

CLEANED, READY-TO-USE, REUSABLE ELECTROCARDIO- GRAPHIC LEAD WIRES AS A SOURCE OF PATHOGENIC MICROORGANISMS

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Background Cleaned electrocardiographic lead wires are a potential source of microorganisms capable of causing nosocomial infection.

Objectives To examine fungal and bacterial growth on cleaned reusable lead wires, determine if microbial growth is associated with hospital site or work environment, determine the prevalence of antibiotic-resistant bacteria, and learn if antibiotic-resistant bacteria are associated with hospital site and work environment.

Methods Cleaned lead wires (N = 320) from critical care and telemetry units, emergency departments, and operating rooms of 4 hospitals were swabbed and the specimens cultured for microbial growth. Bacterial species were grouped by their risk for human infection: at risk (n = 9), potential risk (n = 5), and no risk (n = 10). Work environments were compared by using pairwise contrasts from a generalized estimating equation model.

Results Fungi were rare (0.6%). Of 226 cultures from 201 wires (62.8%) with bacterial growth, 121 were of at- or potential-risk bacteria (37.8%). Urban hospitals had less growth ($P \leq .001$) and fewer bacterial species per wire ($P \leq .001$) than did community hospitals. Presence of any bacteria ($P = .02$) and number of bacterial species per wire ($P = .002$) were lowest in operating rooms; emergency departments and telemetry units had more growth than did critical care units. Among specimens of staphylococci and enterococci, 6 each were sensitive to antibiotics; of 4 resistant staphylococcal species, 1 was not a human opportunistic pathogen and 3 were potential-risk species.

Conclusions Bacteria are common on reusable, cleaned lead wires and differ by hospital and clinical area. (*American Journal of Critical Care*. 2010;19:e73-e80)

Electrocardiographic (ECG) lead wires are a common environmental surface that comes in direct contact with patients in intensive care units (ICUs), intermediate or telemetry care areas (Tele), emergency departments (EDs), and operating rooms (ORs). The lead wires may have pathogens that could be dispersed to immunocompromised patients or patients with open wounds, potentially resulting in health care–associated infections.

Although no research reports of microbial growth on cleaned, reusable ECG lead wires have been published, 2 articles in the literature prompted further study. In 1 article,¹ in an interview format, an investigator provided a brief overview of the results of a single-center study of 100 randomly selected, cleaned, reusable ECG lead wires that were swabbed before being used on new ICU patients. The overall rate of microbial contamination was not reported; however, the investigator found that 77% of the wires had antibiotic-resistant nosocomial pathogens. Of the contaminated lead wires, 67% had vancomycin-resistant enterococci (VRE), and 12% had gram-negative bacilli resistant to extended-spectrum β -lactams. The one-half page review was written by a reporter and did not include the methods of swabbing, data collection, or laboratory analysis and did not give full details of the results. Consequently, conclusions and implications about the high antibiotic-resistant contamination rate could not be made.

The only other article² in the literature that included information on microbial growth on ECG lead wires was an epidemiological investigation of a 13-month-long VRE outbreak in a burn ICU that involved 21 patients. The investigators identified one instance in which a lead wire, swabbed as part of weekly patient surveillance, was positive for VRE. In this instance, the lead wire was on a patient, and

VRE isolates from the wire had the same pattern of pulsed-field gel electrophoresis typing as the patient who had occupied the room before the VRE outbreak ended. Nurses' hands were not studied for bacterial growth at the time the contaminated lead wire was detected, so an association between VRE infection and transmission of the organism by the lead wire was speculative. Transmission could have occurred via health care workers' hands or via other paths.

ECG lead wires may be contaminated with microorganisms; however, the prevalence, types, and sensitivity of such bacteria to antibiotics are unknown. Additionally, little evidence is available on findings from multiple environments within a single hospital or from multiple hospitals when the same research method is used in all environments and in more than a single hospital. Both reports^{1,2} that raised awareness of resistant bacteria on ECG lead wires were from individual medical centers. Personnel in the centers might not have conformed with cleaning policies and procedures for lead wires or with universal precautions and hand washing to prevent exposure to potentially infectious material. Important pathogens, all of which could cause infection, have been found on common hospital and personnel equipment and belongings,³⁻⁸ work surfaces, shared medical devices,^{9,10} and environmental surfaces around patients.⁹⁻¹¹ ECG lead wires may be a vector in the transfer of microorganisms and a source of health care–associated infections.

The primary purpose of our multicenter study was to determine the presence and number of bacterial and fungal species on cleaned, reusable ECG lead wires from multiple hospitals and from multiple work environments in each hospital. Secondary aims were to determine if microbial growth was associated with hospital site or work environment (ICU, Tele, ED, and OR), determine the prevalence of antibiotic-resistant bacteria, and learn if antibiotic-resistant bacteria were associated with hospital site and work environment.

The prevalence and types of bacteria on cleaned electrocardiographic (ECG) lead wires is unknown.

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Methods

Setting and Sample

This descriptive, cross-sectional study involved 4 hospitals selected on the basis of location (North-east, Midwest, West, and South), number of beds, and willingness to swab cleaned, reusable ECG lead wires for detection of microorganisms in 4 work environments: OR, ICU, Tele, and ED. Study teams

were led by a microbiologist from the independent certified, central laboratory that analyzed samples and included a representative from the sponsoring company, who ensured consistent data collection practices at each site, and a nurse from each hospital site. Team members wore masks, gowns, and gloves during swabbing of randomly chosen

cleaned, reusable ECG lead wires that were either hanging from the ECG cable at the bedside of a cleaned, ready-to-use room or in a box, container, or cubby area where cleaned lead wires were stored in each work environment.

A total of 320 swabbings for bacteria and fungi were collected from each hospital (80 per hospital) and each work environment (20 per work environment at each hospital). When hospitals had more than a single ICU, Tele, or OR area, swabbing was completed at the first work environment approached, chosen by the nurse on the study team, until a sample size of 20 was reached. When the target sample size was not reached, another unit of the same work environment type was chosen by the study nurse, on the basis of convenience, to complete data collection for that work environment. Cleaned, reusable ECG lead wires were selected on the basis of availability (convenience sample in an empty, ready-to-use patient room or stored in a central location). Communication about the study was minimized at each hospital to ensure that the swabbings represented usual care practices. The study was deemed exempt from approval by the institutional review boards of the participating hospitals.

Data Collection

Swabbing procedures were carried out in 1 day at each hospital.

Swabs for bacteria and fungi were removed from packaging and moistened with a drop of sterile saline. The swabs were used on the lower third of ECG lead wires and snaps or buttons at the

terminal parts of lead wires and then were placed in transport media and sealed. At each hospital, the study nurse assisted the microbiologist from the central laboratory in packaging and shipping. Case report forms were completed for each swabbing, including information on site and work environment, and then both the microbial specimens and the forms were placed in a ziplock biohazard bag. A requisition form for shipping was placed in the pouch of the biohazard bag. All samples were shipped to the central laboratory within 24 hours.

At the central laboratory, cultures of the swabs were immediately set up and incubated for a minimum of 48 hours for aerobic bacteria and 96 hours for anaerobic bacteria. Fungal cultures were held for a minimum of 30 days before being reported as no growth of fungus. Isolates from the cultures were identified by using standard microbiological and biochemical laboratory techniques. The independent laboratory was accredited by the College of American Pathologists.

Analysis

The independent laboratory provided a written report of the number and type of bacteria and fungi identified on each ECG lead wire and an Excel file of data to the principal investigator. Before research questions about hospital and work environment were answered, microorganisms were grouped by species for risk for human infection. At-risk species were those that could cause infection in urinary, respiratory, and other tracts or on skin or could lead to pneumonia, meningitis, septicemia, or other medical conditions. Bacteria were also labeled at-risk if they had a higher probability of causing a wide variety of infections or were associated with high morbidity or mortality. Potential-risk species were those with potential to cause bacteremia or endocarditis, especially in immunocompromised patients and patients with open wounds. Species labeled no-risk or rare-risk were those not known to cause infection or disease in humans.

After bacterial species were grouped by risk, models of presence vs absence of bacteria were generated by using a generalized estimating equation logistic model with adjustments for multiple species on some lead wires. The number of bacterial species per lead wire was analyzed by using a generalized estimating equation–corrected Poisson regression model. Pairwise differences were used to determine differences in sites and units, and those differences were Bonferroni corrected for the 6 comparisons, resulting in a significance criterion of $P < .008$.

Data were collected in 4 Magnet hospitals from different areas of the country.

A microbiologist from an independent central laboratory led the study teams.

Results

All specimens were collected between November 2007 and February 2008. Among the 4 participating hospitals, the number of beds ranged from 481 to more than 1000. All hospitals were designated as Magnet hospitals by the American Nurses Association, and all had written cleaning policies for reusable ECG lead wires. Of the 4 hospitals, 2 were urban teaching facilities, 1 was a community teaching facility, and 1 was a nonteaching community hospital. Although all swabbed ECG lead wires had been previously cleaned and were ready to use, some appeared visibly dirty and some had dried blood on them. After being rubbed over the surface of the lead wires and snaps or buttons, some swabs had visible stains.

Bacteria

A total of 226 cultures of specimens with bacterial growth were identified from 201 of the 320 ECG lead wires (62.8%). By hospital, the percentage of lead wires with bacterial growth varied from 49% to 80% of those sampled. In total, 24 bacterial species were identified: 9 at-risk species, 5 potential-risk species, and 10 no- or rare-risk species (Table 1). By risk for human infection, at-risk species were detected in 25 of the 226 cultures (11.1%), potential-risk species in 102 (45.1%), and no- or rare-risk species in 99 (43.8%).

Among the hospitals, the 2 urban facilities had less bacterial growth (first urban hospital compared with each community hospital, both $P < .001$; second urban hospital compared with each community hospital, $P = .04$ and $.009$) and fewer bacterial species per ECG lead wire (first urban hospital compared with each community hospital, $P = .001$ and $P < .001$; second urban hospital compared with each community hospital, $P = .01$ and $.002$) than did community hospitals, and the largest urban hospital had less growth of at-risk species and fewer species per lead wire than did the other 3 hospitals (all $P \leq .05$). By hospital, 121 of the 320 ECG lead wires swabbed (37.8%; range, 28.8%-43.8%; see Figure) had at-risk or potential-risk bacteria.

By work environment, presence vs absence of bacteria differed ($P = .02$). Table 2 provides odds ratios for the presence of any bacteria and of at-risk and potential-risk bacteria by work environments. Overall differences in each bacterial category by work environment were not statistically significant. However, lead wires swabbed in an OR were 75% less likely to have any bacterial species present compared with lead wires swabbed in an ED ($P = .006$) and 60%

Table 1
Bacteria cultured from swabs of electrocardiographic lead wires

Isolate	Level of risk ^a	No. of isolates (n = 226)	Percentage of lead wires positive for isolate (n = 201) ^b
<i>Staphylococcus epidermidis</i>	**	60	29.9
<i>Bacillus</i> species	***	51	25.4
<i>Staphylococcus hominis</i>	**	38	18.9
<i>Staphylococcus warneri</i>	***	16	8.0
<i>Staphylococcus haemolyticus</i>	*	8	4.0
<i>Micrococcus</i> species	***	7	3.5
<i>Corynebacterium</i> species	***	7	3.5
<i>Staphylococcus capitis</i>	***	7	3.5
<i>Acinetobacter lwoffii</i>	*	7	3.5
<i>Staphylococcus simulans</i>	***	4	2.0
<i>Enterococcus faecium</i>	*	3	1.5
<i>Staphylococcus aureus</i>	*	2	1.0
<i>Staphylococcus auricularis</i>	***	2	1.0
<i>Enterococcus faecalis</i>	*	2	1.0
<i>Brevibacterium</i> species	***	2	1.0
<i>Staphylococcus lugdunensis</i>	**	2	1.0
<i>Streptococcus agalactiae</i>	*	1	0.5
<i>Enterococcus casseliflavus</i>	*	1	0.5

^a * at risk, ** potential risk, *** no/rare risk.
^b Because of rounding, percentages do not total 100.

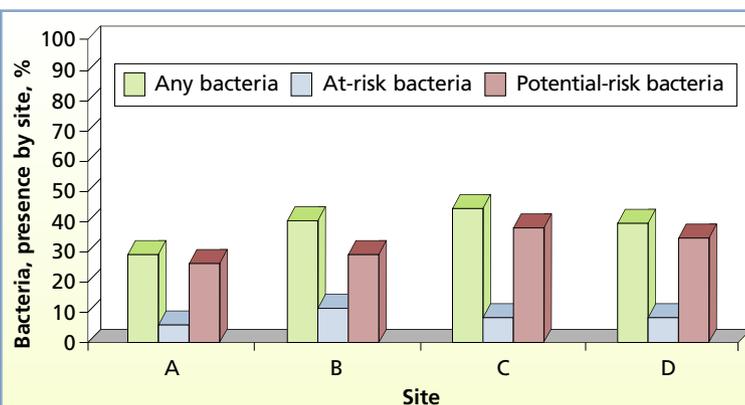


Figure On 201 of 240 electrocardiographic lead wires swabbed (63%), presence of any bacteria (range, 28.8%-43.8%), at-risk bacteria (range, 2.5%-11.3%), and potential-risk bacteria (range, 26.3%-37.5%) varied by hospital site.

less likely to have any bacterial species present compared with lead wires swabbed in Tele areas ($P = .04$).

Table 2
Summary of the presence-vs-absence modeling strategy for growth of organisms, by work environment

Growth	Detail	Odds ratio (95% confidence interval)	P
Any organism			
Work environment			.08
	ED vs ICU	2.83 (0.9-8.5)	.06
	Tele vs ICU	1.72 (0.7-4.4)	.26
	OR vs ICU	0.70 (0.3-1.6)	.40
	Tele vs ED	0.61 (0.3-1.2)	.18
	OR vs ED	0.25 (0.1-0.7)	.006
	OR vs Tele	0.40 (0.2-1.0)	.04
At-risk organism			
Work environment			.06
	ED vs ICU	12.38 (0.9-162)	.06
	Tele vs ICU	14.37 (1.6-127)	.02
	OR vs ICU	1.98 (0.2-21.7)	.58
	Tele vs ED	1.16 (0.4-3.8)	.80
	OR vs ED	0.16 (0.0-1.3)	.08
	OR vs Tele	0.14 (0.0-0.7)	.02
Potential-risk organism			
Work environment			.34
	ED vs ICU	1.50 (0.5-4.7)	.49
	Tele vs ICU	0.97 (0.4-2.7)	.96
	OR vs ICU	0.62 (0.3-1.5)	.28
	Tele vs ED	0.65 (0.3-1.3)	.24
	OR vs ED	0.42 (0.1-1.2)	.10
	OR vs Tele	0.64 (0.3-1.6)	.35

Abbreviations: ED, emergency department; ICU, medical or surgical intensive care unit; OR, operating room; Tele, medical or surgical telemetry unit.

For ECG lead wires sampled in a Tele area, odds for the presence of at-risk bacterial species were 14.4-fold greater than the odds for wires sampled in an ICU ($P = .02$). ECG lead wires sampled in an OR were 86% less likely than lead wires in Tele areas to have at-risk bacteria present ($P = .02$).

By work environment, the number of bacterial species per lead wire also differed ($P = .002$). Table 3 provides the odds ratios for the presence of multiple bacterial species per lead wire for any bacteria, at-risk bacteria, and potential-risk bacteria by work environment. Detection of multiple bacterial species of any type per lead wire differed significantly by work environment ($P = .02$), whereas detection of multiple at-risk species ($P = .05$) and multiple potential-risk species ($P = .23$) per lead wire did not. Specifically, cleaned, reusable lead wires swabbed in an OR were 52% less likely to have multiple bacterial species than were wires swabbed in Tele areas ($P = .007$) and 57% less likely than wires swabbed in an ED ($P = .002$). Likewise, cleaned, reusable lead wires swabbed in an OR were 85% less likely to have multiple at-risk bacterial species than were wires swabbed in a Tele

area ($P = .01$) and 82% less likely to have multiple at-risk species than were wires swabbed in an ED ($P = .05$). Additionally, ECG lead wires swabbed in Tele and ED areas had 13- and 11-fold greater chances, respectively, for the presence of multiple at-risk bacterial species than did wires swabbed in ICU environments ($P = .02$ and $.05$, respectively).

Nine bacterial species were resistant to all penicillin or tetracycline antibiotics (amoxicillin, ampicillin, erythromycin, oxacillin, penicillin, tetracycline); however, none of the resistant bacteria were *Staphylococcus aureus* or enterococci. Of the antibiotic-resistant bacterial species, 1 was an at-risk species (*Acinetobacter baumannii*/*Acinetobacter lwoffii*, found on 1 ECG lead wire), 3 were potential-risk species (*Staphylococcus epidermidis*, found on 2 lead wires; *Staphylococcus hominis*, found on 5 lead wires; and *Staphylococcus lugdunensis* found on 1 lead wire), and 1 was a no- or rare-risk species (*Staphylococcus warneri*, found on 1 lead wire).

Of staphylococcal and enterococcal species found on lead wires, 4 staphylococcal species (3 potential-risk and 1 no- or rare-risk species) were resistant to penicillin antibiotics. The 2 *S aureus* cultures were sensitive to penicillin antibiotics, and the 6 enterococcal species were sensitive to vancomycin.

Fungi

Of 320 cultures, 2 (0.6%) were positive for the presence of fungi. Specific fungi isolated were *Stemphylium*, commonly considered a contaminant and widely distributed outdoors in decaying vegetation and soil and indoors in dust, and *Penicillium*, which can be isolated from air, soil, plants, and sewage and on rare occasions causes opportunistic systemic infections or corneal infections in humans.

Discussion

In this multicenter study encompassing 4 geographic regions of the United States and mid- to large-sized Magnet-designated hospitals, the presence of fungi on ECG lead wires was rare, but bacteria were common. Although 43.8% of bacterial species were not known to be isolated from humans or were highly unlikely to cause infection in humans, 11.1% of the species were at-risk bacteria and 45.1% were potential-risk bacteria. The presence of bacteria on lead wires differed by hospital site and by work environment. The largest hospital had the lowest number of lead wires with bacteria, and OR and ICU environments had lower numbers of lead wires with bacteria and a decreased likelihood of multiple species bacteria on individual lead wires than did Tele and ED environments.

In this study, differences in the prevalence of bacteria on ECG lead wires were associated with hospital size. The presence of bacteria on lead wires was lowest in the largest hospital (hospital A in the Figure); however, cleaning policies varied between work environments of hospital A, as they did in the other 3 hospitals. We could not compare our results with those of other studies of ECG lead wires because of the lack of any research articles on contamination of lead wires and of multicenter reports.

Most of the studies of bacterial contamination rates of environmental surfaces or devices have been single-center studies. However, in an examination⁸ of bacterial growth on tourniquets and exsanguinators used in ORs at 3 hospitals, 1 hospital had a higher level of contamination of tourniquets than did the other 2 hospitals, and 1 hospital had a higher rate of contamination of exsanguinators before decontamination. The type of hospital was the only detail provided about differences in the hospitals. The hospital with less contamination was an elective orthopedic hospital, and the 2 hospitals with higher prevalence of bacterial growth were trauma hospitals. The investigators⁸ speculated that the higher prevalence was due to greater throughput and greater number of patients with hospital- or community-acquired infections and open wounds in the trauma settings. Also, the hospital with higher bacterial counts on tourniquets before decontamination did not clean the tourniquets between surgical procedures. Because of the few data on variation in bacterial growth on environmental surfaces or devices according to hospital size, a possible explanation for our findings is that compared with health care personnel in the other 3 hospitals, health care workers in hospital A washed their hands more often or with greater effectiveness; disinfected patient care, environmental, or device surfaces that come in contact with ECG lead wires; or disinfected reusable ECG lead wires between use in different patients.

Differences in the presence of bacterial growth on lead wires were also associated with work environment. OR and ICU environments had fewer lead wires with bacteria than did ED and Tele areas and a decreased likelihood for multiple bacterial isolates per lead wire. A systematic review¹² of the literature on MRSA in hospital-based studies of health care workers indicated that workers on a general unit had a higher prevalence of MRSA than did health care workers in an ICU and health care providers in an OR had a lower prevalence than did workers in the ICU. In a review by Schabrun and Chipchase¹³ of 23 studies, the pooled mean of the level of bacterial contamination of health care equipment was

Table 3
Summary of the bacterial-species-count-per-electrocardiographic-lead-wire modeling strategy for growth of organisms

Growth	Detail	Odds ratio (95% confidence interval)	P
Any organism			
Work environment			.02
	ED vs ICU	1.91 (1.1-3.5)	.03
	Tele vs ICU	1.71 (1.0-3.1)	.07
	OR vs ICU	0.83 (0.5-1.4)	.48
	Tele vs ED	0.90 (0.6-1.2)	.50
	OR vs ED	0.43 (0.3-0.7)	.002
	OR vs Tele	0.48 (0.3-0.8)	.007
At-risk organism			
Work environment			.05
	ED vs ICU	11.10 (1.0-126)	.05
	Tele vs ICU	13.01 (1.6-107)	.02
	OR vs ICU	1.98 (0.2-19.5)	.56
	Tele vs ED	1.17 (0.4-3.4)	.77
	OR vs ED	0.18 (0.0-1.0)	.05
	OR vs Tele	0.15 (0.0-0.7)	.01
Potential-risk organism			
Work environment			.23
	ED vs ICU	1.29 (0.7-2.5)	.46
	Tele vs ICU	1.07 (0.5-2.1)	.86
	OR vs ICU	0.73 (0.4-1.3)	.29
	Tele vs ED	0.82 (0.6-1.2)	.31
	OR vs ED	0.56 (0.3-1.0)	.05
	OR vs Tele	0.68 (0.4-1.2)	.21

Abbreviations: ED, emergency department; ICU, medical or surgical intensive care unit; OR, operating room; Tele, medical or surgical telemetry unit.

86.6% of all sampled equipment (stethoscope membranes and ear tips, otoscopes, auriscopes, diagnostic ultrasound equipment, and inferential therapy equipment), tested in a variety of environments. In a study⁸ of contamination of medical charts in a surgical ICU and a surgical unit, the surgical ICU had more charts with pathogenic or potentially pathogenic bacteria (90% vs 72%; $P = .002$). Although the prevalence of MRSA in health care workers according to work environment seemed to match our findings, too few studies of bacterial growth on hospital surfaces associated with patient care were conducted in or analyzed according to the work environment to draw conclusions. Moreover, pathogens may persist on inanimate dry surfaces for months,¹⁴ cleaning procedures may facilitate the distribution of bacterial contaminants,¹⁵ and health care workers may transmit bacteria to patients and hospital surfaces. Thus, work environment may play both a direct and an indirect role in the prevalence of bacterial growth on specific surfaces, such as ECG lead wires.

Contaminated ECG lead wires can be both a source of cross-contamination and a mediator of

cross-contamination from contaminated hands or gloves. The literature^{11,16} provides reports of clinically important bacteria that may lead to health care-associated infections, for example, *Stenotrophomonas maltophilia*, *Klebsiella pneumoniae*, *Proteus mirabilis*, and *Acinetobacter baumannii*, some of which are increasingly multidrug resistant. Although cultures of cleaned, reusable ECG lead wires in our study did not reveal all pathogens capable of causing health care-associated infections, 9 at-risk bacterial species and 5 potential-

risk bacterial species were identified. Because contaminated inanimate surfaces such as ECG lead wires can be a source of cross-infection, health care personnel may need to consider interventions that reduce the potential for lead wires to cause health care-associated infections.

This study was limited to 4 mid- to large-sized hospitals and 4 work environments at each hospital. Our results may not be generalizable to hospitals and work environments that differ in size, use of ECG lead wires, patient and personnel characteristics, and other unknown factors that may be associated with bacterial growth on lead wires. Swabbing of ECG lead wires was done in only 4 work environments (ICU, ED, Tele, and OR), preventing multivariate analyses of antibiotic-resistant bacteria according to hospital site and work environment. Finally, our methods involved assessing clean, ready-to-use ECG lead wires and thus did not allow for establishing causality between pathogens on the lead wires and health care-associated infections because the lead wires were not in use on patients when the swabbing was done.

Recommendations for Future Research

Further research is needed to determine the level of risk for bacterial contamination of ECG lead wires and the risk of health care-associated infections in patients who are wearing cleaned, reusable but bacterially contaminated lead wires. Are immunocompromised patients, patients with open wounds, or patients who are older, sedated, or bedridden more susceptible than other patients are? Determining the predominant source of bacterial growth and of cross-infection of patients will be important. Are contaminated hands or gloves of health care workers or ECG lead wires the primary vector of bacteria or the source of cross-contamination of patients? Overall,

data on growth of pathogens on cleaned, reusable ECG lead wires need to be further defined on the basis of hospital and work environment characteristics, including cleaning policies and level of difficulty in cleaning surfaces of the lead wires and snaps or buttons. A long stay in a particular unit or in the hospital may negate optimal cleaning techniques if ECG lead wires are not intermittently cleaned with a germicidal solution while being worn by patients.

Conclusion

This study provided important insights on the lack of fungal growth and the frequency of growth of at-risk and potential-risk bacterial species on cleaned, reusable ECG lead wires. Bacterial growth on the lead wires differed by both hospital size and work environment. Ideally, these factors should not be associated with bacterial growth on lead wires. Nursing teams, including personnel responsible for cleaning ECG lead wires, need to review cleaning procedures, cleaning supplies, and storage practices used with cleaned lead wires. Adherence to universal precautions, hand washing behaviors, and other factors that could be associated with bacterial growth on the wires should be routinely explored at hospitals known to have bacterial contamination on cleaned lead wires. Research is needed to learn if bacterially contaminated ECG lead wires cause infections and if specific populations of patients are more susceptible to such infections than are other patients. Finally, development of cost-effective systems and practices to reduce health care-associated infections are an important goal of infection prevention. Attention to bacterial contamination of cleaned, reusable ECG lead wires may provide a specific target for action.

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REFERENCES

1. Jancin B. Antibiotic-resistant pathogens found on 77% of ECG lead wires. *Cardiol News*. 2004;2(3):14.
2. Falk PS, Winnike J, Woodmansee C, Desai M, Mayhall CG. Outbreak of vancomycin-resistant enterococci in a burn unit. *Infect Control Hosp Epidemiol*. 2000;21:575-582.

Urban facilities had less bacterial growth than did community hospitals.

Contaminated ECG lead wires can be both a source and a mediator of cross-contamination.

3. Ota K, Profiti R, Smaill F, Matlow AG, Smieja M. Identification badges: a potential fomite? *Can J Infect Control*. 2007;22:162, 165-166.
4. Kotsanas D, Scott C, Gillespe EE, Korman TM, Stuart RL. What's hanging around your neck? Pathogenic bacteria on identity badges and lanyards. *Med J Aust*. 2008;188(1):5-8.
5. Runner JC. Bacterial and viral contamination of reusable sharps containers in a community hospital. *Am J Infect Control*. 2007;35:527-530.
6. Marinella MA, Pierson C, Chenoweth C. The stethoscope: a potential source of nosocomial infection? *Arch Intern Med*. 1997;157:786-790.
7. Devine J, Cooke RP, Wright EP. Is methicillin-resistant *Staphylococcus aureus* (MRSA) contamination of ward-based computer terminals a surrogate marker for nosocomial MRSA transmission and handwashing compliance? *J Hosp Infect*. 2001;48:72-75.
8. Brennan SA, Walls RJ, Smyth E, Al Mulla T, O'Byrne JM. Tourniquets and exsanguinators: a potential source of infection in the orthopedic operating theater? *Acta Orthop*. 2009;80:251-255.
9. Oie S, Suenaga S, Sawa A, Kamiya A. Association between isolation sites of methicillin-resistant *Staphylococcus aureus* (MRSA) in patients with MRSA-positive body sites and MRSA contamination in their surrounding environmental surfaces. *Jpn J Infect Dis*. 2007;60:367-369.
10. Archibald LK, Hierholzer WJ. Principles of infectious diseases epidemiology. In: Mayhall CG, ed. *Hospital Epidemiology and Infection Control*. 3rd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2004:3-17.
11. Teng SO, Lee WS, Ou TY, Hsieh YC, Lee WC, Lin YC. Bacterial contamination of patients' medical charts in a surgical ward and the intensive care unit: impact on nosocomial infections. *J Microbiol Immunol Infect*. 2009;42:86-91.
12. Albrich WC, Harbarth S. Health-care workers: source, vector, or victim of MRSA? *Lancet Infect Dis*. 2008;8:289-301.
13. Schabrun S, Chipchase L. Healthcare equipment as a source of nosocomial infection: a systematic review. *J Hosp Infect*. 2006;63:239-245.
14. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. *BMC Infect Dis*. 2006;6:130. doi:10.1186/1471-2334-6-130.
15. Heeg P, Roth K, Reichl R, Cogdill P, Bond WW. Decontaminated single-use devices: an oxymoron that may be placing patients at risk for cross-contamination. *Infect Control Hosp Epidemiol*. 2001;22:542-549.
16. Rodríguez-Baño J, García L, Ramírez E, et al. Long-term control of hospital-wide, endemic multidrug-resistant *Acinetobacter baumannii* through a comprehensive "bundle" approach. *Am J Infect Control*. 2009;37:715-722.

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