Ultrasound on the Frontlines of COVID-19: Report From an International Webinar

The COVID-19 pandemic has spread to 185 countries with over 2.1 million confirmed cases and 145,000 deaths, as per the Johns Hopkins University COVID-19 dashboard provided at https://coronavirus.jhu.edu/map.html. Imaging modalities such as chest radiography, thoracic and cardiovascular ultrasound, and computed tomography (CT) have roles in the diagnosis, prognosis, monitoring, and therapy of COVID-19. However, the potential benefits of imaging need to be balanced against resource utilization and infectious risk.

Point-of-care ultrasound (POCUS) represents an attractive imaging modality in COVID-19 as it involves portable technology without radiation. POCUS is performed by a clinician at the patient's bedside, reducing exposure of additional personnel and avoiding virulent particle transmission during transport to other areas.

On March 18, 2020, the American College of Emergency Physicians (ACEP) hosted a virtual town hall meeting to discuss the use of POCUS in COVID-19 patients. The panel of nine emergency physicians included those on the forefront of outbreaks in Spain, Italy, and Washington State, as well as POCUS leaders who are heavily involved in developing processes for their institutions.

We seek to summarize available literature on imaging in COVID-19 and provide informally derived recommendations of the panel on POCUS use in COVID-19. The webinar may be accessed at https://www.acep.org/how-we-serve/sections/emergency-ultrasound/.

CURRENT IMAGING APPROACHES IN COVID-19

CT

Computed tomography represents the most sensitive imaging modality for COVID-19 involvement of the lungs. Ground glass opacities, patchy bilateral consolidations, or peripheral interstitial changes were found in 97% of confirmed COVID-19 patients, and CT was potentially more reliable than RT-PCR swab testing.[1] Four stages of CT findings demonstrated progression from ground glass opacities to consolidations that gradually resolved. Peak findings occurred 10 days after symptom onset.[2]

Computed tomography may be sensitive for evidence of lung involvement from COVID-19, but resource utilization and infection control risks are significant issues. Airborne transmission and ventilation of CT scanner rooms present concerns, and cleaning after exposure from a COVID-19 patient could render the CT unusable for several hours. Based on the uncertain impact of CT imaging on patient care, as well as infection control issues, the American College of Radiology (ACR) has stated "CT should not be used to screen for or as a first-line test to diagnose COVID-19."[3]

Chest Radiography

Chest radiography (CXT) is widely available, portable, and likely to be utilized in the initial and ongoing evaluation of COVID-19 patients. Comparisons between CXR and CT are not extensive at this time, but suggest that CXR is often normal when the CT is abnormal.[4] CXR still carries risk of exposure to personnel and contamination of machines. One approach to mitigate infectious risk involves obtaining a single-view CXR outside the patient's room through a glass window. The ACR guidelines on radiography in COVID-19 suggest portable CXR when it is considered "medically necessary."[3] Further data are needed on the sensitivity, specificity, and diagnostic impact of CXR on suspected and diagnosed COVID-19 patients.

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Ultrasonography

Ultrasound of the lung utilizes artifacts and findings at the lung periphery, and early reports show that abnormal findings are common in COVID-19 patients. A series of 20 patients with COVID-19 described thickening and irregularity of the pleural line, a variety of B-line patterns, and subpleural consolidations. Pleural effusions were rare.[5] A recent comparison of imaging modalities in intensive care patients suffering from acute respiratory failure demonstrated high agreement between lung ultrasound and CT. Ultrasound outperformed chest radiography particularly when assessing interstitial pathologies as well as ground glass opacities and consolidations.[6] Since the sensitivity of CT is high in COVID-19 patients and progression of disease is apparent, it is likely that lung ultrasound closely mirrors the longitudinal changes found through CT. High sensitivity and specificity of lung ultrasound seen in acute respiratory distress syndrome (ARDS) as well as in H1N1 influenza suggests that similar test characteristics exist for lung ultrasound in COVID-19.[7,8] Lung ultrasound also shows prognostic capabilities in ARDS before hypoxemia becomes evident.[8] While reports on lung ultrasound in COVID-19 are preliminary, they suggest that ultrasound findings are likely more common than findings on plain chest radiography. POCUS may also identify and exclude other pulmonary causes of dyspnea as well as cardiac abnormalities. Future research should further specify test characteristics of ultrasound in COVID-19 as well as assessments of harm to ultrasound operators who risk increased contact with infected patients.

EXPERT OBSERVATIONS FROM THE TOWN HALL

1. Ultrasound in the diagnosis and monitoring of COVID-19

In the initial evaluation of a noncritical patient with suspected COVID-19, panelists posited that either a completely normal or a completely abnormal lung ultrasound may be helpful. A completely normal examination likely excludes a patient requiring further imaging at that time. Characteristically abnormal findings in a person under investigation for COVID-19 may identify patients requiring further evaluation or closer observation before RT-PCR results return. It is unclear whether B-line or consolidation thresholds exist that predict significant clinical deterioration in well-appearing patients who display lung findings. Observations that ultrasound findings may precede clinical symptoms suggests that ultrasound may identify more severe illness prior to the development of severe symptoms.

While lung ultrasound may be of little utility in patients who are critically ill from COVID-19, it may help exclude other pulmonary diseases (including pleural effusion or pneumothorax).[6] Incorporation of cardiac ultrasound could also identify cardiac complications from COVID-19 and it is recommended that a focused cardiac ultrasound be incorporated into the evaluation of symptomatic COVID-19 patients. Early reports suggest there may be direct cardiac ramifications of COVID-19 including gross LV dysfunction, and potential RV dilation.[9,10] Additional to lung ultrasound, cardiac views including the inferior vena cava can help identify or exclude cardiac dysfunction.

Ultrasound may also benefit critically ill patients requiring emergent peripheral or central venous access. Due to respiratory distress, some patients are unable to lie flat, making central venous access difficult. Ultrasound also assists in diagnosis of venous thromboembolism. Table 1 summarizes the main ultrasound applications used and their associated findings in COVID-19 patients.

Future systematic research is needed to clarify the above associations between ultrasound findings and presence of illness, prognostication of illness severity, and ultimate patient outcomes. Panelists emphasized that while ultrasound findings are often characteristic of COVID-19 and may be more prominent in more severe disease, disposition decisions such as admission and level of care would likely be made predominantly on clinical appearance.

2. Ultrasound equipment

Newer pocket-carried ultrasound devices using tablet and smartphone technology may be easier to maneuver, protect, and clean after use on COVID-19 patients. It is feasible for the screen to be completely encased in a covering such as a Ziploc bag, and for transducers to be fully enclosed using sheaths. They may be particularly useful in situations where separate care or triage areas for cohorted COVID-19 patients are established outside the main areas where traditional machines reside. Additionally, teleguidance software built into these devices may be useful in providing remote instruction or evaluation of patients

Table 1
Point-of-Care Ultrasound Applications and Findings in COVID-19 Patients

Lung Ultrasound	
○ Panelists used 6–12 zones or fewer	• Thickened, irregular pleural line
	• B-lines with prominence in different locations ("patchy" appearance). B-lines are ring down artifacts from interstitial fluid characteristic of pneumonitis.
	• Subpleural consolidations
	• Larger consolidations
Cardiac ultrasound	
○ Parasternal long and short axis	• Pericardial effusion
○ Apical four-chamber view	• Depressed ejection fracture or gross LV dysfunction
○ Subxiphoid view	• RV enlargement and evidence of strain
○ Subxiphoid long axis (Inferior Vena Cava) view	• Hypo- or hypervolemia
Vascular	
	• Deep venous thrombosis
	• Guided peripheral or central access
	• Guided arterial lines

NB: Panelists noted that there may be significant difficulties scanning all lung or cardiac views due to patient positioning or comfort and levels of distress.

who are physically located away from typical treatment areas. Telemedicine and cloud-based image sharing may improve the capacity for care outside the hospital setting, and serial lung examinations may provide objective data in remote or virtual clinical decision making.

3. Infection control issues

Aggressive infection control was emphasized by all panelists, as a recent report suggested that the SARS-CoV-2 virus could survive for days on some surfaces.[11] Routine cleaning and disinfection procedures recommended by the Centers for Disease Control and Prevention are particularly important when procedures with high risk of aerosolization are performed. Prior to entering the room, all unnecessary equipment including extra probes should be removed from the machine to minimize surface exposures. If available, transparent covers for machines and probes can be considered. If resources allow, equipment that is dedicated for use in patients with suspected or confirmed COVID-19 may be helpful. The Environmental Protection Agency maintains a list of SARS-CoV-2–approved disinfectants (https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2).

CONCLUSION

Ultrasound as a diagnostic test presents distinct advantages for imaging in COVID-19. It is a mobile technology that can be used in diverse environments, including in triage tents or makeshift hospitals that are now established for COVID-19 evaluation at many centers. POCUS in particular, where the clinician both performs and interprets the images immediately at the bedside, can minimize involvement of additional personnel in an infectious situation and provide immediate diagnostic information. However, care must be taken to avoid increased transmission of disease.

Incorporating ultrasound into the evaluation of COVID-19 patients will depend on available resources, expertise of personnel, and logistic configurations unique to each situation. Further research and data are needed to determine the role of ultrasound as a screening tool for establishing both admission thresholds and level of care, its use in prognostication and monitoring of inpatients, and novel uses like home telemonitoring in discharged patients. Ultrasound appears promising as a first-line and comprehensive diagnostic imaging modality in suspected or diagnosed COVID-19.

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