CONCISE COMMUNICATION

Copper Continuously Limits the Concentration of Bacteria Resident on Bed Rails within the Intensive Care Unit

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Cleaning is an effective way to lower the bacterial burden (BB) on surfaces and minimize the infection risk to patients. However, BB can quickly return. Copper, when used to surface hospital bed rails, was found to consistently limit surface BB before and after cleaning through its continuous antimicrobial activity.

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Microbes have an intrinsic ability to survive and colonize commonly touched surfaces in hospitals. To prevent healthcare-associated infections (HAIs), infection control (IC) guidelines recommend that, in concert with hand hygiene, attention be paid to disinfection of patient-care surfaces, especially those designated high-touch objects (HTOs).[1] Such objects could contribute to transmission by contaminating the hands of healthcare workers (HCWs) who subsequently contact patients.[2] Routine and terminal cleaning of surfaces and objects within the room using a hospital-grade disinfectant has been an accepted method for controlling and limiting the spread of infectious agents.[1] A concentration of less than 250 aerobic colony-forming units (cfu) of bacteria per 100 cm^2 has been proposed as a benchmark where infectious risk to patients is low.[3]

In 2008, the United States Environmental Protection Agency (US-EPA) registered 5 families of copper-containing alloys as antimicrobial, which established that products manufactured from these alloys kill 99.9% (log_{10} 2.0) of bacteria within 2 hours of exposure.[4] Subsequently, copper has been used to limit bacterial burden (BB) found on commonly touched surfaces and objects in healthcare. Casey et al[5] observed a median microbial reduction between 90% and 100% (log_{10} 1.95 to log_{10} 2.0) on copper-surfaced push plates, faucet handles, and toilet seats, whereas Schmidt et al[6] demonstrated an 83% (log_{10} 1.93) reduction in BB for copper-surfaced objects over the course of a 43-month multicenter trial.

Cleaning can effectively remove pathogens from surfaces, but studies have shown that, more than half of the time, surfaces were not adequately terminally cleaned and may become recontaminated within minutes.[7,8] The rails of hospital beds, as a consequence of coincident interactions with patients, HCWs, and visitors, are one of the most frequently touched items in the patient care environment. In this study, we quantitatively assessed the BB present on bed rails to evaluate the effectiveness of the antimicrobial properties of metallic copper to continuously limit the concentration of bacteria resident before and after routine cleaning.

MATERIAL AND METHODS

This institutional review board–approved study was conducted within a 17-bed medical intensive care unit (MICU) of a 660-bed academic hospital. In accordance with hospital policy, visitors were permitted between 8 AM and 8 PM at the discretion of staff. Each single-patient room contained an In Touch Critical Care Bed (Stryker). Routine patient care was provided throughout the course of the study, including teaching rounds, resulting in numerous patient visits with direct contact between the healthcare team, patients, and built environment.

Standard In Touch beds have 4 plastic rails. Three beds were custom fitted with copper (UNS# C110 99.9% metallic copper) surface caps on the rails as described elsewhere by Schmidt et al.[6]

In accordance with MICU policy, all objects and surfaces within the patient's room, including the study bed rails, were cleaned at least daily and upon patient discharge from the hospital (ie, terminally cleaned) using the US-EPA–registered disinfectant Virex II 256, which was dispensed from an automated dilution system (Use Solution, 0.07% n-alkyl dimethyl benzyl ammonium chloride and 0.07% didecyl dimethyl ammonium chloride; Johnson Diversey) as prescribed by the manufacturer.

Bed rail sampling was conducted in candidate rooms if the patient housed there would be continuously occupying the room for the next 8 hours and if sampling at 2-hour intervals would not affect care. Cleaning staff were not made aware of the study. Plastic (control) and copper bed rails were sampled immediately before cleaning (time 0) and then at 30 minutes and 2.5, 4.5, and 6.5 hours after cleaning. Samples were taken on 5 separate occasions over a 3-month period. Three patient-occupied beds with plastic rails (controls) and 3 with copper rails were sampled on each occasion, resulting in evaluation of 30 beds. Samples were collected and processed as described elsewhere.[6,8]

The effectiveness with which copper reduced resident BB was calculated by measuring the difference between the BB on copper bed rails and that on plastic bed rails. A mean reduction in BB was calculated for each type of bed rail and compared using the Mann-Whitney and Wilcoxon rank test (Epi Info, version 3.5.1). In a previous study, copper surfaces were associated with an 83% (log_{10} 1.92) reduction in BB, compared with plastic surfaces.[6] Based on this, we calculated

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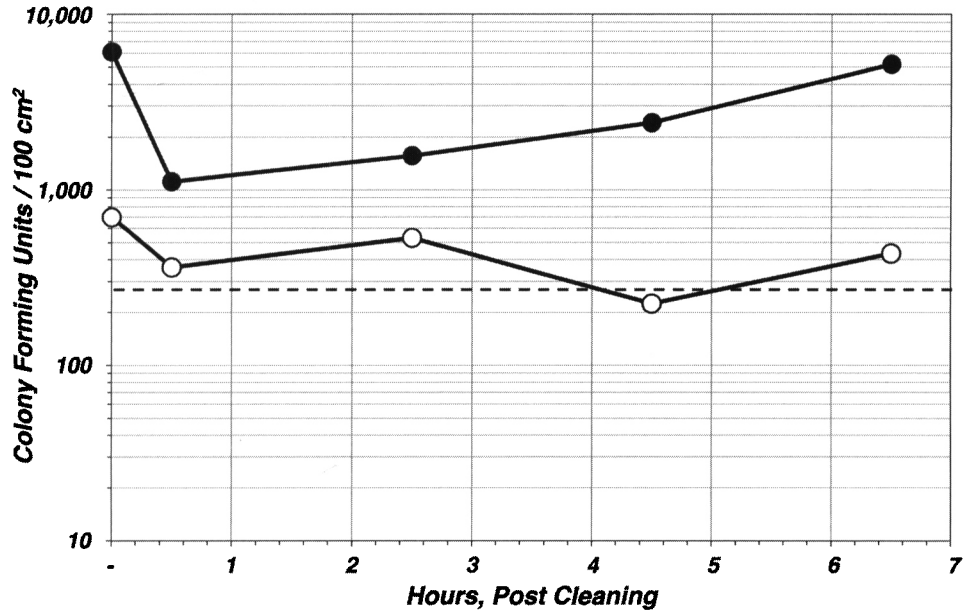


FIGURE 1. Copper continuously limits the concentration of bacteria on bed rails. Shown are the average total aerobic colony-forming units per 100 cm^2 recovered from standard plastic bed rails (filled circles) and copper bed rails (open circles) before and after cleaning with Virex 256. Five independent replicates are shown, and 3 beds of each type were sampled per time period. Dashed line represents the suggested bacterial burden desired immediately after terminal cleaning (250 colony-forming units per 100 cm^2).

that a sample size of 7 beds per group was necessary to have at least 90% power to detect an absolute BB decrease of 83% between copper-surfaced bed rails and standard plastic bed rails at a 5% significance level.

RESULTS

Average length of stay was 7.3 days for patients cared for in the plastic-railed beds and 8.6 days for patients cared for in the copper-railed beds. Compared with the mean BB found on plastic rails, the mean found immediately before cleaning on copper rails was significantly lower (6,102 cfu per 100 cm^2 or $\log_{10}$ 3.79 per 100 cm^2 vs 698 cfu per 100 cm^2 or $\log_{10}$ 2.84 per 100 cm^2; Figure 1). Subsequent cleaning of bed rails resulted in an immediate decrease in BB regardless of the bed rail surface. The mean reduction was 82% (1,112 cfu per 100 cm^2 or $\log_{10}$ 3.05 per 100 cm^2) on plastic rails and 48% (362 cfu per 100 cm^2 or $\log_{10}$ 2.56 per 100 cm^2) on copper rails. Continued sampling subsequent to cleaning found that the mean BB on copper rails remained significantly lower than that on plastic rails (Table 1). Among the beds with unmodified plastic rails, the highest initial BB recorded at any time over the study period was 32,400 cfu per 100 cm^2 ($\log_{10}$ 4.51 per 100 cm^2), whereas the lowest was undetectable for 5 (6.6%) of the 75 plastic-railed beds. Among copper beds, the highest initial BB was 5,310 cfu per 100 cm^2 ($\log_{10}$ 2.56 per 100 cm^2), whereas the lowest was undetectable for 37 (49.3%) of 75 copper-railed beds sampled.

In assessing the frequency with which the BB on the surfaces of bed rails was below a proposed value that was suggested as low risk immediately after terminal cleaning, 250 cfu per 100 cm^2, it was found that the difference observed between the copper-surfaced and plastic-surfaced rails was

TABLE 1. Assessment of the Antimicrobial Activity of Copper to Control the Bacterial Burden between Cleanings with Virex 256

	Plastic bed rails		Copper bed rails		
Time point	Colony count, mean cfu/100 cm^2 (±SE)	Reduction, %	Colony count, mean cfu/100 cm^2 (±SE)	Reduction, %	*P*
Precleaning	6,102 ± 2,572		698 ± 368		.006
Hour 0.5	1,112 ± 802	82	362 ± 282	48	.069
Hour 2.5	1,560 ± 936	74	530 ± 530	24	.012
Hour 4.5	2,396 ± 1,502	61	224 ± 94	68	.013
Hour 6.5	5,198 ± 2,386	15	434 ± 236	38	.002

NOTE. SE, standard error.

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TABLE 2. Frequency Bacterial Burden Was Below Suggested Terminal Cleaning Standard Immediately before and after Routine Cleaning Conducted during Routine Patient Care

	Bed rails with colony count <250 cfu/100 cm^2				
Time point	Plastic rails associated with 15 beds	Bed rail colony count <250 cfu/100 cm^2, %	Copper rails associated with 15 beds	Bed rail colony count <250 cfu/100 cm^2, %	*P* (2-tailed)
Precleaning	4	27	10	67	.067
Hour 0.5	10	67	13	87	.86
Hour 2.5	7	47	12	80	.13
Hour 4.5	8	53	11	73	.44
Hour 6.5	5	33	12	80	.02
Overall	34/75	45	58/75	77	.0001

NOTE. cfu, colony-forming units.

significant ($P = .0001$). A total of 77% of copper-surfaced rails were below this level, whereas only 45% of plastic rails were below this critical threshold (Table 2).

DISCUSSION

The patient room is a kinetic reservoir where hard surfaces, equipment, furniture, and the belongings of patients serve as fomites where casual touch may transfer resident microbes to patients and HCWs. Here, we report the quantitative effectiveness with which copper surfaces were able to augment routine cleaning practices to continuously limit the BB resident on the rails of patient beds.

Bacteria responsible for many HAIs can survive for days, weeks, or months on hospital surfaces in spite of the best efforts of the healthcare team to keep the BB within limits considered safe for patient care.[3] Some have argued that terminal cleaning must achieve a threshold where fewer than 250 cfu per 100 cm^2 of aerobic bacteria are detectable to minimize risk of transfer to HCWs or patients.[9] In previous work, we described the rapid reestablishment of bacteria on bed rail surfaces after cleaning with a hospital-grade disinfectant.[8] These data suggested that, to keep the BB below the risk-based threshold, surfaces would require cleaning at enhanced intervals and that this would result in increased workload for HCWs and environmental services. The current study would suggest that this cleaning interval would need to commence between every 2.5 and 4.5 hours for beds with standard plastic rails. However, in concert with once-daily cleaning, copper bed rails were routinely able to maintain a BB below a low-risk threshold for the entire shift. Low-risk concentrations were associated with 77% of the sampled copper beds.

The use of copper to control BB on surfaces found in healthcare has been recently reviewed.[10] Here, we demonstrate that the antimicrobial activity was continuous in its ability to limit BB found on bed rails. Weber and Rutala,[11] in their commentary of work conducted by Karpanen et al,[12] argued that it was impractical or impossible to coat each environmental surface with copper. However, the data provided here and in other studies suggest that the strategic placement of copper in key high-touch areas offers a novel strategy to limit BB on a continuous basis.[6] Other no-touch methods for room disinfection (hydrogen peroxide vapor [HPV] and UV light) rely on discontinuous modalities of application to reduce environmental BB.[13] Consequently, like the US-EPA–registered disinfectants that are regularly used to disinfect patient rooms subsequent to cleaning, both UV and HPV will likely have the same limitation of rapid restoration of BB intrinsic to HTOs. In contrast, copper-alloyed surfaces offer a continuous way to limit and/or control the environmental burden. Hospital and environmental services need not perform additional steps, follow complex treatment algorithms, obtain "buy-in" from other providers, or require additional training or oversight.

It is intuitive to argue that, to minimize infectious risk to a patient, any method that augments the effectiveness of hand hygiene and routine cleaning will likely translate into lower rates of HAIs and/or hospital-acquired colonizations with epidemiologically important pathogens. The continuous antimicrobial activity of copper surfaces demonstrated here should enhance routine and terminal-cleaning practices required of hospitals.

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