Superiority of chlorhexidine 2%/alcohol 70% wipes in decontaminating ultrasound equipment

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Abstract

Ultrasound equipment is known to act as a reservoir for potentially pathogenic organisms. The aims of these studies were to establish current cleaning practices, to review the extent of bacterial contamination of ultrasound equipment in our hospital, to establish an effective cleaning regimen and to ensure that cleaning does not cause damage. A questionnaire was sent to all acute NHS hospitals in England to establish current cleaning practices. A review of our current practice was performed to establish the extent of bacterial contamination of ultrasound equipment currently in use. Laboratory studies compared cleaning the probes with soap and water with decontaminating with a chlorhexidine 2% and alcohol 70% wipe, including quantifying the residual effect. Accelerated aging was performed on the probe and staff surveyed to establish potential problems with using the wipes on the probe. The survey revealed that a variety of cleaning methods were used to decontaminate ultrasound probes; 57% of our ultrasound machines were contaminated with bacteria. The laboratory studies showed superiority of the chlorhexidine and alcohol wipes over soap and water due to a residual effect, both immediately after cleaning and after 24 hours. The staff survey demonstrated no apparent change in function of the probe after cleaning with the chlorhexidine wipes. Cleaning ultrasound probes with chlorhexidine and alcohol wipes is effective and provides additional protection against bacterial contamination due to its residual effect, and appears in the short term to have no detrimental effect on the probe.

Keywords: Ultrasound, anaesthesia, infection control, decontamination, chlorhexidine

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Introduction

Nosocomial infections have a significant impact on individual patient care and the wider health service.¹ There is increasing concern that medical equipment, including ultrasound probes and coupling gel, can be a vector for transmission of nosocomial infections.^{2–6} Although the incidence of cross-contamination is difficult to determine, there have been serious and even fatal consequences reported.^{7,8}

There is little clear guidance as to which agent may be the most effective at decontaminating ultrasound equipment. Indeed, the Association of Anaesthetists of Great Britain and Ireland (AAGBI) guidelines on infection control do not mention ultrasound equipment, which has become an essential tool in modern anaesthetic practice for vascular access and regional anaesthesia.⁹ The American Institute of Ultrasound in Medicine (AIUM) produces guidelines for endocavity probes written by a multidisciplinary task force. It recommends initial cleaning of the probe followed by disinfection with a liquid chemical germicide, but does

not validate any particular agent. Indeed there are no published studies detailing the most commonly used methods for cleaning non-endocavity ultrasound equipment.¹⁰

In many hospitals, concerns that certain alcohol-containing wipes may damage the sensitive ultrasound probes and reduce their lifespan has led to avoidance of using any cleaning agents.^{6,11} However, simply wiping the ultrasound probes with paper towels or towels wetted with soap and water has previously been found to be ineffective at removing all potential contaminants.^{5,12–16} Alternative methods, such as the use of disposable sheaths or other protective barriers, may be safe with little change in image quality,¹⁷ but the sheaths may be breached, have cost implications, are time consuming to apply and require non-latex formulations.^{5,18} Probe covers are useful for endocavity scans or when the ultrasound probe may be used within a sterile field, but the probes still require decontamination.

Chlorhexidine is a disinfecting agent that is well-known to have a residual effect and has been found to be effective in decontaminating other pieces of anesthetic equipment.^{19,20}

Sani-Cloth CHG 2% (Professional Disposables International Ltd, Flint, UK) wipes contain chlorhexidine gluconate 2% and alcohol 70% and are routinely available in hospitals. We hypothesized that these wipes would be more effective than our current cleaning practice of using soap and water. We designed a series of laboratory experiments to establish whether using a chlorhexidine 2% alcohol 70% cleaning regime is superior to standard soap and water in decontaminating ultrasound equipment. We also conducted a survey to establish the current practice in the cleaning of ultrasound equipment in acute hospitals in England, performed a review of our current practice to assess the current cleanliness of ultrasound probes within our hospital and performed a limited accelerated aging process to ensure the use of the wipes does not reduce the function or appearance of the ultrasound equipment.

Methods

Postal survey

Written confirmation was received from the West Anglia Research Ethics Committee that formal ethical approval was not required for surveys of National Health Service (NHS) staff. A questionnaire was sent to the lead Operating Department Practitioner in all acute NHS hospitals in England. Repeat questionnaires were again mailed to trusts which did not respond to the first mailing and further non-responders were asked to complete the questionnaire as a telephone-based survey.

Review of current practice

The local Research Governance Committee waived requirement for formal ethical review for the review of our current practice. Ultrasound equipment in the emergency setting (operating theatre, emergency department and intensive care unit) was swabbed during a normal working day. No prior warning was given to the clinical areas, to ensure that the audit matched routine practice. The equipment in each location was believed to have been cleaned using soap and water after each patient contact and was deemed ready for use.

Rayon tipped microbiology swabs (Sterilin Limited, Cambridge, UK) were moistened with sterile saline solution and a non-touch technique was used to swab four components of the ultrasound equipment – the monitor, cable, handle and head of the probe. The swabs were coded and sent to the microbiology laboratory in Amies transport medium with charcoal, where they were cultured on Columbia agar and 5% horse blood (Oxoid Limited, Basingstoke, UK). These were then incubated in carbon dioxide at 37°C for 48 hours and then 21°C for 48 hours. The plates were subsequently examined by blinded laboratory staff for number of colonies formed. The types of organisms were subsequently identified by standard laboratory techniques using appearance, Gram stain and coagulase tests and VITEK identification.

Re-review of practice

Following the initial study, a change in practice was introduced into the hospital for the routine cleaning of ultrasound equipment. Cleaning was performed, using a Sani-Cloth CHG 2%, to thoroughly wipe the ultrasound equipment including the probe head, handle and cable every morning, as well as before and after each use. Two weeks after the recommendations were implemented into each department, a repeat swabbing of the equipment was undertaken. The swabbing and subsequent analysis of the cultures was repeated using the techniques previously described.

Laboratory study

Twenty ultrasound probes (C60X, Sonosite Ltd, Hitchin, UK) were contaminated with a microbial broth containing *Escherichia coli*, vancomycin-resistant enterococcus (VRE) and methicillin-resistant *Staphylococcus aureus* (MRSA) at a concentration of approximately 1×10^7 colony-forming units (cfu)/ml; 20 microlitres of this broth was pipetted onto the probe and allowed to dry. In order to establish whether this was a successful way of transferring microbes, each probe was subsequently swabbed. Swabbing involved using wet then dry cotton-tipped applicators over both the rubber and plastic surfaces of the probe. The two swabs were then inserted into a 3-ml bijoux bottle containing purified water, snapped at the mouth of the bottle and the lid replaced. The bottle was spun on a vortex for 10 seconds to encourage removal of microbes from the swabs. A total of 100 microlitres of this contaminated purified water was pipetted onto a Brilliance MRSA 2 agar and a further 100 microlitres onto a Columbia agar with horse blood plate. The plates were allowed to dry and transferred to an incubator at 37°C for 48 hours.

Following this, the US probes were re-contaminated with the microbial broth and then cleaned. Ten probes were cleaned with soap and water. A Premier gauze swab (Type 13 light, Shermond, Brighton, UK) was immersed in a soap and water solution containing 5 ml Cutan hypoallergenic soap (Deb Ltd, Denby, UK) in 500 ml water. The excess water was squeezed from the gauze swabs, the probes were cleaned with the swabs and allowed to dry. The remaining 10 probes were cleaned with a Sani-Cloth CHG 2% wipe for approximately 10 seconds and allowed to air-dry. To establish whether either method was effective at cleaning the probes, the swabbing and plating method previously described was repeated.

To establish whether either of the cleaning techniques had a residual effect, after cleaning, the probes were re-contaminated with the microbial broth and were swabbed and plated again.

To establish how long this residual effect lasts, following cleaning with either the soap and water or a Sani-Cloth CHG 2% wipe, the probes were left on a bench top for 24 hours. The handles were then contaminated with 20 microlitres of the microbial broth and subsequently swabbed and plated as before. After incubation, the plates were examined for microbiological growth, and the number of cfu was

counted for each plate. Growths over 100 cfu were considered very heavy, and thus were not counted further.

Accelerated ageing

A Sonosite C60X ultrasound probe was wiped 250 times using Sani-Cloth CHG 2% wipes, allowing the probe to dry adequately in between wiping, to reflect accelerated aging of the probe. Members of staff considered to be experienced in ultrasonography were individually surveyed to assess this pre-treated probe in comparison with an untreated one, which were considered to be of similar age. Consent was obtained prior to involvement in the survey and all individuals were blinded to the treatment of the two probes and asked to rate differences between them on a scale of one (no difference) to ten (very different). Differences in visual appearance were assessed and functionality was tested by using the probe on models. Comments were encouraged to support the scores given.

Statistics

All statistical analysis was performed using StatsDirect statistical package.²¹ The Wilcoxon signed rank test was performed to compare the audit data and the laboratory data. Confidence intervals are given for the statistical tests performed if appropriate. A p value <0.05 was considered statistically significant.

Results

Postal survey

A total of 164 hospitals were sent the postal questionnaire; 93 hospitals responded by post, with a further 24 being contacted by telephone. This led to an overall response rate of 71.3%. Of the hospitals that were surveyed, the most common practice for decontamination of ultrasound probes was the use of a disinfectant wipe (74.4%). A variety of brands were used, including both alcohol containing and

alcohol-free wipes. Only a small minority (5.1%) specifically mentioned using chlorhexidine-containing cleaning products; 8.5% of hospitals used either soap and water or a clean cloth as the only method of cleaning. More commonly, the probes were cleaned with soap and water prior to use of a disinfectant wipe. Some hospitals commented on using sterile sheaths or covers in addition to their cleaning policy for additional protection.

Initial review of current practice and re-review of practice

Seven ultrasound machines were swabbed during the initial audit. This initial review revealed that 57% (4) of our ultrasound equipment that was considered clean and ready to use was heavily contaminated with bacteria. The swabs taken from the handle and monitor grew the most bacterial colonies (Figure 1).

The individual organisms grown from the swabs were identified in the microbiology lab. The majority was *Bacillus* (60.4%), with *Micrococcus*, *Diphtheroids*, *Flavobacterium* and coagulase negative *Staphylococcus* also grown (Figure 2).

The repeat review of practice was performed after a change in cleaning regimen to include daily cleaning with Sani-Cloth CHG 2% wipes. The repeat review found significantly lower bacterial load on the ultrasound machines $p=0.0159$ (CI 0.5–3). Figure 2 shows the types of bacteria grown after the change in cleaning regimen.

Laboratory studies

The results show that the probe was successfully contaminated with the microbial broth, as all probes grew heavy growth following contamination. Both soap and water and Sani-Cloth CHG 2% wipes were equally successful at decontaminating the probes ($p=0.75$). With recontamination, the probe cleaned with soap and water became contaminated (Figure 3). However, the probe cleaned with the

Figure 1 The total number of bacterial colonies grown from various parts of the ultrasound equipment during the initial audit and following a change in the cleaning regimen to daily wiping with Sani-Cloth CHG 2%

Figure 2 The various bacterial species grown from the ultrasound equipment. The total number grown from the initial audit (dark bar) and following a change in the cleaning regimen to daily wiping with Sani-Cloth CHG 2% (light bar)

Figure 3 Before cleaning, all probes were successfully contaminated with bacteria. After cleaning with soap and water (dark bar) or Sani-Cloth CHG 2% wipes (light bar) the probes were successfully disinfected. Following recontamination with the microbial broth, the probes cleaned with soap and water became contaminated. The swabs from the probes cleaned with Sani-Cloth CHG 2% showed no growth. This effect was repeated even when the probes were left for 24 hours after cleaning

Sani-Cloth CHG 2% wipe was significantly different ($p = 0.002$) and remained clean despite microbial re-contamination. This occurred with re-contamination both immediately post-cleaning and after the probe had been left for 24 hours.

Accelerated ageing

Fourteen members of staff from the anaesthetic, radiology and emergency departments were surveyed. All individuals surveyed noted no difference in functionality between the probes (Figure 4). However, some differences were noted in the gross visual inspection, with a median difference score of 1.75. Comments about the visual differences included that the probe cleaned with the Sani-Cloth CHG 2% wipes 'looked newer', was 'very slightly cleaner' and

appeared 'more uniformly clean' whilst other commented about 'streaks' and 'smears' on the untreated probe.

Discussion

Our postal survey gives a good indication of the variation in practice seen with ultrasound probe decontamination. Despite attempts made to follow up on the survey, a response rate of only 71% was seen. This could have led to non-response bias in our results.²² Whilst some institutions specifically mentioned a method of cleaning prior to disinfection, this is not something that was asked in the survey. Similarly, the use of probe covers was not specified, thus departments who routinely use probe covers may not feel that full disinfection of the probe between patients is essential. Certainly some of the practices that were reported

Figure 4 The differences between a probe cleaned repeatedly with chlorhexidine and a probe cleaned by soap and water. Differences in visual appearance of the probe and functionality were rated on a scale of zero (no difference) to ten (very different)

are considered insufficient to effectively remove microbial contamination.¹⁵

The initial review of practice demonstrates that the standard cleaning protocol for our hospital was ineffective at decontaminating ultrasound equipment, as various colonies of potentially pathogenic bacteria were grown from machines that were considered to be ready for use. Even the presence of non-pathogenic bacteria is of concern as it shows the potential for the equipment to act as a reservoir for more significant pathogens. The introduction of Sani-Cloth CHG 2% wipes as part of the cleaning protocol dramatically reduced the number of colonies grown after swabbing the equipment. The repeat swabs were taken two weeks after the protocol was implemented to allow time for all members of the various departments to adjust to the change in cleaning regimen. Our repeat review, however, did not assess adherence to the protocol, and this may be a contributing factor to the small amount of contamination seen, despite use of the chlorhexidine wipes. Despite this, the results show that there is a significantly reduced bacterial load following the change in cleaning regimen.

We chose the swab streaking method of detecting bacteria on the ultrasound probes as it has been well described in the literature and we had successfully used similar methodology in previous studies. However, this method may have resulted in underestimation of the magnitude of bacterial contamination.

The review of practice results were interesting in demonstrating that whilst the heads of the ultrasound probes themselves were relatively clean, the handles and monitors were very heavily contaminated. Whilst it may only be the head of the probe itself that comes into direct contact with the patient, the presence of microbes on the handle and monitor is concerning. These act as fomites, providing a

reservoir for pathogenic bacteria which can then easily be transferred to the patient. The laboratory study assessed only the effectiveness of cleaning on the heads of the ultrasound probes, whilst the audit shows that in practice the wipes appeared to be effective on all parts of the ultrasound equipment.

The laboratory studies confirmed that Sani-Cloth CHG 2% decontaminates the equipment of MRSA and *E. coli* and, importantly, prevents recontamination, unlike cleaning with soap and water solutions. This effect persisted even when the probe had been left for 24 hours. This means that chlorhexidine-based wipes confer additional protection, reducing the likelihood of transmission of potentially serious infection. Whilst we chose to only use two bacteria to simulate probe contamination, it can be seen from the reviews and other work that chlorhexidine has a wide anti-bacterial action. It is reported to have anti-viral properties, although these were not tested during the laboratory studies.²³ It is particularly important to note that chlorhexidine is not effective against spores such as that of *Clostridium difficile*, so additional measures should be employed for use with infected patients.

The limited accelerated ageing and subsequent survey shows that the effects of Sani-cloth CHG 2% on the integrity of the probe were not damaging. Whilst the appearance of the probe itself is less relevant, we used it to ensure there was no visible damage to the probe. More significantly, there was no difference between the two probes in terms of image quality or clarity. This is important, as concerns over the long-term use of alcohol-containing solutions and wipes have previously limited their use.¹¹ Other studies have shown no apparent defect in ultrasound beams when alcohol-treated probes were analysed.²⁴ However, there is a possibility of long-term damage with some

possible reduction in image brightness with linear array probes. Certainly, a limitation of this part of our study is the relatively short duration of the accelerated aging that was performed. Additional work might aim to look at longer term use of the wipes, as most departments would anticipate keeping their ultrasound machines and probes for a number of years.

Conclusions

From our results, we conclude that Sani-Cloth CHG 2% wipes decontaminate ultrasound probes more effectively than standard soap and water solutions. The wipes also confer an additional protective residual effect. These wipes are inexpensive (0.02 each), quick and convenient to use and appear to have no detrimental effect in the short term on the ultrasound probes. These have been introduced as part of a cleaning protocol within our trust. The nationwide variation in cleaning and decontamination techniques highlights the need for evidence-based guidelines on the decontamination of ultrasound equipment.

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DECLARATION

Competing interests: The authors have no conflicts of interest to declare.

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Ethical approval: West Anglia Research Ethics Committee confirmed that formal ethical approval was not required for surveys of National Health Service (NHS) staff. The local research governance committee did not require a formal ethical review for the review of our current local practice.

Guarantor: PJ Young.

Contributorship: JC, PY and BS researched literature and conceived the study. JC and AG designed the postal survey. PY, BS, ML and AT designed and carried out the microbiology audit. BS, JC and PY carried out the accelerated ageing. PY and VH undertook the laboratory studies. BS and VH did the data analysis. JC and BS wrote the first draft of the manuscript. VH wrote the final version of the manuscript. All authors reviewed and approved the final version of the manuscript. PY was the project supervisor.

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