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ULTRASOUND IN THE SARS-COV-2 PANDEMIC: SUMMARY OF APPLICATIONS, ADVANTAGES, AND LIMITATIONS

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Abstract — **COVID-19 is caused by the coronavirus 2 (SARS-Cov-2) that may promote a severe acute respiratory distress syndrome (ARDS), pneumonia and hypoxemia. Ultrasonography has been used for decades as a tool to detect biological tissues abnormality, although its B-mode imaging has only recently been used in lung exams. The aim of this paper is to report documents related to the use of ultrasound as a tool to evaluate COVID-19 during the first pandemics year. Lung ultrasound has been shown as an important tool regarding an early and reliable way to diagnose lung symptoms of respiratory diseases and for patients' follow-up.**

Keywords — **COVID-19; SARS-CoV-2; ARDS; lung ultrasonography; ultrasound imaging.**

I. INTRODUCTION

A Public Health Emergency of International Concern (PHEIC) was officially declared by the World Health Organization (WHO) on January 30th, 2020. The so called COVID-19 is a disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2).

SARS-CoV-2 infected worldwide more than millions, many of them presenting respiratory symptoms as a disease casualty. Complicated pneumonia cases may result in a severe hypoxemia associated with low lung compliance, defined as acute respiratory distress syndrome (ARDS) [1].

COVID-19 was identified and spread initially in Wuhan, Hubei province, China, in late 2019. The disease was defined as a respiratory syndrome liable to lead to pulmonary commitment, thereafter hypoxemia and pneumonia would be an outcome for COVID-19. Accurate diagnosis, provided as early as possible and preferably with minimum transportation of patients from and to health care centers, would be extremely convenient. In a review of COVID-19 patients, about 20% of the studied cases required hospitalization in an intense care unit (ICU), whilst about 33% presented ARDS.

Ultrasound B-mode imaging has been used for decades as a tool to detect biological tissues abnormality. Every tissue has its own typical echogenicity and overall ultrasonographic appearance, with a good correlation to its anatomy. Recently, lung ultrasonography (LUS) has been considered a potential simple, fast, and reliable test, to be applied for COVID-19 diagnostics (Fig 1). Nonetheless, proper image resolution and right choice of transducer is needed to a correct evaluation and decision making [2].

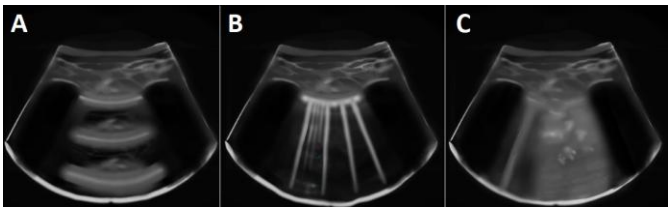

Fig 1: Images of lung ultrasonography. From the top-to-bottom of each image: skin layer, muscle layer, and a hyperechoic pleural line on the edge of lung surface. A) A-lines image. Health lung. B) B-lines image. Lung with water (more B-lines mean more parenchymal water). C) Lung consolidation image. Loss of pleural line continuity, coalescent B-lines and hyperechoic air bronchograms in consolidation areas can be seen in deflated lungs. Source: Graphic representation prepared by the authors.

This paper disclose a summary of applications, advantages, and limitations os LUS to detect ARDS due to COVID-19 for the lay biomedical engineering audience on this subject. The findings were obtained from a scoping review of the literature from Nov 2019 to May 2022.

II. MATERIALS AND METHODS

The databases explored were Scopus, Web of Science and Pubmed Central.

The research strategy comprised the use of the following terms:

- T1. (ultraso*) AND (coronav*) AND (pneum*)
- T2. (ultraso*) AND (covid*) AND (lung*)

- T3. (ultraso*) AND (covid*) AND (lung*) AND (pneum*)
- T4. (ultraso*) AND (coronav*) AND (lung*) AND (pneum*)

After the documents retrieval (289 articals), 40 articals were selected by title relevance, and 9 were selected by critical analysis. They were undertaken as the most relevant documents to this review and their main findings or outcomes were discussed.

III. Results and Discussion

The first records recommending the use of ultrasound in the diagnosis of COVID-19 came from researchers working at a medical referral center in Sichuan province. As an example, Pan et al. [3] highlighted the advantage of reducing cross-contamination probability with the use of ultrasound, in relation to other imaging resources, since the portability of the equipment minimized patient displacement.

Moro et al. [4] presented how to employ LUS in the guidance of obstetricians and gynecologists in cases of pulmonary infection by COVID-19 in pregnant women. The application of imaging under non-ionizing radiation was the main highlight in the confrontation of SARS-CoV-2.

In Stone 2020 [5], it was discussed how portable ultrasound imaging equipment can be used in the assessment of pleural wall thickness and areas of pulmonary congestion, typical of pneumonia and that may suggest COVID-19. With regard to the post-examination, he highlighted that one of the advantages is the possibility of rapid disinfection, in addition to being able to be used at the patient's bedside, unlike other methods that involve disinfecting entire rooms.

Baker and Rippey [6] points out some concerns about LUS as a diagnosis tool for COVID-19. Ultrasound may help with diagnosis, although it does not replace clinical signs and golden standards exams as CT and RT-PCR. LUS results are not specific findings and require a long period of training before proper application, as learning during a pandemic is not recommended. Additionally, Baker (2020) reported some concerns about the use of LUS as a diagnostic tool for COVID-19. She reported that LUS results are not specific nor direct findings, and it also requires training before proper application.

The idea of applying technological resources of artificial intelligence was also started in the first months of the pandemic. Dr. Libertario Demi, head of the Ultrasound Laboratory at the University of Trento, Italy, engaged with collaborators from several hospitals in Italy. It was developed algorithms that can assist in the interpretation of ultrasound images, with support for a database with more than 60,000 images obtained from patients with Covid-19 [7].

The works by Hussain et al. [8], and Evans et al. [9] discussed the importance of using robotic and remotely operated ultrasonic systems capable of diagnosing the infection caused by the new coronavirus. Among the benefits, these studies report the great applicability of these resources in low- and middle-income countries that do not have medical infrastructure for computed tomography, especially in places far from large population centers.

IV. Conclusions

As mentioned by several authors, the use of LUS played a prominent role in the diagnosis and monitoring of patients who arrived at health centers for diagnosis and investigation of the evolution of the new coronavirus. It can be noted that the classic advantages of this tool supported the recommendation of its use since the beginning of the pandemic. It is expected in the Biomedical Engineering field that both the improvement of image processing techniques, mainly in real time, and the automation procedures that imply the creation of portable products, where wireless sensors have already been observed, allow the expansion of their applications.

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