

Ultrasound Workflow in a Pandemic

Lessons Learned from COVID-19



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KEYWORDS

• COVID-19 • SARS-CoV-2 • Coronavirus • Pandemic • Ultrasound • Sonography

KEY POINTS

- Ultrasound imaging during the COVID-19 pandemic poses unique risks due to the prolonged close contact during image acquisition.
- Imaging triage for ultrasound requests in COVID-19 positive or suspected patients can reduce unnecessary risks of exposure.
- Modified and abbreviated ultrasound imaging tailored to the clinical question can minimize imaging acquisition times but still provide the needed diagnostic information.
- Infection control measures including hand hygiene, personal protective equipment (PPE), and disinfecting equipment are important sterilizing precautions.

INTRODUCTION

Global confirmed cases of COVID-19 have continued to increase since the COVID-19 pandemic began. There are greater than 294 million globally and 57 million nationally according to the latest available information as of January 4, 2022[1]. Our academic institution is located centrally in downtown Chicago, Illinois. The unprecedented COVID-19 pandemic presented unique challenges to the ultrasound division given the prolonged close contact of patients with sonographers and imaging equipment. Due to the increased prevalence of COVID-19 in our population, ultrasound examinations requested for both COVID-19 positive and suspected patients have notably increased. Risks of exposure to COVID-19 have been a concern both before and after the introduction of vaccinations and

treatments. The hierarchy of controls outlined by The National Institute for Occupational Safety and Health (NIOSH) to control occupational hazards to protect workers recommends the following actions. First, there should be elimination or physical removal of the hazard; this can be conducted by cleaning and disinfection. Secondly, substitution or replacement of the hazard can work in some scenarios although this is not as relevant with Coronavirus. Third, engineering controls are the next impactful and usually entail the isolation of the hazard or people at risk from the hazard so that employees do not encounter the hazard. Lastly in the hierarchy but most often used are administrative controls, and personal protective equipment (PPE). Administrative controls and PPE are the factors most manipulated in the ultrasound department to mitigate risk. Herein,

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we modified our scheduling, workflow, and protocols to minimize exposure risks while continuing to provide diagnostic imaging.

INSTITUTIONAL APPROACH USED TO ADDRESS THE PROBLEM

To perform ultrasound imaging in the context of a pandemic, we modified our workflow in keeping with infection control measures to ensure the safety of both patients and providers, using administrative controls and PPE.

Triage and Scheduling of Patients

At the onset of local outbreaks during the pandemic, many elective procedures and nonurgent evaluations were postponed or canceled to prevent community exposure and spread. All ultrasound requests on COVID-19 positive or suspected patients were and are still referred to the radiologist for triage. Although there are urgent indications such as acute cholecystitis, there are nonurgent scenarios or questions answered by recent prior cross-sectional imaging. At our academic

institution, a “triage rotation” was created for our radiology residents to have remote access to the Electronic Medical Record (EMR). Under the supervising radiologist, the residents or sonographers investigate the clinical context of the requested examinations and stratify urgency based on the risks and benefits. The following 3 categories have been created to assign an appropriate level of urgency to the requested examination (Table 1). Potentially nonurgent or postponable requests are discussed with the referrer for rescheduling or cancellation as deemed appropriate. The work of categorizing urgency, discussing with referrers, and calling to reschedule patients was distributed among the radiology residents, radiology attendings, and available sonographers.

Two specific indications for which many ultrasound examinations were requested at the onset of the pandemic were abnormal liver and renal function tests. Patients with COVID-19 often have aberrations of their LFTs that can have either a hepatocellular or cholestatic pattern. We, as well as other institutions, noticed that these examinations were low yield, often not revealing any pathology [2]. Our early data of 42 abdominal US

TABLE 1
Scheduling Urgency of Ultrasound Examinations

A – Urgent: Must Be Performed Now	B- Nonpostponables: Perform Within 4 wk	C – Postponable: A Delay Is Unlikely to Significantly Impact Patient Outcomes.
All liver, kidney, pancreas transplant and all TIPS ultrasounds	Cases that are neither urgent (category A) nor postponable (category C). Majority are case-by-case scenarios.	Thyroid, parathyroid and majority neck ultrasounds
All acute abdomen including RUQ pain for suspected acute cholecystitis; acute pelvic pain with suspected ovarian torsion or tubo-ovarian abscesses; and acute scrotal pain for suspected torsion, epididymitis or orchitis	Physician’s preference to keep on schedule	Nonurgent examinations, such as evaluation for varicocele, palpable abnormality, or work up for chronic symptoms
Acute kidney injury with suspected hydronephrosis or recent or tentative intervention	Patient’s preference o keep on schedule	Known or recently evaluated pathologies
Acute septic joint		Majority of hernia or groin examinations
Other acute/time-sensitive indications (suspected postoperative/postprocedure complications)		Many US contrast examinations evaluating focal hepatic or renal lesions

cases of suspected COVID-19 over a span of 5 weeks (between 3/21/2020 and 4/30/2020) demonstrated no acute changes in management based on the US imaging. 45% (19/42) of these cases were COVID-19 positive. 36% of these cases were ordered from the emergency department (15/42) and the rest were ordered from the inpatient setting. The most common ultrasound examinations included right upper quadrant ultrasound for pain in 36% (15/42) and elevated liver function tests in 29% (12/42), and renal ultrasound for abnormal renal function tests in 17% (7/42). Our data demonstrated that the abdominal US with these indications of liver or renal function test derangements is low yield.

Since the early days of the pandemic, several papers have shown similar findings. Similarly, renal function laboratory abnormalities can be seen in patients with COVID-19 infection; however, subsequent ultrasound examinations are typically normal and low yield [3]. Given this early data and subsequent confirmation in the literature, patients with COVID-19 with mild abnormalities in liver or renal function are often followed and their laboratory values are trended rather than going to immediate ultrasound and risk exposure to others.

Furthermore, patient scheduling is also modified to purposefully increase the intervals between examinations to decrease waiting room crowding and allow time for adequate infection control measures, which will be detailed further [4–9].

Prescan Planning and Precaution While Scanning

Preparation before scanning can reduce the duration of exposure required to perform the ultrasound examination. Before entering the patient examination room, the sonographer reviews patient records to readily identify the clinical question to answer and accordingly mentally rehearses the techniques, including optimal patient positioning. For example, a left posterior oblique position with patient's head facing away from the sonographer can be used for a right upper quadrant ultrasound. Also, the required patient data are entered into the ultrasound machine before entry into the examination room.

Proper hand hygiene before and after each examination includes either handwashing for at least 20 seconds with soap and water or cleansing with a 70% ethanol-based hand sanitizer. Additionally, PPE including but not limited to N95 or surgical masks, eye shields, surgical gloves, and disposable surgical gowns are used by the sonographers.

On entering the examination room, the sonographer obtains as much information from across the room as possible and instructs the patient to save questions for the end of the examination. Also, the sonographer steps away from the patient while not scanning. After image acquisition, the sonographer disinfects the equipment and room while still in proper PPE.

Infection Control Implementations

Scheduling: Physical distancing is considered when modeling the waiting room. This includes directing the flow of foot-traffic and selecting nonadjoining examination rooms for increased distancing when the volume of ultrasound examinations being performed was below capacity. Increased time between examinations is implemented to accommodate the more time-consuming deep cleaning of the rooms.

Infection control: Droplet and contact precautions are implemented, per the Centers for Disease Control and Prevention (CDC) guidelines. Facial masks are required for everyone on the premises and provided on entry. Aerosolizing procedures and suctioning are discouraged during the sonography examination. Timely testing of suspected patients with COVID-19 in the emergency department (ED) and inpatient ward is very important to identify cases and limit exposure [5,6,10,11]. Patient mask-wearing should be in accordance with hospital and local governmental policy.

COVID-19 suspected ultrasound examinations in the ED are performed in a physically isolated room with dedicated staff and equipment and minimum traffic to reduce interruptions. Access to this room is restricted, and nonessential supplies such as infrequently used transducers have been removed. Inpatient examinations are performed by a sonographer with a dedicated machine that is stored separately within the department.

Disposable ultrasound consoles and probe-covers are used for replacement, cleaning, and disinfection of the equipment in between cases. Use of gel packs or gel-filled syringes is encouraged over bringing a bottle of gel into the room.

Cleaning and disinfection: After an ultrasound examination is performed on an inpatient, the ultrasound machine is removed from the patient's room, and the sterile screen or probe covers are removed. The probe is disconnected, and cleaning is performed with disinfectant, wipes, or clean towels to remove soiling, gel, or residue from all surfaces of the machine including screen/touchscreen, probe, and cords. Care is taken to clean the keypad and trackball. A different disinfectant, as per the manufacturer's guide, might be needed to

safely disinfect the screen/touchscreen and probes. During disinfection, care is taken to ensure that fluids do not seep into any openings on the ultrasound system, such as the seams on the control panel.

All probes are cleaned and disinfected irrespective of use and a biohazard bag can be placed over the probe while using generic disinfectant for the rest of the machine as they may damage the transducer crystal. The probe can also be immersed in a manufacturer's approved disinfectant solution for 10 to 15 min, especially for intra-cavitary probes or probes used for ultrasound-guided procedures.

Disinfectants: Although ultrasound probes are proven to withstand high-level disinfectants, nontoxic agents with approved viricidal and other antimicrobial activity, as listed on the CDC website and compliant per manufacturer's guidelines [12], are used during this pandemic. In our experience, hydrogen peroxide or ethanol-based disinfectants are less toxic to the operator than many available agents. We recommend against harsh methods of disinfection for transducers; for example, immersing into a disinfectant for more than an hour, or using other potentially harmful disinfecting compounds including cold gas, organic solvents, ethylene oxide, or even commonly used isopropyl alcohol as they pose potential damage to the transducer crystal.

Cleaning the room and other supplies: Cleaning and disinfecting procedures are encouraged to apply for all patient visits with an underlying assumption that any patient may have COVID-19. Before beginning the daily work, the ED ultrasound room and equipment and portable inpatient ultrasound equipment are also cleaned every morning following the procedures described above. Room cleaning and disinfection again follow similar principles with the cleaning of gross contamination followed by the disinfection of the whole room including the examination table with a viricidal agent. Wiping is preferred, rather than the spray form for disinfection.

Disposal: Proper disposal of the gowns, gloves, and other PPE following room and equipment cleaning is guided by hospital policy. Proper biohazard disposal is recommended, per institutional recommendations.

Modification of Existing Protocols

Our existing conventional ultrasound imaging protocols are now abbreviated to reduce the examination time in patients with documented or suspected COVID-19 infection. These abbreviated examinations still include all the diagnostically necessary images for diagnosis. This is made possible by the liberal use of

cine clips as opposed to static images which require a separate breath-hold with each image and a long time for examination performance. The goal is to reduce acquisition times to limit exposure, while obtaining sufficient images to answer the specific clinical question. The examination is tailored to the area of clinical interest. The sonographer obtains select views of each organ per the abbreviated protocol. Supplemental images are obtained as needed for the identified pathology if the sonographer or radiologist deems them necessary. These examinations are labeled as abbreviated in the picture archiving and communication systems (PACS) for interpretation and future reference. Additionally, the abbreviated protocol for a patient's examination can be discussed in advance of performing the ultrasound examination between the sonographer and the interpreting radiologist to better plan which images a sonographer should obtain. No measurements are taken by the sonographer at bedside as measurements can be performed on the workstation on either static or cine images.

Technological Considerations

Currently, there are many technological features on ultrasound machines that allow for both physical distancing and improvements in ultrasound workflow, although the availability of these features may vary by institution. For instance, ultrasound machines allow for wireless transfer of images without the need for physically plugging into a network port. This decreases the total sonographer examination time while also allowing for the radiologist to review images in real-time. If needed, a radiologist can request additional images without the sonographer needing to doff PPE.

Early in our institution's response to the pandemic, the radiology department and information services staff ordered and deployed home workstations for attending radiologists and laptops for residents and fellows. In addition to these remote reading capabilities, FDA-approved 4K monitors were deployed to physician offices. These office reading stations were used by both onsite attending radiologists and onsite trainees to promote social distancing.

To continue providing services that are typically considered to be "in person" activities (eg, resident or fellow readouts, clinical consults, consultation at multidisciplinary conferences, and participation in lectures for trainees), multiple changes were made to the attending radiologist workflow. First, hospital voice over internet protocol (VoIP) phones was installed as part of the attending home reading station that mirrored the extension for the radiologist's individual

office. These hospital phones make calls that originate from a “local” hospital extension when attempting to contact a trainee for a remote readout or a clinical service to discuss a critical finding. Second, our department began offering video conferencing as part of the institution’s IT infrastructure suite. The institution’s video conferencing provides a HIPAA compliant platform for 2 or more individuals to share their screens and audio. Since this program allows for easy handoff of screen sharing between participants, interactive readouts can be continued whereby a trainee can begin by showing their thoughts on a case and the attending can then finish with their final thoughts and teaching points. Finally, with the transition of trainee conferences to a virtual environment when appropriate, audience response technology is being increasingly used by faculty including ultrasound topics. This technology greatly increases attendee engagement and allows lecturers to get immediate feedback on whether they are conveying material in an effective manner.

Additionally, there are some emerging technologies now commercially available which allow the possibility of interactive video conference between the technologist and the radiologist with real-time imaging and real-time probe positioning in 3D space.

Reactivation and Deactivation of Operations

After the initial wave of the COVID-19 pandemic, public health departments created plans of action for reopening [13]. Safe and sustainable outpatient diagnostic operations should be reviewed and revised as needed according to public health conditions of the moment, as well as contingency plans for any resurgence of COVID-19. Factors that an ultrasound department should consider regarding reactivation and deactivation include testing capabilities, spacing of operations, scheduling that avoids overcrowding, preserving PPE, and triaging of examinations, as well as changes in policies and procedures governing individual appointments [14]. Cleaning and disinfecting guidelines are accessible on the CDC website [12].

Reactivation Plans for Outpatient Diagnostic Operation

Limited access to elective examinations during a pandemic results in a backlog of examinations that need to be performed. To increase the scheduling of ultrasound examinations during reactivation, the patients are grouped into 3 categories A, B, and C depending on time-sensitivity of the involved level of care (Table 2), that is, the urgency of diagnosis. The patients in group A include those already receiving in-person care who

TABLE 2
Patient Groups Based on Level of Care Needed for Reactivation Planning

Patient Group	Description
Group A	Patients who are already receiving in-person care
Group B	Acute symptomatic, chronic, or complex patients who can no longer be postponed and need in-person care
Group C	Patients requiring routine in-person care (eg, less time-sensitive care)

often require an urgent diagnosis. The patients in group B include those who are acutely symptomatic or have chronic or complex cases that cannot be postponed and need in-person care. The patients in group C include those requiring routine in-person care (eg, less time-sensitive care). The ramping up of operations can be divided into three phases (phases 0, 1, and 2) based on the patient groups described above, level of care needed, and achievement of safety milestones met (Table 3).

DISCUSSION OF FUTURE DIRECTIONS

A wide range of radiology and nonradiology practices from tertiary care centers to community hospitals all require diagnostic ultrasound, including the breast,

TABLE 3
Phases of the Reactivation of Operations

Phase	Description of Operations
Phase 0	Continue to provide in-person care for Group A patients (and tele-visits for appropriate Group B and Group C patients).
Phase 1	Pending the achievement of safety milestones, begin providing in-person care for Group B patients (and continue to provide tele-visits for all groups wherever appropriate).
Phase 2	Pending achievement of safety milestones, begin providing in-person care for Group C patients (and continue to provide tele-visits for all groups when appropriate).

obstetric, vascular, cardiac, and interventional departments. The COVID-19 pandemic has created a need to rapidly modify traditional ultrasound protocols, procedures, and guidelines. Ultrasound experts should continue to lead initiatives to develop, refine, and implement new protocols and procedures as the COVID-19 pandemic evolves. Future ultrasound research and innovation can explore avenues of telemedicine, tele-radiology, robotics, and automated processes in medical imaging, which will help during the COVID-19 pandemic and beyond. With these procedures and guidelines in place, ultrasound health care workers will be prepared to efficiently manage the evolution of the COVID-19 pandemic and will be systematically prepared for any future pandemics or emergencies.

DISCLOSURE

The authors have no relevant disclosures.

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