DOI: 10.17648/RBUS-V29N30-10

REVIEW ARTICLE

PULMONARY ULTRASONOGRAPHY AT COVID-19: A WINDOW OF OPPORTUNITY FOR ITS APPLICATION AND DISSEMINATION

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ABSTRACT

COVID-19 manifests itself predominantly as a pulmonary infection that can be diagnosed and controlled through ultrasound. This procedure, in a hospital environment, can be performed at the bedside, including in intensive care units, decreasing the locomotion of patients and the exposure of other patients and health professionals. This study aims to review the technique and pulmonary ultrasound findings related to COVID-19. To this end, it performed a narrative review of articles that address pulmonary ultrasound, as well as literature on COVID-19, in national and international databases. Articles were selected that highlighted the quality of the images and didactically prepared text, so that the examination technique and the most frequent findings related to pulmonary infection of this etiology were addressed. According to the literature, ultrasonography allows for the screening of clinically stable symptomatic patients, especially in view of possible limitations to hospital access and computed tomography, standing out as a complementary diagnostic method when coping with the pandemic of COVID-19.

KEYWORDS: COVID-19; ULTRASOUND; LUNG; PULMONARY ASSESSMENT; VIRAL PNEUMONIA.

INTRODUCTION

COVID-19, a disease caused by the new coronavirus (Sars-Cov-2), started in December 2019 in Wuhan, China. Since then, it has taken on a pandemic proportion, spreading across the world[1].

The most common symptoms are fever and cough, associated with sore throat, nasal congestion, headache, malaise, body pain, with an average incubation period of 4-5 days, which may progress with dyspnea[1,2]. Other symptoms have been described, such as nausea or vomiting, diarrhea, disorders of smell and taste, such as anosmia and dysgeusia, asthenia, anorexia[2].

Special attention is given to symptomatic patients with comorbidities (heart disease, lung disease, diabetes, people with low immunity, neoplasms) and/or higher risk groups (children under two years of age, pregnant women, adults aged 60 or over) , due to the greater possibility of worsening[2].

The initial flu state evolves to a type of pneumonia, whose imaging finding on chest computed tomography (CT) is, more often, ground-glass opacity1. Computed tomography is the gold standard for the diagnosis of lung injuries. However, ultrasonography stands out for the possibility of diagnosis, control and monitoring of pulmonary changes in adults and children, regardless of the severity of the cases and the complexity of the hospitalization site. It also includes the possibility of follow-up after hospital discharge at home. Ultrasonography is not a substitute for computed tomography.

The recovery of patients can vary from two weeks, for mild cases, up to three to six weeks for severe illnesses[2].

In view of the worrying virulence, transmissibility, morbidity and mortality, with admissions in intensive care units and the extremely high demand for care due to them, there is an urgent need for the instruction and training of sonographers.

This study aims to review the technique and pulmonary ultrasound findings related to COVID-19.

METHODS

We performed a narrative review of articles addressing pulmonary ultrasound, as well as literature on COVID-19, information from the Brazilian Society of Infectious Diseases, guidelines from the Health Surveillance Agency, and, to specifically address the pulmonary ultrasound findings of COVID-19, we used search strategy (ultrasound OR ultrasonography and COVID and Lung) in the PubMed database. Articles that were in agreement with the objective of this study were selected, including good quality images and didactically elaborated texts.

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RESULTS AND DISCUSSION

It was initially thought that ultrasound could not be used to assess the chest. The main organs of the chest contain air, which does not adequately transmit the ultrasound, associated with the fact that the ribs block it.

Ultrasonography has become a very valuable resource in the evaluation of the abnormal chest. Its role in the evaluation of various respiratory conditions has been widely documented for a long time, but it is only recently, due to the improvement of equipment and specifically the low cost of high frequency transducers, that the method has been gaining coverage in several situations[1,3], providing results similar to computed tomography scan of the chest and superior to standard chest radiography to assess pneumonia and/or adult respiratory distress syndrome[4].

A recognized limitation of pulmonary ultrasound is that it cannot detect lesions deep within the lung, as the aerated lung blocks the transmission of ultrasound, that is, the abnormality must extend to the pleural surface to be visible on ultrasound examination. Chest CT is necessary to detect pneumonia that does not extend to the pleural surface1[4].

Ultrasonography and chest X-ray have known sensitivity and specificity, according to Tables 1 and 2.

	Sensitivity (%)	Specificity (%)
Ultrasound		
Pleural effusion (7)	94	97
Alveolar consolidation (11)	90	98
Interstitial syndrome (18)	93	93
Pneumothorax (23)	95	94
Complete pneumothorax (20)	100	96
Hidden pneumothorax (24)	79	100

Translated from Lichtenstein, 2009[5]

Table 1. Performance of ultrasound compared to computed tomography

	Sensitivity (%)	Specificity (%)
X-ray		
Pleural effusion (7)	39	85
Alveolar consolidation (11)	68	95
Interstitial syndrome (18)	60	100

Translated from Lichtenstein, 2009[5]

Table 2. Performance of radiography in critically ill adults

Standardized imaging criteria for assessing pulmonary pathology in adults with ultrasonography also apply to neonates, potentially providing an alternative to bedside X-ray, with a reduction in associated radiation[5].

Among the advantages of performing ultrasound at bedside, we highlight the reduction in the number of professionals exposed to contamination and the possibility of imaging control every 12 or 24 hours[1]. Pulmonary ultrasonography is very useful in the treatment of COVID-19 with respiratory impairment due to its safety, reproducibility, absence of radiation, low cost and use at the service location; chest CT can be reserved for cases in which pulmonary ultrasound is not sufficient to answer the clinical question[4]. The removal of patients to the radiology service is often not possible due to clinical conditions, in addition to the potential exposure of other patients and professionals[1].

Examination technique and systematization

Soldati et al 6 published a standardization of areas of the chest to be examined. The ultrasound scans can be identified with progressive numbering from the right posterior basal region (Figure 1), for the patient capable of maintaining the sitting position[6]. There are fourteen areas (three posterior, two lateral and two anterior) namely (Figure 1):

1. Right basal in the paravertebral line;
2. Right middle third on the paravertebral line at the lower angle of the scapula;
3. Upper right on the paravertebral line;
4. Left basal in the paravertebral line;
5. Middle third on the paravertebral line at the lower angle of the scapula;
6. Upper left on the paravertebral line;
7. Right basal in the middle axillary line;
8. Upper right in the middle axillary line above the intermammary line;
9. Left basal in the middle axillary line;
10. Upper left in the middle axillary line above the intermammary line;
11. Right basal in the middle clavicular line below the intermammary line;
12. Upper right on the middle clavicular line above the intermammary line;
13. Left basal in the middle clavicular line below the intermammary line;
14. Upper left in the middle clavicular line above the intermammary line.

Performing ultrasound in intensive care settings (such as patients on mechanical ventilation) and for patients who are unable to maintain a sitting position, it may be difficult to assess the posterior areas. In such cases, the operator should try to have a partial view of the posterior basal areas; despite the importance of assessing these areas for COVID-19, ultrasound assessment can be started from reference point number 7 [6].

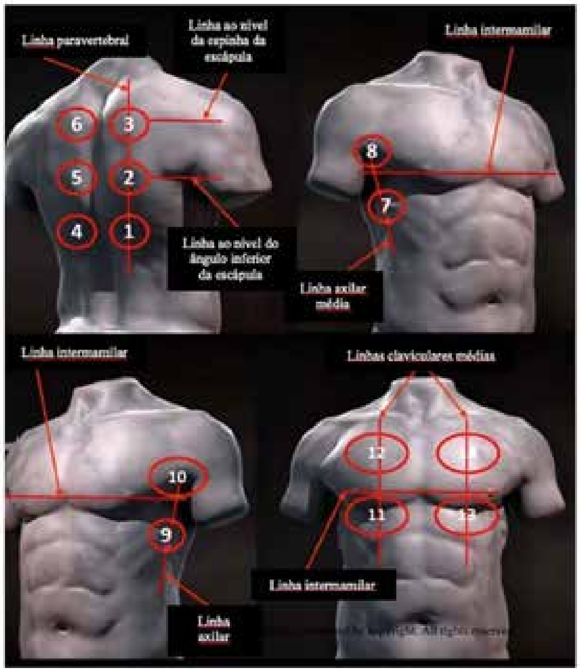

Figure 1 - Fourteen areas suggested by Soldati et al [6].

Proposal for the following systematization for extracardiac thoracic ultrasonography:

1. Start the examination with a convex or sectorial transducer (these provide the assessment of a larger area with an initially adequate depth);
2. Longitudinal scan of each hemithorax on the anterior, lateral and posterior sides;
3. In a suspicious region, the transducer is rotated approximately 90 degrees, so that the acoustic beam reaches the intercostal space;
4. Additional evaluation is indicated with a linear transducer (due to the increased frequency inherent in this transducer, the superficial planes, such as pleural line and subpleural space, are adequately examined).

Ultrasound findings at covid-19

The patterns observed on ultrasound occur progressively, from a mild alveolar interstitial pattern to a severe bilateral interstitial pattern and pulmonary consolidation[4].

The characteristic ultrasound findings related to covid-19 are[4]:

1. Thickening of the pleural line with irregularity;
2. B lines in a variety of patterns, including focal, multifocal and confluent;
3. Consolidations in a variety of patterns, including small multifocal, non-translobar and translobar, with occasional mobile air bronchograms;
4. Appearance of A lines during the recovery phase;
5. Pleural effusions are uncommon.

Figures 2 and 3 show the normal pattern on ultrasound.

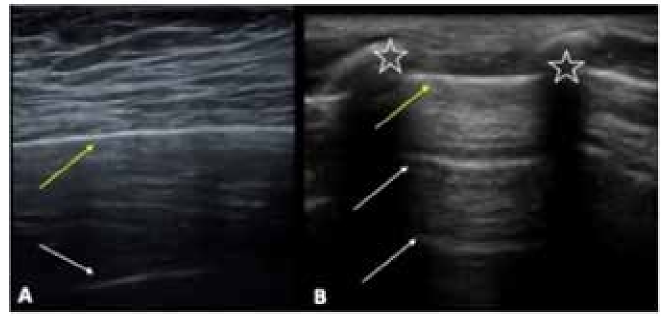

Figure 2 - Normal examination. Pleural line (yellow arrow); A lines (white arrows); ribs (white stars) [7].

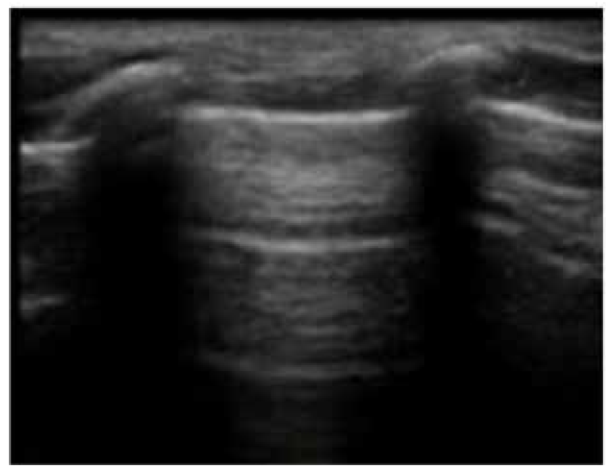

Figure 3 - Normal examination, showing regular pleural line and sporadic B lines[7].

Figures 4 to 7 show pathological ultrasound findings that may be related to COVID-19.

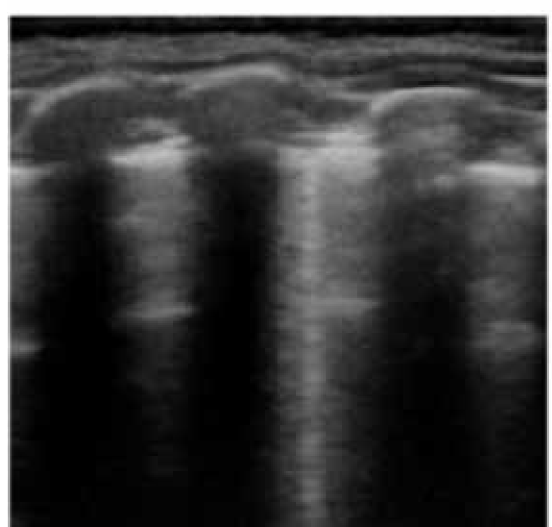

Figure 4 - Irregular pleural line and sporadic B lines[7].

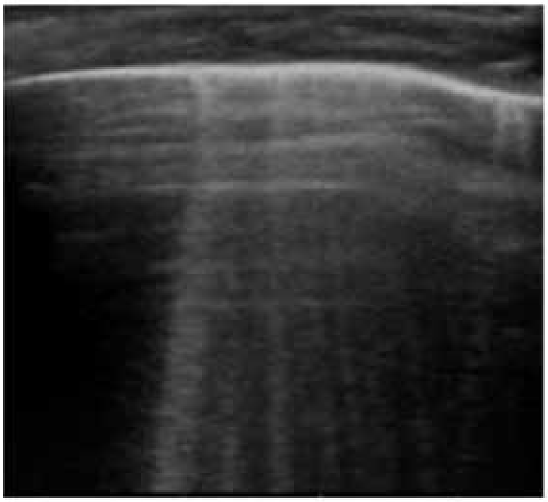

Figure 5 - Irregular pleural line and multiple B lines [7].

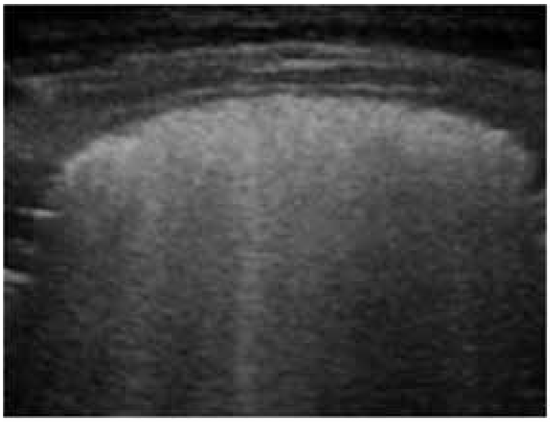

Figure 6 - Irregular pleural line and pulmonary parenchyma with increased echogenicity, making it impossible to characterize the A lines[7].

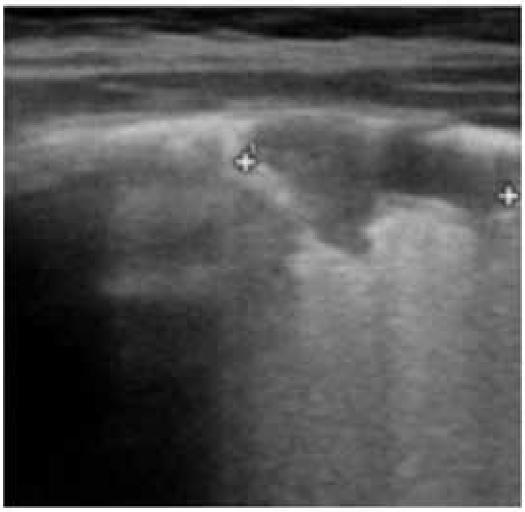

Figure 7 - Irregular pleural line and subpleural consolidation[7].

Below are pulmonary images with the respective findings and scores proposed by Soldati et al [6]. Note the characteristics of the images captured with convex and linear transducers (Figures 8, 9, 10 and 11).

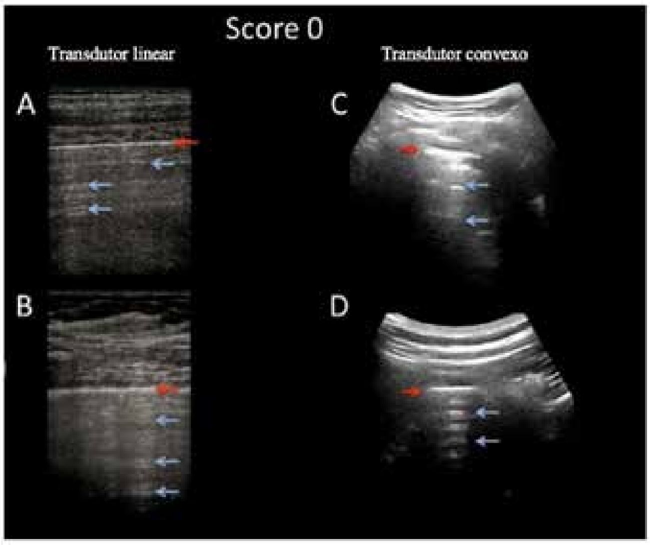

Figure 8 - Pulmonary ultrasound images obtained with a linear (A-B) and convex (C-D) probe. The pleura line (indicated by the red arrows) is continuous. Below, horizontal artifacts, or A lines (indicated by blue arrows) may be visible. This standard is classified as Score 0[1].

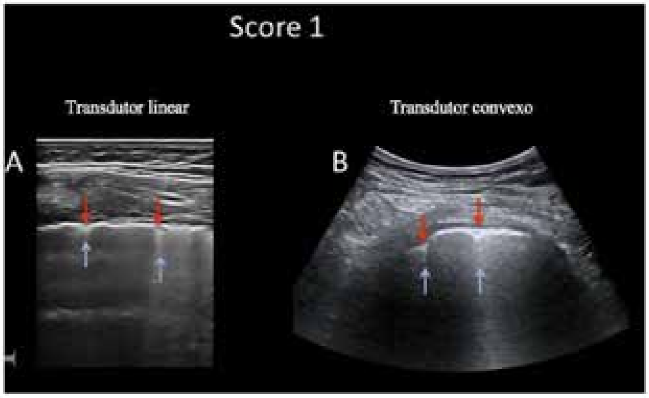

Figure 9 - Pulmonary ultrasound images obtained with a linear (A) and convex (B) probe. The pleura line is not continuous. Below the point of discontinuity (indicated by the red arrows), vertical white areas are visible, or B lines (indicated by the blue arrows). This standard is classified as Score 1[6].

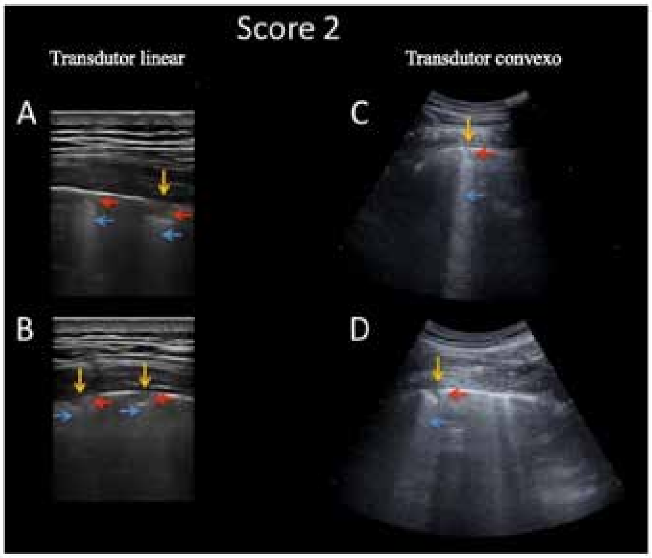

Figure 10 - Pulmonary ultrasound images obtained with a linear (A-B) and convex (C-D) probe. The pleura line is severely broken. Below the point of discontinuity (indicated by the orange arrows), small consolidated areas (darker areas indicated by the red arrows) appear with associated white areas (indicated by the blue arrows) in correspondence with the consolidations. This standard is classified as Score 2[6].

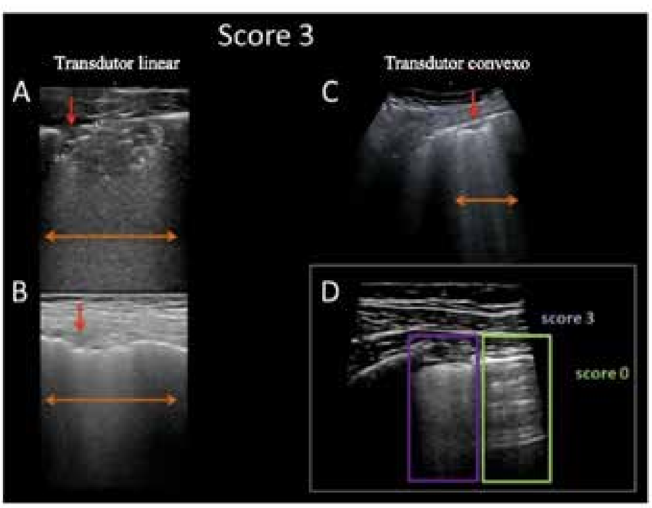

Figure 11 - Pulmonary ultrasound images obtained with a linear (A-B) and convex (C) probe. The pleura line is severely broken. Below the point of discontinuity, large areas of consolidation (more hypoechogenic areas indicated by red arrows). Hyperechogenic images between consolidation are suggestive of aerobronchograms. The "white" lung pattern, with increased echogenicity is indicated by orange arrows. This pattern is classified as Score 3. In the box at the bottom right (D), a lung image is shown where the boundary between a pattern of Score 0 (green box) and Score 3 (purple box) is clearly visible[6].

FINAL CONSIDERATIONS

Ultrasonography allows screening of clinically stable symptomatic patients, especially in view of possible limitations to hospital access and computed tomography1.

Once a pulmonary ultrasound evaluation is requested, all precautionary contact measures, for droplets and aerosols, guided by the World Health Organization and the National Health Surveillance Agency, must be respected, using the appropriate personal protective equipment[8].

There was no intention to exhaust such a large amount of information in recent publications. Given the above, it is understood that it is, above all, a time of need for unity and sharing of secure information.

ACKNOLEDGEMENTS

Gratitude to all who motivate our studies.

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