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Review

Review of strategies to prevent infections related to ultrasound-guided nerve blocks and vascular access

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Abstract

Ultrasound guidance has become ubiquitous in the clinical practice of regional anesthesia and vascular access. Because the ultrasound transducer and an acoustic coupling medium (e.g. ultrasound gel) are applied directly to the patient's body, the contact of a non-sterile ultrasound transducer with the site of intervention during the breach of the skin integrity by the needle carries the risk of infection transmission. Surprisingly, however, recommendations on how to prevent ultrasound-related outbreaks are often conflicting. With the increasing use of ultrasound in interventional procedures, such as vascular access, regional anesthesia, and pain medicine, the development of clear guidelines on how to prevent infection from patient to patient is essential for patient and operator safety. This review aims to provide a current understanding of the mechanisms and prevalence of infection transmission and to summarize the current recommendations for infectious precautions with interventional ultrasound. We also provide practically implementable and pragmatic recommendations for infectious precautions, based on the available information.

Keywords: **Ultrasound, hygiene, infection, peripheral nerve blocks, recommendations**

Introduction

Ultrasound guidance has become a tacit "gold standard" in the clinical practice of regional anesthesia and peripheral vascular access. An increasing number of ultrasound-guided procedures are being performed and ultrasound training is universally introduced in medical schools and clinical training programs. As ultrasound skills and equipment become ubiquitously available, the use of ultrasound in interventional medicine will continue to increase, requiring standardized guidance for infection prevention. Ultrasound cable- and gel-related infections have been reported as a source of hospital infection outbreaks[1,2], yet the recommendations for preventing these ultrasound-related outbreaks appear to be lacking in organized societies' recommendations. The lack of unified recommendations may be related to the heterogeneity of infectious precautions regarding ultrasound practices in Europe, as reported by a survey conducted by the European Society of Radiology (ESR)[3].

We performed a literature and internet search for guidelines and recommendations on the prevention of interventional ultrasound-related infections. The search included European[3], American, and Australasian[4] societies' recommendations and manufacturer recommendations. This review summarizes the currently available recommendations with the goal to synthesize a set of clinically applicable recommendations on preventive measures for the risk of ultrasound equipment-related infections.

Ultrasound-associated transmission of infectious diseases

Since most reports on serious ultrasound-related infection outbreaks were associated with endocavity use of ultrasound, it is not surprising that guidelines were created for this application of ultrasound[5,6]. However, guidelines on how to prevent infections with respect to ultrasound-guided regional anesthesia (LRA) and vascular access are lacking[7]. The up-to-date literature on infectious complications

of ultrasound-related interventions for LRA and vascular access identifies two factors: contaminated ultrasound gel and direct transmission from the provider to the patient or from patient to patient.

Several case reports describe bacterial outbreaks as a result of contaminated ultrasound gel[2]. Ultrasound gel that is applied on the patient during the procedure as an acoustic coupling medium between the ultrasound transducer and the patient, should be sterile when the skin integrity will be violated by the needle or other instruments. For that reason, multi-dose gel preparations which can easily get contaminated through repeated use on different patients and in-hospital storage, should not be used to maintain sterility during a procedure. Guidelines for minimizing the risk of contamination of ultrasound gel were first published in 2012[8], while recommendations on the use and storage of non-sterile ultrasound gel were published in the most recent ESR and Australasian guidelines in 2017[2,4]. The main recommendations are: 1) use single-use gel packages rather than refillable ones, 2) once opened, use the opened gel container only for a short period, 3) avoid gel container warmers, 4) avoid contact with the gel container dispensing tip with the patient's skin and 5), do not store gel containers upside down.

Direct transmission of pathogens from one patient to another, or from a healthcare provider to a patient is also possible. The prevalence of infection transmission by this route remains unknown as information in the literature is lacking[9]. Contamination of ultrasound transducers has been described in a number of observational studies from different countries[1,9]. Pathogens contaminating ultrasound-related equipment surfaces can be infectious for days and even up to several months. As an example, methicillin-resistant Staphylococcus aureus (MRSA), Pseudomonas aeruginosa, and Candida albicans can survive for several months on the ultrasound transducer[4,10]. Furthermore, most ultrasound machines contain edges and crevices (e.g. the keyboard, transducer surface) which are difficult to clean and disinfect, and therefore, carry a risk of transmission of infectious material from operator to patient or from patient to patient. Although high-quality evidence lacks, most authors consider the ultrasound-associated transmission of infections a threat to patient safety that requires measures for patient protection in daily clinical practice.

Infections associated with ultrasound-guided nerve blocks and peripheral vascular access

Most reports of infections associated with nerve blocks are related to indwelling perineural catheters[11]. Contamination of catheter insertion sites appears to be relatively common, with reported rates between 28.7% and 54%[11,12]. In addition, the incidence of ultrasound transducer contamination with skin flora ranges from 58% to 67%[13-15] and rises to 70% when the patient has skin or soft-tissue infections[16]. The incidence of clinically relevant infections associated with nerve blocks is relatively low (0-3%), including when ultrasound guidance was used for catheter insertion (infection rate of 0.13%)[17]. The use of ultrasound guidance does not seem to increase the risk of contamination[18], if performed with a strict aseptic technique, including probe dressing[19]. Regardless, in addition to catheter contamination-related infections, the risk factors associated with perineural catheter infections include postoperative hyperglycemia, omission of antibiotic prophylaxis, catheterization of > 48 hours, and admission to the intensive care unit[19]. Although the exact risk of infections related to ultrasound-guided procedures that violate the skin barrier is not known, the importance of barrier precaution is increasingly recognized in the recommendations and guidelines of various anesthesia societies[20]. A summary of published recommendations with a historical perspective is highlighted later in this publication.

The Spaulding classification

First published in 1968, the Spaulding classification is still referenced today, albeit in its modified form. The classification provides general guidelines for the sterilization and disinfection of medical instruments, including the ultrasound transducer[21]. The classification is detailed in American Centers for Disease Control and Prevention (CDC) guidelines and European law[22]. Depending on the risk classification of the procedure, the recommendations vary from low-level disinfection (LLD), high-level disinfection (HLD), or sterilization (Table I). HLD is recommended for ultrasound-guided LRA and both peripheral and central vascular access[3,4,23]. Since compliance with HLD may require the transport of the ultrasound machine to a central sterilization unit, the application of commercially available wipes that are validated for HLD could be a more practical solution. However, the wipes method for HLD has been validated only for reusable endolaryngoscopes in the otorhinolaryngology department and not for the ultrasound machine, although the method could be applicable for ultrasound indications as well[24].

Full-length ultrasound transducer covers

Another alternative is the use of dedicated, full-length ultrasound transducer covers that provide protection for both the transducer and its cable

Table I. — Spaulding classification.

Spaulding class	Invasiveness	Disinfection level	Possible ways of decontamination	Probe examples
Critical	Insertion in sterile cavities	Sterilization	Sterilization	Probes for endovascular insertion, intra-operative use, and endobronchial procedures
Semi-critical	Contact with non-intact skin or mucous membranes	HLD	Glutaraldehyde-based formulations UV-c OPA 0.55% Hydrogen peroxide 7.5% Hypochlorite Pasteurization Wipes approved for HLD	Probes for TEE, locoregional anesthesia, vascular access Endovaginal and endorectal use probes
Non-critical	Contact with intact skin only	LLD	Detergents	Diagnostic procedures on intact skin Freehand biopsy with no possible contact between probe and puncture site or needle

TEE, transesophageal echocardiography; HLD, high-level disinfection; LLD, low-level disinfection; UV-c, ultraviolet C; OPA, Ortho-phthalaldehyde.

during ultrasound-guided peripheral vascular access procedures. Various guidelines and safety recommendations regarding the use of transducer covers during LRA procedures have been published by different organizations and societies. All existing guidelines appear to recommend a transducer cover, whether or not sterile gel is used. The European Society of Radiology Ultrasound Working Group recommends that "transducer covers must be used for all major and minor interventional procedures, whenever transducers may be in contact with body fluids such as blood, secretions, pus, etc.", including invasive interventions as well as injections, fine needle aspirations, and transducer contact with infected or broken skin, eczema, and wounds[3]. In analogy with this European recommendation, the American College of Emergency Physicians recommends that "transducers which are used during percutaneous procedures (e.g. vascular access, thoracentesis, paracentesis, arthrocentesis, pericardiocentesis, lumbar puncture, regional anesthesia) or on non-intact skin should be covered with a single-use sterile transducer cover"[25]. The Australasian society recommends that all transducers used for needle-guided procedures should be covered with a single-use high-quality transducer cover[4,23].

Clinically applicable recommendations

The following summary is a compendium of the published recommendations with a historical perspective. This summary will first discuss the recommended general hygiene measures, then precautions recommendations for procedures without breach of skin, and then the practical recommendations for procedures where the skin is breached during the procedure, such as in RA and vascular access. As the universally accepted recommendations do not exist, and the recommendations may vary in different geographies and institutions, where appropriate, we also provided alternative views to allow for the necessary geographical flexibility.

1. General hygiene measures

I. Hand hygiene remains important as its role in infection transmission is well documented. Local/specific protocols should be followed at all times with hand disinfection before and after patient contact.

II. Wiping/cleaning the transducer before disinfection is important since any matter that adheres to the transducer (e.g. transmission gel) may diminish the efficacy of the disinfectant by preventing its reach to the surface of the transducer. Contamination may persist after disinfection if the transducer is not properly cleaned first.

III. The device manual with cleaning and disinfection recommendations by the manufacturer should be adhered to. Certain

cleaning and disinfecting methods may damage the transducer and create micropores in which pathogens can survive, even after thoroughly cleaning and disinfecting.

2. Ultrasound procedures on intact skin

Barrier precautions are not recommended for ultrasound use where the skin integrity is not breached, as long as the patient has no conditions that require additional barrier or hygiene precautions (e.g. MRSA, immunocompromised patients). After the procedure, at least low-level disinfection (LLD) is recommended.

3. Semi-critical procedures including ultrasound-guided vascular access and RA

Barrier precautions

Evidence-based guidelines on the use of barrier precautions to prevent contamination when performing ultrasound-guided nerve blocks and peripheral vascular access are lacking. As an example, neither the European Society of Anaesthesiology (ESA) guidelines on the perioperative use of ultrasound-guided vascular access (PERSEUS vascular access), nor the European recommendations on the proper indication and use of peripheral venous access devices (the ERPIUP consensus), nor the Australasian Society for Ultrasound in Medicine (ASUM) or the Australasian College for Infection Prevention and Control (ACIPC) recommend guidelines regarding barrier precautions for ultrasound-guided peripheral vascular access[4,23,26,27]. In contrast, the Belgian Association for Regional Anesthesia (BARA) guidelines do recommend barrier precautions for the practice of nerve blocks, and the anesthesiologist should wear a surgical mask, surgical cap, and sterile gloves, and disinfect the insertion site with chlorhexidine 0.5%[28]. If a catheter insertion technique is planned, the use of a sterile gown and drapes, and a transducer cover is additionally recommended. The procedure should start only when the skin is sufficiently dry after disinfection with chlorhexidine[29], as chlorhexidine can be neurotoxic[30]. The German Society of Ultrasound in Medicine (DEGUM) guidelines do not routinely recommend the use of sterile gloves or a sterile transducer cover (Figure 1) for single-shot nerve blocks or ultrasound-guided peripheral

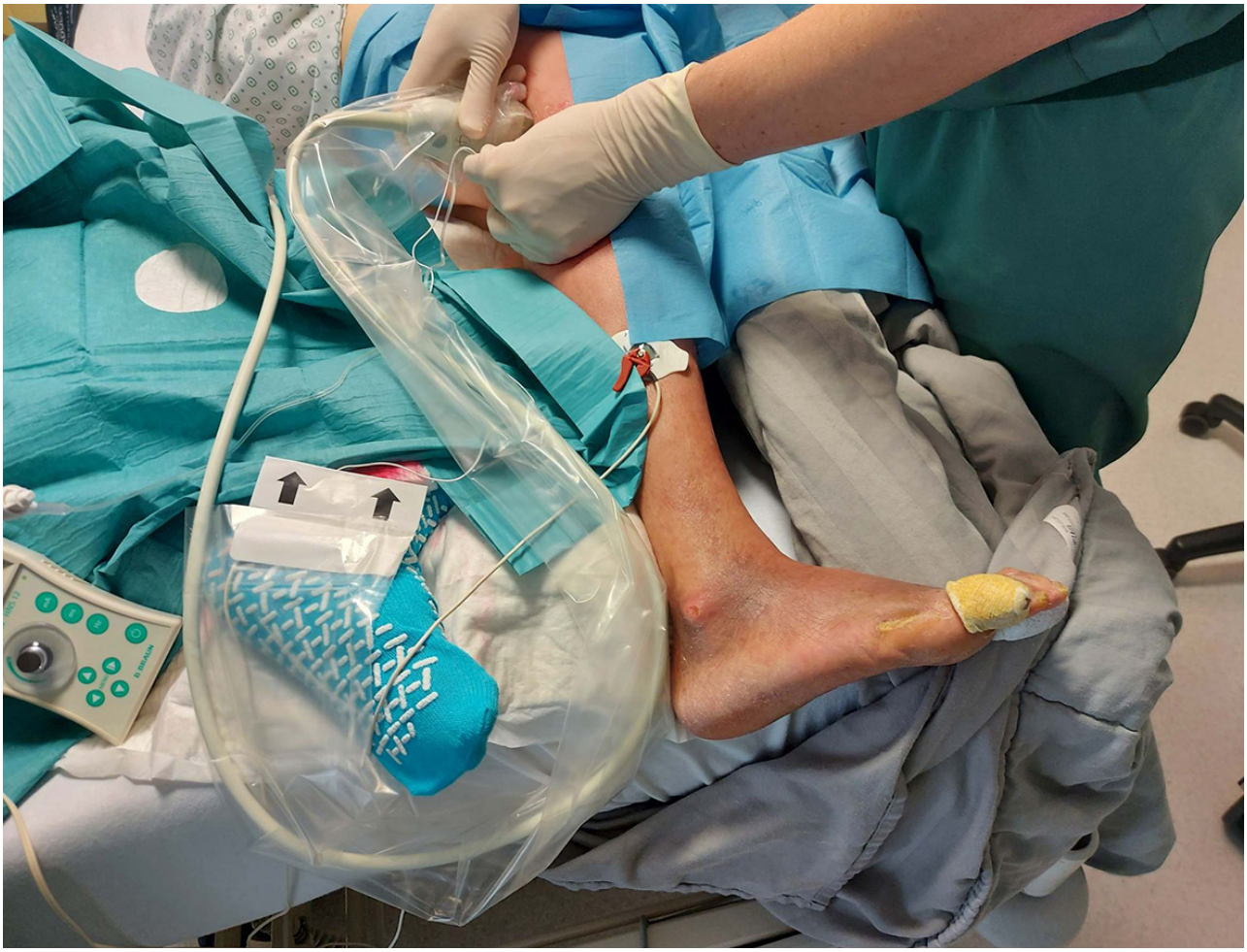

Fig. 1 — Visualization of the risk of transducer cable contamination during the popliteal block procedure, highlighting the necessity of a transducer cover that includes the transducer cable.

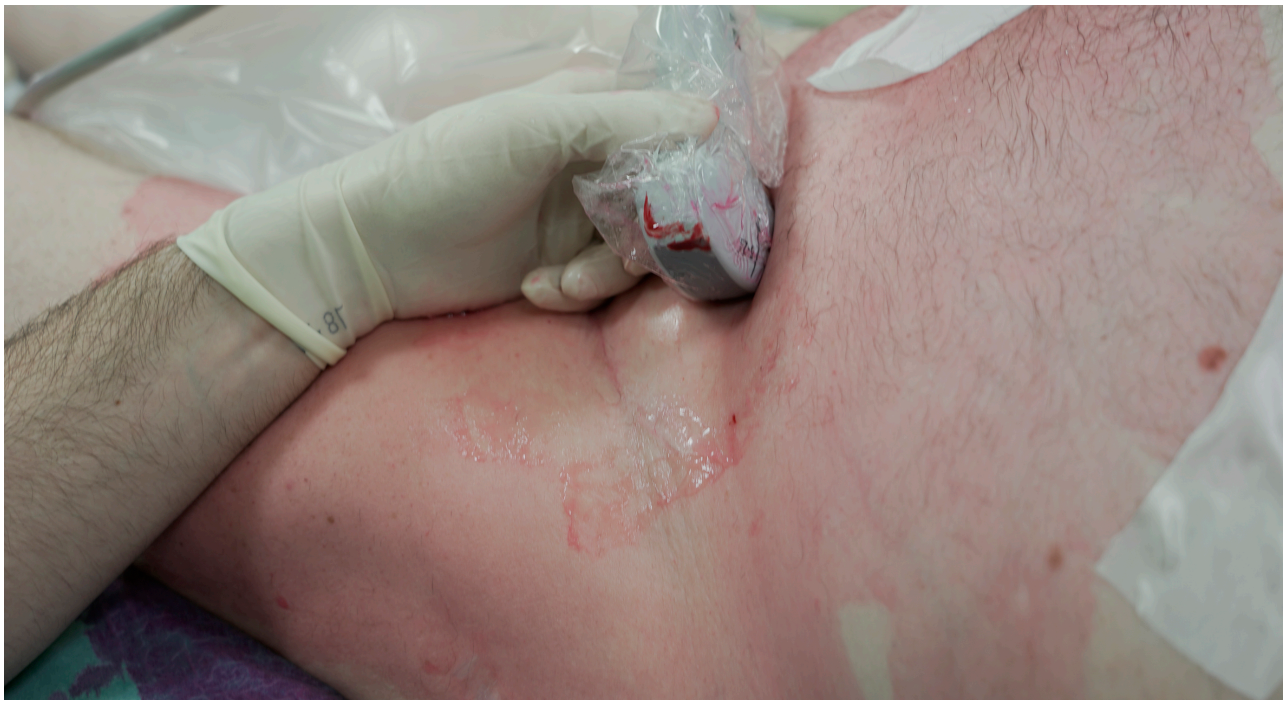

Fig. 2 — Blood on the probe cover on the transducer and cable after nerve block injection. Without the probe cover, the probe and cable would be contaminated with blood.

vascular access, on the condition that contact with the transducer can be prevented or ruled out20. However, it is difficult or impossible to reliably prevent such contact during ultrasound-guided regional anesthesia. As an example, entry of a 20-22 gauge needle through the skin during nerve block procedures invariably results in oozing through the skin insertion site, often soiling the cable with the blood or serum (Figure 2).

Further heterogeneity among these German DEGUM and Belgian BARA guidelines does exist. First, surgical draping is not routinely recommended for single-shot blocks by BARA, in contrast to DEGUM guidelines which recommend surgical draping in procedures requiring a syringe change. Second, sterile gloves and a sterile transducer cover are routinely recommended by BARA, while DEGUM recommends the use of these only when contact between the needle and transducer cannot be ruled out. However, as mentioned before, it is impossible to reliably prevent such contact during ultrasound-guided nerve block or peripheral vascular access, and, therefore, a transducer cover should always be used during these procedures. Third, BARA guidelines do not exist for ultrasound-guided peripheral vascular access, and European recommendations (ERPIUP consensus) do not specifically address ultrasound-guided peripheral vascular access, however, they recommend applying full sterile precautions whenever inserting peripheral cannulas longer than 5 cm, whether or not under ultrasound-guidance[28]. The DEGUM guidelines, on the other hand, recommend using germ-free (non-sterile) gloves and a sterile coupling medium for peripheral vascular access when using the "aseptic no touch" technique. If contact between the needle and transducer cannot be avoided, as is often the case, sterile gloves, and a transducer cover are additionally recommended but sterile draping is not required20. The cost of incorporating single-use sterile protective cover as a standard may constitute an additional barrier to reaching a universal consensus, in view of the low risk of clinically relevant infection.

Ultrasound transducer covers

A transducer cover should include both the transducer and the cable as recommended by BARA, DEGUM, and the ESR guidelines[3,20,28]. Likewise, the use of sterile gel on both the outside and the inside of the transducer cover is recommended by ESR[3].

Transducer disinfection

Both the American Institute of Ultrasound in Medicine (AIUM) and the American College of Emergency Physicians (ACEP) state that the use of sterile gel and single-use protective covers during ultrasound-guided peripheral vascular access justify the application of LLD before and after any insertion[31]. However, this statement is contradicted by the CDC's Healthcare Infection Control Practices Advisory Committee (HICPAC), the Association for Vascular Access (AVA), and the Association for Professionals in Infection Control and Epidemiology (APIC) as they all confirmed that even with the use of transducer covers, ultrasound-guided peripheral

vascular access is classified as semi-critical requiring HLD before and after any insertion[32,33]. Indeed, all procedures that involve breaking sterile barriers with otherwise sterile compartments or involve contact with mucosae, with or without insertion of a catheter, should require HLD (Table I)[4].

Adequate personnel training

The training in the use of the ultrasound machine as well as the quality of ultrasound machines have been both improved in recent years. Adequate training helps with the correct use of preventive infection measures, such as the application of sterile covers or disinfection strategies, as insertion and maintenance of peripheral vascular catheters by untrained personnel have been associated with higher infection risks[34]. Adequate training can also decrease the number of attempts to perform an ultrasound-guided interventional procedure, possibly reducing the number of puncture sites and the risk of infection[35].

Conclusion

The review of the literature suggests that ultrasound-associated pathogen transmission is a clinically relevant problem. However, guidelines on how to prevent infections related to ultrasound-guided LRA and peripheral vascular access are lacking. With respect to general hygiene, it is recommended to follow local hospital protocols and basic hand hygiene rules. Regarding barrier precautions, all reviewed guidelines recommend full sterile draping, a gown, a surgical mask and cap, sterile gloves, and a transducer cover including the cable when performing LRA with catheter insertion or a peripheral vascular access procedure. In case of single-shot LRA, German DEGUM and Belgian BARA guidelines both recommend that all of the aforementioned measures, with the exception of the surgical gown, should be applied. Disinfection of the ultrasound transducer, after being used with a transducer cover to perform nerve blocks and peripheral vascular access, requires HLD. A transducer cover should include both the transducer and the cable. Likewise, the use of sterile gel on both the outside and the inside of the transducer cover is recommended. Moreover, it is recommended to clean and disinfect equipment such as the ultrasound machine regularly and thereby pay close attention to crevices and difficult-to-clean surfaces, such as the keyboard or buttons. Finally, adequate training of personnel is important to prevent unnecessary contact between the transducer, unintentional contamination of the equipment and to minimize perforation rates.

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