

Importance of Infection Control During Ultrasonography

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Abstract

Background/Objectives: Hand hygiene is the most effective way to prevent healthcare-associated infections. This research aims to compare different hand hygiene methods and their effects on bacterial patterns on the hands.

Methods/Statistical analysis: The bacterial reduction rates before and after the use of plain soap and water, alcohol-based hand sanitizer, and hand sanitizing wipes were compared in five sonographers. Hand-shaped bacterial plate kits were used to collect the pathogens. The plates were incubated at 37°C for 24 hours. The bacterial colonies were then transferred to a blood agar medium and gram stained. The colonies were then identified using the VITEK II system.

Findings: The colony forming units (CFUs) before and after handwashing with plain soap and water were 500 and 176, respectively. Upon converting these values to percentages, the bacterial reduction rate was 65% (0.04 < p). With alcohol-based hand sanitizer, the CFUs before and after handwashing were 443 and 240, respectively. Converting this to a percentage, the bacterial reduction rate was 44% (0.01 < p). With the use of hand sanitizing wipes, the CFUs before and after handwashing were 350 and 60, respectively. Converting this to a percentage, the bacterial reduction rate was 82% (0.02 < p).

Improvements/Applications: The study demonstrated that hand sanitizing wipes have the greatest antibacterial effects. Therefore, the use of hand sanitizing wipes could prevent infections and improve the safety of the ultrasound environment.

Keywords: Ultrasound, Microorganism, Healthcare-associated infection, Hand hygiene, Alcohol-based hand sanitizer, hand sanitizing wipes

1. Introduction

Hand hygiene is the most basic and essential infection control element to stop the transmission of microorganisms and prevent infections in healthcare workers and patients. Hand hygiene is a term that refers to handwashing, hand antisepsis, hand disinfection, antiseptic hand wash, antiseptic hand rub, etc. Hand washing refers to using plain soap without antiseptics and water to wash the hands. Hand antisepsis includes both antiseptic hand wash and antiseptic hand rub. Hand disinfection refers to the use of medicinal soap or skin disinfectant solution, such as alcohol, to clean the hands. Antiseptic hand wash refers to using antiseptic ingredients containing agents or water and soap to clean the hands. Antiseptic hand rub refers to applying waterless antiseptic agents to decrease the number of microorganisms on the hands[1]. Microorganisms on the skin can be classified into transient skin flora and resident skin flora. Transient skin flora refers to microorganisms that are deposited on the skin surface, and resident flora refers to microorganisms colonizing the deeper layer of the skin. Transient skin flora cannot survive long on the surface of the skin but are potentially pathogenic microorganisms. Such microorganisms are often transferred during contact with the patient or the contaminated area adjacent to the patient and cause the majority of hospital infections and spread antibiotic-resistant bacteria. Transient skin flora can be removed with general hand hygiene procedures. Resident flora, on the other hand, are unlikely to be pathogenic unless they enter the body through an insertion mechanism but are quite challenging to remove with regular hand hygiene procedures[2]. Owing to the spread of the coronavirus disease 2019 that started in China in December of 2019, the practice of hand hygiene has gained significance. The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) are actively recommending that healthcare workers perform hand hygiene as the core activity to prevent infection

and create safe environments [1,3]. With handwashing, the spread of pathogens that are hard to treat and resistant to antibiotics can be prevented. CDC reported that the number of times healthcare providers wash their hands on average does not reach even half the recommended frequency, and at least 1 out of 31 patients a day are exposed to healthcare-related infections[4]. There are variations among observational methods and healthcare institutions, but the average compliance rate of hand hygiene in healthcare workers is reported to be as low as 40%[5]. The number of microorganisms on the hands of healthcare workers is as high as $3.9 \times 10^4 \sim 4.6 \times 10^6$. Since performing examinations or tests with unhygienic hands can infect patients, diligence adherence to hand hygiene is critical[6].

Ultrasound is especially prone to infection risk because there is frequent contact between the examiner and the examinee's body through hands. There is a high need to prevent the spread of pathogenic microorganisms during ultrasonography, a procedure that involves much use of the hands. This study was conducted to create a safe and infection-free ultrasonography environment by comparing the bacterial reduction rates of different hand hygiene methods.

2. Materials and Methods

2.1. Subjects

In January 2021, changes in the colony forming units (CFUs) before and after hand hygiene procedures were analyzed in five sonographers working at the health examination center, which is visited by approximately a hundred thousand people annually and located in Daegu, Korea.

2.2. Sampling and culture method

To sample all microorganisms on the hands, both palms were placed on the surface of hand-shaped bacterial plates (Asan Pharm, Seoul, Korea) for 10 seconds each before and after the hand hygiene procedures. Then, the lid was closed, and the plates were placed in a 37°C incubator (VS-1203P3V, Vision Scientific, Korea) for 24 hours. Afterward, the CFUs were counted for general microorganisms.

2.3. Identification

The bacterial colonies grown on the hand-shaped plates were transferred to blood agar medium (Asan, Seoul, Korea) and gram stained to classify the organisms into Gram-positive bacteria and Gram-negative bacteria. They were then identified using VITEK II automated microbial identifier (BioMerieux, Durham, NC, USA).

2.4. Hand hygiene method

As recommended by Korea Disease Control and Prevention Agency, palms, backs of the hands, fingers, and fingertips were cleaned in six different steps with running water and a plain soap for 30 seconds (Lionkorea, Incheon, Korea)[7]. Hand sanitizing wipes that can easily be purchased in the market (Hanul Herb Pharm, Gyeonggi-do, Korea) and the most commonly used 63% alcohol-based hand sanitizer (Green World Pharm, Gyeonggi-do, Korea) were used. For alcohol-based hand sanitizer, a method recommended by WHO was selected and applied. The surfaces of both hands and fingers were rubbed for 30 seconds following 8 steps until the sanitizer dried out[3] [Figure 1]. Finally, the surfaces of both hands and fingers were cleaned using an ethanol-based hand sanitizer wipe and dried.



Figure 1. Recommended hand hygiene method by the Korea Disease Control and Prevention Agency and World Health Organization

2.5. Statistical analysis

To confirm the statistical significance of the difference between the CFUs before and after hand hygiene, the Wilcoxon test was performed using SPSS 24.0 for Windows (SPSS, Chicago, IL, USA). If the p-value was <0.05, the difference was considered statistically significant.

3. Results and Discussion

3.1. Comparison between before and after handwashing

3.1.1. Plain soap and water

The number of bacterial colonies before and after washing the hands with plain soap and water is shown in Table 1. The bacterial colony patterns are depicted in Figure 2. Before handwashing, there was a total of 500 CFUs, including 170 *Staphylococcus chromogens*, 185 *Micrococcus luteus*, 35 *Gardnerella vaginalis*, 20 *Staphylococcus lugdunensis*, 10 *Alloioiococcus otitis*, 10 *Kocuria rosea*, 10 *Staphylococcus saprophyticus*, 5 *Enterococcus faecium*, 5 *Acinetobacter lwoffii*, 5 *Leuconostoc mesenteroides* spp. *cremoris*, and 5 *Staphylococcus epidermidis*. However, after handwashing, only 175 CFUs remained, including 165 *Staphylococcus chromogens* and 10 *Kocuria rhizophila*. *Kocuria rhizophila*, which was not detected before handwashing, was detected after handwashing [Table 1] [Figure 2].

Table 1: Comparison of bacterial colonies before and after handwashing using plain soap and water

Bacteria	pre	post
<i>Staphylococcus chromogens</i>	170	165
<i>Micrococcus luteus</i>	185	0
Positive Rod)	0	10
<i>Gardnerella vaginalis</i>	35	0
<i>Staphylococcus lugdunensis</i>	20	0
<i>Staphylococcus otitis</i>	10	0
<i>Kocuria rosea</i>	10	0

<i>Staphylococcus saprophyticus</i>		
<i>Enterococcus faecium</i>		
<i>Pseudomonas aeruginosa</i>		
<i>Stenotrophomonas maltophilia</i>		
<i>Staphylococcus epidermidis</i>		
<i>Kocuria rhizophila</i>		



Figure 2. Before and After using Plain soap and water

3.1.2. Alcohol-based hand sanitizer

The number of bacterial colonies before and after applying alcohol-based hand sanitizer is shown in Table 2. The bacterial colony patterns are illustrated in Figure 3. Before handwashing, 15 *Staphylococcus lentus*, 5 *Enterococcus caseliflavus*, 235 *Staphylococcus epidermidis*, 35 *Staphylococcus hominis*, 28 *Micrococcus luteus*, 5 *Kocuria rhizophila*, 70 *Spingomonas paucimobilis*, and 20 *Aerococcus viridans* detected. After handwashing, there were 5 *Staphylococcus lentus*, 220 *Staphylococcus epidermidis*, 5 *Staphylococcus hominis*, and 5 *Kocuria rhizophila*. Hence, the number of CFUs decreased from 434 to 240. *Enterococcus columbae*, which was not detected earlier, was detected after handwashing [Table 2] [Figure 3].

Table 2: Comparison of bacterial colonies before and after handwashing using an Alcohol-Based Hand Sanitizer

Bacteria	Before	After
<i>Staphylococcus lentus</i>		
Positive Rod)		
<i>Enterococcus columbae</i>		
<i>Enterococcus caseliflavus</i>		
<i>Staphylococcus epidermidis</i>		
<i>Staphylococcus hominis</i>		
<i>Micrococcus luteus</i>		
<i>Kocuria rhizophila</i>		
<i>Spingomonas paucimobilis</i>		
<i>Aerococcus viridans</i>		



Figure 3. Before and After Applying Alcohol-base Hand Sanitizer

3.1.3. Hand sanitizing wipes

The number of bacterial colonies before and after applying hand sanitizing wipes is listed in Table 3. The bacterial colony patterns are shown in Figure 4. Before handwashing, 35 *Staphylococcus lentus*, 10 *Enterococcus columbae*, 170 *Staphylococcus epidermidis*, 50 *Staphylococcus homini*, 30 *Micrococcus luteus*, 15 *Kocuria rhizophila*, and 35 *Spingomonas paucimobilis* were detected. After handwashing, 30 *Staphylococcus epidermidis*, 20 *Staphylococcus hominis*, and 10 *Micrococcus luteus* were detected. The number of CFUs decreased from a total of 350 before handwashing to 60 after handwashing [Table 3] [Figure 4].

Table 3: Comparison of bacterial colonies before and after handwashing using Hand Sanitizing wipes

Bacteria	pre	after
<i>Staphylococcus lentus</i>		
Positive Rod)		
<i>Enterococcus columbae</i>		
<i>Staphylococcus epidermidis</i>		
<i>Staphylococcus hominis</i>		
<i>Micrococcus luteus</i>		
<i>Kocuria rhizophila</i>		
<i>Spingomonas paucimobilis</i>		



Figure 4. Before and After applying Hand Sanitizing Wipes

3.2. Measuring the bacterial reduction rates of different hand hygiene methods

The statistical analysis results of changes in CFU for different types of hand hygiene methods are demonstrated in Table 4. In the plain soap and water group, the difference in the number of CFU before

and after handwashing was statistically significant ($0.04 < p$), with 500 CFU before and 175 CFU after the hand hygiene. Converting this result to a percentage, the bacterial reduction rate was 65%. In the alcohol-based hand sanitizer group, the difference in the number of CFU before and after handwashing was statistically significant ($0.01 < p$), with 443 CFU before and 240 CFU after hand hygiene ($0.01 < p$). Converting this data to a percentage, the bacterial reduction rate was 44%. In the hand sanitizing wipes group too, the difference in the number of CFU before and after was statistically significant ($0.002 < p$) with 350 CFU before and 60 CFU after the hand hygiene. Converting this data to a percentage, the bacterial reduction rate was 82%. These results confirmed that the antibacterial effect was the greatest in hand sanitizing wipes. It was then followed by plain soap and water and alcohol-based hand sanitizer in the order of bacterial reduction rate.

Table 4: Changes in colony forming units among different hand hygiene methods

Hand Hygiene Method	Before Cleaning	After Cleaning	p-value	Reduction Rate (%)
Plain soap and water	500	175	0.04	65
Alcohol-Based Hand Sanitizer	443	240	0.01	44
Hand Sanitizing wipes	350	60	0.02	82

*Unit: CFU (Colony Forming Unit)

For effective hand hygiene, hand sanitizer, handwashing method, appropriateness, and frequency of handwashing should be considered. Factors affecting handwashing include the amount of soap, amount of friction, frequency and duration of handwashing, and the method of drying hand[8]. It has been reported that handwashing using soap instead of only water removed more microorganisms from the hands[5], and washing for 30 seconds compared to 15 seconds removed more microorganisms from the hands[1]. This difference is attributed to the fact there is more mechanical washing involved with the bubble formed from soap and water rather than the ingredients in plain soap[9]. According to the WHO recommended hand hygiene guidelines, regular handwashing using plain soap is not effective in removing pathogenic microorganisms in the healthcare environment and can even increase the number of microorganisms on hands[3]. From the result of this study, there was hardly a change in the number of CFU of *Staphylococcus chromogens* before and after handwashing, with 170 CFU and 165 CFU, respectively. Also, *Kocuria rhizophila*, which was not detected initially, was detected after handwashing. The efficacy of alcohol-based hand sanitizer is dependent on the alcohol amount, applied amount, the technique used, and application consistency and is not ideal for highly contaminated situations. The result of this study also demonstrated that the bacterial reduction rate of alcohol-based hand sanitizer was the lowest. This may be because unlike soap, which is used with water to wash down the pathogen, ethanol from alcohol stays on hands and is less likely to be removed with water as it is less hydrophilic [10,11]. Moreover, if the ethanol from the alcohol-based hand sanitizer enters the eyes or if one touches one's eyes with hands cleaned using a sanitizer, it can cause corneal burn[12]. There can also be dryness, itchiness, and cracked skin due to contact dermatitis. Special caution is required since ethanol can cause moderate to serious allergic contact dermatitis with even breathing difficulties in some cases[13]. Among the three hand hygiene methods investigated in this study, hand sanitizer wipes demonstrated the highest bacterial reduction rate. However, because hand sanitizer wipes also contain ethanol, caution is required to dry hands sufficiently and not to touch the eyes. Among the strains identified in this study, *Enterococcus columbae*, *Kocuria rhizophila*, *Leuconostoc mesenteroides* *layspp. cremoris*, *Staphylococcus epidermidis*, *Micrococcus luteus*, etc. are mostly resident flora with low pathogenicity. However, these organisms display antibiotic resistance and can cause lethal opportunistic infections in patients with weak immunity. In particular, *Staphylococcus epidermidis* can cause arthritis, endocarditis, bacteremia, etc. in

the patients with granulocyte leukopenia, prosthetic implants such as a long-term catheter, and a history of shunt surgery or cardiovascular surgery[14]. Thus, to prevent transmission of resident flora to the patient, it is essential that the sonographer adheres to standard precautions, including hand hygiene during ultrasound scanning. The limitation of the study is that comparison between different sanitizers, sanitization methods, and different circumstances of ultrasound rooms were not taken into evaluation. Furthermore, the death of pathogenic bacteria such as *Escherichia coli* and *Staphylococcus aureus* was not analyzed in this study, which is a potential topic for future investigation.

4. Conclusion

In conclusion, the importance of hand hygiene and the efficacy of each hand hygiene method on bacterial reduction were confirmed in this study. With plain soap and water, the CFUs before and after handwashing were 500 and 175, respectively. With plain soap and water, the bacterial reduction rate was approximately 65%. The CFUs before and after alcohol-based sanitizer were 443 and 240, respectively. The bacterial reduction rate was 44%. With hand sanitizing wipes, the CFUs before and after were 350 and 60, respectively. The bacterial reduction rate was 82%. Hence, it was demonstrated that the antibacterial efficacy is the greatest when applying hand sanitizing wipes for hand hygiene. Based on the results of this study, it is considered that washing hands frequently and using hand sanitizing wipes when inconvenient can protect both practitioners and patients from infections and contribute to improving the ultrasound scanning environment.

5. References

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