (OS 98% without oxygen supplementation, BP 140/93 mmHg: RR 22, HR 115 bpm, BT 38°C). The physical examination revealed only minor inspiratory rales.

Based on the symptoms, the differential diagnosis included bacterial or viral upper respiratory tract infection, bacterial pneumonia caused by *Streptococcus pneumoniae* or *Legionella pneumophila*, which could cause Gastrointestinal (GI) symptoms, viral pneumonia caused by influenza viruses, or viral or bacterial primary GI infectious. However, due to the timing of the pandemic, the most likely diagnosis was SARS-CoV-2 infection.

Investigations and management

The arterial blood gas testing without oxygen supplementation did not find respiratory failure (Ph 7,38; pO2 68 mmHg; pCO2 36 mmHg; P/F 324; HCO3- 25 mmol/L). RT-PCR assay from nasopharyngeal swab was diagnostic for SARS-CoV-2 infection. Two instrumental examinations were performed at the same time at the ED: lung ultrasound and chest CT scan.

Lung US, executed with topographic scheme and standardized

score,[8] detected three areas with isolated B-lines and three areas with coalescent B-lines next to intact zones obtaining a final score of 9/45 (L2 region was excluded because it was completely occupied by the heart).

Chest CT-scan reported areas of ground glass opacities and consolidation bilaterally patchy spread that are typical of chest CT manifestations of new coronavirus 19 disease.[1,9] Videoclip n.1 shows each thoracic area explored with ultrasound and CT acquisitions performed at the ED, corresponding to the ninth day from the onset of symptoms (Videoclip n.1: First CT and Lung US (03/17/20) LUS score 9/45).

The patient was admitted in the Infectious Diseases Department and started an antiviral drug (lopinavir/ritonavir 400/100 mg PO twice daily), hydroxychloroquine (200 mg PO twice daily), antibiotics (ceftriaxone 2 gr IV once daily and doxycycline 100 mg PO twice daily) and antithrombotic therapy (enoxaparin 6000 UI SC once daily), according to local protocols available in that period.[10] The patient also received supplemental oxygen at the rate of 3 L/min through nasal cannula.

During the fourth day of hospitalization (03/21/20) the clinical conditions worsened. The patient presented dyspnoea requiring oxygen therapy with fraction of inspired O2 of 50%. The arterial blood gas testing detected a P/F of 180 (PaO2 90/ FiO2 0.5).

A lung US examination was immediately performed detecting large bilateral consolidation in inferior and posterior areas and coalescent B-lines[11] in the others without defined spared areas. The final Lung Ultrasound (LUS) score was 36/45.

Chest-CT scan confirmed bilaterally widespread consolidations, some of them with air bronchograms and a crazy paving pattern in the superior and medium lobes and in the lingula.

Two doses of an interlukin-6 inhibitor (Tocilizumab 400 mg IV) were administered at 12 hours interval of time and the patient started. Considering the respiratory conditions, high flow nasal cannulas (FiO2 60%) were applied in dedicated negative pressure rooms of the infectious disease ward, in line with the indications regarding the ventilatory support of COVID-19 patients.[12,13]

Videoclip n. 2 shows lung ultrasound and chest CT performed on the fourth day of hospitalization, corresponding to the twelfth day from the onset of symptoms (Videoclip n.2: Second CT and Lung US (03/21/20) LUS score 36/45).

After six days (03/27/20) the patient improved, he did not need to use high flow nasal cannulas and had a 95% oxygen saturation with 35% FiO2 delivery set on Venturi mask. The P/F value at arterial blood gas testing was 350. Chest imaging exams were repeated to confirm the positive clinical changes.

LUS showed regression of the previous large consolidations that gave way to interstitial involvement with several areas of coalescent and others of isolated B-lines. Some spread areas also reappeared. The final LUS score was 25/45.

The CT-scan described regression of the consolidations in the inferior lobes occurring in some ground-glass areas. In the superior lobes could be seen a redistribution of the consolidations that remained in the lingula.

Videoclip n. 3 shows both instrumental examinations, performed on the seventeenth day from the onset of symptoms (Videoclip n.3: Third CT and Lung US (03/27/20) LUS score 25/45).

The patient was discharged asymptomatic after nineteen days of hospitalization (04/04/20) with a P/F of 450 without oxygen supplementation.

Follow-up

After three months (07/25/20) the patient was called to a follow-up assessment and performed both LUS and chest CT scan. LUS examination showed a full recovery with no pulmonary areas involved by B-lines or consolidations. LUS score was 0/45. Chest CT-scan confirmed the healing: quite total regression of high-density areas bilaterally barely noticeable in the upper regions of the left superior lobe and right inferior lobe (Videoclip n.4: Follow-up CT and Lung US (07/25/20) LUS score 0/45).

Materials and Methods

Data for this clinical case were collected during a prospective observational clinical study in accordance with the ethical principles expressed in the Helsinki Declaration, in accordance with the Good Clinical Practice Internationals standards. This research protocol was approved by the local ethics committee on April 7th, 2020. The clinical case in question dates from the first pandemic wave, when validated LUS assessment schemes were not yet available. We used a 16-area scanning scheme (8 for each hemi-thorax) to emphasize posterior chest analysis in order to obtain the most accurate topographical description possible.[4] To cover the largest possible surface with a single scan, we used convex probes (frequency 2.5-5 MHz) along the intercostal spaces with the transverse approach. The standardized scanning scheme enabled each area to be evaluated and a numerical score based on lung aeration to be assigned. The score is similar to the one used in ARDS,[8] with score 0 in case of normal aeration, score 1 in case of 3 or more B-lines or coalescent B-lines occupying ≤50% of the screen, score 2 for B-lines occupying >50% of the screen, score 3 for tissue-like consolidation. The sum of all values obtained within the 16 areas yields a final LUS score, which indicates a decrease in lung aeration as the score increases. The medical personnel who performed the LUS scans were already experts in LUS and had received additional training on COVID-19 pneumoniae.

Discussion

Approximately 400 cases of SARS-CoV-2 infections were diagnosed by our ED in March and April 2020, with 318 of them requiring hospitalization.[10] To stage the severity of lung involvement, all patients had an initial lung ultrasound exam and a chest CT-scan, and then patients were monitored using lung ultrasound.[10] Additional CT-scans were requested based on clinical conditions.

Lung ultrasound was performed in this case using a scanning technique adapted from a previously validated scheme.[8,11] We chose four anterior [1-4] and four posterior [5-8] areas per hemithorax, divided vertically by anterior and posterior axillary and scapular lines and horizontally in the middle, from various clinical reports.[6] Each lung zone was assigned a score that described lung aeration and ranged from 0 if A-lines were predominant or there were three distinct B-lines to 3 if large consolidations (at least > 1 cm) were detected. Score 1 e 2 were characterized by B-lines occupying respectively ≤ 50% or > 50% of the screen. The final score was calculated by adding the scores from each area.

This case demonstrates a similar capacity of the two techniques in detecting lung involvement, both in severity and distribution, due to the large number of examinations with corresponding timing between ultrasound and CT.

During our experience with lung ultrasound in patients infect-

ed with SARS-CoV-2, we noticed a good ability of this exam to detect lung findings and LUS scores correlated to the severity of clinical conditions,[12,14] but we were not often able to compare LUS and CT-scan in such advanced stages of the disease as in this case to understand how precisely LUS can predict CT-scan patterns.

Several studies comparing LUS and CT-scan have been published,[3,5] and more will be published in the coming months. This parallel is intriguing not only for monitoring hyperacute phases, but also for imaging performed after disease recovery, with the possibility of promoting lung ultrasound as a remote follow-up tool.[15]

Why should an emergency physician be aware of this?

This clinical case describes an intriguing parallelism between LUS and chest CT-scan, bolstering our efforts to study and perform lung ultrasound and opening the door to future considerations. Clinical judgment was used to perform the examinations (US and CT) in order to shed light on the patient's course and the underlying pathophysiological mechanisms. The presented case demonstrates that LUS can be an accurate and versatile tool for confirming pneumonia progression as the cause of clinical worsening in a patient admitted for COVID-19, with an interesting parallelism with chest CT.

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