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ORIGINAL ARTICLE

An Investigation of the Bacterial Contamination of Ultrasound Equipments at a University Hospital in Saudi Arabia

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ABSTRACT

Objective: Nosocomial infections present a widespread problem in today's healthcare environment, with a significant number of patients acquiring an infection annually. With the contemporary transition of immunocompromised and high-risk patients to community-based care, ultrasound has the potential to be a vector of infection in the Radiology setting. The purpose of the present study was to determine the degree of contamination on ultrasound equipment and gel after routine clinical use and to determine the effectiveness of three different methods of ultrasound probe cleaning for the prevention of nosocomial infections.

Methods: A total of 444 culture swabs from different parts of the three ultrasound machines and from the gels were taken. All samples were tested in a microbiology laboratory at King Khalid University Hospital, Riyadh, Saudi Arabia, using different culture media. The isolates were identified by using standard techniques. All isolates were subjected to antimicrobial susceptibility testing using the Kirby-Bauer disc diffusion technique on Muller-Hinton agar and commercial antibiotic discs were used for antimicrobial testing. In addition to this, MIC was performed for all isolates according to the Clinical and Laboratory Standards Institute (CLSI) interpretative criteria.
Results: The majority of organisms which are found in normal skin and environmental flora were isolated from different parts of the ultrasound machines. The gels were heavily contaminated with opportunistic and potentially pathogenic organisms like *Staphylococcus aureus* and *Enterococcus faecalis*. No multi-resistant organisms were identified. There was a significant reduction in the bacterial count after applying either of all the three cleaning methods for the ultrasound probe as compared to the count on the probes before cleaning ($p<0.001$). However, the soap cleaning method was the most effective one in decreasing the bacterial count to the minimum level in comparison to other two methods ($p<0.001$). The overall reduction in the pathogenic bacterial count after performing each cleaning method was 46%, 75% and 97% for the paper cleaning, the normal saline and the soap cleaning methods, respectively.
Conclusion: The non-invasive ultrasound equipment is a potential vector for nosocomial infection in Radiology patients. Cleaning the ultrasound probe after performing each procedure is a cost-effective practice with a potential for reducing nosocomial infections. The soap cleaning technique is the most effective method for reducing the bacterial count which is acquired due to the patients' body contact with the ultrasound probes. Further research into the possible strategies to reduce the risk of infection from the ultrasound gels is needed.

Key Words: Ultrasound, Nosocomial infection, Cleaning methods, Disinfection.

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Nosocomial infections either develop in hospitals or occur due to microorganisms which are acquired from hospitals, leading to significant patient morbidity and mortality [1],[2]. The Radiology department in the hospital is a potential source of nosocomial infections as it is an integral part of the medical services for the admitted as well as for the walk-in patients. The ultrasonography suite is one of the busiest areas and the most commonly used imaging modality and a large number of sonographic examinations are performed in tertiary care hospitals. Many studies have shown that ultrasound (US) probes are an ideal vector for transmitting the pathological organism from one patient to another vulnerable patient, unless there are effective cleaning methods [3],[4],[5],[6],[7],[8],[9],[10]. This is particularly relevant in interventional ultrasound procedures and endocavitary sonographical examinations. The limited literature is divided, regarding the potentiality of US probes to act as a vector for cross infection and its prevention [4], [6], [7]. Aylirffe [11] summarized the infection control guidelines in hospitals, which needs to be tailored in sonographical practice and there are no clear international guidelines regarding the cleaning methods of the ultrasound probes.

If any part of the ultrasound transmission media (gel), (which acts as a coupling medium that enables the transmission of sound from the ultrasound probe through into the patient's body and back again), the probe that is placed onto the gel to scan, or even the keyboard that the practitioners touch during scanning, then there is a risk of cross-contamination from the equipment to the patient. In a public health care facility, a single ultrasound machine can be used to scan over 30 patients on a normal day, including both patients who may act as a source of infection and those patients who are susceptible to infections [3]. A study [12] carried out in 1998 confirmed that it was apparent that ultrasound procedures transferred colonizing *Staphylococci* from the patient's skin onto the ultrasound instruments. It has also been demonstrated that the bacterial colonization of probes with pathogenic bacteria occurs under in-use conditions [13]. A recent study has incriminated the ultrasound gel as a potential source of infection [14].

Paper wipe and alcohol wipes have been recommended as sufficient to clean the ultrasound probe, hence, reducing the risk of cross-infection. The use of dry wipe is effective for abdominal scanning, whereas alcohol wipes are recommended for the axillar and the inguinal regions [15]. A more recent study recommends the cleaning of the ultrasound probes with disinfectant spray and the other areas with a 70% alcohol wipe [16]. The prevention of disease transmission between patients is of primary importance in any busy sonography department. The department of ultrasonography at King Khalid University Hospital in Riyadh, Saudi Arabia, examines more than 16,000 patients annually. In a significant number of sonograms, the probe is placed adjacent to or directly over the disrupted skin, as well as within the scanning fields which are contaminated with bacteria. The ultrasound probes are routinely cleaned after each procedure, simply by wiping them until they are visibly clean with a dry, nonsterile, soft, absorbent paper towel. Additionally, alcohol wipes are used to clean the probes.

The present study was planned to assess (i) the microbiological contamination of the ultrasound equipments which were used for non-invasive examinations (ii) efficacy of the present decontamination regimes for the ultrasound equipment and (iii) to formulate effective cross-trust decontamination guidelines for the ultrasound equipment.

Material and Methods

The Dept. of Radiology had three different ultrasound machines. The following sites- – keyboard, probe holder, probe and gel - of each ultrasound machine were swabbed. The swabs were kept in Stuart's transport medium and were sent to the Microbiology laboratory for culture. The three swabs from the same site were pooled

and inoculated in Brain Heart Infusion broth for 48 hours at 37°C. The broth was then cultured on the following media: Sheep blood agar, chocolate agar, MacConkey's agar plates and Sabouraud's Dextrose agar and was incubated aerobically at 37°C for 24-48 hours. The resulting growth on any of these media was reported and the isolates were identified using standard techniques [17]. In addition, API 20 E and API 20NE (BioMerieux, France) were used for the identification of gram negative bacilli.

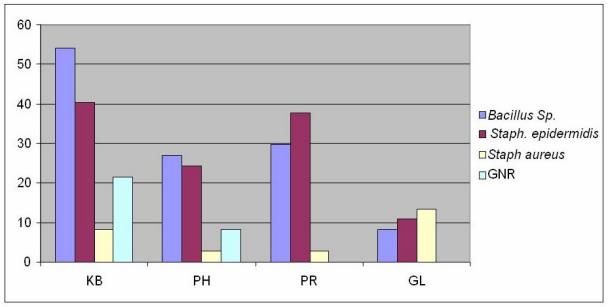
Antibiotic susceptibility testing was carried out using the Kirby-Bauer disc diffusion technique on Muller-Hinton agar and commercial antibiotic discs (Oxoid Limited, Hampshire, United Kingdom) were used for antimicrobial testing [18]. The antibiotic discs used were: Ampicillin (10 µg), Amoxicillin-Clavulanic Acid (20/10 µg), Tetracycline (30 µg), Gentamicin (10 µg), Amikacin (30µg), Tobramycin (30 µg), Trimethoprim-Sulphamethoxazole (1.25/ 23.75 µg), Cefotaxime (30 µg), Ceftazidime (30 µg), Ceftriaxone (30 µg), Ciprofloxacin (5 µg), Cefoxitin (30 µg), Cefuroxime (30 µg), Aztreonam (30 µg) Imipenem (10 µg), Oxacillin disc (1µg), Penicillin G (10U), Erythromycin (15µg), Cephalothin (30µg), Clindamycin (2µg) and Vancomycin (30µg) and different combinations of these were chosen for different organisms according to the Clinical and Laboratory Standards Institute (CLSI) recommendations. The antibiotic disc impregnated culture plates were incubated at 37°C overnight. The diameter of the zone of inhibition was measured and recorded as resistant or susceptible according to the Clinical and Laboratory Standards Institute (CLSI) interpretative criteria [19]. In addition to this, MIC was performed for all isolates according to the Clinical and Laboratory Standards Institute (CLSI) interpretative criteria [19].

Results

A total of 444 swabs were taken from different parts (keyboard, probe holder, probe) of the three ultrasound machines and from the gels. No organisms were isolated from 67% of the swabs from the gel, while only 8.1% of swabs from the keyboard were sterile. Around one third of the swabs from the probe and the probe holder were also sterile. Aerobic spore bearers were the commonest isolates from all specimens and the least from the gel. About 54% of the swabs from the keyboard grew *Bacillus Sp*. as compared to only 8.1% from the gel. Similarly, the skin flora (*Staphylococcus epidermidis, diphtheroids , and Micrococcus sp.*) was present more on the keyboard, probe and probe holder and least in the gel. However, *Staphylococcus aureus* was isolated more from the gel (13.5%) than from the keyboard (8.1%), probe and the probe holder (2.7% each). It was also noted that 2 isolates of enterococci grew only from gel specimens. Gram negative rod bacteria were isolated from the keyboard (21.6%), probe holder (8.1%), and the probe (2.7%), but not from the gel. *Acinetobacter spp. (Acinetobacter lwoffii and Acinetobacter baumanii)* and *Pseudomonas spp. (Pseudomonas stutzerii and Pseudomonas aeruginosa)* were the commonest isolates (40% each). None of the specimens yielded the growth of yeasts. All strains of *Staph.aureus* were fully sensitive to all the antibiotics tested. Similarly, all the gram negative bacteria were fully sensitive to all the common antibiotics tested, with the exception of one strain of *Acinetobacter baumanii* which showed resistance to Ciprofloxacin.

(Table/Fig 1) Potential Pathogens isolated from different sites of ultrasound equipments and gel

Site	*Pathogens*
Probe	*Staphylococcus aureus* *Pseudomonas aeruginosa* *Pseudomonas spp.* *Enterococcus faecalis*
Probe holder	*Staphylococcus aureus* *Pseudomonas aeruginosa* *Acinetobacter lwoffii* *Acinetobacter baumanii* *Enterococcus faecalis*
Keyboard	*Staphylococcus aureus* *Enterococcus faecalis* *Pseudomonas aeruginosa* *Acinetobacter Lwoffii*
Gel	*Staphylococcus aureus* *Staphylococcus epidermidis* *Enterococcus faecalis*



(Table/Fig 2) Distribution of isolates from various sites of ultrasound machines

KB= Key board; PH=Probe holder; PR=Probe; GL=Gel; GNR=Gram negative rods

Discussion

Nosocomial infections are hospital-acquired infections that occur 48 hrs after the admission of the patients to the hospital [20]. They are a significant cause of morbidity and mortality in the hospitalized patient [21]. The prevalence of nosocomial infections reported from the hospitals of South-East Asia is 10%, which is the second highest regional distribution in the world [2]. Medical instruments including bronchoscopes, gastrointestinal endoscopes and stethoscopes have all been previously implicated in the transmission of nosocomial infections [22], [23]. Recently, an electronic thermometer was also implicated as the vehicle of transmission in an outbreak of nosocomial infections due to a multidrug-resistant strain of *Enterococcus faecium* [24]. Ultrasound probes can be a potential source of nosocomial infections which can act as vectors for transferring pathogenic organisms (commonly *Staphylococcus aureus*), which is particularly risky for immunocompromised patients [13], [25]. The department of ultrasonography at our institution has 7 sonography units in full-time operation and examines more than 16,000 patients yearly. Each standard ultrasound probe is used for more than 8 examinations each day. Because of the limited number of ultrasound probes and machines and the limited number of sonographical technologists, the department must adopt a time-efficient protocol for probe decontamination that will ensure the optimal control of infection. Avoidance of disease transmission is of particular concern in departments that perform procedures on patients with disrupted skin or contaminated scanning fields, which may increase the potential for contamination of the probe with microorganisms. These issues have led some departments to adopt measures which are aimed at reducing the potential risk of probe contamination. These measures include covering the ultrasound probe with a clean plastic bag for each study, routinely washing the probes with various antiseptic solutions and advising all technologists to wear gloves. These precautions may contribute to a significant and unnecessary increase in the operating costs. In our department, the ultrasound probes are wiped after each procedure with a dry, clean, soft paper towel. This ensures a basic standard of probe decontamination. Furthermore, it maintains a clean, neat, practical working environment for examining a large volume of patients. It was unclear, however, whether this low level of disinfection was sufficient to prevent cross-contamination between patients. The purpose of our study was to investigate the potential for the ultrasound probe and the coupling gel to serve as a vehicle of nosocomial infection and to devise a time-efficient and cost effective protocol for the decontamination of these instruments that would also minimize the risk of cross-contamination.

In the initial part of this study, we evaluated the likelihood of the ultrasound probe to become colonized with bacteria after scanning patients with disrupted skin.

A significantly high number of bacteria were identified in this study in the US probe before they were cleaned, highlighting the importance of the proper cleaning of the probe before applying it to the next patient. An uncleaned sonographical probe may become a source of bacteria for the next patient and may lead to nosocomial infections. In this study, it was proved that by applying appropriate simple cleaning methods, the number of bacteria on the US probes can largely be reduced. The paper wipe technique may not be highly effective as it only reduces 45% of the bacteria and these results are consistent with those reported by Spencer, Tesch and Fröschle [3],[7],[8]. However, other studies considered paper towel cleaning as a simple and effective method for ultrasound probe cleaning [4], [14]. This method may not be appropriate for our patients where poor hygienic conditions prevail in

our population. Moreover, another study suggested that the paper cleaning method can be applicable with acceptable effectiveness in outpatients but not for admitted patients who already are at a higher risk of nosocomial infections and the single paper cleaning method might not be effective enough for routine use [26]. Paper wipe followed by normal saline wipe is 76% effective and appeared to be better as compared to simple paper towel cleaning. However, the soap wipe technique was found to be the most effective of the cleaning methods tested, with an effectiveness of 98% and this is comparable to the alcohol effectiveness of 99% [25],[26]. It can be used routinely as the soap will not degrade the rubber seal as alcohol does and it also increases the working life of the probe. However, large longitudinal studies are required to see the long-term effects of the soap on the probe. Findings of this study support the use of soap in probe cleaning like hand washing, which is a simple, easily available and cost-effective way of decontamination.

Furthermore, a cleaning method needs to be tailored for the clinical situation to achieve an appropriate cost-to benefit ratio and we are in the process of adopting the following approach towards infection control in the ultrasound department. Before the examination of outpatients and short-stay inpatients, the soap wipes technique is ensured to be an adequate cleaning method. Before the examination of patients who are at a risk for contracting infection (i.e. neonates or immunocompromised patients, those undergoing genital examination, or those with unhealed wounds), the covering of the probe with a simple plastic glove is appropriate. After the examination of the patients who may be a potential source of infection (those with MRSA-positive results, those who are in the intensive therapy unit, or those who have undergone multiple antibiotic courses), paper wipe followed by an alcohol wipe provides adequate cleaning to protect the next patient from cross infection. Frequent hand washing by sonographers and the use of disposable hand gloves would also be helpful in preventing nosocomial infections. Furthermore, some of the studies suggest that prior cleaning of the body surface of the patient undergoing the sonographical examination with disinfectant is a better option for preventing nosocomial infections through the ultrasound probes [27], but this technique may be inconvenient to the patient as well as for operator and needs to be tested in our population. Although the sonographical gels used for examination were standardized and aseptic, microbiological testing of the gels showed the presence of pathogenic bacteria. Our gels were contaminated with different bacterial pathogens which are associated with different diseases. Our findings were in agreement with those of others [3],[28]. So, the use of a gel having antibacterial properties is recommended in order to further reduce the risk of the transfer of microorganisms from the equipment to the patient. Effects of the chemical components of soap on the ultrasound probes were not tested and needed further exploration to establish their long-term impact.

In conclusion, applying simple cleaning methods can prevent nosocomial infections from ultrasound probes; all the three methods of cleaning like the paper towel, alcohol and soap wipes can reduce the pathogenic bacterial count up to a certain extent. However, the soap wipes technique is the most effective and the cost-effective method of cleaning which can be used in routine clinical practice for cleaning ultrasound probes. Special infection control measures should also be taken in a high-risk group of patients. It is highly recommended that other ultrasound departments must review their probe cleaning and sterilizing procedures to assess whether they are safe. In particular, do they provide a safe working environment for the practitioner, do they comply with the manufacturer's requirements and restrictions and do they ensure that the risk of cross infection is minimized.

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