Ultrasound probes as a possible vector of bacterial transmission

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Abstract
Ultrasound probes are usually in a direct contact with the skin when used for detecting pathologic abnormalities. The probe could be a vector of bacterial transmission, but there have been few studies on this topic. We have made such studies, briefly reviewing 1) the conditions governing a possible bacterial transmission by probe, 2) the deterioration of an ultrasound probe by alcohol disinfection, 3) a suitable method for evaluating bacterial contamination of an ultrasound probe, and 4) the best procedure for decontaminating such probes. This paper may lead to a formal consideration of the relationship between ultrasound probes and their roles in bacterial transmission in clinical practice.

Keywords: ultrasound; transducer; bacterial transmission; disinfection

Introduction
Infection control has recently been referred to a risk management in daily practice [1,2].

The diagnostic equipment that is used in ultrasound practice can be a source of bacterial transmission among patients [3-5]. To the best of our knowledge, the first report on the risk of cross-infection with ultrasound equipment was published in 1988 [3]. Ultrasound probes come into direct contact with the skin of patients and can transmit bacteria. Clinical cases of infectious disease due to cross-infection via ultrasound probes have rarely been reported [4,5], but careful attention must be paid to prevent infection via ultrasound equipment in order to avoid such iatrogenic events. The bacterial condition of each ultrasound probe should be routinely evaluated, and the probes should be disinfected after examination; however, standard procedures for evaluation and disinfection of probes have yet to be established.

To regulate bacterial transmission, we, as clinical laboratory physicians, should ascertain the true of the relationship between ultrasound probes and any related bacterial transmission. Disinfection of equipments is, in practice, one of the most important procedures in the prevention of bacterial transmission among patients. However, ultrasound physicians may give insufficient attention to the treatment of probes, because they are less aware of the risk of probe-related bacterial transmission (due to rare infectious events), while they know that frequent disinfection can cause ultrasound probes to break down, which leads to impaired ultrasound imaging.

We have studied these topics as a unique and important field [6-8]. In this review, we briefly summarize our knowledge of ultrasound probe-related bacterial transmission. In particular, we described: 1) bacterial contamination via ultrasound probes, 2) methods of evaluating bacterial contamination of ultrasound probes, 3) the deterioration of ultrasound probes caused by alcohol disinfection, and 4) various procedures for decontaminating...
ultrasound probes. This paper may be useful as a starting point for sharing some ideas on infection control among clinical laboratory physicians.

**Bacterial contamination via ultrasound probes**

A previous report have presented a case of pyoderma caused by *Staphylococcus aureus* cross-infection related to contaminated ultrasound gel among neonate [4]. An additional report has presented a case of nosocomial outbreak of *Klebsiella pneumoniae* originated from a contaminated ultrasonography coupling gel [5].

Our previous study also confirmed that unwiped ultrasound probes could become contaminated with bacteria that might be transmitted from patient to patient [6]. That study detected coagulase-negative *Staphylococcus* (CNS) from as major bacterial species transmitted via ultrasound probes, followed by *Corynebacterium* species, *Bacillus* species, and *Staphylococcus aureus* including Methicillin-resistant *Staphylococcus aureus* (MRSA). Although CNS and *Corynebacterium* species are common skin microbiota [9], they can cause critical infectious disease in immnosuppressed patients [10,11]. *Bacillus subtilis* is not a human pathogen, but *Bacillus cereus* causes various infectious diseases, such as food poisoning, bacteremia, meningitis, pneumonia, and endocarditis [12]. *Staphylococcus aureus* is one of the main causes of hospital-and community-acquired infections which can have in serious consequences [13], and MRSA is an especially dangerous pathogen because of its resistance to many antibiotics [14]. These data indicate that full consideration of bacterial transmission via ultrasound probes is essential.

**Methods for evaluating bacterial contamination of ultrasound probes**

Bacterial contamination of stethoscopes has been considered by swabbing or by the direct imprinting of agar plates with the stethoscopes [15-17]. There are some methods for evaluating bacterial contamination of ultrasound probes. For example, 1) a single trypticase soya agar plate was streaked with a cotton-tipped swab that had been applied to the surface of the probe [18], 2) a sterile cotton swab was used to collect a bacterial specimen from the entire scanning surface of the probe. The swab was immediately placed in a bottle of Brain Heart Infusion broth. This broth was poured onto a Blood Agar Plate [19], and 3) ultrasound probes were immersed in brain-heart infusion broth, which was then inoculated onto agar plates [20]. However, which methods are the most suitable for evaluating bacterial contamination of ultrasound probes remains to be determined.

Our previous study compared three methods of examining the sensitivity and reproducibility of bacterial detection: “Probe imprinting method” (in which the surface of an ultrasound probe was applied directly to 5% sheep blood agar plates), “Swab streaking method” (using sterile cotton swab moistened with sterile physiological saline, which was then applied to the surface of an ultrasound probe, and then streaked directly onto blood agar plates.), and “Swab suspension method” (that involved sterile cotton swabs moistened with sterile physiological saline being applied to the surface of an ultrasound probe, and then placed in screw-cap tubes containing 1-mL sterile physiological saline and mixed in a vortex mixer, and finally, 100 μL of this swab suspension was inoculated onto blood agar plates) [7]. That study revealed that the “Probe imprinting method” offered a higher degree of bacterial detection than the either of the swab methods [7]. In addition, the results of bacterial detection by the “Probe imprinting method” correlated more closely with the actual contamination of the probes than those obtained by either of the swab methods. The lower sensitivities observed using swabs likely point to their unsuitability for detecting bacterial contamination of ultrasound probes. This is because the swabs that are used widely are made of cotton, and a problem with cotton is that bacteria are trapped within the fiber matrix, resulting in incomplete release of bacteria from swab [21].

Our study found CNS as the major bacterial species, followed by *Staphylococcus aureus*, *Bacillus* species and *Corynebacterium* species, in the probes after use [7]. Colonies of *Staphylococci* and *Bacillus* species were detected after 1 day of incubation, whereas *Corynebacterium* species took 3 or 4 days to become detectable [7]. Therefore, the culture period should be extended to 3 or 4 days in order to allow their detection. The development of methods for evaluating bacterial contamination of ultrasound probes is thus thought to be an important future task.

**Deterioration of ultrasound probes caused by disinfection with alcohol**

A 70% alcohol wipe following a dry wipe of the probe has been shown to render the probe bacteriologically clean [3]. This procedure is quick, inexpensive and convenient. Although wiping with alcohol is one of the most effective methods of disinfection, there is a possibility of deterioration of ultrasound probes.

Our previous study also investigated the degree of deterioration of ultrasound probes that results from their disinfection with alcohol [8]. That study used convex array-probe and linear array-probe to clarify the degree of
deterioration of ultrasound probes that results from their disinfection with alcohol. No apparent defect in the ultrasound beams was found regardless of the type of probes, but a significant decrease of the brightness of imaging was found after a certain period of use of linear array-probe. Alcohol disinfection did not affect the brightness of the convex array-probe. We think that this difference in the brightness between the probes is because linear array-probes have thinner elements and narrower intervals between the element arrays, and more susceptible to alcohol damage than the convex array probes. We also consider that longer periods of alcohol disinfection may cause deterioration of the probes even in using convex array-probes because the long-term effects are not examined in that study.

**Procedures for decontaminating ultrasound probes**

Our study showed that bacterial transmission could be almost completely prevented by wiping ultrasound probes with an alcohol-soaked paper towel [6]. Again, frequent alcohol disinfection can cause ultrasound probes to break down and impaired imaging [8], so wiping probes with alcohol-soaked paper towel after every examination may be a limited driving-force in clinical practice. Ultraviolet C may provide a useful method for reducing the bacteria [22], but this may also cause damage.

We found that bacterial transmission via ultrasound probes can be prevented by wiping probes with a plain paper towel, which does not cause any damage to probes [8]. We would like to recommend that at least, wiping the probes with a plain paper towel can reduce the numbers of bacteria, although to a degree that is not comparable with that obtained by using an alcohol-soaked paper towel. We think that, for practical purpose, ultrasound probes must be wiped at least with a plain paper towel after every ultrasound examination, and with an alcohol-soaked paper towel before examination for some disease states (e.g. immunosuppression disease) or after the examination of a patient with a skin infection. In addition, the probe must be wiped with an alcohol-soaked paper towel at the end of each working day.

It would be important to make the guidelines for disinfection of medical equipments. This has been recognized in other medical fields rather than ultrasonic practice. For instance, outbreak of multidrug-resistant New Delhi metallo-β-lactamase (NDM-1) Klebsiella in urological endoscopic was reported in UK [23]. Outbreak of multidrug-resistant *Pseudomonas aeruginosa* (MDRP) caused by contaminated transesophageal echocardiography was reported in Japan [24]. This transesophageal echocardiogram (TOE) probe was proved to have a defect of 5 mm in diameter at the surface near the transducer, and MDRP strain was traced to this defect [24]. There are no guidelines for disinfection of the endoscopy [22] and TOE [24]; and making guidelines has been debated [22,25].

The “Protex” (Parker; Fairfield, NJ, USA), which contains dimethyl ammonium chloride as its disinfectant agent, has been recently used on the United States, Hong Kong, South Korea, Trinidad, Venezuela and the United Arab Emirates. In our study, we showed that Protex was approximately as effective for disinfecting ultrasound probes as alcohol. More studies, however, are needed to clarify whether frequent disinfection with Protex-soaked paper causes any deterioration of ultrasound probes [26].

**Conclusions**

The phenomenon of bacteria transmission via ultrasound probes requires more attention. It is important to establish acceptable methods for evaluating bacterial contamination of ultrasound probes, but so far, little progress in this direction has been made. Several our studies have shown that bacteria can be almost completely eliminated by wiping with an alcohol-soaked paper towel; while disinfection with alcohol can cause deterioration of the probes. Wiping the probes with a plain paper towel can also reduce the numbers of bacteria. Additional methods and ideas have recently been considered. Further studies are needed for the evaluation of bacterial contamination and the disinfection of ultrasound equipments.

**Conflict of interest**: none

**References**

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