Original Article

Hand Hygiene among Anesthesiologists and Microorganisms Contamination in Anesthesia Environments: A Single-Center Observational Study*



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Abstract

To investigate the baseline levels of microorganisms' growth on the hands of Objective anesthesiologists and in the anesthesia environment at a cancer hospital.

Methods This study performed in nine operating rooms and among 25 anesthesiologists at a cancer hospital. Sampling of the hands of anesthesiologists and the anesthesia environment was performed at a ready-to-use operating room before patient contact began and after decontamination.

Results Microorganisms' growth results showed that 20% (5/25) of anesthesiologists' hands carried microorganisms (> 10 CFU/cm²) before patient contact began. Female anesthesiologists performed hand hygiene better than did their male counterparts, with fewer CFUs (P = 0.0069) and fewer species (P =0.0202). Our study also found that 55.6% (5/9) of ready-to-use operating rooms carried microorganisms (> 5 CFU/cm²). Microorganisms regrowth began quickly (1 hour) after disinfection, and increased gradually over time, reaching the threshold at 4 hours after disinfection. Staphylococcus aureus was isolated from the hands of 20% (5/25) of anesthesiologists and 33.3% (3/9) of operating rooms.

Conclusion Our study indicates that male anesthesiologists need to pay more attention to the standard operating procedures and effect evaluation of hand hygiene, daily cleaning rate of the operating room may be insufficient, and we would suggest that there should be a repeat cleaning every four hours.

Key words: Hand hygiene; Anesthesiologists; Contamination; Anesthesia environments

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INTRODUCTION

nesthesiologists play a decisive role in determining the mode of anesthesia, maintaining the stability of patients'

intraoperative vital signs and implementing postoperative analgesia, and also in reducing healthcare-associated infections. Several studies have shown that anesthesiologists may still lack awareness in operating room infection control and

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self-monitoring of hand hygiene^[1-6]. In China, very few studies concentrated on the effectiveness of hand hygiene among anesthesiologists or microorganisms contamination in anesthesia environments. In 2012 and 2019, China issued "Regulation of disinfection technique in healthcare settings" (WS/T 367-2012) and "Specification of hand hygiene for healthcare workers" (WS/T 313-2019)^[7,8], respectively, which stipulated the maximum number of total viable counts monitored after environment disinfection and hand disinfection. Although the regulations were issued, not every health worker can comprehend and implement properly, nor the monitor is timely. In particular, the specific colony count also requires a lot of work to do, and not every hospital can meet the standard. Obtaining the baseline levels of microorganisms' growth on the hands of health workers and in the environment before and after disinfection is really important for the local government to set or adjust the standards or guidelines, but the data in China are still unclear. In this study, we only focused on the neglected population anesthesiologists, and tried to establish the baseline levels of microorganisms' growth on the hands of anesthesiologists and in the anesthesia environment from a single center's point of view.

To characterize the baseline levels of contamination on anesthesiologists' hands and in the anesthesia environment, we conducted a prospective observational study in nine operating rooms and on 25 anesthesiologists at a cancer hospital in 2021. We further studied the effectiveness of the decontamination on providers' hands and in the anesthesia environment to help understand the necessity and practical frequency of decontaminating behaviors.

METHODS

Statement

The study was approved by the appropriate Institutional Review Board (IRB), and the requirement for written informed consent was waived by the IRB.

General Description

This was an observational trial on a convenience sample performed in nine operating rooms and among 25 anesthesiologists at a cancer hospital over 2 consecutive months (June and July 2021). Sampling of the hands of these anesthesiologists and the anesthesia environment was performed at a readyto-use operating room before patient contact began. After decontamination of hands (Apply a palmful of 70% alcohol and cover all surfaces of the hands. Rub hands more than 15 seconds until dry) and anesthesia environments (using a 5.5%–6.5% chlorine solution), sampling was repeated in 2 minutes after dry to help understand the effectiveness of decontaminating behaviors.

A designated investigator sampled and recorded in the present study, he was notified to enter the operating room (randomly chosen by lot) in the morning of working days before all anesthesiologists and cleaning staff were informed. Considering the influence of different operation times on the results, only the first operation was employed for observation, and the operation time should be greater than 4 hours because the working table should be monitored at least 4 hours. The arrangement of the anesthesiologists and the operating room is carried out according to the normal schedule, some unexpected situations such as temporary shifts, cancellation of surgery, which leading to a situation where the same anesthesiologist entered the same operating room twice in different observational days should be excluded in analysis to make sure that all anesthesiologists and operating rooms were sampled and analyzed only once, but the inoculation on agar plates was duplicated. All anesthesiologists and cleaning staff could access his/her result and the best practice guidance^[7,8] after the investigation was finished.

Protocol

As depicted in Figure 1, we first obtained bacterial or fungal cultures from the hands of anesthesiologists when they entered the operating room before contacting any surfaces to determine if they had performed active decontamination on their hands (WS/T 313-2019^[8], handwashing at least 15 seconds) before entering the operating room (Figure 1, Panel A). After that, their hands were decontaminated with 70% alcohol in the standard manner from WS/T 313-2019 and WHO handhygiene guidelines (Apply a palmful of 70% alcohol and cover all surfaces of the hands. Rub hands more than 15 seconds until dry)^[8], and then participants' hands were sampled again for bacterial or fungal cultures to determine the effectiveness of decontaminating behavior in this situation (Figure 1, Panel A).

Secondly, in ready-to-use operating rooms, we also sampled for bacterial or fungal cultures three parts of the anesthesia cart (Figure 1, Panel B) that anesthesiologists typically touched very often. We

sampled these three parts of the anesthesia cart again 30 minutes after decontamination with 5.5%–6.5% chlorine solution, to determine the necessity and effectiveness of decontaminating behavior in this situation (Figure 1, Panel B).

Thirdly, we sampled the monitor screen (Figure 1, Panel C 1), working table (Figure 1, Panel C 2), and keyboard and mouse (Figure 1, Panel C 3) of the anesthesia machine, the areas most frequently contacted by anesthesiologists. Thirty minutes after decontaminating them with 5.5%–6.5% chlorine solution, we sampled the three parts again to assess the necessity and effectiveness of decontaminating behavior in this situation (Figure 1, Panel C). In this study, we also monitored the microorganisms' growth sampled from the working table of the anesthesia machines at different time points to determine how soon there should be a repeat cleaning (Figure 1, Panel C).

Sampling of Anesthesiologists' Hands

The method of sampling the hands of anesthesiologists was based on the health industry standards of the People's Republic of China: "Specification of hand hygiene for healthcare workers" (WS/T 313-2019)^[8].

Per these specifications, the five fingers of the tested anesthesiologists are held close together, and a sterile fiber test piece soaked with sterile normal saline is rubbed back and forth on the finger surface of both hands from the finger root to the finger end twice (the Biomed Environ Sci, 2022; 35(11): 992-1000

wiping area of one hand is 30 cm²), and then the sampling swab is rotated, the test piece is immersed in the sampling tube containing preservation solution, the hand contact part is bent off, and the tube is covered. After the sampling tube is thoroughly shaken, 0.2 mL of eluent with different dilution times is inoculated on BHI agar plates (duplicates), smeared evenly with a sterilized L rod, then placed in a 35–37 °C incubator for 48 hours. The number of colonies is calculated in the sampling area of a square centimeter (cm²). For hand disinfection, the total number of bacterial or fungal colonies monitored should be \leq 10 CFU per cm² (WS/T 313-2019)^[8].

Sampling of the Anesthesia Environment

The method of sampling the anesthesia environment was based on WS/T 367-2012^[7]. Per these specifications, for sampling surfaces less than 100 cm², all surfaces are taken; for surfaces > 100 cm², 100 cm² is sampled. One sterile fiber swab soaked with sterile normal saline is applied to the surface to be tested, applied vertically and back and forth five times within the range of 5 cm × 5 cm, and then the swab is rotated to continuously sample 1 to 4 areas. The swab is immersed into the sampling tube containing preservation solution, the hand contact part is bent off, and the tube is covered. After the sampling tube is thoroughly shaken, 0.2 mL of eluent with different dilution times is inoculated on BHI agar plates (duplicates), smeared evenly with a sterilized L rod, then placed in a 35-37 °C incubator for 48 hours. The



Panel B: Sampling of the anesthesia environment (anesthesia cart 1, 2, 3 resprsent three part)



Panel C: Sampling of the anesthesia environment (anesthesia machine 1, monitor screen; 2, working place; 3, keyboard and mouse)



Figure 1. Protocol for sampling anesthesiologists' hands (A), the anesthesia environment (B), and the anesthesia machine (C).

number of colonies is calculated within a sampling area of a square centimeter. For operating rooms, the total number of bacterial or fungal colonies observed should be $\leq 5 \text{ CFU/cm}^2 (\text{WS/T 367-2012})^{[7]}$.

Bacterial Identification

Microorganisms recovered from anesthesiologists' hands and the anesthesia environment were identified by MALDI-TOF MS as previously described^[9]. The acquisition and analysis of mass spectra were performed by the M-Discover 100 MS (MS-ID version v3.2, Zhuhai Meihua Medical Technology Co., Ltd. China). Per the instructions of the M-Discover 100 MS^[9], identification scores of \geq 90 indicated species-level identification, scores of 60–90 indicated genus-level identification, and scores of \leq 60 were considered "not reliable" (NRI).

Statistical Analysis

Microorganisms' growth from samples of

anesthesiologists' hands and anesthesia environments before and after disinfection were statistically evaluated employing the two-tailed Mann-Whitney test (Figures 2–3). Comparison of microorganisms' growth of monitor screen, working table, and keyboard and mouse before and after disinfection were statistically evaluated using oneway ANOVA test (multiple comparisons) (Figures 4–5). A *P*-value < 0.05 was considered significant.

Data Availability

All data are incorporated into the article and its online supplementary material.

RESULTS

Baseline Microorganisms' Growth on Anesthesiologists' Hands

The microorganisms' growth results from the



Figure 2. Baseline microorganisms' growth on the hands of anesthesiologists and the effectiveness of disinfection. (A) and (B) represent microorganisms' growth before and after hands disinfection in terms of the total CFUs and number of species, respectively. (C) and (D) indicate microorganisms' growth before and after hands disinfection between male and female anesthesiologists in terms of total CFUs, respectively. (E) and (F) represent microorganisms' growth before and after hands disinfection between male and female anesthesiologists in terms of number of species, respectively. CFU, colony-forming units. The two-tailed Mann-Whitney test was used in this section, and a *P*-value < 0.05 was considered significant.

hands of the 25 anesthesiologists sampled at a ready-to-use operating room before patient contact showed that the overall mean number of total CFUs and CFU/cm² were 407 (range: 2-2091) and 7 (range: 0-35) (Figure 2, Supplementary Table S1, available in www.besjournal.com), respectively. Five anesthesiologists' hands (Providers 3, 7, 10, 23, and 25) (5/25, 20%) carried microorganisms more than 10 CFU/cm² (Supplementary Table S1, Figure 2). Only one major pathogen Staphylococcus aureus was isolated, from 5/25 anesthesiologists (20%; Providers 1, 2, 3, 4, and 13) (Supplementary Table S1, Figure 2). Considering the possible impact of gender, we compared the microorganisms' growth between male and female anesthesiologists before uniform disinfection, and found no differences (Figure 2). Not surprisingly, after disinfection, the microorganism growth significantly decreased regardless of the total CFUs (P < 0.0001) or the number of species (P < 0.0001) 0.0001), but obvious divergences were determined between male and female providers, notably that female anesthesiologists performed hand hygiene better than male anesthesiologists, resulting in fewer CFUs (P = 0.0069) and fewer species (P = 0.0202) (Figure 2).

Baseline Microorganisms' Growth in Anesthesia Environments

In this study, anesthesia environment samples were obtained from all nine operating rooms at the hospital. In each ready-to-use operating room we sampled the anesthesia cart, monitor screen, working table, and keyboard and mouse of the anesthesia machine (Figure 1). The microorganisms' growth results showed that the overall mean numbers of total CFUs found on the anesthesia cart, monitor screen, working table, and keyboard and mouse of the anesthesia machine were 376 (range: 36–1,114), 13 (range: 0–50), 223 (range: 13–684), and 469 (range: 38–2,000) (Supplementary Tables S2 and S3, available in www.besjournal.com), respectively. Based on CFU/cm² results, five of the



Figure 3. Baseline microorganisms' growth in the anesthesia environment and the effectiveness of disinfection. (A) and (B) represent microorganisms' growth before and after disinfection at the key board and mouse in terms of CFUs and number of species, respectively. (C) and (D) indicate microorganisms' growth before and after disinfection at the medicative cart in terms of CFUs and number of species, respectively. (E) and (F) represent microorganisms' growth before and after disinfection at the monitor in terms of CFUs and number of species, respectively. (E) and (F) represent microorganisms' growth before and after disinfection at the monitor in terms of CFUs and number of species, respectively. CFU, colony-forming units. The two-tailed Mann-Whitney test was used in this section, and a *P*-value < 0.05 was considered significant.

nine operating rooms (55.6%)carried microorganisms more than 5 CFU/cm² on the anesthesia cart (Rooms 3 & 8), working table (Room 7), or the keyboard and mouse of anesthesia machine (Rooms 1 & 9) (Supplementary Tables S2 and S3). One major pathogen, Staphylococcus aureus, was isolated in three rooms (33.3%; Rooms 1, 3, and 7) (Supplementary Tables S2 and S3). Considering the importance of disinfection, we disinfected the working areas determined in this study with 5.5%-6.5% chlorine and then re-sampled after 30 minutes. Not surprisingly, after disinfection, microorganisms' growth significantly decreased regardless of the total CFUs (P < 0.05) or numbers of species (P < 0.05) (Figure 3). Furthermore, Figure 4 shows that the microorganisms' growth are very likely to be hand contact-related because the keyboard and mouse of the anesthesia machines, as the most frequently touched areas, carried the highest number of colonies, whereas the monitor



Figure 4. Comparison of microorganisms' growth among different parts of anesthesia environment and the effectiveness of disinfection. (A) and (B) represent microorganisms' growth before and after disinfection at different parts of anesthesia environment in terms of CFUs, respectively. CFU, colony-forming units. The one-way ANOVA test (multiple comparisons) was used in this section, and a P-value < 0.05 was considered significant.

screens carried the fewest colonies; these differences remained statistically significant even after disinfection. In this study, we also monitored the microorganisms' growth sampled from the working table of the anesthesia machines at different time points to determine how soon a repeat cleaning is needed. The results showed that microorganisms regrowth began 1 hour after disinfection, and increased gradually over time (Figure 5) until reaching an excessive amount (> 5 CFU/cm²) at 4 hours after disinfection (Supplementary Table S3).

DISCUSSION

Hand-mediated transmission is a paramount infection causing associated factor with healthcare^[10]. Effective and timely hand disinfection before patient contact will decrease the incidence of transfer of potential pathogens^[11]. Anesthesiologists are usually a neglected population who may still lack consciousness in operating room infection control and hand hygiene^[1-6]. In China, two regulatory instructions were issued on regulation of disinfection in healthcare settings (WS/T 367-2012) and health workers^[7,8], but whether the anesthesiologists and cleaning staff implemented properly was still unknown. In this study, microorganisms' growth results showed that the hands of 20% (5/25) of anesthesiologists carried excessive bacteria or fungi, and significantly decreased after disinfection with fewer CFUs and species. It is well worth mentioning that the method of hand hygiene used in this study had already been standardized (WS/T 313-2019)^[8], specifying that the whole hand and fingers



Figure 5. Microorganisms' growth on anesthesia machines (working tables) and the effectiveness of disinfection. CFU, colony-forming units.

(particularly the tips) should be exposed to the alcohol hand sanitizer after rubbing them for 10 to 15 seconds, and that alcohol hand sanitizer should be conveniently placed. We found that female anesthesiologists performed hand hygiene better than did their male counterparts, because men had a higher CFU count and number of species. Therefore, male anesthesiologists need to pay more attention to the standard operating procedures and effect evaluation of hand hygiene. However, whether the results mentioned above indicate that male anesthesiologists are more likely to cause handmediated transmission and higher incidence of subsequent hospital-acquired infections remains unknown and will require further study.

Surfaces in the anesthesia environment, especially the anesthesia cart and the anesthesia machine, which are used frequently during operations, are often neglected as important potential sources of bacterial transmission^[12]. Munoz-Price and Birnbach^[13] found that pathogenic organisms were present in 16.6% of ready-to-use operating room surfaces. Our study found that 55.6% of ready-to-use operating rooms carried excessive bacteria or fungi on the anesthesia cart, working table, or keyboard and mouse of anesthesia machine (Supplementary Tables S2 and S3). Disinfection can largely reduce microorganisms' growth with fewer CFUs (P < 0.05) and number of species (P < 0.05) (Figure 3), but the regrowth began quickly (1 hour) after disinfection, and increased gradually over time (Figure 5) until reaching excessive levels at 4 hours after disinfection (Supplementary Table S3). Jefferson et al.^[14] evaluated 71 operating rooms across six acute care hospitals and found an average daily cleaning rate of 25% of the objects monitored. A similar study^[13] also found a baseline daily cleaning rate of 47%. In this study, all operating rooms are cleaned daily. Yet the results of this study confirm that daily cleaning rate may be insufficient because unawareness of hand contact with excessively bacteria-colonized surfaces may increase the risk of subsequent hospitalacquired infections.

The hospital environment is a major reservoir of multidrug-resistant bacteria, including MRSA, vancomycin-resistant *enterococci*, *C. difficile*, and *A. baumannii*^[15-21], even in areas such as operating rooms that were previously thought to be "sterile"^[22]. *Staphylococcus aureus*, usually colonized on the skin of human beings and on environmental surfaces, is a common cause of healthcare-associated infections worldwide and has become a major screened and

monitored pathogen on admission as a key infection prevention strategy^[23-26]. In this study, the major pathogen *Staphylococcus aureus* was isolated from the hands of 20% of anesthesiologists and in 33.3% of operating rooms, but we did not determine the antimicrobial susceptibility of these isolates, and therefore whether they were MRSA or MSSA is unknown. Loftus et al^[27] found that 7% (12/164) and 11% (18/164) of anesthesia providers' hands were contaminated with MRSA and MSSA, respectively, and MRSA and MSSA can also be isolated from anesthesia machines.

A key point of the present study is giving us a specific name list of all possible pathogens in hands anesthesiologists and in the anesthesia of environment. Most of the detected species were not thought to be pathogenic, but commensal species have been confirmed to serve as reservoirs of antibiotic resistance and virulence genes for the pathogenic species^[28,29], which may not take a toll on patients now but long-term colonization on surfaces in the anesthesia environment is still a potential risk because patients admitted in cancer hospitals are usually more vulnerable to microorganisms^[30]. It is also worth mentioning that we found that the number of detected species seemed to change much less than the counts. This is likely to be expected, previous study^[31] also reported that cleaning procedures were very effective in eliminating coliforms, in contrast, gram-positive bacteria were not totally eliminated, possibly due to the greater resistance of gram-positive bacteria (with their thicker peptidoglycan cell wall layer) to ethanolbased sanitizers and disinfectants.

There are some limitations in this study. Firstly, because this is a single-center study, the results obtained may not be applicable to other hospitals. Secondly, we sampled hands only in the short time period immediately before patient contact, which may underestimate the importance of hand hygiene throughout the entire process of patient care because Loftus and others^[32-35] suggested that hand hygiene use of 4–8 times/hour reduced surgical site infections. Thirdly, the test procedures employed in the present study were dictated by the national standards, which probably limit the external validity.

Despite these limitations, we characterized the baseline levels of contamination on the hands of anesthesiologists and in the anesthesia environment. Our study indicates that male anesthesiologists need to pay more attention to the standard operating procedures and effect evaluation of hand hygiene, daily cleaning rate of the operating room may be insufficient, and we would suggest that there should be a repeat cleaning every four hours. These results of this study provide a theoretical basis for the formulation of future measures to control and prevent nosocomial infection.

CONFLICTS OF INTEREST

None declared.

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DISCLOSURES

LIU Hong Lei helped design the study, conduct the study, analyze the data, and write the manuscript. LIU Ya Li helped design the study, has seen the original study data, reviewed the analysis of the data, approved the final manuscript. LI Zong Chao has seen the original study data, reviewed the analysis of the data, approved the final manuscript. TAN Hong Yu, SUN Fang Yan and XU Ying Chun helped design the study, approved the final manuscript.

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	6	E	Before Disinf	ection of Hands		After Disinfe	ection of Hands
Name	Gender	CFU/total	CFU/cm ²	Bacteria	CFU/total	CFU/cm ²	Bacteria
				Brevibacillus parabrevis			Bacillus cereus
				Kocuria marina			
Provider 1	М	114	2	Staphylococcus aureus	1	0	
				Staphylococcus epidermidis			
				Staphylococcus hominis			
				Staphylococcus epidermidis			Bacillus megaterium
				Bacillus cereus			Staphylococcus capitis
Drovidor 2	NA	205	F	Moraxella osloensis	2	0	
Provider 2	IVI	505	5	Kocuria rhizophila	5	0	
				Staphylococcus aureus			
				Staphylococcus hominis			
				Staphylococcus aureus			Micrococcus luteus
				Staphylococcus haemolyticus			Kocuria palustris
Provider 3	М	950	16	Micrococcus luteus	304	5	Staphylococcus aureus
							Staphylococcus capitis
							Staphylococcus warneri
				Bacillus firmus			Lactobacillus plantarum
				Bacillus megaterium			Staphylococcus capitis
Dueviden 4		20	0	Enterobacter cloacae	C	0	Staphylococcus epidermidis
Provider 4	IVI	28	0	Staphylococcus aureus	б	U	
				Staphylococcus capitis			
				Staphylococcus epidermidis			
				Bacterium [*]			Corynebacterium tuberculostearicum
				Neisseria mucosa			Staphylococcus epidermidis
Providor 5	NA	80	1	Staphylococcus capitis	r	0	
FIONUEI 5	IVI	89	I	Staphylococcus epidermidis	2	0	
				Staphylococcus hominis			
				Staphylococcus pettenkoferi Corynebacterium tubarculastaariaum			Bacterium*
Provider 6	М	330	6	Micrococcus antarcticus	3	0	Micrococcus luteus
				Staphylococcus epidermidis			Bacterium*
				Staphylococcus capitis			Staphylococcus epidermidis
Provider 7	Μ	2000	33	Kocuria marina	7	0	
				Bacillus cereus			Bacillus cereus
				Bacillus megaterium			Staphylococcus capitis
Provider 8	М	10	0	Moraxella osloensis	8	0	
				Bacterium [*]			

Supplementary Table S1. Bacterial growth on the hands of anesthesiologists before and after disinfection

Continued

	a 1	E	Before Disinf	ection of Hands		After Disinfe	ction of Hands
Name	Gender	CFU/total	CFU/cm ²	Bacteria	CFU/total	CFU/cm ²	Bacteria
Provider 9	М	2	0	Aerococcus viridans Lactobacillus fermentum	0	0	
				Acinetobacter baumannii			Bacillus flexus
				Acinetobacter nosocomialis			Brevibacterium linens
Provider 10	М	1352	23	Brevibacterium linens	15	0	Sphingomonas aerolata
				Staphylococcus epidermidis Sphingomonas paucimobilis			
				Bacillus cereus			Bacillus infantis
				Bacillus flexus			Bacillus megaterium
Provider 11	М	352	6	Bacillus infantis	13	0	Bacillus simplex
				Bacillus megaterium Dermacoccus nishinomiyaensis Bacillus megaterium			Staphylococcus cohnii Micrococcus luteus
				Micrococcus luteus			Where colocids hateus
Provider 12	М	109	2	Neisseria meninaitidis	2	0	
	IVI	105	2	Serratia ruhidaea	2	0	
				Stanbulococcus sn			
				Micrococcus luteus			Bacillus horikoshii
				Moraxella sn			Stanhylococcus canitis
Provider 13	F	120	2	Stanhylococcus hominis	2	0	Stupitylococcus cupitis
				Staphylococcus aureus			
				Micrococcus luteus			Bacillus pseudofirmus
Provider 14	F	67	1	Ralstonia svzvaji	2	0	Buemus pseudojnimus
		07	-	Stanhylococcus canitis	2	Ū	
				Micrococcus luteus			
Provider 15	F	77	1	Stanhylococcus enidermidis	0	0	
		,,	-	Stanhylococcus hominis	0	Ū	
				Bacterium [*]			
				Kocuria marina			
Provider 16	F	15	0	Staphylococcus capitis	0	0	
				Staphylococcus hominis			
				Bacillus moiavensis			Brevibacillus borstelensis
				Kocuria rhizophila			Brevibacterium linens
Provider 17	F	202	3	Staphylococcus sciuri	11	0	Bacterium [*]
				Staphylococcus epidermidis			
				Bacillus subtilis			
Provider 18	F	2	0	Staphylococcus capitis	0	0	
				Brevibacterium linens			
Provider 19	F	450	8	Bacterium [*]	0		

53
Continued

	O states	E	Before Disinf	ection of Hands		After Disinfe	ction of Hands
Name	Gender	CFU/total	CFU/cm ²	Bacteria	CFU/total	CFU/cm ²	Bacteria
				Acinetobacter pittii			Bacillus idriensis
				Brevundimonas vesicularis			Micrococcus antarcticus
	_		-	Yeast [*]			
Provider 20	F	127	2	Micrococcus luteus	2	0	
				Ralstonia syzygii			
				Staphylococcus caprae			
				Pasteurella dagmatis			
				Brachybacterium			
Provider 21	F	103	2	conglomeratum	0	0	
				Brachybacterium			
				conglomeratum			
				Bacillus cereus			Neisseria perflava
Provider 22	F	60	1		5	0	Staphylococcus cohnii
							Staphylococcus epidermidis
				Bacillus cereus			
Drovidor 22	F	1047	17	Bacillus megaterium	0	0	
Provider 23	F	1047	17	Staphylococcus cohnii	0	0	
				Staphylococcus saprophyticus			
				Bacillus cereus			
D D	-	100	2		0	0	
Provider 24	F	183	3		0	0	
				Bacillus sp			Bacillus circulans
Provider 25	F	2091	35	Brevibacterium casei	2	0	
				Neisseria meningitidis			

Note. ^{*}Indicates identification scores of \leq 60, considered "not reliable". CFU, colony-forming units.

Certybani CUntani CUntani CUntani CUntani CUntani Straphytococcus latera Straphytococcus latera Straphytococcus latera Straphytococcus stratic Straphytococcus straphyt		Before	disinfection	Aft	er disinfection	Before	disinfection	After	disinfection	Before	edisinfection	After disinfection
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Microaction lutes Monella pin Microaction	5 E	/total; J/cm²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ² Bacteria
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	e disinfection licative Cart)	Bacteria	Bacillus cereus	Micrococcus luteus	Staphylococcus epidermidis Staphylococcus	naemolyticus Staphylococcus lugdunensis	Corynebacterium	aurimucosum Micrococcus	antarcticus	Staphylococcus warneri		Acinetobacter Imoffii	Micrococcus luteus	Staphylococcus cohnii		Bacillus cereus	Micrococcus luteus	According and another
	Before (Mec	CFU/total; CFU/cm ²			100; 1					208; 2				488; 5			96.0	0,00
	lisinfection d and Mouse)	Bacteria	Staphylococcus hominis				Paenibacillus	glucanolyticus				Micrococcus	Pseudomonas	Staphylococcus sanronhyticus		Actinomyces funkei	Micrococcus antarcticus	Staphylococcus
	After o (Keyboar	CFU/total; CFU/cm ²			17; 0					1; 0				46; 0			C.	2
	disinfection rd and Mouse)	Bacteria	Kocuria rhizophila	Staphylococcus epidermidis	Staphylococcus pettenkoferi		Racterium*		Kocuria rosea	Staphylococcus epidermidis Staphylococcus	nominis Bacterium [*]	Micrococcus	Staphylococcus onidormidic	Staphylococcus haemolyticus	Staphylococcus hominis	Escherichia coli	Moraxella osloensis	Staphylococcus
	Before (Keyboai	CFU/total; CFU/cm ²			38; 0					91; 1				416; 4			C.COC	202, 2
	No. of	Operating Room			4					Ŋ				9			٢	

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$ \begin{array}{ c c c c c c c c c c c c c$	Jo of	Before	e disinfection	After d	isinfection	Before	disinfection	After (lisinfection	Before	lisinfection	After disinfectio	on
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Interaction Interaction Veat Microaccus Nicroaccus Rouria rhizophila Kouria rhizophila Microaccus 13;1 Paulons Paulons Rouria rhizophila Microaccus 12;0 Paulons Paulons Staphylococcus Rouria rhizophila 13;0 Hueus 1114;11 Rounoida 2;0 Rouria rhizophila Rouphylococcus 13;0 Hueus 1114;11 Rophylococcus 2;0 Capita Rouphylococcus 13;0 Hueus 1114;11 Rophylococcus 2;0 Capita Rouphylococcus 13;0 Hueus 1114;11 Rouphylococcus 2;0 0;0 0;0 Rouphylococcus Micrococus Yeash Kouria rose 0;0 0;0 0;0 Routentidis 11;0 Micrococus Yeash Kouria rose Bacteriuri 0;0 Routentidis 11;0 Staphylococcus 5;0 5;0 5;0 0;0 0;0	Room	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; Bacte CFU/cm ²	eria
8 197.2 Staphylococcus staphylococcus 12,0 Microccus humonicola Pandonaea staphylococcus Staphylococcus staphylococcus 0,0			Dietzia maris		Enterococcus pallens		Yeast [*]		Micrococcus Inteus				
8 197,2 Staphylococcus 12,0 Inteus 1114;11 pulmonicola 2,0 capits 0,0 0,0 9 621;6 Staphylococcus 11,0 Raphylococcus Yeast Youris rosea 0,0 0,0 0,0 9 621;6 Staphylococcus Vast Youris rosea Bacterium [*] Nicrococcus Bacterium [*] 0,0 0,0 9 621;6 Staphylococcus Vast Vast Kocuria rosea Bacterium [*] 9 621;6 Staphylococcus 71;5 heenolyticus 5,0 5;0 0;0			Kocuria rhizophila		Micrococcus		Pandoraea		Staphylococcus				
0 15/1,2 Staphylococcus 114/1,11 Staphylococcus 2,0 0,0 0,0 1 epidermidis teminis hominis teminis 0,0 0,0 0,0 1 temolyticus Staphylococcus saprophyticus teminis teminis 0,0 0,0 0,0 1 temolyticus Micrococcus Yeast Kacuria rosea Bacterium 0,0 0,0 0,0 1 antarcticus Yeast Kacuria rosea Bacterium teminis 0,0 0,0 0,0 0,0 1 antarcticus Yeast Kocuria rosea Bacterium teminis 0,0 0,0 0,0 0,0 1 0 Staphylococcus Staphylococcus Staphylococcus 5,0 5,0 0,0 0,0 0,0 1 teminis 11;0 epidermidis 471;5 haemolyticus 5,0 5,0 0,0 0,0 0,0 0,0 1 teminis teminitis 5,0 5,0 5,0 0,0 0,0 0,0 0,0	c				luteus		pulmonicola	Ċ	capitis	Ċ		Ċ	
epidermidis Staphylococcus hominis Staphylococcus Staphylococcus Staphylococcus Bacilus idriensis Micrococcus Bacilus idriensis Nicrococcus Bacterium [*] Nicrococcus Bacterium [*] Nicrococcus Bacterium [*] Nicrococcus Bacterium [*] Veast [*] Raterium [*] Nicrococcus Bacterium [*] Nicrococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus Staphylococcus	x	197; Z	Staphylococcus	12; U		1114; 11	Staphylococcus	7; U		n; n		n; n	
9 621; 6 Staphylococcus haemolyticus Staphylococcus saprophyticus Staphylococcus saprophyticus 9 621; 6 Cohni 11; 0 Vasti staphylococcus Vasti staphylococcus Kocuria rosea Bacteriumi 9 621; 6 Cohni 11; 0 Staphylococcus epidermidis 8acillus sp Staphylococcus hominis 5; 0 5; 0 0; 0			epidermidis				hominis						
haemolyticus saprophyticus Bacillus idriensis Micrococcus Yeast Kocuria rosea Bacterium [*] Bacterium [*] Micrococcus Yeast Kocuria rosea Bacterium [*] Bacterium [*] Micrococcus Staphylococcus Staphylococcus Bacterium [*] 9 51,6 Staphylococcus 5,0 5,0 0,0 9 521,6 cohnii 11,0 epidermidis 471,5 haemolyticus 5,0 5,0 0,0			Staphylococcus				Staphylococcus						
9 621; 6 Bacterium [*] Micrococcus Yeast [*] Kocuria rosea Bacterium [*] Bacterium [*] Micrococcus Staphylococcus Bacterium [*] Micrococcus Caphylococcus Bacillus sp hominis Inteus epidermidis 471; 5 haemolyticus 5; 0 5; 0 0; 0 Staphylococcus epidermidis 471; 5 haemolyticus 5; 0 5; 0 0; 0			haemolyticus				saprophyticus						
9 621; 6 Bacterium [•] Micrococcus Staphylococcus Bacillus sp Staphylococcus Iuteus epidermidis epidermidis 471; 5 haemolyticus 5; 0 5; 0 0; 0 0; 0 staphylococcus epidermidis epidermidis 471; 5 haemolyticus 5; 0 5; 0 0; 0 0; 0 0; 0 0; 0 0; 0 0;			Bacillus idriensis		Micrococcus antarcticus		Yeast [*]		Kocuria rosea		Bacterium*		
9 621; 6 Staphylococcus Staphylococcus equations Staphylococcus 11; 0 Staphylococcus 5; 0 5; 0 0; 0 Staphylococcus fieldermidis 471; 5 haemolyticus 5; 0 5; 0 0; 0 Staphylococcus fieldermidis 5; 0 5; 0 0; 0 Staphylococcus fieldermidis 471; 5 haemolyticus 5; 0 5; 0 0; 0			Bacterium [*]		Micrococcus		Staphylococcus		Bacillus sp		Staphylococcus bominic		
Staphylococcus epidermidis Staphylococcus	6	621; 6	Staphylococcus cohnii	11; 0	iuteus Staphylococcus epidermidis	471; 5	epidentias Staphylococcus haemolvticus	5; 0		5; 0	SIIIIIOII	0;0	
epidermidis Staphylococcus			Staphylococcus		-								
Staphylococcus			epidermidis										
			Staphylococcus										

Note. ^{*}Indicates identification scores of ≤ 60, considered "not reliable". CFU, colony-forming units.

No. of	Before Ta	ble Disinfection	After Tab	le Disinfection	After Tak	ole Disinfection	After Tab	le Disinfection	After Ta	ble Disinfection	After Tab	le Disinfection
Onerating			9	hours)		1 hour)	5	hours)		3 hours)	4	hours)
Room	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria
		Micrococcus antarcticus Micrococcus luteus Stanbuloroccus		Staphylococcus hominis		Bacillus mycoides Staphylococcus epidermidis Stanhylococcus		Kocuria rosea Paenibacillus apiarius Stanhvloroccus		Pseudomonas avellanae Staphylococcus capitis Stanhylococcus		Micrococcus luteus Staphylococcus capitis Stanhylococcus
÷	110; 1	staphylococcus Staphylococcus capitis Staphylococcus cohnii Staphylococcus hominis	5; 0		19; 0	hominis	60; 1	staphylococcus Staphylococcus hominis	133; 1	haemolyticus haemolyticus Staphylococcus hominis Bacterium [*]	252; 3	supryrococcus Staphylococcus haemolyticus
		Kocuria rosea Moraxella osloensis		Bacillus megaterium Bacillus sp		Bacillus megaterium Bacillus sp		Bacillus vallismortis Kocuria rhizophila		Yeast [*] Kocuria rosea		Bacillus subtilis Bacterium [*]
7	345; 3	Staphylococcus capitis Staphylococcus epidermidis Staphylococcus haemolyticus	10; 0	Kocuria rhizophila Staphylococcus hominis	43; 0	Bacterium [*] Staphylococcus epidermidis	50; 1	Netzephilo Netzeria Staphylococcus Capitis Staphylococcus epidermidis	51; 1	Staphylococcus capitis Staphylococcus cohnii Staphylococcus epidermidis	54; 1	Moraxella osloensis Staphylococcus epidermidis Staphylococcus kloosii
		Bacillus Bacillus Kocuria rhizophila Moraxella osloensis		Staphylococcus epidermidis Staphylococcus hominis		Micrococcus Iuteus Staphylococcus aureus Staphylococcus		Staphylococcus pettenkoferi Candida parapsilosis Staphylococcus hominis		Bacterium [*] Brachybacterium Conglomeratum Staphylococcus haemolyticus		Bacterium [*] Moraxella osloensis Yeast [*] Staphylococcus epidermidis
m	445; 4	Staphylococcus aureus Staphylococcus capitis Staphylococcus epidermidis Staphylococcus hominis	ů; 6		47; 0		57; 0		72; 1	Staphylococcus sciuri	115; 1	Staphylococcus saprophyticus

Supplementary Table S3. Bacterial growth in the anesthesia environment (working table) before and after disinfection

Biomed Environ Sci, 2022; 35(11): S1-S9

S7

												Continued
No. of	Before Ta	ble Disinfection	After Tab (0	le Disinfection	After Tab	le Disinfection	After Tab	le Disinfection	After Tab	ole Disinfection t hours)	After Tab	le Disinfection houre)
Operating Room	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria
		Kocuria marina				Bacterium*		Bacterium*		Yeast*		Yeast [*]
		Paenibacillus chitinolvticus				Staphylococcus canitis		Enterobacter cloacae		Micrococcus antarcticus		Micrococcus
4	30; 0	Bacterium [*]	0;0		3; 0		25; 0	Staphylococcus	175; 2	Micrococcus	719; 7	Moraxella
		Staphylococcus hominis						epidermidis		luteus Staphylococcus capitis		osloensis Staphylococcus capitis
		Bacterium [*]		Bacterium*		Staphylococcus capitis		Bacillus cohnii		Bacillus sp		Bacterium*
Ŋ	684; 7	Neisseria subflava Staphylococcus hominis	1; 0		6; 0		18; 0	Yeast*	34; 0	Staphylococcus cohnii Staphylococcus luadunensis	264; 3	Staphylococcus warneri
		Staphylococcus sciuri								gacterium*		
		Bacillus cereus		Staphylococcus hominis		Bacterium*		Brevibacterium iodinum		Micrococcus luteus		Bacillus megaterium
		Enterobacter				Staphylococcus		Bacterium*		Paenibacillus		Moraxella sp
9	115; 1	cloacae Micrococcus	1; 0		3; 0	cohnii Staphylococcus	3; 0	Kocuria marina	20; 0	massiliensis Pseudomonas	24; 0	Staphylococcus
		antarcticus Staphylococcus				epidermidis		Staphylococcus		flavescens		cohnii Staphylococcus bominic
		Kocuria marina		Bacillus mannanilvticus		Neisseria perflava		spinermus Staphylococcus enidermidis		Micrococcus		Bacillus meanterium
		Micrococcus		Lactobacillus		Rothia		Staphylococcus		Neisseria		Neisseria
		antarcticus		paracasei		mucilaginosa		haemolyticus		flavescens		flavescens
7	74; 1	stapnylococcus capitis	7; 0	Neisseria perflava	40; 0	stapnylococcus aureus	42; 0	stapnylococcus pettenkoferi	65; 1	Neisseria sicca	201; 2	stapnylococcus hominis
		Staphylococcus		Staphylococcus		Staphylococcus				Rothia		
		epidermidis Ctanhulococcus		haemolyticus		hominis				mucilaginosa		
		haemolyticus										

											Continued
No. of Operating	Before Ta	ble Disinfection	After Table Disinfection (0 hours)	After Ta	ble Disinfection (1 hour)	After Ta (ble Disinfection 2 hours)	After Tab (3	le Disinfection hours)	After Tal	ole Disinfection 4 hours)
Room	CFU/total; CFU/cm ²	Bacteria	CFU/total; Bacteria CFU/cm ²	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria	CFU/total; CFU/cm ²	Bacteria
		Kocuria rhizophila		-	Arcanobacterium phocae		Bacillus cereus		Staphylococcus epidermidis		Alkalibacillus haloalkaliphilus
		Kocuria rosea			Cardiobacterium sp		Corynebacterium sp		Staphylococcus haemolyticus		Micrococcus luteus
8	13; 0	Moraxella osloensis	0; 0	5; 0	Staphylococcus hominis	8; 0	Kocuria palustris	11; 0		105; 1	Staphylococcus capitis
		Staphylococcus capitis					Staphylococcus haemolyticus				Staphylococcus epidermidis
		Staphylococcus hominis									
		Bacillus simplex			Staphylococcus haemolyticus		Bacillus smithii		Micrococcus Iuteus		Corynebacterium afermentans
σ	187; 2	Staphylococcus epidermidis Staphylococcus	0; 0	1; 0		3; 0	Micrococcus antarcticus Staphylococcus	6; 0	Staphylococcus epidermidis Staphylococcus	10; 0	Staphylococcus hominis Staphylococcus
		nomms Staphylococcus saprophyticus					chinestinas		2010101		Marier
	*										

J, colony-forming units.
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