Original Article

Comparison of Cleaning Methods for Ultrasound Probes at an Emergency Department in a Resource-Limited Country

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Background: Bacterial contamination of medical equipment is a serious problem. If effective cleaning methods are not employed, sonographic examinations performed in the emergency department can lead to patient-to-patient transmission of pathogens.

Objective: To compare the effectiveness of four different ultrasound probe cleaning methods in reducing bacteria and to determine the types of bacteria found on ultrasound probes.

Materials and Methods: This was a randomized experimental study. The sample consisted of 104 ultrasound probes used at the Srinagarind Hospital emergency department from August 2019 to December 2019. Probes were randomized into four groups of 26. Cultures were examined before and after cleaning using one of four different techniques including wiping with a dry paper towel or washing with liquid soap, 4% chlorhexidine gluconate, or dimethyl ammonium chloride. Quantitative grading of bacterial colonies was performed to determine cleaning effectiveness.

Results: All four cleaning method resulted in significant reductions in bacteria ($p<0.001$), but 4% chlorhexidine gluconate was the most effective (no bacterial growth in 84.62% of cases; $p<0.001$). The bacteria found were *Staphylococcus coagulase-neg*, *Pseudomonas spp.*, *Bacillus spp.*, *Micrococcus spp.*, and *Corynebacterium*. We also found fungus on two of the ultrasound probes.

Conclusion: The authors found many types of bacterial contamination on the surfaces of ultrasound transducers. Cleaning probes after performing sonographic examination is necessary. Based on both its ability to control infection control and its cost-effectiveness, 4% chlorhexidine gluconate is recommended.

Keywords: Cleaning methods, Ultrasound, Emergency department, Disinfection

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In recent years, the use of point-of-care ultrasound has increased in many areas of medicine, especially in the emergency department. The surfaces of ultrasound probes come into contact with skin, blood, and mucosa of patients, which are well-known sources of bacterial contamination by both normal skin flora and multi-resistant pathogens[(1)]. Moreover, previous studies have more bacterial contamination on ultrasound probes than on public toilet seats[(2)]. If probes are used in different patients without proper decontamination in between each usage, bacteria can be transmitted from one patient to another or from one patient to the doctor, leading to possible hospital-acquired cross infections[(3)].

There is currently no standardized method for cleaning ultrasound probes at Srinagarind Hospital. In everyday practice, the authors use a dry paper towel to clean the probes, as it this method is low-cost and easily implemented. However, a study by Mirzal et al found that dry sterilized paper towels were not very effective in reducing bacterial contamination of ultrasound probes[(4)].

In 2018, the American College of Emergency Physicians released guidelines for ultrasound transducer cleaning and disinfection, which suggest using quaternary ammonia sprays or wipes for low-level disinfection and chemical sterilants or germicides for high-level disinfection[(5)]. However, these products are not available in Thailand.

The primary objective of the present study was to determine the effectiveness of four cleaning methods at reduce bacterial colonization of ultrasound probes. The authors selected methods that would be easy to implement, low-cost, and widely available in resource-limited countries. The methods we examined were wiping with a sterilized paper towel and washing with liquid soap, 4% chlorhexidine gluconate, or dimethyl ammonium chloride (one of the ingredients recommended by the American College of Emergency Physicians)[(5)]. The authors also aimed to determine the prevalence of bacterial and fungal colonization by performing cultures of pathogen on ultrasound probe scanning surfaces.

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Materials and Methods

This was a randomized experimental study. The sample consisted of 104 ultrasound probes used in the Srinagarind Hospital emergency department from August 2019 to December 2019. The sample size was calculated based on the repeated regimen means described in a study by Mirza et al. In order to achieve a significance level of 5% and power of test of 0.8, we determined that a sample size of 104 would be required.

Linear, curvilinear, and phased array probes were used for ultrasound examination. Probes used for intracavitary ultrasound, including transvaginal and endocavitory probes, or in invasive procedures were excluded. The authors used a convenience sampling technique performed by a clinician to enroll the sample probes. After each ultrasound examination, a trained emergency medicine resident took a microbiological sample using a probe imprinting method, in which the ultrasound probe was placed on 5% sheep blood agar for 10 seconds, from the exposed transducer surface before cleaning and a second sample taken after cleaning. Cleaning methods were randomly assigned, with dry paper, liquid soap, 4% chlorhexidine gluconate, and dimethyl ammonium chloride coded in green, red, yellow, and blue, respectively. Group allocation was in sealed 104 envelopes, each containing one of the four color codes (26 envelopes for each cleaning method). When a patient presented for sonography, an envelope was randomly chosen to determine the cleaning method to be applied. Specimens were coded and sent to the central microbiology lab every weekday at 3.00 PM. The sizes of bacterial colonies grown on standard agar plates used for growing microorganisms were graded as numerous, moderate, few, rare, and no growth[6]. All samples were tested in single microbiology lab using the same bacterial growth media provided by the same manufacturer. A microbiologist graded each colony and determined the type of bacteria present.

Ethics approval was provided by the Khon Kaen University Ethics Committee for Human Research (HE621020). The primary outcome was the comparative effectiveness of the four different ultrasound probe cleaning methods described above at reducing the grading of bacterial colonies, which was determined using Pearson's Chi-squared test and linear regression. The authors also aimed to determine types of bacteria present before and after cleaning ultrasound probes and number of infected ultrasound probes.

Results

One hundred four ultrasound probes were examined, almost all of which were used in non-trauma patients. Only 2 transducers were used in trauma patients. We examined 22 linear probes, 54 curvilinear probes, and 28 phased array probes. The probes were most frequently used at the abdominal region (52 out of 104 times). The most common indication was diagnostic (99%). Most of the probes were in contact with intact skin (98%), with only 2% in contact with inflamed or infected skin.

Cleaning using a dry paper towel (green, n = 26), liquid soap (red, n = 26), 4% chlorhexidine gluconate (yellow, n = 26), and dimethyl ammonium chloride (color, n = 26) all resulted in significant reductions in bacterial contamination (7.69%, 30.77%, 84.62%, and 73.08%, respectively; $p<0.001$; Table 1).

All three methods that used cleaning solutions had negative coefficient in regression coefficients compared with that using a using dry paper alone. The 4% chlorhexidine gluconater, dimethyl ammonium chloride, and liquid soap groups reduced bacterial grading by 3.52, 3.14, and 1.28 points more than the dry paper towel alone, respectively ($p<0.001$; Table 2). The authors found *Staphylococcus coagulase-neg*, *Pseudomonas spp.*, *Bacillus*, *Micrococcus spp.*, *Corynebacterium* and *Fungus spp.* on the surface of the ultrasound probes before cleaning. After cleaning using dimethyl ammonium chloride or 4% chlorhexidine gluconate, there was no *Staphylococcus coagulase-neg* and *Bacillus spp.*

Table 1. Percentages of probes with no bacterial growth using four cleaning methods

Type of cleaning methods	The percentage of no growth bacterial (%)	
	Before cleaning	After cleaning
Dry paper towel	0	7.69
Liquid soap	0	30.77
4% chlorhexidine gluconate	0	84.62
Dimethyl ammonium chloride	0	73.08
$p<0.001$*		

* Statistical significance

Table 2. Reductions in bacterial contamination after cleaning using three cleaning solutions compared to a dry paper towel alone

Cleaning Methods	Coefficients	Std. Error	t	*p*-value	95% CI
Dimethyl ammonium chloride	-3.142	0.535	-5.87	<0.001*	-4.203, -2.081
Liquid soap	-1.281	0.535	-2.39	0.019*	-2.342, -0.220
4% chlorhexidine gluconate	-3.524	0.530	-6.65	<0.001*	-4.580, -2.472

* Statistical significance

growth in 96.15% and 96.15% of probes, respectively. The authors found that 4% chlorhexidine gluconate was the most effective in eliminating *Pseudomonas spp.* (92.31% of probes tested had no growth), and that dimethyl ammonium chloride was the most effective at eliminating *Micrococcus spp.* (96.15% of probes had no growth). All four cleaning methods eliminated all *Corynebacterium spp.* and *Fungus spp.* (100%; Table 3).

Discussion

Point-of-care ultrasound is performed in many areas of medicine, especially in the emergency department. Publications dating back to 1988 have raised concerns regarding the risk of cross-infection via ultrasound probes(7), suggesting that detecting bacterial transmission through ultrasound probes is an important factor in controlling infection. Several other studies have highlighted cases in which pathogens were transmitted to patients after sonographic examination using contaminated equipment(8-14). Significantly high bacterial contamination was identified in the present study. The authors found *Staphylococcus coagulase-neg*, *Pseudomonas spp.*, *Bacillus*, *Micrococcus spp.*, *Corynebacterium*, and *Fungus spp*. on the surfaces of ultrasound probes before they were cleaned. This is consistent with the results of studies by Koibuchi et al(15) and Ohara et al(16). It is thus important that ultrasound probes are properly cleaned before being used on another patient. We found that the cleaning method most effective at eliminating bacterial growth was 4% chlorhexidine gluconate (84.62% of cases). This is consistent with the cleaning guidelines published in 2016 by the Siriraj Hospital Department of Anesthesiology(17). Dimethyl ammonium chloride was also an effective cleaning agent and diminished bacterial pathogens in 73.08% of cases. This is consistent with ACEP guidelines, which recommended using quaternary ammonia, an ingredient in dimethyl ammonium chloride used for low-level disinfection(18). The present study found that cleaning with liquid soap was able to reduce pathogens in approximately 30.77% of cases. Some studies have found inconclusive data with regard to the effectiveness of simple cleansing methods such as those using dry paper wipes, saline, or soap(4,19). The authors found that wiping probes with a dry paper towel alone was the worst cleaning method, resulting in no bacterial growth in only 7.69% of cases. Although many studies have suggested using a dry paper towel as a simple and economical method for ultrasound probe cleaning, it may not be very effective in reducing bacterial contamination(3,4,20).

The present study found that all four methods tested significantly reduced bacterial contamination ($p<0.001$). As 4% chlorhexidine gluconate will not degrade the rubber seal, is easy to use, readily available, and cost-effective, it may be the most appropriate alternative cleaning agent for ultrasound probes in resource-limited countries.

Conclusion

There were many bacterial pathogens on the surfaces of ultrasound probes. Cleaning with 4% chlorhexidine gluconate was the most effective and cost-effective method for reducing contamination with these pathogens. A policy for cleaning ultrasound probes in the emergency department should be established.

What is already known on this topic?

Recent studies have found that bacterial contamination on the surfaces of ultrasound probes is a serious problem, as it can lead to the transmission of pathogens among patients. Healthcare facilities in most developed countries have policies for cleaning ultrasound probes but many in resource-limited countries in Asia do not.

What this study adds?

Cleaning with 4% chlorhexidine gluconate was the most effective method in this study. We should thus consider using this agent in addition to establishing a protocol for cleaning ultrasound probes in the emergency department.

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Potential conflicts of interest

The authors declare no conflicts of interest.

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Table 3. Type of Pathogen classified by quantitative bacterial grading according to type of cleaning method

Pathogen	Bacterial grading	Before cleaning				After cleaning			
		Liquid soap (n = 26)	4% chlorhexidine gluconate (n = 26)	Dimethyl ammonium chloride (n = 26)	Dry paper towel (n = 26)	Liquid soap (n = 26)	4% chlorhexidine gluconate (n = 26)	Dimethyl ammonium chloride (n = 26)	Dry paper towel (n = 26)
Staphylococcus coagulase neg	Numerous	7	9	4	7	1	0	0	0
	Moderate	12	7	8	12	2	0	0	4
	Few	7	8	6	4	7	0	0	5
	Rare	0	0	1	2	8	1	1	9
	No growth	0	2	7	1	8	25	25	8
Pneudomonas spp.	Numerous	8	6	10	9	0	0	0	1
	Moderate	4	4	7	5	2	0	0	5
	Few	5	0	2	1	6	0	2	7
	Rare	0	1	1	0	0	2	1	3
	No growth	9	15	6	11	18	24	23	10
Bacillus spp.	Numerous	8	3	3	3	0	0	0	1
	Moderate	3	4	1	1	0	0	0	1
	Few	6	5	5	5	0	2	1	2
	Rare	3	4	3	7	1	7	0	7
	No growth	6	10	14	10	25	17	25	15
Micrococcus spp.	Numerous	6	3	2	2	1	0	0	0
	Moderate	6	5	4	7	1	0	1	2
	Few	3	7	3	7	2	0	0	2
	Rare	2	5	4	2	4	2	0	6
	No growth	9	6	13	8	18	24	25	16
Corynebacterium	Numerous	0	0	0	0	0	0	0	0
	Moderate	1	0	0	1	0	0	0	0
	Few	0	0	0	0	0	0	0	0
	Rare	0	0	0	1	0	0	0	0
	No growth	25	26	26	24	26	26	26	26
Fungus spp.	Numerous	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	0	0	0
	Few	0	1	0	0	0	0	0	0
	Rare	0	0	0	1	0	0	0	0
	No growth	26	25	26	25	26	26	26	26

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การศึกษาเปรียบเทียบระหว่างวิธีการทำความสะอาดของหัวตรวจเครื่องอัลตราซาวด์ที่แผนกฉุกเฉินในประเทศที่มีทรัพยากรจำกัด

กมลวรรณ เอี้ยงฮง, กานต์พิชชา กลีบบัวขวัญ, กรกฎ อภิรัตน์วรากุล, ปริวัฒน์ ภู่เงิน, ดนุ เกษรศิริ, วัชรพงศ์ พุทธิสวัสดิ์

ภูมิหลัง: การปนเปื้อนของเชื้อแบคทีเรียในวัสดุอุปกรณ์ทางการแพทย์เป็นปัญหาที่สำคัญ หากไม่มีการทำความสะอาดอุปกรณ์ที่มีประสิทธิภาพ การตรวจอัลตราซาวน์สามารถนำเชื้อโรคจากคนสู่คนได้

วัตถุประสงค์: เพื่อศึกษาเปรียบเทียบวิธีการทำความสะอาดหัวตรวจอัลตราซาวน์ทั้งสี่วิธี โดยวิธีใดที่สามารถลดแบคทีเรียบนหัวตรวจเครื่องอัลตราซาวด์ได้มีประสิทธิภาพสูงสุด และเพื่อศึกษาเชื้อโรคบนหัวตรวจอัลตราซาวน์

วัสดุและวิธีการ: การศึกษาการทดลองแบบสุ่ม ประชากรศึกษาคือ หัวตรวจอัลตราซาวน์ที่ใช้ตรวจผู้ป่วยที่แผนกฉุกเฉินจำนวน 104 หัวตรวจ ระหว่าง เดือนสิงหาคม พ.ศ. 2562 ถึง เดือนธันวาคม พ.ศ. 2562 โดยหัวตรวจได้มีการสุ่มแบ่งเป็น 4 กลุ่ม กลุ่มละ 26 หัวตรวจ การเพาะเชื้อที่หัวตรวจทำก่อนและหลังทำความสะอาดด้วยวิธีที่ต่างกัน 4 วิธี ได้แก่ การเช็ดด้วยกระดาษแห้ง การทำความสะอาดด้วยน้ำสบู่ การใช้ 4% chlorhexidine gluconate และการใช้ dimethyl ammonium chloride จากนั้นจึงวิเคราะห์ประสิทธิภาพ การทำความสะอาดโดยใช้จำนวนแบคทีเรียที่อยู่บนหัวตรวจ

ผลการศึกษา: วิธีการทำความสะอาดทั้ง 4 วิธี สามารถลดจำนวนแบคทีเรียบนหัวตรวจได้อย่างมีนัยสำคัญทางสถิติ (p<0.001) อย่างไรก็ตาม 4% chlorhexidine gluconate เป็นวิธีที่มีประสิทธิภาพสูงสุด เนื่องจากหลังทำความสะอาดไม่พบเชื้อแบคทีเรียบนหัวตรวจถึงร้อยละ 84.62 (p<0.001) เชื้อแบคทีเรียที่พบบนหัวตรวจได้แก่ *Coagulase-neg*, *Pseudomonas spp.*, *Bacillus spp.*, *Micrococcus spp.*, and *Corynebacterium* และยังพบเชื้อราบนหัวตรวจจำนวน 2 หัวตรวจ

สรุป: การศึกษานี้พบเชื้อแบคทีเรียจำนวนมากบนหัวตรวจ การทำความสะอาดหัวตรวจหลังการใช้งานมีความจำเป็น จากประสิทธิภาพการควบคุมเชื้อและราคา จึงแนะนำให้ใช้ 4% chlorhexidine gluconate ในการทำความสะอาดหัวตรวจ