Infection Control Resource

Vol. 3 No.2

Prevention Strategies for IC Practitioners and Professional Nurses

In this issue

The urinary tract is the most common site of nosocomial infection, accounting for more than 40% of the total number reported by acute-care hospitals and affecting an estimated 600,000 patients per year. Most of these infections follow mainly urinary catheterization. Catheter-associated urinary tract (CAUTI) infections are generally assumed to be benign. Occasionally, infection persists and leads to such complications as prostatitis, epididymitis, cystitis, pyelonephritis, and gram-negative bacteremia, particularly in high-risk patients The last complication is serious since it is associated with a significant mortality. In 2001, Doctors Dennis G. Maki and Paul A. Tambyah published an important article on CAUTI in the CDC journal, *Emerging Infectious Diseases.* At that time, Doctors Maki and Tambyah concluded that novel impregnated urinary catheters or catheters coated with a silver-alloy hydrogel reduced the risk of CAUTI for short-term catheterizations. *Infection Control Resource* (ICR) asked Dr. Maki how and what has changed in the intervening years.

Silver is perhaps one of the world's oldest antimicrobial agents. Today silver is still a very important ally in preventing infection. In hospitals, its main uses are in burn wards, where silver sulfadiazine is commonly used as an antiinfective. Silver-containing dressings have recently been introduced for wound management, and silver-coated or -impregnated catheters are used for their slow-release antiseptic activities to prevent urinary tract infections. In her article, Dr. Ovington provides an overview of silver as a modern healthcare antiseptic.

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Interview with Dennis. G. Maki MD

In 2001, Drs Dennis G. Maki and Paul A. Tambyah published an important article on catheter-associated urinary tract infection (CAUTI) in the CDC journal. *Emerging Infectious Diseases.*[1] In their article they noted that CAUTI was the most common nosocomial infection. Each year, more than 1-million patients in US acute-care hospitals and extended-care facilities acquired such an infection, and the risk with short-term catheterization was 5% per day. They also noted that CAUTI was the second most common cause of nosocomial bloodstream infection, and studies suggested that patients with CAUTI had an increased institutional death rate that was unrelated to the development of urosepsis .

At that time, Drs Maki and Tambyah concluded that novel urinary catheters impregnated with nitrofurazone or minocycline and rifampin or coated with a silver-alloy hydrogel exhibited antiinfective surface activity that significantly reduced the risk of CAUTI for short-term catheterizations (not exceeding 2–3 weeks). We now have almost 4 years experience with these types of catheters. *Infection Control Resource (ICR)* asked Dr. Maki how and what has changed in the intervening years. The following is a synopsis of Drs Maki and Tambyah's article followed by an interview with Dr. Maki.

Synopsis

At over 40% of all acquired infections, catheter associated urinary tract infection (CAUTI) is the most common nosocomial infection found in hospitals and nursing homes. These infections develop in up to 25% of patients who require a catheter for seven days or more with a daily risk of infection of 5%. CAUTI is also the second most common cause of nosocomial bloodstream infection and may be associated with substantially increased institutional death rates unrelated to the occurrence of urosepsis.

The most common pathogen, hospital wide, is *E.coli* at 26% followed by enterococci (16%), *P. auruginosa*, klebsiellae and enterobacter spp (12% each) and then candida at 9%. However, candida is the most common pathogen in intensive care units (25%). Organisms may gain access into the bladder via extraluminal or intraluminal routes.

Extraluminal infection occurs early at the time of catheter insertion or later by capillary action. Intraluminal infections result from breaks in the closed drainage system or by contamination of the collection bag urine. The extraluminal route may be of greater importance in women because of their short urethra and its proximity to the anus.

Infected urinary catheters are covered by a thick biofilm containing the infecting microorganisms and while the role of the biofilm in the pathogenesis of CAUTI has not been established, antiinfective impregnated and silver hydrogel catheters that inhibit adherence of microorganisms significantly reduce the risk of CAUTI. This is most

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Silver and healthcare antisepsis

by Liza G. Ovington, PhD, CWS

Silver is an element found in nature as a free metal or as an ore. Its chemical symbol is Ag, which comes from the Latin word for silver: argentum.

Silver has been recognized as a valuable and useful substance throughout history. Physically, it is one of the most ductile and malleable metals and was therefore widely manipulated into a variety of useful forms and aesthetic objects by early humans. It is, however, a soft metal and is often alloyed with small percentages of copper to harden it; for example, the sterling silver of tea sets and tableware is 92.5% silver and 7.5% copper. Of all the metals, silver is also one of the best conductors of heat and electricity.

Chemically, silver is quite stable. It does not corrode and is easily polished to a high luster, making it a good option for coinage. Silver coins usually include 10% by weight of copper for increased hardness. Silver tarnishes due to a reaction with sulfur, found in either the atmosphere or food, and it is easily polished back to its original luster.

Silver as an antimicrobial agent

Silver is perhaps one of the world's oldest antimicrobial agents. It was first used in ancient times to control spoilage. The preservative effects of silver on liquids were noted by the seafaring Phoenicians in the ninth century BCE. They observed that water, as well as wine and milk, kept in silver as opposed to earthenware vessels remained potable during long sea voyages. American pioneers of the eighteenth century noted that placing silver coins in barrels of water taken on wagon trains kept the water fresh. Silver was therefore one of the earliest water purification agents used even before the discovery of bacteria.

Silver is still a key ingredient in modern-day filters for both drinking water and swimming-pool water. Silver has even found its way into space as a part of the water-purification systems aboard the MIR space station and on U.S. space shuttles.

> Ionic silver is a potent antimicrobial agent because it can attack and damage bacterial cells at multiple sites.

Antimicrobial mechanism of action

Silver's antimicrobial action is due to the positively charged silver atom, which is also referred to as the silver cation or ionic silver. The atoms in silver metal are neutral and can be transformed to the positively charged atom through oxidation. Silver metal is relatively insoluble in most fluids and will release ionic silver in only very small amounts. More commonly, the silver cation is compounded with some form of negatively charged species. When a silver compound is placed in an aqueous environment, it will release both ions, the positive silver ion and the negative species.

Ionic silver is a potent antimicrobial agent because it can attack and damage bacterial cells at multiple sites. Specifically, the silver cation attaches to certain chemical groups (such as thiols, which contain sulfur and hydrogen) found in a wide variety of proteins that play structural and functional roles in cells. Once the silver cation attaches to these groups on the proteins, it alters them with consequent structural and functional changes in the cell. For example, when ionic silver binds to proteins in a cell membrane, the membrane can rupture causing the internal cell contents to leak out, resulting in cell death.

Ionic silver can also bind to cellular enzymes and prevent them from performing their functions, resulting in the cell's inability to carry out necessary processes (e.g., respiration, taking in or processing nutrients) and its subsequent death. Additionally, ionic silver can bind to DNA and interfere with cell division and the replication process.[1]

In order to use ionic silver as an antimicrobial agent in an infection-control product, the product must incorporate either a metallic silver coating or an impregnated silver compound that acts as a reservoir for the release of silver cations when the product comes in contact with an aqueous medium. Silver and silver compounds can be coated onto surfaces such as textile fibers or polymers and can also be impregnated into carriers or mixed into powders, gels, creams, and ointments.

Medical uses of silver

Silver compounds and products were common antimicrobial agents in medicine until the 1930s, when the advent of antibiotics caused a decline in their use as medical antimicrobials. In the early part of the nineteenth century, silver sutures were used to close incisions in surgeries, such as the repair of vesico-vaginal fistulas, that were known to commonly result in post-operative infections.[2] Dilute (1–2%) silver nitrate solutions were used commonly to treat gonorrhea and to prevent or treat eye infections in newborn babies.[3] Thin silver foils were used to cover open wounds as well as surgical wounds.[1]

Silver products are still common in today's medical and dental practices as antimicrobial agents. In hospitals, its main uses are in burn wards, where silver sulfadiazine is commonly used as an antiinfective. Silver-containing dressings have recently been introduced for wound management, and silver-coated or -impregnated catheters are used for their slow-release antiseptic activities to prevent urinary tract infections.

Topical agents and dressings for wound management

Silver is perhaps best known in the treatment of burns. Since the 1950s, 0.5–2.0% silver nitrate solutions and compresses have been widely available and perceived as safe, broad-spectrum antimicrobials with specific action against *Pseudomonas aeruginosa* in burn wounds.

Silver nitrate is a specific compound that combines the silver cation (Ag^+) with a nitrate anion ($NO3^-$), and it will blacken skin and other surfaces upon contact or

on exposure to light. Silver nitrate is used in aqueous solutions for irrigation or as a soak for compresses or gauze placed on wounds. It is also available in solid form on the tip of a cautery stick; in this concentrated form it will destroy tissues and is used for wound debridement.

Another compound, silver sulfadiazine (SSD), is used by hospitals worldwide to kill bacteria at the surface of the burn wound. Sulfadiazine is a known antibacterial agent and, combined with silver, is at least 50 times more active than other antibacterial agents.[4] Silver sulfadiazine has been readily accepted as a topical barrier treatment for burn wounds since 1967 and is available under several different brand names. It has proven bactericidal activity against many Gram-negative bacteria, including *P aeruginosa* and *Staphylococcus aureus*, as well as against some relevant Gram-positive organisms.[5] It can be applied topically to wounds, where it combines the antimicrobial action of silver cations with the specific antibiotic action of the sulfonamide anion. Patients with allergies to sulfa drugs should not be treated with SSD. It is also contraindicated for use with enzymatic debriding agents, as the silver cation can inactivate them.

Topical wound dressing products have been developed for use in wound management where silver sulfadiazine proves ineffective or difficult to use. Recently, a wide variety of sustained-release delivery systems for silver have been developed. These include silver salts, silver complexes, and silver coatings in an array of moisture-retentive vehicles such as foams, films, alginates, hydrocolloids, hydrofibers, hydrogels, fabrics, and wound-contact layers.

Silver in urinary catheters

Urinary tract infection is the most common hospital-acquired infection, accounting for approximately 40% of nosocomial sepsis.[6,7] The major associated cause is indwelling urinary catheters. Silver compounds have been coated onto or impregnated into catheters in an effort to prevent bacteria from adhering to the external surfaces or lumen and from entering the bloodstream.

Some of the earliest silver technology developed for catheter applications utilized silver-oxides. These silver-oxide impregnated catheters have not been associated with a statistically significant reduction in bacteriuria in short-term catheterized hospitalized adults[8,9]. Other technologies have incorporated silver into alloys used for coatings for catheters both internally and externally and these approaches have proven more effective than silver-oxide in reducing bacteriuria.[10] More recently, next generation ionic silver-hydrogel coatings for catheters are showing promise and are the subject of current clinical study (see associated article). A critical feature of any silver coating is that it effectively releases the antimicrobial silver cations at the catheter surface. One of the latest approaches involves incorporating an inorganic silver compound into a hydrogel coating. The inorganic silver compound is water-soluble and hydrolyzes on contact with body fluids to release ionic silver from the hydrogel coating.

While the cost of silver coated catheters may be higher than non-silver coated catheters, the incremental cost is likely to be offset if the cost of treating a even a single nosocomial UTI is avoided.

While the cost of silver coated catheters may be higher than non-silver coated catheters, the incremental cost is likely to be offset if the cost of treating even a single nosocomial UTI is avoided. Future comparative studies should incorporate this economic outcome.

Silver and bacterial resistance

The silver cation is an effective antimicrobial against multiple types of bacteria. Unlike antibiotics, which are usually quite specific in the type or strain of bacteria that they kill, silver can kill both Gram-positive and Gram-negative species. While bacteria can evolve to develop resistance to antibiotics, ionic silver has the ability to kill these antibiotic-resistant bacteria because it attacks them in a different manner than the antibiotics. Ionic silver has demonstrated ability to kill methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE). Ionic silver can also attack and kill fungi (e.g., *Candida albicans*), which can be a problem in certain wounds.

Since antibiotics usually act at a particular chemical site on the bacterial cell wall or by attacking a specific enzyme, a single mutation might enable the bacteria to change the enzyme or cell-wall binding site and give them immunity or resistance to the antibiotic's method of attack. Because antiseptics like silver act by attacking simultaneously at multiple sites, it would require multiple mutations to become fully resistant. The odds against such an occurrence are very great, and this is why most antiseptics have been used against the same strains of bacteria for thousands of years without significant instances of resistance.

There are some rare cases of bacteria becoming resistant to silver. These are usually restricted to a lab or special situation (such as a resistant *Pseudomonas* strain found in a film processing plant where silver-salt solutions are used around the clock) and have generated no significant clinical impact. There is one strain of silver-resistant *Pseudomonas* that has not been seen clinically but was found growing in silver mines.

Clinically, there have been only isolated case reports of resistant Pseudomonas and *Escherichia coli* associated with long-term use of silver sulfadiazine cream in individual burn patients.[11,12] There have also been laboratory reports of strains of Salmonella with resistance to silver.[13]

Safety of silver products

Silver has been used in its capacity as an antimicrobial for many years and is generally accepted as safe. There are a few potential side effects or adverse reactions that may result from prolonged topical use of silver-containing compounds.[14]

Argyria results from prolonged contact with or ingestion of silver salts.[15] Silver deposition in the tissues produces a bluish-gray to gray-black staining of skin and mucous membranes. Cases have resulted from prolonged use of silver salts for the irrigation of urethral or nasal mu-

cous membranes, in eye drops, in wound dressings, and from the excessive use of an oral smoking remedy containing silver acetate. Argyria has also occurred subsequent to surgical and dental procedures (e.g., silver dental amalgams, silver sutures used in abdominal surgery). There is a wide range of exposure times and dosages among individuals who experience argyria. Unbroken skin does not normally absorb enough silver from any product to evoke argyria.

Another potential side effect of silver-containing products is leukcopenia or a drop in the number of white blood cells. This is also a relatively rare condition that has been associated with the prolonged use of silver sulfadiazine over large body surfaces.

Conclusion

Silver is a chemically stable element that has been used as an antiinfective since ancient times. Today's silver infection-control products incorporate either a metallic silver coating or an impregnated silver compound that acts as a reservoir for the release of silver cations when the product comes in contact with an aqueous medium. Silver is used mostly in dressings for burn cases and wound management, and in silver-coated urinary catheters for prevention of CAUTI. Antibiotics are usually quite specific in the type or strain of bacteria that they kill. Silver, in contrast, can kill both Gram-positive and Gram-negative species. It works by attacking bacterial cells at multiple sites, and it also binds to cellular enzymes, making it a particularly useful antimicrobial because few organisms develop resistance to it.

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common for Gram-positive organisms or yeast. Other infections not involving biofilm are probably caused by the mass transport of intraluminal contaminants into the bladder by retrograde reflux of microbe-laden urine when a catheter or collection system is moved.

CAUTI is defined by most experts as bacterial concentrations of $>10^2$ or 10^3 CFU/mL in urine collected with a needle from the sampling port of the catheter. This concentration can be reproducibly detected in the laboratory and this definition is useful for both therapeutic decisions and epidemiological research.

Risk Factors for Catheter-Associated Urinary Tract Infection (CAUTI)

Factor	Relative Risk
Prolonged catheterization >6 days	5.1-6.8
Female	2.5-3.7
Catheter insertion outside operating room	2.0-5.3
Urology Service	2.0-4.0
Other active sites of infection	2.3-2.4
Diabetes	2.2-2.3
Malnutrition	2.4
Azotemia (creatinine > 2.0 mg/dL)	2.1-2.6
Ureteral stent	2.5
Monitoring of urine output	2.0
Drainage tube below level of bladder and above collection bag	1.9
Antimicrobial drug therapy	0.1-0.4

Table 1.

While this definition is lower than that used by clinicians for noncatheterized patients (bacteriuria $>10^5$ CFU/mL), any microorganisms identified in the urine of catheterized patients will grow to this level unless drug therapy is given.

The risk factors for CAUTI and the relative risk associated with each are presented in Table 1.

The most important modifiable risk factor is prolonged catheterization and infection is near universal by the 30th day. While drug therapy has been shown to be effective to prevent or delay the onset of infection, it too is a risk factor for infection caused by multidrug resistant microorganisms such as *P. aeruginosa* and other Gram-negative bacilli, enterococci and yeasts.

Guidelines for preventing CAUTI include avoiding unnecessary catheterizations, considering alternatives to urethral catheterization, insertion using aseptic techniques, using closed drainage, ensuring dependent drainage and avoiding frequent manipulations of the catheter and drainage system and monitoring urine output only as often as is absolutely necessary. Catheterized patients should be separated geographically from others if possible to reduce the risk of cross-infection. While these practices are universally recommended, few of them have been proven effective with randomized controlled trials.

A number of novel technologies have been developed to try to prevent infections. They are summarized below with their risk reductions from randomized trials in Table 2.

The silver hydrogel catheter reduced the incidence of CAUTI by 26% in a double blind trial of 850 patients and its greatest benefit was in preventing infections caused by Gram-positive organisms, enterococci and staphylococci and candida. These microorganisms normally gain access to the bladder extraluminally. It was of no benefit for microorganisms that gain entry intraluminally such as Gram-negative bacilli.

A cost benefit analysis suggested that the silver hydrogel catheter can produce savings for health care institutions of $6500 per 100 catheters. While these coated catheters are the first major advance for preventing CAUTI since the wide scale adoption of closed system drainage 35 years ago, they are not the final answer.

The Future

The first major advance for preventing CAUTI since the wide-scale adoption of closed drainage 35 years ago is the development of catheters with antiinfective surfaces. These advances should not be considered the final answer, however.

Other technologies that should be pursued include new, more potent antiinfective materials; microbe-impervious antireflux valves; urethral stents; conformable (collapsible) urethral catheters; and vaccines for enteric Gram-negative bacilli and staphylococci. Antiseptics are far more likely than antibacterials to confer greater resistance to surface colonization and not to select for infection with antimicrobial drug resistant bacteria or yeasts. New surface technologies that release far greater quantities of ionic silver or other antiinfective agents into the aqueous environment contiguous to the catheter surface might even prevent CAUTIs caused by intraluminal contaminants. (To read full text of article, visit our website at www.infectioncontrolresource.org)

Interview with Dr. Maki

ICR: Has clinical practice changed since your article on CAUTI—that is, has there been less catheter use? Has the length of time that patients have indwelling catheters shortened?

DGM: It's been my general impression that there has been a trend in infection control practice to use fewer implanted devices. We're using fewer central venous catheters and, clearly, far fewer pulmonary artery catheters. On the other hand, I think that we are probably overusing PICCs (peripherally-inserted central venous catheters). I think we're using fewer urinary catheters, but we're probably not having as much impact on their use as on conventional central venous catheters. I don't think that CAUTIs are yet on the radar screen for the average practicing physician or nurse as a threat to hospital safety —at least, not nearly to the degree that central venous catheters are.

ICR: Do you have any concerns about promoting resistance of CAUTI pathogens as a consequence of coating urinary catheters with antiseptics or antibiotics?

DGM: I have no concerns about resistance with regard to coating with antiseptics, such as silver. Acquired silver resistance has been identified, albeit very rarely, almost exclusively in burned patients. Silver sulfadiazine and silver nitrate have been used almost universally on burn wounds for the last 35 or 40 years, worldwide, and there's been so little silver resistance that it has not materially compromised the effectiveness of silver salts for reducing burn wound colonization and invasive infection. So I'm not very worried. I think it's very unlikely we'll see much silver resistance with the use of silver-coated catheters.

It's important for infection control practitioners and healthcare providers to understand that antiseptics have a mechanism of antiinfective action very different from antibiotics. The mutation of a single gene (~1 in every 106 organisms)—an alteration of a single base pair—can change the configuration of the molecular target binding site for an antibiotic and result in resistance. Antiseptics lyse cell membranes or denature entire protein systems. Acquired resistance to antiseptics would require mutation of multiple genes, which is far less likely to occur (<< 1 in every 1012 organisms). It's no surprise that there's been remarkably little acquired resistance to chemical antiseptics detected in the several hundred years that antiseptics have been used in vast quantities around the world.

Antibiotic resistance, on the other hand, is a whole different ballgame, and readily occurs in the catheterized urinary tract following exposure of infecting microorganisms to antibiotics. I think that the greatest threat that CAUTIs pose is that, in aggregate, the huge numbers of patients with silent (and unrecognized) CAUTI comprise the single largest reservoir of resistant organisms in the hospital. About 30% of patients who have a urinary catheter will get a CAUTI if the cath-

Novel Technologies for Preventing Catheter-Associated Urinary Tract Infection

Technological Innovation	Risk Reduction
Antiinfective lubricant	Unproven
Sealed catheter collection tubing junctions	Unproven
Anti-reflux valves	Unproven
Continuous irrigation of bladder with antiinfective solution	Unproven
Instillation of antiinfective into collection bag	Unproven
Antiinfective catheter material	
Antimicrobial drug-impregnated Nitrofurazone	0.7 (0.3 for bacterial CAUTI)
Minocyline rifampin	0.4
Silver oxide	Unproven
Silver hydrogel	0.2-0.7

Table 2

eter is in place for more than a week. Most of these infections are asymptomatic and are never detected, and they commonly involve methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE) and, especially, multi-resistant *Pseudomonas aeruginosa* and other nosocomial Gram-negative bacilli.[2] This is a huge reservoir of resistant organisms that can be spread to other sites on the same patient or spread to other patients in the unit. I would reaffirm: the most powerful incentive for trying to prevent CAUTIs—probably more important than trying to protect patients from infection per se, because mostly these infections are asymptomatic and don't make people sick—is that CAUTIs promote the spread of resistant organisms that cause far more serious infections such as ventilator-associated pneumonia, line sepsis, and surgical site infections.

ICR: Are there any updates on extraluminal (vs intraluminal) pathogenesis or the relative value of coating the inner as contrasted with the outer surface of the catheter? Anything on the newer silver-based catheter technologies?

DGM: There's been little further as regards studies of pathogenesis, to my knowledge, beyond the prospective study we published in the *Mayo Clinic Proceedings* which suggested that *both* routes are important but that more CAUTIs derive from the extraluminal route to the patient's catheterized urinary tract.[3] It is essential to understand the pathogenesis of CAUTI: silver is only bactericidal in an ionic form, especially beneath a thin layer of hydrogel, and is most likely to be effective in preventing *extraluminally-acquired* CAUTIs, leaching off the external surface into the very thin aqueous film between the catheter and the patient's urethral mucosa.

In terms of your second question, it's important to understand that when we talk about silver, we're talking about one very broad generic technology. There are many forms of silver being used for prevention of infection, and some of these technologies have not worked at all, whereas some appear to work fairly well, and some work very well—there's a great deal of variability in protective efficacy.

There is an urgent need for future studies to comprehensively study other promising silver-based technologies with urinary catheters. These studies need to be well powered—i.e., be sufficiently large to have a reasonable chance to detect significant differences in rates of CAUTI and potential side effects—and, ideally, should be multicenter, if possible double-blinded and, especially, they need to compare promising and competing technologies head to head, rather than simply comparing a new medicated catheter against a nonmedicated control catheter ("been there, done that").

> New surface technologies that release far greater quantities of ionic silver into the aqueous environment contiguous to the catheter surface might even prevent CAUTIs caused by intraluminal contaminants.

ICR: What is your opinion regarding the value of silver in the collection system? Might it reduce CAUTI?

DGM: In the collection bag—probably not. The problem is that you are unlikely to ever get enough silver ions leaching off the surface into the huge volume of intraluminal urine to kill organisms. Remember that silver ions bind avidly with chloride to make silver chloride, which precipitates out. Silver ions have a powerful affinity for chloride. There are plenty of chloride ions in urine, and it will inactivate silver when it binds to it. I'm not optimistic that coating the collection system with silver is ever going to be able to kill organisms suspended in urine in the collection tubing or bag. Maybe someone will find a way to do it, but it will be a formidable undertaking.

ICR: Do you have any concerns about argyria or hypersensitivity to silver?

DGM: It's not out of the question that a patient might develop hypersensitivity to silver, but nobody has reported it in any of the studies of silver catheters that have been done, to my knowledge. There have been no reports of which I'm aware. I'd never say "never", but I suspect that silver hypersensitivity is very rare. There may be cutaneous discoloration, but this is benign and temporary. The black tinge to the skin interface washes away and is unlikely to be an issue.

ICR: Given tight budgets, how do hospitals justify the added cost of medicated catheters?

DGM: That's a very good question. We showed in our article that the technology we studied is very clearly cost-effective. We reduce the risk of infection enough that we actually are spending less money in the long run. You have to do cost-benefit analyses when you study a new technology that has cost added to it. That's important.

ICR: Is there a clinical difference between silicone and latex catheter materials?

DGM: To my knowledge, nobody has shown it conclusively in a large unimpeachable comparative trial. There might be, but I'm dubious. In the acute-care, university-based hospitals where almost all of the prospective studies have been done, in which all study patients were cultured daily for evidence of CAUTI, a very comparable overall rate of infection was found. Some of these studies used silicone catheters, some used latex catheters. It is possible that if you did a large head-to-head prospective randomized trial comparing latex and silicone catheters, you might see differences in the rate of CAUTI. Small trials have suggested that silicone catheters may be less vulnerable to CAUTI and other catheter-related complications than latex catheters, all things equal.[4,5,6]

ICR: What are the key characteristics that a clinician should consider in choosing an indwelling catheter?

DGM: I would reaffirm that there are not

comparative large-scale clinical trials of different types of catheter materials. I'm not as comfortable with latex catheters as I am with silicone or polyurethane catheters because I worry about latex allergy.[7,8] Latex allergy clearly occurs, particularly in children or patients with spinal-cord injury who have prolonged exposure to latex in all forms. As noted, long-term exposure to latex indwelling catheters is also associated with cytotoxicity, urethritis, annd urethral strictures that can block drainage and increase the risk of CAUTI and urosepsis.[4,5,6]

If you're considering a medicated catheter, I think you want good evidence that it clearly works--that it reduces the risk of CAUTI—vis-à-vis, good randomized trials and, ideally, data addressing cost-benefit (vide supra).

ICR: What key characteristics of silver (and any other) coatings should clinicians consider when selecting a coated catheter?

DGM: We're still at a very early stage in our understanding here. Very few silver technologies have been tested head-on, even *in vitro*, and there have been no comparative head-on trials of different technologies with CAUTI as the outcome measure, to my knowledge. *We need prospective randomized outcome studies that actually compare different silver technologies head-on.*

I would state again, silver oxide does not work. In the large, randomized studies done, there was such minimal reduction in infection that we can conclude that silver oxide probably does not bring much benefit.

I would reaffirm, I think there's far more benefit with coating the outside as opposed to the inside of the catheter. There may be benefit with an internal coating, but, as summarized previously, I'm skeptical that it will have much impact. In the lumen, infecting organisms gain access to the patient's bladder and urinary tract by retrograde reflux—I'm talking about a bolus of urine refluxing from downstream up into the bladder—in essence, what the chemical engineers call mass transport—organisms sweeping by so rapidly, millions of microns from the surface. I'm very skeptical that any internal surface antiinfective activity is going to do much for preventing CAUTIs caused by intraluminal contaminants refluxing into the bladder. I think we need alternate strategies for blocking this route of infection.

ICR: So your bottom line, in terms of infection control, is that CAUTIs still don't get the attention they deserve, and silver is an excellent anti-infective, but the jury's out on the best technology?

DGM: That's correct.

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Dr. Maki is one of the nation's foremost experts on infectious diseases. He is currently the Ovid. O Meyer Professor of Medicine and Head of Infectious Diseases at the University of Wisconsin Medical School. In addition to his clinical and academic activities, Dr. Maki 's research interests over the past three decades have included the study and prevention of nosocomial infections, the clinical application of novel agents for the treatment of septic shock, and the epidemiology and prevention of infections caused by antimicrobial resistant pathogens. He is the past-president of the Association for Hospital Epidemiologists. Dr. Maki has published extensively — over 300 journal articles and 20+ textbooks. He has presented at numerous national and international conferences.

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Upon completion of this program, the participant will be able to:

1) Identify the risks associated with urinary catheter use.
2) List the bacteria most oftenidentified in patients with catheter associated UTIs.
3) Discuss the risks associated with using latex catheters.
4. Describe the mechanism of action of silver as an antimicrobial agent.
5. Identify the common medical uses of silver in infection control applications

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The *Infection Control Resource* is a quarterly newsletter distributed free of charge to healthcare professionals. The *Infection Control Resource* is published by Saxe Healthcare Communications and is funded through an educational grant from Covidien, Sharps Safety Division. Our objective is to explore practical, clinically relevant topics in the field of infection control.

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1. **Methods for preventing CAUTI include:**
   a) Using aseptic technique during insertions
   b) Ensuring dependent drainage
   c) Avoiding manipulations of the catheter
   d) All the above
2. **The bacteria most associated with CAUTI is**
   a) Staphylococcus Aureus
   b) Streptococcus
   c) E. Coli
   d) Serratia
3. **In patients who have catheters in place for greater than 7 days, what percent develop UTIs?**
   a) 10%
   b) 50%
   c) 70%
   d) 25%
4. **CAUTI promotes the spread of resistance organism leading to more serious infections such as:**
   a) Line sepsis
   b) Pneumonina
   c) Surgical wound infection
   d) All the above
5. **The cost of silver coated catheters may be higher than non-silver coated catheters. The incremental cost is likely to be offset if the cost of treating even a single nosocomial UTI is avoided.**
   a) True
   b) False
6. **The risks associated with long-term latex catheter use include:**
   a) Cytotoxicity
   b) Urethral stricture
   c) Development of a latex allergy
   d) All the above
7. **The addition of sliver to the collection system will decrease the chance of developing a CAUTI.**
   a) True
   b) False
8. **The risk of developing resistance to antiseptics is greater that developing resistance to antibacterials.**
   a) True
   b) False
9. **The antimicrobial form of silver is:**
   a. Metallic silver
   b. Elemental silver
   c. Cationic silver
   d. Anionic silver
10. **The antimicrobial activity of silver is due to:**
    a. Binding to polysaccharides
    b. Binding to proteins
    c. Binding to chloride ions
    d. Binding to toxins
11. **Which of the following silver products is used in wound management:**
    a. Silver sulfadiazine
    b. Silver nitrate
    c. Silver alginates
    d. All of the above
12. **To date, the least effective silver technology for application in urinary catheters has been:**
    a. Silver alloys
    b. Silver oxides
    c. Silver hydrogels
    d. Silver salts
13. **Bacterial resistance to silver is**
    a. Impossible
    b. Rare
    c. Common
    d. More common than antibiotic resistance
14. **A bluish discoloration of the skin caused by excessive exposure to silver is:**
    a. Leukcopenia
    b. Amalgamation
    c. Argyria
    d. transient

Mark your answers clearly with an "X" in the box next to the correct answer. Please print clearly. Illegible writing will delay processing.

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4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐
11	☐	☐	☐	☐
12	☐	☐	☐	☐
13	☐	☐	☐	☐
14	☐	☐	☐	☐
15	☐	☐	☐	☐

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Resource Volume 3, No. 2

Score ☐ **14**

Participant's Evaluation

1. What is the highest degree you have earned (circle one)? 1. Diploma 2. Associate 3. Bachelor's 4. Master's 5. Doctorate
2. Indicate to what degree you met the objectives of this program using 1= strongly agree to 6 = strongly disagree rating scale. Please circle the number that best reflects the extent of your agreement to each statement:

	Strongly Agree					Strongly Disagree
a. Identify the risks associated with urinary catheter use.	1	2	3	4	5	6
b. List the bacteria most often identified in patients with catheter associated UTIs.	1	2	3	4	5	6
c. Discuss the risks associated with using latex catheters.	1	2	3	4	5	6
d. Describe the mechanism of action of silver as an antimicrobial agent.	1	2	3	4	5	6
e. Identify the common medical uses of silver in infection control applications	1	2	3	4	5	6

3. How long did it take you to complete this home-study program? _____
4. Have you used home study in the past? ☐ Yes ☐ No
5. How many home-study courses do you typically use per year? _____
6. What other areas would you like to cover through home study? _____

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Supported by an educational grant from Covidien, Clinical Care Division

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