Ultrasound-guided regional anesthesia in COVID-19 and future pandemics: infection control

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Purpose of review
Infection control is inherent in ultrasound-guided regional anesthesia practice, because ultrasound transducer and coupling gel can be vectors for pathogen transmission. We reviewed the current standards and recommendations of ultrasound transducer cleaning, disinfection, and safe handling of ultrasound equipment. Based on the available data, we propose a set of practical recommendations applicable to coronavirus disease 2019 (COVID-19) pandemic and future epidemics.

Recent findings
Regional anesthesia is often preferred over general anesthesia for COVID-19 patients. Avoidance of general anesthesia reduces the need for aerosol generating procedures. Administration of ultrasound-guided regional anesthesia and surgery under regional anesthesia in COVID-19 patients requires careful infectious precautions to prevent the viral spread through the use equipment.

Summary
Ultrasound machine, transducer and coupling gel can serve as a vector for transmission of pathogens. In the era of COVID-19 pandemic, standardized strategies are recommended to minimize the risk of spread of COVID-19 to both patients and the healthcare providers.

Keywords
COVID-19, disinfection, droplet precautions, personal protection equipment

INTRODUCTION

With the widespread use of real-time ultrasound guidance for regional anesthesia, infectious precautions during handling of the ultrasound machine and transducers are important. American Institute of Ultrasound in Medicine considers infection control as an integral part of the safe and effective use of ultrasound in medicine [1]. Clinicians involved in medical ultrasound should be familiar with the disinfection protocols for ultrasound transducers to ensure safety of patients and healthcare providers. Education on ultrasound transducer cleaning and disinfection is crucial [1,2]. During the novel coronavirus disease 2019 (COVID-19) pandemic, taking practical measures to prevent COVID-19 infection during surgery under regional anesthesia is important. Fortunately, practical measures for COVID-19 patients can be applied to other patients and epidemics. In this review, we summarize the infection control for ultrasound-guided regional anesthesia.

DEFINITIONS OF INFECTION CONTROL PROCEDURES AND TERMS RELATED TO THE ULTRASOUND TRANSDUCER

The development of infection control strategies requires a clear outline of the key processes involved. This section aims to provide the needed definitions while leaning to the terminology used by the Center for Disease Control and Prevention (CDC) for disinfection and sterilization in healthcare facilities.

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KEY POINTS

- Ultrasound transducers and coupling gel can be potential vectors for pathogen transmission.
- Ultrasound transducers should be cleaned and disinfected according to the purpose of use.
- Ultrasound transducers in regional anesthesia use should be covered with a single-use sterile transducer cover.
- Sterile gel should be used on the disinfected skin during the procedure.
- After use, the transducer cover is removed, excess gel on the transducer is removed, and the transducer is subject to low-level disinfection.

(1) Cleaning: To remove foreign material (e.g., soil, and organic material) from objects and is normally accomplished using water with detergents or enzymatic products.
(2) Disinfection: A process that eliminates many or all pathogenic microorganisms, except bacterial spores.
(3) Low-level disinfection (LLD): Destruction of most bacteria, some viruses, and some fungi. LLD may not inactivate *Mycobacterium tuberculosis* or bacterial spores.
(4) Intermediate-level disinfection (ILD): Inactivation of *Mycobacterium tuberculosis*, bacteria, most viruses, most fungi, and some bacterial spores.
(5) High-level disinfection (HLD): Destruction/removal of all microorganisms, except bacterial spores.
(6) Sterilization: A process that destroys or eliminates all forms of microbial life and is carried out in healthcare facilities by physical or chemical methods. Steam under pressure, dry heat, ethylene oxide gas, hydrogen peroxide gas plasma, and liquid chemicals are the principal sterilizing agents used in healthcare facilities. When chemicals are used to destroy all forms of microbiologic life, they can be called chemical sterilant. These same germicides used for shorter exposure periods also can be part of the disinfection process (i.e., HLD).

In addition to the above-mentioned definitions, medical instruments are classified into three categories according to the risk of pathogen transmission associated with their use. Systems used for this purpose include the original Splauding's classification: noncritical, semi-critical and critical, also referred to as low risk, medium risk, and high risk [3].

(1) Critical devices: Instruments that penetrate skin or mucous membranes or are used in sterile body areas, such as the intravascular space. Sterilization of these devices is imperative. These devices pose the highest risk of infection. However, no ultrasound transducer is included in this category [1].
(2) Semi-critical devices: Transducers that come into contact with mucous membranes but do not penetrate membranes (e.g., endocavitary/endovaginal transducers, transesophageal transducers). These devices pose a higher risk of infection because of contact with nonintact skin or mucous membranes. HDL with destruction/removal of all microorganisms except bacterial spores is recommended using various chemical components.
(3) Noncritical devices: Instruments that come into contact with intact skin, but not mucous membranes. These devices pose the lowest risk of infection because they only contact intact skin. Linear, curvilinear, and phased array transducers placed on clean intact skin are categorized as noncritical devices. Therefore, LLD or ILD is recommended, which eliminates most bacteria (but not bacterial spores) and fungi, as well as certain types of viruses, including human immunodeficiency virus. If added decontamination is desired (for a wider range of viruses and mycobacteria), additional use of disinfectants, such as alcohol, aldehyde, phenolic and quaternary ammonium compound-based disinfectants, is recommended [3]. This represents ILD (inactivation of bacteria, most viruses, most fungi, *Mycobacterium tuberculosis* and some bacterial spores).

CURRENT STANDARD OF ULTRASOUND TRANSDUCER CLEANING AND DISINFECTION FOR REGIONAL ANESTHESIA

When performing ultrasound-guided regional anesthesia, an aseptic technique should be followed [4]. Adequate transducer cleaning and preparation are mandatory to protect patients from potential infection [5▪]. Ultrasound transducer for interventional percutaneous procedures, including lumbar puncture and ultrasound-guided regional anesthesia, should be cleaned using LLD (for example, 70–90% alcohol [6]) and be used in conjunction with a single-use sterile transducer cover during the procedure [1]. The operator should always clean hands with LLD and use sterile gloves [5▪,7]. Some guidelines even recommend HLD for percutaneous procedures. However, this recommendation has been

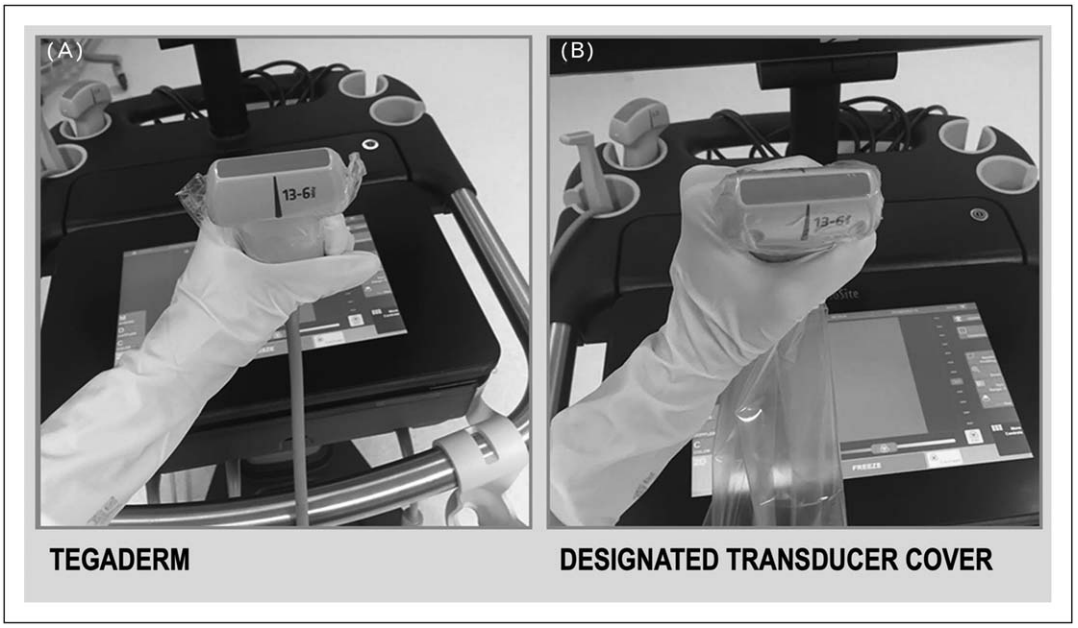

FIGURE 1. Incomplete and complete transducer covers. Comparison of Tegaderm (A) and full transducer cover (B). Note that the Tegaderm does not cover the transducer cable.

challenged by the report of Alakkad and colleagues who communicated that the risk of block-related infection after using a practical and efficient LLD technique and sterile barrier dressing is extremely low [5▪,8]. Needle guidance aids that are affixed to the transducer must be sterilized if re-used, but sterile and disposable attachments may be better suited for use in a pandemic.

At the end of each procedure, the gel or debris should be cleaned after removing the transducer cover [1,5▪,9,10]. A small brush may be used for crevices and areas of angulation, depending on the transducer design. All remaining gel should be wiped off. If at any point during patient care the transducer gets contaminated with patient blood or body fluid, the transducer should be treated using LLD that is effective against mycobacteria and bloodborne pathogens (including hepatitis B virus, hepatitis C virus, and human immunodeficiency virus). Figure 1 illustrates the inadequacy of the commonly used wound dressings over the transducer, unless the entire transducer and cable are subjected to disinfection between procedures. Such barrier protection is incomplete as parts of the transducer and its cable are not protected and can be a vector of viral transmission. This is eliminated by using full transducer covers that also cover the transducer cable (Figure 1B and Figure 2). Ultrasound transducers should be cleaned and disinfected adhering to the manufacturer's instructions.

ULTRASOUND TRANSDUCER AND GEL AS POTENTIAL VECTORS FOR PATHOGEN

Ultrasound coupling gel is necessary for the quality of ultrasound images obtained during ultrasound-guided regional anesthesia [11]. However, both ultrasound coupling gel and transducers can be sources of nosocomial infection [4,12]. For ultrasound-guided regional anesthesia, sterile single-use gel should be used on the side that interfaces with the patient [1]. Although sterile gel or sterile saline can be used inside the transducer sheath (not in contact with the patient) [13], it may not be necessary. Indeed, some clinicians do not use nonsterile gel inside the sterile transducer cover (i.e., between the transducer surface and inside surface of the transducer sheath). The transducer is typically not sterilized between uses; instead, the sterility is accomplished with sterile covers. Some transducer cover designs feature an adhesive on the inside surface, in which case the coupling gel may not be required for imaging.

Practitioners should be aware that ultrasound transducers and coupling gel are potential vectors for pathogen transmission, especially in immunocompromised and high-risk patient populations [14]. The practice of wiping the transducer which was exposed to the disrupted skin with a soft paper towel after each procedure until it is visibly clean is long outdated and below the standards of infection control [9]. Pathogenic microorganisms, such as methicillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa* [15], *Klebsiella pneumoniae*

FIGURE 2. Full transducer cover.

producing extended-spectrum β-lactamases [16], were identified from the ultrasound transducer surface [17] or the coupling gel. Recent guidelines recommend that transducers used for ultrasound-guided regional anesthesia should undergo LLD after removing bulk gel on the transducer surface [1,5▪]. Ultraviolet C light is used by some as an additional aid for pathogen reduction on transducer surfaces [18].

Clinicians also should know that sterile transducer covers may become contaminated during the manufacturing, storage, and handling process; a visual inspection is often adequate to discover such defects. The ultrasound gel sachet within the ultrasound transducer cover kit may be contaminated with pathogen [19]. It may be effective to avoid applying gel on the intended puncture site of the skin to minimize the risk of iatrogenic infection.

INFECTION CONTROL UNDER CORONAVIRUS DISEASE 2019 PANDEMIC

The World Health Organization has declared the COVID-19 outbreak a global pandemic on March 11, 2020. The severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) that causes COVID-19 infection is known to be highly infectious and has been transmitted from human to human via contact, droplet, and likely airborne routes [20]. A recent meta-analysis revealed that the basic reproduction number (R0) was as high as 4.08 [21]. One of the strategies to minimize the exposure to SARS-CoV-2 is to avoid aerosol generating procedures (AGPs). Hence, general anesthesia which requires airway intervention, such as bag-mask ventilation, open airway suctioning, and trachea intubation, bear the risk of COVID-19 transmission to healthcare providers or patients in the operating room [22▪▪,23▪▪]. The odds of transmission of an acute respiratory infection to a healthcare provider during intubation are 6.6 times greater than to a worker not exposed to intubation [24].

Regional anesthesia is the preferred choice for providing anesthesia care to COVID-19 positive patients, whenever possible. This is because regional anesthesia avoids AGP and preserves respiratory function [22▪▪,23▪▪,25,26▪,27]. Thrombocytopenia can occur in patients with severe COVID-19 disease; however, neuraxial anesthesia and peripheral nerve blocks are rarely contraindicated in COVID-19 patients [25]. Use of ultrasound guidance is recommended for peripheral nerve blocks to avoid vascular injury, systemic local anesthetic toxicity [23▪▪], and to achieve a high success rate to obviate the need for conversion to general anesthesia. Several publications suggested a set of recommendations on the use of regional anesthesia in COVID-19 patients [26▪,28].

Table 1. Level of personal protection equipment (PPE) for management of COVID-19 infection [23▪▪,29]

Level of PPE	Clinical situation	Equipment required
Contact precautions	> 2 m away from patient	Gloves, fluid resistant gowns
Droplet precautions	Within 2 m of patient	Gloves, fluid resistant gowns, face shield/goggles[a], fluid resistant face mask
Airborne precautions	Aerosol generating procedure	Gloves, fluid resistant gowns, face shield/goggles[a], respiratory mask (FFP2/3 or N95 mask, fit testing required)/PAPR

The levels of protection are incremental: droplet precautions are also designed to prevent contact transmission; airborne precautions include prevent droplet and contact transmission [29].
FFP, filtering facepiece; PAPR, powered air purifying respirator.
[a]Personal glasses are insufficient.

Personal protective equipment (PPE): PPE, such as protective clothing, helmets, goggles, and other equipment, is to protect the wearer's body from injury or infection [29]. PPE is essential to protect medical staff and patients from COVID-19 transmission. PPE is classified according to the desired level of protection, that is, contact, droplet, and airborne precautions (Table 1) [29]. PPE should logically be matched to the potential mode of viral transmission occurring during patient care. The readers should be advised that the nomenclature of the level of PPE in the literature is often inconsistent [23▪▪,29].

Preparation of the operating room, equipment, and supplies: Confirmed or possible COVID-19 patients should be reviewed, blocked, and recovered inside the operating room where surgery is performed [22▪▪]. The number of staff within the operating room should be kept to a minimum. Only indispensable equipment and medications packed in a plastic bag should be brought into the operating room to minimize the risk of contamination and waste, as consumables may be discarded if they are not used for each patient [22▪▪,23▪▪,26▪,30,31▪]. When additional equipment that is not initially anticipated becomes required, it should be delivered by dedicated staff ('runners') who are familiar with equipment required for anesthesia and surgery [22▪▪,23▪▪,26▪,30].

Preparation and disinfection of ultrasound machine: One ultrasound machine should be designated as COVID-19 specific to avoid contamination of multiple machines, and to avoid the need for 'deep' cleaning and decontamination of multiple machines [32]. As the ultrasound machine has a large footprint and numerous surfaces that can harbor droplets, handheld ultrasound devices could be preferable over large units for COVID-19 patients [23▪▪]. If trolley-based ultrasound machines are designated, extra attachments such as baskets and printers should be removed [31▪]. The ultrasound machine should be protected from contamination using plastic covers [22▪▪,23▪▪], and the ultrasound transducer including cable should be covered with a disposable sheath. If the commercially available disposable sheaths are not long enough to cover the entire length of the transducer, two transducer sheaths can be combined to cover the entire transducer and cable [22▪▪]. The controllers of the ultrasound machines can be operated through a plastic cover or transparent drape. The operators should be gloved and should ascertain that the touch-sensitive displays respond appropriately to touch through the drape.

Although COVID-19 virus can remain viable for up to 72 h on plastic [33], most available low-level disinfectants, such as 70% ethanol, 0.5% hydrogen peroxide, 0.1% sodium hypochlorite, and 0.05–0.2% benzalkonium chloride, are effective against SARS-CoV-2 [34]. It is recommended that ultrasound machines should be wiped twice with disinfectant wipes [23▪▪], once inside the operating room prior to doffing, and then again outside the operating room after doffing contaminated PPE and donning new gloves [32]. The manufacturer's instructions for use should be followed. It is important to ensure that the disinfectants are approved for use on a specific ultrasound transducer and has proven virucidal efficacy [31▪,34]. Infection preventionists can aid with practice and training if it does not comply with the institutional guidelines [35].

CONCLUSION

Proper handling of the ultrasound transducer and its related materials is required to achieve sterile conditions during ultrasound-guided regional anesthesia. Adherence to recommendation guidelines and maintaining high standards for infection precautions especially in case of increased exposure to pathogens are essential. A systematic, standardized approach to infectious precautions while utilizing ultrasound equipment is required to protect patients and medical staff from viral and nosocomial cross-contamination. The experience learned during the

COVID-19 pandemic should be summarized into standardized infectious precautions algorithms to prevent pathogen transmission.

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Conflicts of interest

There are no conflicts of interest.

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