

Pulmonary ultrasound in COVID-19: case series

Ultrasonografía pulmonar en COVID-19: serie de casos

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Abstract

Objective: To describe the pulmonary ultrasound findings in a case series of patients with COVID-19. **Method:** Ten patients with a confirmed diagnosis of COVID-19 by PCR were included. A 2-dimensional, 12-quadrant lung ultrasound was performed on each patient. **Results:** The identified patterns were: alterations of the pleural line due to disruption/unevenness (100%), pleural thickening (100%), subpleural consolidation (90%) and laminar pleural effusion (80%), pattern B1 (60%), pattern B2 (40%) and consolidation (20%), which correlates with autopsy findings reported in literature, characterized by interstitial infiltrate, alveolar collapse, and pulmonary condensation. **Conclusions:** Pulmonary ultrasound provides information on the status of patients with COVID-19, which allows modifying the therapy used, impacting clinical results and optimizing the use of available resources. The findings of this descriptive study correspond to those described worldwide, concluding that most patients will have some pathological pleuropulmonary finding at the time of their initial evaluation, which shows that ultrasound is a useful study in evaluation and follow-up of patients with COVID-19.

Keywords: Consolidation. COVID-19. Pleural effusion. B lines. Pulmonary ultrasound.

Resumen

Objetivo: Describir los hallazgos ultrasonográficos pulmonares en una serie de casos de pacientes con COVID-19. **Método:** Se incluyeron 10 pacientes con diagnóstico de COVID-19 confirmado por reacción en cadena de la polimerasa. Se realizó ultrasonido pulmonar de dos dimensiones y de 12 cuadrantes a cada enfermo. **Resultados:** Los patrones identificados fueron alteraciones de la línea pleural por disrupción/desnivel (100%), engrosamiento pleural (100%), consolidación subpleural (90%) y derrame pleural laminar (80%), patrón B1 (60%), patrón B2 (40%) y consolidación (20%), lo que se correlaciona con los hallazgos de autopsias reportados en la literatura, caracterizados por infiltrado intersticial, colapso alveolar y condensación pulmonar. **Conclusiones:** El ultrasonido pulmonar brinda información sobre el estado de los enfermos con COVID-19, que permite modificar el tratamiento empleado, impactando en los resultados clínicos y optimizando el uso de los recursos disponibles. Los hallazgos de este estudio descriptivo coinciden con los descritos en todo el mundo, concluyendo que la mayoría de los pacientes tendrán algún hallazgo pleuropulmonar patológico en el momento de su evaluación inicial, lo que muestra que la ultrasonografía es un estudio de utilidad en la evaluación y el seguimiento de los pacientes con COVID-19.

Palabras clave: Consolidación. COVID-19. Derrame pleural. Líneas B. Ultrasonido pulmonar.

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Introduction

The disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), called coronavirus disease 2019 (COVID-19), was first described in December 2019. It is a disease that shares clinical characteristics with the severe acute respiratory syndrome by coronavirus described in 2003 (SARS-CoV).

Due to its rapid spread, this disease became an epidemic. On January 30, 2020, it was defined as a public health emergency of international concern¹ and was declared a pandemic by the World Health Organization on March 11, 2020².

SARS-CoV-2 binds to angiotensin-converting enzyme type 2 receptors and primarily causes respiratory system involvement; however, there is evidence of compromise of the nervous, cardiovascular, gastrointestinal, renal and hematological systems³.

According to observations published by Huang et al.⁴, the main clinical characteristics of this disease are fever (77-98% of cases), cough (67.8%), fatigue (38.1%), myalgia and arthralgia (14.9%), odynophagia and headache (13.5%), and dyspnea (18.7%).

As for imaging studies, plain chest X-rays may not show abnormal patterns at disease onset, and in the case of computed tomography (CT), alterations may appear even after the first six days⁵.

Chest X-ray, although less sensitive than CT, is the first-line modality, used for evaluating patients with suspected COVID-19. In the cohort studied by Wong et al.⁶, made up of COVID-19 patients, chest X-ray showed a sensitivity of 69% in comparison with 91% for polymerase chain reaction (PCR).

Main findings on chest X-ray are asymmetrical, diffuse "ground glass" opacities, while on CT, sub-pleural consolidations with poorly defined margins and with a certain tendency to preferably affect the right lower lobe are common⁷. They can evolve into diffuse bilateral opacities, consolidations and reticular or mixed pattern involving several lung segments^{5,7}. Findings of bilateral interstitial pneumonia are also described, with patchy lesions, asymmetrical and mainly distributed at pulmonary periphery⁸.

Within this context, PCR and CT imaging are the basis for diagnosis. The need to mobilize the patient to the radiology area limits the performance of CT, and it is necessary to take into account protective measures for both health personnel and the rest of patients who require CT tests in order to this way avoid cross-infection¹.

In current epidemiological situation, rapid identification of cases, severity determination and correct treatment selection are essential for increasing health systems' response capacity, and it is here where lung ultrasound is introduced as a diagnostic tool.

Ultrasound in general, carried out at patient bedside, is a safe, non-invasive, low-cost, ionizing radiation-free, readily available, reproducible and dynamic procedure, but it is the imaging modality that most depends on the operator, i.e., on his/her expertise and knowledge⁹.

It is necessary to take into account that, despite the advantages described for this imaging technique, availability of equipment and trained personnel can be a limitation for its use as a diagnostic tool.

The basic principles for its use are the technical art in its performance, establishment of its indications, recognition of normal anatomical structures, distinction between normal structures and areas with pathology, description of findings, establishment of diagnostic possibilities and recommendations for the performance of other tests or interventions⁹.

Ultrasound introduction

The introduction of ultrasound in emergency and critical care units has been gradual. The first ultrasound device was developed in 1950, but it was until 1980 that real-time images could be acquired, which is one of the most important factors for the widespread use of ultrasound¹⁰.

One of the first protocols was "Focused Assessment with Sonography in Trauma" (FAST), a term coined in 1996 by Rozycki and collaborators, which was designed to determine the presence of fluid within the abdominal cavity, pericardial space and pleural spaces in trauma victims¹¹. Over the past three decades, this protocol has been extensively studied both in blunt and penetrating trauma¹². In the hands of most operators, it allows to detect a minimum of 200 mL of fluid. It is considered the most important advance in the initial evaluation of the patient with blunt trauma since the introduction of diagnostic peritoneal lavage¹¹.

Ultrasound in Mexico

In Mexico, since 2007, a formal ultrasound course was implemented as a higher university diploma course and, subsequently, competency-based courses endorsed by the World Interactive Network Focused On Critical Ultrasound (WINFOCUS), with the purpose

to implement dissemination strategies, training and certifications aimed at and based on objectives.

From that moment on, training in critical ultrasound was formally initiated by Dr. Rincón Salas in Mexico, and spread to the entire country^{13,14}.

Chest ultrasound

Chest ultrasound is not a new procedure; there are reports dating back to 1986¹⁵. Initially, the lungs were considered not approachable by ultrasound due to the limitation of this imaging technique for traversing air and bone tissue. An aerated lung cannot be visualized by ultrasound and behaves like an ultrasound mirror. Ultrasound waves are reflected when making contact with air, with deep reflection artifacts, the so-called A-lines¹⁶, being generated. The presence of A-lines, together with the existence of pleural sliding, virtually rule out pneumothorax with 100% specificity and 88% sensitivity¹⁴.

Ultrasound acts as a pulmonary densitometer, which allows to distinguish between three fundamental patterns depending on the ratio between air and fluid: aeration A pattern, interstitial B pattern and consolidation C pattern¹⁶ (Fig. 1).

In the presence of an A pattern, the search for the cause of hypoxia has a sensitivity of 89% and specificity of 97% for diagnosing chronic obstructive pulmonary disease or asthma¹⁴.

The B pattern represents a wet lung, mainly at the interstitial level. In the diagnosis of pulmonary edema, the presence of a B pattern (predominance of B-lines in a number higher than 3) has a sensitivity of 97% and specificity of 95%. The finding of three or more B-lines is considered pathological and is called interstitial syndrome. If isolated B-lines are identified, it is defined as a B1 pattern, and if they are confluent, as B2 pattern¹⁴.

The A/B pattern indicates the presence of an A pattern in certain areas of the lung and of a B pattern in other. It can diagnose pneumonia with 99% specificity and 11% sensitivity¹⁴ (Fig. 2).

The C pattern corresponds to consolidations, which may be sub-pleural or parenchymal, and may or may not be associated with pleural effusion.

Since 1995, pleural ultrasound has been known to be the best tool for pneumothorax diagnosis, with a sensitivity of 95% and a negative predictive value of 100%¹⁷. In the case of pleural effusion, sensitivity is 94% and specificity 97%¹⁸, and for pulmonary thromboembolism, together with ultrasound of the lower limbs for deep vein thrombosis, sensitivity is 81%, and specificity, 99%.

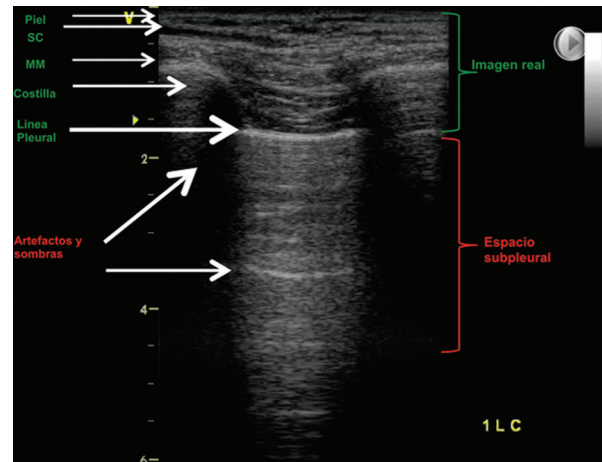


Figure 1. Acoustic window in normal lung ultrasound. Note the pulmonary field that is generated between the two acoustic shadows generated by the ribs and the hyperechoic pleural line corresponding to parietal pleura, which with respiratory movements will cause sliding and the artifacts that are generated below. Piel: skin; SC: subcutaneous tissue; MM: muscle mass; Costilla: Rib; Línea Pleural: Pleural Line; Imagen real: Real image; Artefactos y sombras: Artifacts and shadows; Espacio subpleural: Sub-pleural space.

Lung ultrasound is a useful tool for approaching different acute respiratory diseases, with acute respiratory distress syndrome (ARDS) standing out. When carried out by a trained physician, it can optimize COVID-19 patients triage and care, both at the emergency department and the intensive care unit (ICU)¹⁹; for this reason, it has been implemented as a diagnostic and follow-up procedure in patients with COVID-19⁸.

In the study published by Zanobetti et al.²⁰, which evaluated the concordance between chest ultrasound and chest X-ray in patients with dyspnea, using chest CT as a reference method in case of discrepancy between both modalities, mean time between the request for an X-ray and its final interpretation is reported to be 1 hour and 35 minutes. Ultrasound, when immediately interpreted as the scan is carried out, has advantages over X-ray²⁰. In particular, ultrasound showed higher sensitivity than X-ray in patients with pleural effusion ($p < 0.0001$). When ultrasound and X-ray yielded discordant results, CT confirmed ultrasound findings in 63% of patients ($p < 0.0001$)²⁰.

Lichtenstein and Mezière²¹ studied the potential of lung ultrasound for the diagnosis of acute respiratory failure. They carried out an observational study in which consecutive ultrasounds were performed on patients admitted to the ICU with acute respiratory failure and compared the findings at the time of initial presentation with ICU team final diagnosis. The results showed that anterior alveolar consolidations, diffuse

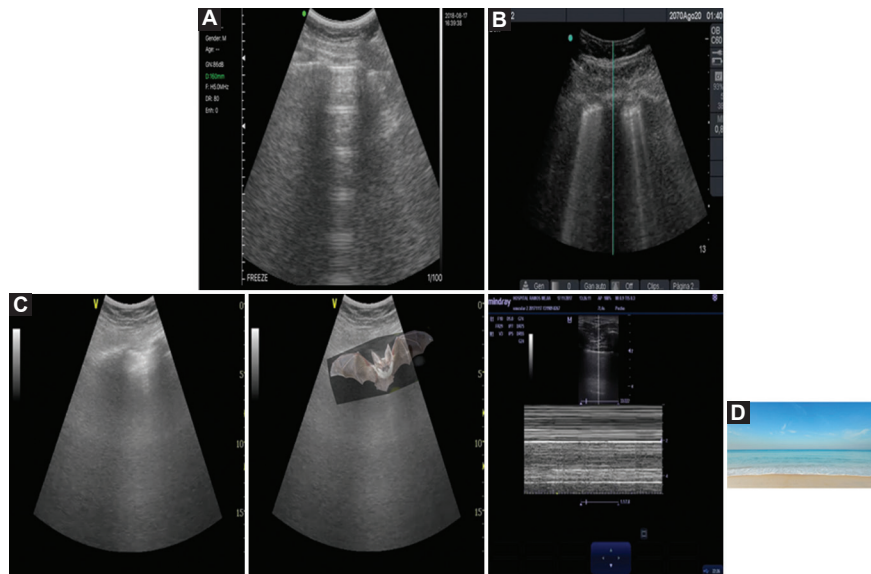


Figure 2. Artifacts generated by the pleural line. **A:** Hyper-echogenic horizontal lines, equidistant between each other. **B:** Hyper-echogenic vertical lines that reach the end of the acoustic window and move with pleural movement. In a number less than 3, they do not indicate pathology. **C:** Image that is formed between the ribs and the pleural line that resembles a bat. **D:** In M-mode, the ultrasound pulmonary field resembles an image of sand, sea and sky, also called the “sea-shore sign” owing to its similarity.

anterior B-lines with pleural sliding disappearance, asymmetric anterior interstitial patterns, and posterior consolidations or effusion without diffuse anterior B-lines were indicative of pneumonia, with a sensitivity of 89% and specificity of 94%.

Ultrasound findings in COVID-19 change as the disease progresses. This characteristic allows emergency personnel to initially classify and diagnose suspected patients, and subsequently allows disease progression monitoring during hospitalization²².

During the first week, unilateral or bilateral, dispersed multilobar B-lines will be visualized. As the disease progresses (7 to 14 days) an alveolar-interstitial syndrome, with diffuse bilateral B-lines, sub-pleural consolidations formation and aerial bronchogram may develop. After 14 days, during convalescence, there may be a regression of previous findings²².

Due to the above, ultrasound is useful at different phases and disease presentation forms, while allowing patient monitoring.

The purpose of this work is to present ultrasound findings in patients with COVID-19 and correlate them with the findings described in the literature on autopsies of this type of patients.

Method

Descriptive, prospective, observational, single-center, case series study²³.

Patient selection

Ten patients with PCR-confirmed COVID-19 diagnosis in April 2020 at a secondary care hospital belonging to the public sector and social security of Mexico City were included. These patients were admitted for meeting the operational definition of COVID-19 suspected case, established by the National Epidemiological Surveillance Commission (CONAVE – *Comisión Nacional de Vigilancia Epidemiológica*)²⁴ and updated in March 2020. A number from 1 to 10 was assigned to each case and plain chest X-rays were collected from each one of them. Personal, pathological history and other relevant clinical data were obtained from the medical record. All recruited patients signed an informed consent document for performing the lung ultrasound and reviewing their medical records. Of the total number of evaluated patients, four had severe disease and six had moderate disease. Evaluated patients were between the first 5 to 14 days of symptom onset at the time of examination.

Ultrasound equipment

A SonoScape E2 equipment with convex and linear transducers was used, with frequencies ranging from 3.7 to 4.5 MHz and 10 to 13.5 MHz, respectively. Protective measures were used to avoid equipment contamination, with the monitor and keyboard being covered

with transparent plastic, the cables with disposable sterile fields, and the probe being protected with a self-adhesive transparent patch, all this after sanitizing the equipment with towels moistened with a 20% chlorinated solution.

Exploration methodology and image acquisition technique

The chest was divided into 12 exploration regions or quadrants. The reference lines are the parasternal line, anterior axillary line, posterior axillary line, and the para-vertebral line on both sides. These lines delimit six areas at each pulmonary hemifield: upper anterior, lower anterior, upper lateral, lower lateral, upper posterior and lower posterior, both right and left (Fig. 3).

After the described reference lines were identified, the convex transducer was placed on these areas looking for the representative lesion image and making a minimal adjustment of gains and transducer position. In some cases, the linear transducer was used to better visualize pleural line details. Each observation field is limited by two acoustic shadows produced by the ribs.

Considering normal echo-anatomy, all those pleural line lesions, including alterations in pleural anatomy, continuity and unevenness, thickness, presence of associated lesions at sub-pleural region, as well as any finding suggestive of pleural line pathology, were identified. In addition, B-lines were identified, both B1 and B2 pattern, as well as C pattern.

Results

Of the 10 included patients, 80% were men ($n = 8$) and 20% were women ($n = 2$), with an age range of 29 to 77 years (median: 58 years). The following personal medical history data were recorded: hypertension in 50% of cases ($n = 5$), diabetes mellitus in 30% ($n = 3$), ischemic heart disease in 10% ($n = 1$) and chronic kidney disease in 10% ($n = 1$). In addition, 40% had overweight ($n = 4$), 40% had grade I obesity ($n = 4$), and 20%, grade II obesity ($n = 2$). Fever was recorded in 90% of patients ($n = 9$), cough in 70% ($n = 7$), headache in 70% ($n = 7$) and dyspnea of varying degrees during the course of the disease until hospital admission in 90% ($n = 9$). Arthralgia was also reported in 20% ($n = 2$), myalgia in 30% ($n = 3$),odynophagia in 40% ($n = 4$) and chest pain in 10% ($n = 1$). Mechanical respiratory support was received by 40% of the patients ($n = 4$) (Figs. 4 and 5).

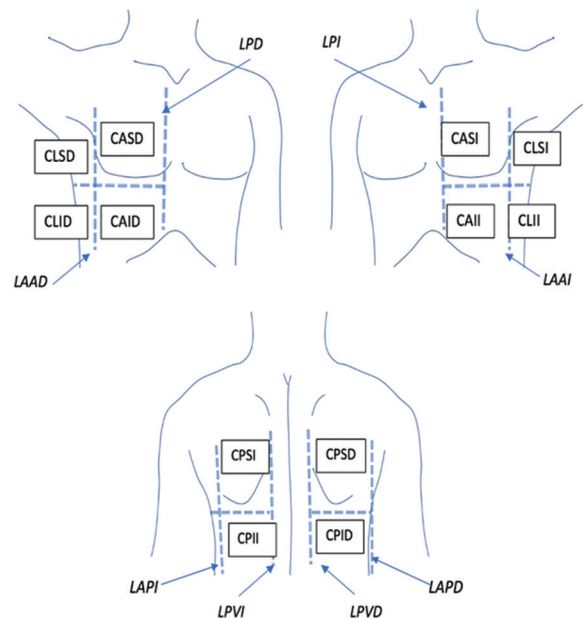


Figure 3. Chest ultrasound scanning regions or quadrants. The reference lines delimit six quadrants at each pulmonary hemifield. CAID: right lower anterior quadrant; CAII: left lower anterior quadrant; CASD: right upper anterior quadrant; CASI: left upper anterior quadrant; CLID: right lower lateral quadrant; CLII: left lower lateral quadrant. CLSD: right upper lateral quadrant; CLSI: left upper lateral quadrant; CPID: right lower posterior quadrant; CPII: left lower posterior quadrant; CPSD: right upper posterior quadrant; CPSI: left upper posterior quadrant; LAAD: right anterior axillary line; LAAI: left anterior axillary line; LAPD: right posterior axillary line; LAPI: left posterior axillary line; LPD: right parasternal line; LPI: left parasternal line; LPVD: right para-vertebral line; LPVI: left para-vertebral line.

Individual analysis of cases

The ultrasound images that were obtained were evaluated, taking into account the most relevant lesions and characteristics of the 12 exploration quadrants. Identifying all the main lesions already described in the literature for COVID-19 in the different exploration areas was possible. In all patients was any of the ultrasound pleura-associated manifestations regarded as pathological observed, either pleural line interruption or unevenness, pleural thickening or sub-pleural consolidations (Table 1).

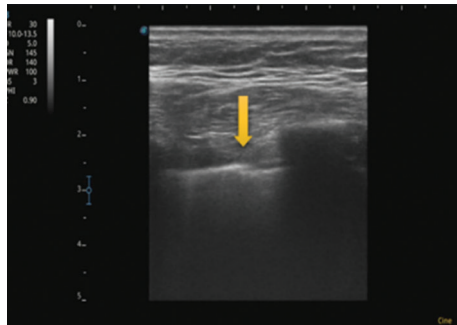
In 90% of cases, sub-pleural consolidations were identified ($n = 9$), and out of these, 33% ($n = 3$) were observed to be organized, which is called “crazy paving” pattern, characterized by multiple hyper-echoic areas, of more or less regular distribution, over an anechoic zone typical of consolidation.

Six patients (60%) showed the B1 pattern, 40% ($n = 4$), the B2 pattern, and 20% ($n = 2$), the C pattern.

Lung ultrasound

Anteroposterior chest X-ray

Case 1. Six days of symptom evolution

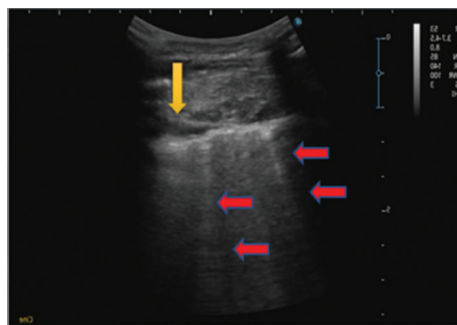


Discontinuous pleural line with unevenness (arrow).
Non-confluent B-lines



Radiopaque images suggestive of consolidations at right pulmonary hemifield region and basal left region, in correlation with ultrasound imaging, which shows B-lines and right side pleural line disruption

Case 7. Eight days of symptom evolution

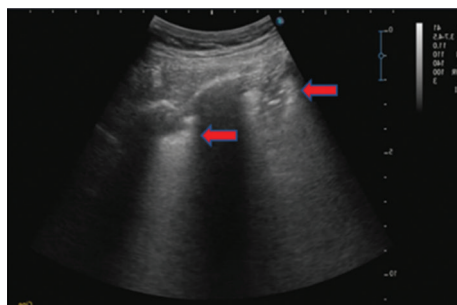


Pleural line irregularities due to thickening, disruption and unevenness
Separation of both pleurae by laminar effusion, trapezoid sign (vertical arrow) and B1 pattern by non-confluent B-lines (horizontal arrows).



Macronodular radiopacities at posterolateral regions that correspond to the alterations reflected on pleural line and B1 pattern
Sub-pleural consolidations predominantly at posterobasal quadrants corresponding to ultrasound findings

Case 8. Nine days of evolution



Sub-pleural consolidations characterized by an anechoic area below the pleural line, with hyper-echogenicity within, crazy paved pattern (arrows)
Artifacts by cascading confluent B-lines



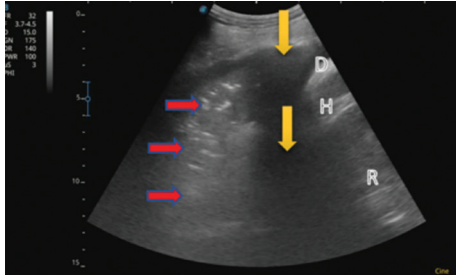
Radiopacities caused by posterolateral consolidations corresponding to ultrasound findings: pleural line multiple alterations including inter-pleural effusion, disruption, unevenness, multiple multilobar sub-pleural consolidations, as well as hyper-echoic vertical coalescent artifacts below these lesions

Figure 4. Pleural ultrasound findings and their radiographic correlation.

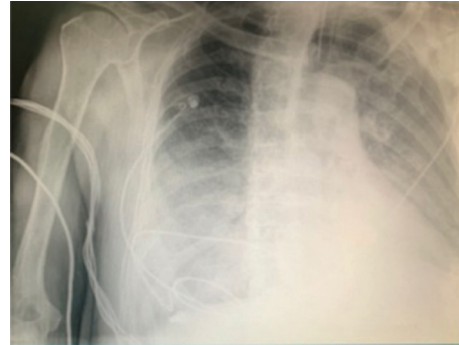
Lung ultrasound

Anteroposterior chest X-ray

Case 4. Twelve days of evolution

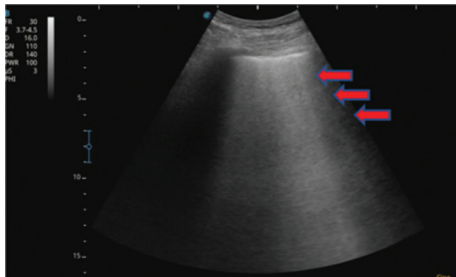


The kidney (R), liver (H) and diaphragm (D) are observed, as well as a non-aerated zone due to a C pattern, produced by a consolidation zone in which hyper-echoic images (horizontal arrows) are observed, which indicate an air-fluid dynamic bronchogram surrounded by an anechoic zone due to pleural effusion (vertical arrows)



Radiopaque images suggestive of consolidations are observed at right pulmonary hemifield region and left basal region, in correlation with an ultrasound scan that finds right side B-lines and pleural line disruption and sub-pleural consolidation at lower left posteroinferior region

Case 6. Seven days of evolution

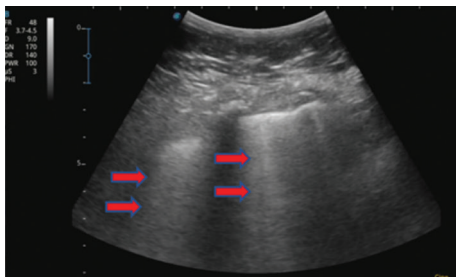


"White" lung, thus named due to the large number of B-lines that clearly converge with each other due to inflammatory-type interstitial syndrome, with a B -pattern being determined (arrows)



Reticular interstitial pattern that corresponds to and correlates with pulmonary interstitial syndrome, characterized by coalescent B-lines, displaying the "white" lung image characteristic of the B2 pattern observed on ultrasound

Case 9. Fourteen days of evolution



Pleural line thickening that produces irregularly-distributed coalescing and non-coalescing B-lines



Interstitial pattern caused by macronodular and confluent radiopacities at both hemifields, which correspond to ultrasound interstitial syndrome caused by confluent B-lines.

Figure 5. Parenchymal ultrasound findings and their radiographic correlation.

Table 1. Most relevant ultrasound findings in evaluated cases

No.	Ultrasound findings							
	Days of symptom evolution	Pleural				Parenchymal		
		Pleural line disruption	Pleural line thickening	Sub-pleural consolidation	Pleural effusion	B1 pattern	B2 pattern	C pattern
1	6	x	x	X	x	x		
2	9	x	x	X		x		
3	8	x	x	X				
4	12	x	x	X	x	x	x	x
5	7	x	x	X	x		x	
6	7	x	x		x		x	
7	8	x	x	X	x	x		
8	9	x	x	X	x	x		
9	14	x	x	X	x		x	X
10	5	X	x	X	x	x		
Total		100%	100%	90%	80%	60%	40%	20%

Regarding the C pattern, in one of the cases it was observed to occur in a basal, bilateral form, with an air-fluid dynamic bronchogram image, and in the other case, with an “hepatization” image, when consolidation had a tissue-like appearance, producing an image that resembles the echogenic appearance of the liver.

One of the most relevant findings in this group of patients was the identification of laminar effusions, with both pleurae being separated to a greater or lesser extent, coinciding with the so called “quad sign” in 80% of cases (n = 8).

Discussion

A good medical history and a thorough physical examination are essential in the evaluation of any patient, which allows to guide diagnostic tests and thereby reach a specific diagnosis. Chest X-ray is the most commonly performed imaging test and is usually the first complementary diagnostic test available to the doctor who faces a respiratory pathology; it accounts for 40% of the tests carried out at any radio-diagnosis department²⁵. Unlike the limited diagnostic spectrum of X-ray, plain chest CT scan is a superior diagnostic and follow-up tool for patients with COVID-19, since it allows changes to be observed at early stages of the disease, even in asymptomatic individuals²⁶.

The correspondence of radiographic, tomographic and ultrasound findings is related to the evolution of the disease and the moment at which each one of these tests are performed. Feng Pan et al.²⁷ describe four phases since the onset of symptoms based on chest CT quartiles and the degree of lung involvement from day 0 to day 26 after disease onset (phase 1: 0-4 days; phase 2: 5-8 days; phase 3: 9-13 days; phase 4: ≥ 14 days). All patients had symptoms at between days 5 and 14 at the time of evaluation, which corresponded to the last three phases.

According to the observations published by Ng et al.²⁸, the most common radiological findings in these patients with COVID-19 were “ground-glass” opacities as the main finding, followed by consolidation, with clear peripheral predominance. The “unpolished, frosted or ground glass” image is described in both X-ray and CT images, and is characterized by an opacification of the lung parenchyma due to an attenuation increase, but with pulmonary vessels and bronchial walls differentiation, unlike consolidation, in which distinguishing them is no longer possible²⁶.

The “crazy paved” pattern can also be observed, which is secondary to interlobular and intralobular septa thickening, overlapped with “ground glass” images, simulating a cobble stone floor, characteristic and more easily identified on CT than on X-ray imaging²⁶.

Lung ultrasound is also an available option for the diagnosis, treatment and follow-up of COVID-19. Its reproducibility, the possibility of performing it at patient bedside and its capacity to identify early pleural-pulmonary findings put it at an advantage over other imaging tests.

In this study, using lung ultrasound as a tool, all patients were observed to show pathological ultrasound findings, mainly pleural. In addition, it was possible to observe that both hemithoraces can be compromised²⁹, but more pathological findings were identified at right lower lateral quadrant (60% of cases), which corresponds to ipsilateral lower lobe, in accordance with what is described in the literature¹.

To date, anatomopathological findings have been reported in patients who have died from COVID-19. On gross examination, an increase in lung weight, data consistent with pleuritis, pericarditis, pulmonary consolidation and pulmonary edema are described, which are findings highly similar to those identified in patients with SARS-CoV or Middle-East respiratory syndrome coronavirus (MERS-CoV) infection³⁰.

In one study, post-mortem samples were obtained in cases where “ground glass” lesions were radiologically found. On gross examination, an edematous and firm pulmonary parenchyma was observed, which is a finding that supports ARDS clinical diagnosis. In addition, data consistent with diffuse alveolar damage and inflammation were described. All lungs were classified as being heavy³¹.

According to observations published by Xu et al.³², from a pulmonary histology point of view, bilateral diffuse alveolar damage with fibromyxoid cellular exudate and inflammatory interstitial infiltrates by mononuclear cells, in particular lymphocytes, were identified. In this case, pneumocytes and hyaline membrane desquamation was identified, which indicates ARDS.

Autopsy findings correspond to those identified by ultrasound and CT, which is why the clinician must bear in mind that ultrasound findings are a representation of what occurs in the patient with regard to pulmonary tissue histology.

Conclusions

Imaging tests are a fundamental pillar in the diagnosis and follow-up of patients with COVID-19. Lung ultrasound is a highly useful tool in this scenario.

Ultrasound equipment characteristics allow the test to be carried out at patient bedside, even in the

emergency department, which enables early triage of the potentially seriously ill patient and thus avoid further complications. Early identification of these patients has been shown to result in better clinical outcomes and resource optimization.

The results of this descriptive study are consistent with what has been described all over the world and it can be concluded that most patients will have some pathological pleural-pulmonary finding at initial evaluation, with ultrasound offering a clear advantage for early detection. Imaging tests findings, whether radiographic, ultrasonographic or tomographic, correspond to what is reported in the literature on autopsies of patients with COVID-19.

New evidence from published studies, statements from international organizations and expert discussions have recognized the usefulness of lung ultrasound in the diagnosis, evolution monitoring and treatment of coronavirus lung disease all over the world³³.

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Conflicts of interest

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Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this research.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained informed consent from the patients and/or subjects referred to in the article. This document is in the possession of the corresponding author.

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