

Disposable vs Reusable Electrocardiography Leads in Development of and Cross-contamination by Resistant Bacteria

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Hospital-acquired infections caused by antibacterial-resistant microorganisms are associated with high mortality and morbidity rates and markedly affect hospital economics. The expense became greater in 2008 when reimbursement for treatment of hospital-acquired infections was no longer provided by Medicare. Infections caused by cross-contamination with resistant bacteria can be eliminated by 3 methods: kill the bacteria before resistance develops, stop bacteria from communicating and acquiring resistance, and eliminate the pathway from one patient to another. Because electrocardiography wires cannot be completely disinfected 100% of the time, they may be contributing to the growth of resistant bacteria. The many pathways provided by reusable wires for cross-contamination with resistant bacteria increase the risk for hospital-acquired infection when these wires are used. Disposable electrocardiography leads eliminate risk of infection through these pathways. Adoption of disposable electrocardiography leads as an adjunct to an overall infection control program can decrease infection rates in acute health care facilities. (*Critical Care Nurse*. 2011;31[3]:62-69)

CE Continuing Education

This article has been designated for CE credit. A closed-book, multiple-choice examination follows this article, which tests your knowledge of the following objectives:

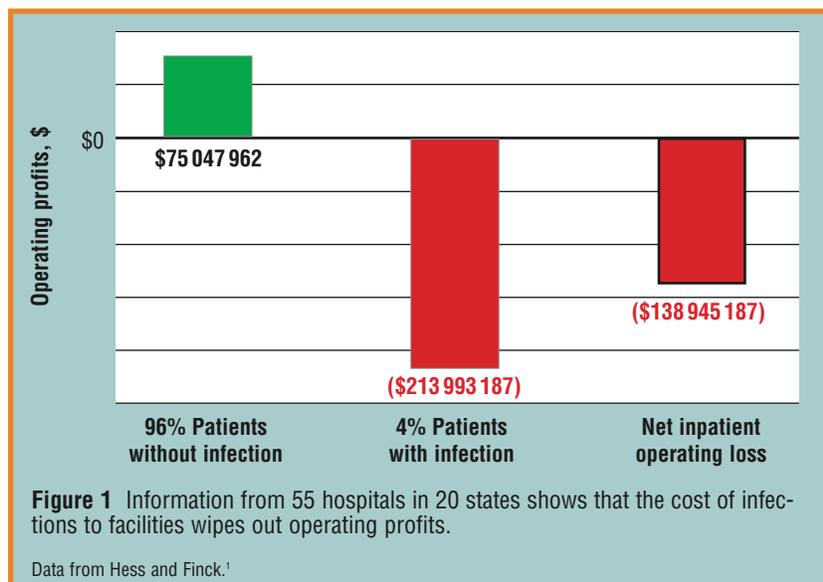
1. Identify 3 methods to eliminate cross-contamination of resistant bacteria
2. Examine how reusable electrocardiography wires can cause resistant bacteria to multiply
3. Review cost and potential savings of switching to disposable electrocardiography wires

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During the current economic crisis, hospital budgets are strained as never before. Nurses and nurse managers are being tasked to decrease costs yet still provide optimal care. One area of concern, the cost of treating patients with hospital-acquired infections (HAIs), has increased markedly. In a report from 55 hospitals in 20 states,¹ the

cost of care of the 4% of patients with HAI wiped out 185% of the operating profits from all other patients (Figure 1). These numbers were generated before October 2008, when the Center for Medicare and Medicaid Services began to deny reimbursement for HAIs.² Now that hospitals are no longer being reimbursed for selected HAIs, the loss of revenue is greater than ever before. The challenge to infection control nurses and practitioners is to steer acute health care facilities to a course on which all measures that can prevent HAIs are identified and adopted, with a focus on eliminating the most costly infections, those caused by antibiotic-resistant bacteria.

Compared with HAIs caused by drug-susceptible organisms, HAIs caused by antibiotic-resistant microbes increase the length of hospital stay, mortality, and cost of infections.^{3,4} The cost of drug-resistant infections is significant. Pennsylvania, the first state to



comply with mandatory reporting of HAIs, found that excess charges associated with HAIs were more than \$150 000 per infection.⁵ This finding may be due in large part to the 16.1 days increase in the length of stay for patients who had HAI. In addition, the mortality rate was 12.9% for patients with HAI and only 2.3% for patients who did not acquire an infection during their hospital stay.

Drug-resistant bacteria and the development of new strains with resistance are a worldwide concern.⁶ Drug-resistant pneumococci in Iceland and the United States were shown to be the progeny of strains originally identified in Spain.⁷ According to the Centers for Disease Control and Prevention,⁸ only 2% of *Staphylococcus aureus* infections were caused by methicillin-resistant

S aureus (MRSA) in 1974. By 2004, the percentage had soared to 64%. By 2008, approximately 70% of all bacteria that caused infections in hospitals were resistant to at least 1 of the drugs most commonly used for treatment.⁹

The huge drain on resources caused by HAIs requires nurses and other hospital employees to investigate all avenues of cross-contamination and sources of drug-resistant bacteria in an effort to eliminate the organisms. The movement in infection control is one of zero tolerance for HAI.¹⁰

Electrocardiographic Wires as a Source of HAI

Reusable electrocardiography (ECG) wires, specifically the wire lead sets that connect the electrodes placed on a patient's chest to the

trunk cable of a hardwired monitor or to a telemetry box, are a ubiquitous pathway for communication of HAIs caused by resistant organisms.¹¹⁻¹⁶ The finding that reusable ECG wires carry and transport resistant bacteria after the wires are cleaned per hospital protocol was first reported in 2003¹³ and again 5 years later in 2008.¹⁴ A multicenter study^{15,16} conducted in early 2009 also indicated that ECG wires were a potential source of HAI.

Because of the nature of bacteria and the methods of development and transfer of antibiotic resistance, cleaning methods with bactericidal agents may be compounding the problem and contributing to the development of drug-resistant organisms.^{17,18} Disposable ECG leads may eliminate the problem and the pathway created by reusable ECG wires. Thus, use of disposable ECG wires could help prevent growth of drug-resistant bacteria and aid in attaining the goal of zero HAIs.

Preventing Cross-contamination by Resistant Bacteria

Methods that stop the progression of cross-contamination by resistant bacteria through a pathway that could result in HAI become complicated when applied to the variables inherent in the use of reusable ECG wires. In general, 3 approaches are used.

Eliminate the Bacteria

The first approach, attempting to eliminate the bacteria with soaps, disinfectants, antiseptics, and so on, has the advantage of eliminating bacteria with which the cleaners come into physical contact, but also

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have 2 disadvantages when applied to ECG wires. The cleansing agents must come into physical contact with the bacteria and must either carry the bacteria away to an innocuous area or kill the bacteria. Manufacturers' specifications for cleaning ECG wires prohibit soaking or spraying, do not mention sterilization or autoclaving, and restrict the options to wiping the wires with antibacterial wipes.¹⁹ The varied surfaces and recesses of ECG wires (Figure 2) make this conventional method of cleaning reusable ECG wires questionable because whether or not all areas are completely disinfected 100% of the time is not known. Further, hospital protocols do not always delineate who is responsible for cleaning medical equipment. Additionally, industry standards¹⁹ state that patients' lead wires must be capable of being cleaned and disinfected 15 times, and manufacturers are not required to guarantee that ECG wires will withstand further cleanings without degradation of signal.

Stop Bacteria From Becoming Resistant

Bactericidal solutions used by nurses and other health care associates to clean disposable ECG wires could pose a threat: the solutions may actually be contributing to the development of resistance in bacteria. The surface residues left behind by antibacterial cleansers create an environment that can foster the development of resistance. Antibacterial agents remain, killing bacteria, but not every single bacterium.^{17,20} Bacteria left behind can develop resistance to the agent used to kill them.^{14-17,20} Therefore, the second method of halting the spread of resistant bacterial infections is to

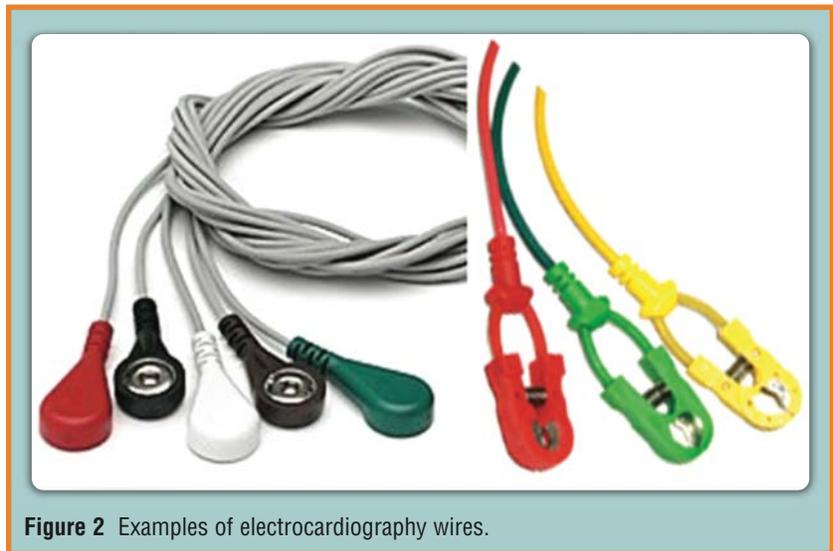


Figure 2 Examples of electrocardiography wires.

eliminate the development of resistance in the bacteria.

Two main types of antibacterial resistance exist: intrinsic and acquired.^{20,21} Intrinsic resistance is an inherent resistance to antibacterial agents. This type of resistance either occurs naturally in bacteria or is inherited. In the latter instance, bacteria in which resistance to antibacterial agents has developed pass on the resistance trait to their offspring. The offspring are then “superbugs,” and because bacteria multiply approximately every 20 minutes, the opportunity for resistant strains to enter the bacterial community occurs rapidly.²²

Acquired resistance is a microevolutionary event natural to almost all of a given bacterial species or genus in which resistance can be developed as a response to repeated exposure to antibacterial agents. Through mutation, some of the progeny of these bacteria emerge with resistance to the antimicrobial agent used against the parental organisms, and possibly to other bactericidal agents as well.¹⁸ Bacterial resistance to the widely used bactericidal agent chlorhexidine has been documented

as far back as 1982.²³ In 2002, the widespread use of chlorhexidine in hospital units involved with the care of catheterized patients was linked to an increase in chlorhexidine-resistant gram-negative bacterial species with multidrug resistance.¹⁸ Additionally, chlorhexidine-resistant bacteria, pan-resistant *Acinetobacter* and *Klebsiella*, multidrug-resistant *Pseudomonas*, and MRSA have been isolated from the surfaces of dispensers of hand soap containing 2% chlorhexidine.²⁴

Acquired resistance can also be communicated from one bacterium to another. The conveyance extends to multiple different bacteria and can involve multiple antibacterial agents. Resistance to a specific antibacterial agent can be conferred along with resistance to other bactericidal agents. Transfer of resistance in bacteria is not a new occurrence. In the 1980s, Yamamoto et al²⁵ found that a strain of MRSA that was also resistant to gentamicin had a plasmid that also conferred resistance to kanamycin, tobramycin, amikacin, benzalkonium chloride, acriflavin, ethidium bromide, and chlorhexidine.

In addition, one species of bacteria can transfer a gene for resistance to an entirely different species or genus. Gram-positive bacteria can confer resistance to other gram-positive bacteria. For example, vancomycin-resistant enterococci (VRE) can transfer resistance to vancomycin to MRSA, MRSA can transfer resistance genes to methicillin to VRE,²⁶ and *Staphylococcus epidermidis* can confer resistance to antibiotics to previously antibiotic-sensitive *S aureus*.²⁷ Gram-negative bacteria can also transfer resistance genes to other gram-negative bacteria. Examples include transfers between *Enterobacter cloacae* and *Acinetobacter baumannii*²⁸ and between *Escherichia coli* and *Serratia marcescens*.²⁸ And finally, since the 1990s, evidence^{29,30} has indicated “trans-gram promiscuity”; resistance can be transferred between phylogenetically different bacterial genera, such as between gram-positive and gram-negative bacteria.

The finding that antibacterial resistance is promoted by pan-use of antibacterial agents has resulted in a call for responsible antimicrobial stewardship and a need to find alternatives to antimicrobial exposure that might help reduce the genetic propensity of these bacteria to become drug resistant.³ One intervention could include cessation of the use of reusable ECG wires.

After repeated exposure to antibacterial agents, bacteria are left behind on reusable ECG wires. These bacteria can either be developing resistance or transferring that resistance to other bacteria, resulting in contamination of recently cleaned reusable ECG wires with one or more resistant pathogens.¹²⁻¹⁶ The conclusion that ECG wires have been an infection threat is supported by the

results of an investigation³¹ in a burn intensive care unit in an 800-bed university medical center in Galveston, Texas, that had experienced an outbreak of VRE. Five weeks after the VRE epidemic had been stopped, the outbreak reemerged. The cause was traced to a single ECG lead that had been contaminated in the original outbreak but “had not been previously identified.”

In health care areas, VRE can survive on hands or gloves for up to 60 minutes and may survive on inanimate surfaces for up to 4 months. Additionally, many other pathogens have vastly longer survival rates on surfaces than on hands and gloves. Contaminated surfaces can be the source of bacterial colonization and communication.³² In the outbreak in the burn unit, the reusable ECG lead was comparable to a petri dish; the lead sustained VRE for more than 5 weeks, subsequently causing a new cross-contamination HAI.

Eliminate the Pathway of Contamination

The third method of stopping the spread of antibacterial-resistant infections is to eliminate the cross-contamination pathways that enable physical transmission of bacteria from one host to another. Patients in acute care facilities leave behind bacteria for subsequent occupants



Figure 3 Photograph of woman after bilateral lung transplant surgery shows at least 3 reusable electrocardiography wires directly contacting her exposed incision.

Photo reproduced with permission from Melissa Reta Thompson, <http://www.olivija.com/melissa>.

and can pass on infections.³³ The less “sharing” of equipment, the less likely contaminated objects can transmit the source of the contamination. Although standard precautions would still be necessary, because ECG wires are handled frequently and nothing replaces adequate hand hygiene, single-patient-use leads provide no reservoir of bacteria and no risk of cross-contamination from patient to patient. Figure 3 shows a young woman who had bilateral lung transplant surgery. No fewer than 3 reusable ECG wires are directly contacting her exposed, fresh incision line. Of note, single-patient-use leads would not solve the problem of cross-contamination from one area of the body to another, and all efforts should be made to prevent cross-contamination, either by vigorously cleaning leads, a step that may not be adequate, or by using a new set of leads when appropriate. Figure 4 shows a man who was severely burned over the entirety of his head, neck, shoulders, and chest area. Unavoidably, the

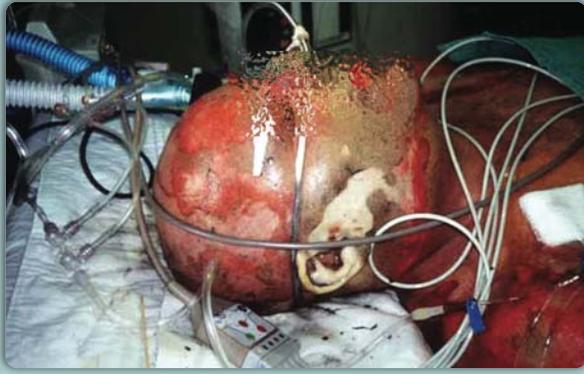


Figure 4 Photograph of man with severe burns of head, neck, shoulders, and chest shows reusable electrocardiography wires unavoidably in direct contact with vulnerable areas.

Photo by Jeffrey Phelps from September 28, 1998, issue of the *Milwaukee Journal Sentinel*. Copyright 2007, Journal Sentinel, Inc, reproduced with permission.

reusable ECG wires directly touch all of these most vulnerable, open areas, completing the pathway of cross-contaminating organisms from the wires to a new host.

Disposable ECG Leads in Practice

Hospitals have become creative in their exploration of methods of reducing resistant bacterial infections and are realizing the benefits of including disposable ECG leads in their infection control bundle. St Anthony's Medical Center in St Petersburg, Florida, reported a 70% decrease in combined MRSA, VRE, and *Acinetobacter* HAIs and a 30% decrease in *Clostridium difficile* HAI in the first quarter of 2008 when disposable ECG wires were added to the hospital's infection control bundle. The results were subsequently presented to the Centers for Disease Control and Prevention. Further anecdotal evidence indicates a benefit from disposable ECG leads in the following facilities that use them in as part of the facilities' infection control practices.

intensive care units was noted, the surgical services department began to use disposable leads. Subsequently, surgical site infections decreased 40%.^{11,12}

William W. Backus Hospital, Norwich, Connecticut, experienced an increase in infections associated with use of central catheters in the months preceding the implementation of disposable ECG leads in combination with some education of the staff to heighten awareness of the care of central catheters. The result was a 5-month zero infection rate for infections associated with central catheters. On the basis of the infection control results, the facility received the John D. Thompson Award for Excellence in the Delivery of Healthcare Through the Use of Data.³⁴

Other hospitals reporting infection control benefits with the use of disposable ECG leads are Emory Crawford Long Hospital, Atlanta, Georgia; SSM DePaul Health Center, St Louis, Missouri; Holy Cross Hospital, Ft Lauderdale, Florida; and Mercy Hospital, Miami, Florida.¹²

At Bon Secours St Francis, Midlothian, Virginia, a 23-month zero infection rate was achieved when use of disposable ECG leads was part of the infection control bundle. When the success with disposable ECG leads in the telemetry and

Administrators of Holy Cross and Mercy hospitals subsequently suggested that disposable ECG leads should be a part of the corporate initiative for Catholic Health East.

Public Demand

Patient advocacy concerning HAI can be found on a multitude of Internet sites. People are clamoring for information on and accountability for HAIs, and contaminated reusable ECG leads are being addressed in the public forum. The public is educated and aware of issues with HAIs, and references to the need for disposable leads can be found on several patient advocacy Web sites.

Cost vs Benefits

If replacement costs alone in changing from a reusable to a disposable piece of equipment are considered, a hard cost-value analysis on the use of disposable ECG leads would not be attractive to budget-crunched nurses and health care facilities. The replacement cost of reusable leads is stretched over hundreds of patients, whereas each set of disposable leads is used on only a few patients or on a single patient, or multiple sets may be required during a patient's stay, depending on the manufacturer. Costs for a single disposable 5-lead set also varies from manufacturer to manufacturer, as does the availability of disposable sets of 3, 5, 6, and 10 (12) leads³⁵⁻⁴⁰ (see Table). Additionally, some brands of disposable leads may be more flexible than others in adapting to monitoring equipment from different manufacturers. Thus, leads that are most adaptable to an individual hospital's

Table Comparison of electrocardiography leads from various manufacturers

Feature	Manufacturer ^a				
	AMC&E	Covidien	Curbell	LifeSync	Philips
Flexibility of use	Single patient use, or reusable at health care provider's discretion	Single patient use only	Single patient use only	Single patient use only	Single patient use only
Ability to change electrodes	Available	Available	Available	Available	Not available
Availability for telemetry	Available for 5- and 6-lead telemetry	Available for 5- and 6-lead telemetry	Available for 5- and 6-lead telemetry	Available for 5-lead telemetry	Not available
Availability of lead sets	Available for 3-, 5-, 6-, and 10-lead systems ^b	Available for 3-, 5-, 6-, and 10-lead systems ^b	Available for 5- and 6-lead systems	Available for 3-, 5-, and 10-lead systems ^b	Available for 3- and 5-lead Philips systems
Compatibility	Compatible with major monitoring systems	Compatible with major monitoring systems	Not compatible with 10-lead systems	Not compatible with 6-lead systems	Compatible with Philips monitoring systems only
List price for 5-lead set	\$15.00	\$20.00	\$17.90	\$23.95	\$9.64
Cost for 3+ day patient stay	\$15.00 or less if reused	\$20.00	\$17.90	\$23.95	More than 1 set needed for each patient per manufacturer's "72-hour wear time"

^a Manufacturers: AMC&E, Advantage Medical Cables & Electronics, Inc, Coral Springs, Florida; Covidien, Dublin, Ireland; Curbell, Curbell Electronics, Orchard Park, New York; LifeSync, LifeSync Corp, Fort Lauderdale, Florida; Philips, Philips Healthcare, Andover, Massachusetts.

^b The 10-lead system is used for acquisition of 12-lead electrocardiograms.

monitoring systems, transport monitors, and so on allow a patient to have a dedicated lead set throughout the patient's stay, further increasing the benefits and decreasing the overall cost. The Table gives some indication of which leads are more adaptable, but validation by trial use would indicate which leads would work best for each facility. Due diligence on the part of critical care nurses, infection control practitioners, and other health care professionals is also needed to establish the



To learn more about reusable electrocardiography leads, read "Cleaned, Ready-to-Use, Reusable Electrocardiographic Lead Wires as a Source of Pathogenic Microorganisms" in the *American Journal of Critical Care*, 2010; 19:e73-e80. doi:10.4037/ajcc2010304. Available at www.ajconline.org.

value of disposable ECG leads from an infection control point of view.

Few studies are available in which a relationship between ECG leads and HAI has been either proved or disproved. Studies reporting that resistant bacteria can be cultured from reusable leads and anecdotal evidence from different facilities that use disposable ECG leads indicate the need for further investigation of ECG wires as a cross-contamination pathway. Despite the higher cost of disposable leads, health care providers could realize marked savings if use of disposable leads did decrease infection rates in their facilities. Standardization and optimization of methods for such studies are necessary, however, as indicated by the marked difference

in the number of cultures positive for resistant bacteria when different culture methods are used. Compared with the percentage (<20%) of resistant bacteria cultured from standard (swab) specimens from ECG lead wires,^{15,16} the percentage (74%-77%) was significantly higher when the leads were either immersed in tryptic soy broth or were sponged thoroughly with gauze soaked with sterile saline and the gauze was then incubated in tryptic soy broth.^{13,14}

Answers

Solutions in the fight against HAI caused by resistant bacteria exist, but the resolution must be complete. No pathway for cross-contamination can be overlooked when the goal is zero tolerance; use

of nondisposable ECG leads is one such pathway. Conceivably, patients who come to the emergency departments of the future will be assigned a packet of disposable equipment—with their own dedicated ECG leads as part of that package—that will be used throughout their stay and be disposed of at the time of discharge. Hospitals that initiate this trend can, quite possibly, be light years ahead of the rest in the struggle against the spread of HAI caused by resistant bacteria. **CCN**

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Financial Disclosures

None reported.

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CE Test Test ID C3113: Disposable vs Reusable Electrocardiography Leads in Development of and Cross-contamination by Resistant Bacteria
Learning objectives: 1. Identify 3 methods to eliminate cross-contamination of resistant bacteria 2. Examine how reusable electrocardiography wires can cause resistant bacteria to multiply 3. Review cost and potential savings of switching to disposable electrocardiography wires

- Which of the following statements describes how cross-contamination by resistant bacteria can be eliminated?
 - Place all suspected patients with resistant bacteria in isolation.
 - Use soap and water only with patients with resistant bacteria.
 - Eliminate the pathway of cross-contamination from one patient to another.
 - Cohort all patients with drug-resistant bacteria on one unit.
- Which of the following statements is true about the cost of treating patients with hospital-acquired infections (HAIs)?
 - The cost of care of the 4% of patients with HAI accounts for 185% of operating profits.
 - The cost of care of the 28% of patients with HAI accounts for 300% of operating profits.
 - The cost of care of the 6% of patients with HAI accounts for 98% of operating profits.
 - The cost of care of the 4% of patients with HAI accounts for 300% of operating profits.
- Pennsylvania, the first state to comply with mandatory reporting of HAIs, found that the dollar value associated with each HAI was which of the following?
 - \$38 000
 - \$340 000
 - \$150 000
 - \$80 000
- What is the mortality rate for patients with HAI versus those without HAI?
 - 22.1% versus 3%
 - 12.9% versus 2.3%
 - 12.9% versus 3%
 - 22.1% versus 2.3%
- What percentage of bacteria that caused HAI were resistant to at least 1 of the drugs most commonly used for treatment?
 - 34%
 - 57%
 - 78%
 - 70%
- Which of the following statements describes how cleaning nondisposable electrocardiography (ECG) wires may lead to the formation of resistant bacteria?
 - Cleansers used to clean ECG wires do not contain appropriate amounts of antimicrobial agents.
 - The antimicrobial agents kill most bacteria, but not every single bacterium.
 - ECG wires are not consistently cleaned.
 - The antimicrobial agent wears down the surface of the ECG wires, allowing bacteria to grow inside the wires.
- Which of the following is the definition of bacterial intrinsic resistance?
 - Intrinsic resistance is a result of antimicrobial treatment.
 - Intrinsic resistance occurs naturally in the bacteria or is inherited.
 - Bacterial mutation creates intrinsic resistance.
 - Intrinsic resistance occurs over time with repeated exposure to the same antibiotic.
- Which of the following bacteria have been isolated from the surfaces of hand soap dispensers?
 - Acinetobacter* and *Pseudomonas*
 - Acinetobacter* and methicillin-resistant *Staphylococcus aureus* (MRSA)
 - MRSA and *Pseudomonas*
 - Acinetobacter* and *Klebsiella*
- Vancomycin-resistant enterococci can survive on hands and surface for how long?
 - 30 minutes on hands and 4 hours on a surface
 - 45 minutes on hands and 4 hours on a surface
 - 60 minutes on hands and 7 hours on a surface
 - 60 minutes on hands and 4 hours on a surface
- What percentage of decrease in MRSA, vancomycin-resistant enterococci, and *Acinetobacter* did St Anthony's Medical Center report after using disposable ECG wires?
 - 70%
 - 43%
 - 43%
 - 83%
- What percentage of decrease in surgical site infections did Bon Secours St Francis report after switching to disposable ECG wires?
 - 30%
 - 40%
 - 50%
 - 60%

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

1. <input type="checkbox"/> a	2. <input type="checkbox"/> a	3. <input type="checkbox"/> a	4. <input type="checkbox"/> a	5. <input type="checkbox"/> a	6. <input type="checkbox"/> a	7. <input type="checkbox"/> a	8. <input type="checkbox"/> a	9. <input type="checkbox"/> a	10. <input type="checkbox"/> a	11. <input type="checkbox"/> a
<input type="checkbox"/> b	<input type="checkbox"/> b									
<input type="checkbox"/> c	<input type="checkbox"/> c									
<input type="checkbox"/> d	<input type="checkbox"/> d									

Test ID: C3113 Form expires: June 1, 2013 Contact hours: 1.0 Fee: AACN members, \$0; nonmembers, \$10 Passing score: 8 correct (73%) Synergy CERP: Category A
 Test writer: Diane Byrum, RN, MSN, CCRN, CCNS, FCCM

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Program evaluation

	Yes	No
Objective 1 was met	<input type="checkbox"/>	<input type="checkbox"/>
Objective 2 was met	<input type="checkbox"/>	<input type="checkbox"/>
Objective 3 was met	<input type="checkbox"/>	<input type="checkbox"/>
Content was relevant to my nursing practice	<input type="checkbox"/>	<input type="checkbox"/>
My expectations were met	<input type="checkbox"/>	<input type="checkbox"/>
This method of CE is effective for this content	<input type="checkbox"/>	<input type="checkbox"/>
The level of difficulty of this test was:		
<input type="checkbox"/> easy <input type="checkbox"/> medium <input type="checkbox"/> difficult		
To complete this program, it took me _____ hours/minutes.		

Name _____ Member # _____
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 E-mail _____
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