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In this issue

Hypersensitivity to latex, affecting both patients and healthcare, is well documented. Since 1979, the U.S. Food and Drug Administration has received thousands of reports of type-1 hypersensitivity reactions to latex products including anaphylaxis leading to death. Chronic latex exposure via an indwelling urethral catheter is associated with adverse effects including cytotoxicity, urethritis, urethral stricture, increased risk of urinary tract infection, and encrustation with blockage of urinary drainage. Dr. Gray and Ms. Achmetov provide a detailed discussion of latex-associated reactions in the patient undergoing long-term indwelling catheterization.

Healthcare practitioners are often challenged by the common catheter-care issues to prevent infections. These include questions about how often to change the catheter, when to treat urinary tract infections, catheter size, and preventing encrustations and blockage. Adding to the confusion is the choice of catheter product; currently available models include silicone, latex, silicone- and TEFLON-coated latex, hydrophilic gel, and antiseptic- and antimicrobial-impregnated catheters. Dr. Moore describes how judicious use of catheters in individual situations, size of catheter, all-silicone catheters, and adequate fluid intake can go far to delay the onset of complications.

Adverse reactions to latex in the clinical setting: *A urologic perspective*

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By Tanya Achmetov, RN, BSN and Mikel Gray, PhD, CUNP, CCCN, FAAN

The ongoing use of latex products in clinical practice has raised awareness of the potential for adverse reactions affecting both patients and healthcare workers. Hypersensitivity to latex is well documented in the medical and nursing literature.[1,2] Contact dermatitis associated with use of latex gloves has been observed for decades,[3] but a type-1 hypersensitivity response to latex was initially reported in 1979.[4] Since that time, the U.S. Food and Drug Administration has received thousands of reports of type-1 hypersensitivity reactions to latex products in patients and healthcare workers, including anaphylaxis leading to death. Chronic latex exposure via an indwelling urethral catheter also may be associated with adverse effects,[5] including cytotoxicity,[6,7] urethritis,[8] urethral stricture,[9,10] increased risk of urinary tract infection,[11–13] and encrustation with blockage of urinary drainage.[14] This article will briefly review latex hypersensitivity and provide a more detailed discussion of latex-associated considerations in the patient undergoing long-term indwelling catheterization.

Natural rubber latex

The tropical rubber plant, *Hevea brasiliensis*, like many other plant species, has evolved sophisticated defense mechanisms to protect itself from injury and disease.[15] Through the synthesis of sticky proteins, *H. brasiliensis* is able to repair wounds and inhibit the growth of pathogenic microorganisms. The harvested cytosol, or sap, contains large amounts of cis-1, 4-polyisoprene that is coated with layers of proteins, lipids, and phospholipids.[16] Latex rubber is formed when the polyisoprene units polymerize into long, cross-linked chains after the sap is treated with ammonia. Chemical accelerators may be added to vulcanize the raw material into finished latex that is incorporated into multiple medical products including gloves and urinary catheters.[17] While processing renders latex usable for medical products, it does not remove all potential allergens contained in the unrefined sap, and it may add chemicals that increase the risk of hypersensitivity.[6]

Latex hypersensitivity

Latex hypersensitivity occurs when an individual produces immunoglobulin E (IgE) antibodies when exposed to antigens found in latex-containing products. The magnitude of this response varies from mild dermatitis to extreme reactions, including anaphylaxis and death, depending on the route of exposure, the amount and type of antigens present at exposure, and the cumulative effect of repeated exposures. The biochemical mechanisms in allergic and hypersensitivity reactions to products containing latex are complex and not completely understood.[18] As of August 2002, eleven *H. brasiliensis* proteins had been defined as allergens by the International Nomenclature Committee of Allergens and were assigned official numbers.[15,19] The protein content of each batch of latex varies depending on the genetic, chemical, and metabolic makeup of the rubber tree, cultivation factors, and chemical processing techniques. Establishing exposure limits for latex allergens to prevent hypersensitivity is not yet feasible.

Assessment

The diagnosis of latex hypersensitivity begins with a focused health history that queries risk factors and suggestive clinical signs or symptoms.[20] Common manifestations associated with latex affect the skin (redness, irritation, urticaria or itching), or the ocular and respiratory system (watery eyes, rhinitis, sneezing, asthmatic symptoms). The clinician should attempt to temporally associate these manifestations with exposure to latex-containing products. This information may

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Encrustations on Indwelling Urinary Catheters

by K.N. Moore, RN, PhD

Indwelling catheters are associated with chronic recurrent urinary tract infections, urinary calculi, urethral strictures, epididymitis, orchitis, leakage, and blockage. At the root of catheter-associated complications are bacteriuria and alkaline urine. The catheter is itself a nidus for infection. Catheter care practices to prevent or delay the onset of bacteriuria include aseptic technique for insertion, early removal of the catheter, maintaining a closed drainage system and dependent drainage, securing the catheter to the body, washing hands and wearing gloves between patients, and separating catheterized patients, but none of these strategies has been completely effective in patients catheterized long-term.[1,2]

There are few randomized controlled trials on which to base practice, and healthcare practitioners are often challenged by the common catheter-care issues that arise. These include questions about how often to change the catheter, when to treat urinary tract infections, catheter size, and preventing encrustations and blockage.[3,4] Adding to the confusion is the choice of catheter product; currently available models include silicone, latex, silicone- and TEFLON®-coated latex, hydrophilic gel, and antiseptic- and antimicrobial-impregnated catheters. At present, all-silicone catheters appear to be the best choice for reducing allergic reactions, urethritis, infections, strictures, and encrustation.

Urinary tract infections/colonization

Colonization by gram-negative organisms occurs as soon as 3 days and as late as 30 days after catheterization; it affects all patients and is usually asymptomatic and uncomplicated.[5] In the short-term catheterized surgical patient, colonization is usually treated with a fluroquinolone or TMP-SMX (trimethoprim-sulfamethoxazole) after catheter removal. In the asymptomatic long-term catheterized patient, antibiotic treatment is unnecessary and potentially harmful if resistant organisms develop. Unfortunately, up to 30% of long-term catheterized patients will become symptomatic and require some intervention.[6] If symptomatic infection persists, potential complications include prostatitis, epididymitis, cystitis, pyelonephritis, and, rarely, bacteremia.[2] Numerous strategies, all ineffective in preventing bacteriuria in catheterized patients, have been tried. For example, antibiotic ointments at the meatus, bladder irrigations with antibiotic solutions, antiseptic solutions in the catheter drainage bags, and oral antibiotics have not decreased bacteriuria and bacteremia.

Indications for urine culture

Historically, management of catheterized patients included routine urine cultures. This practice is no longer supported and should be done only if the patient is symptomatic as evidenced by hematuria, fever, flank or low back pain, urinary urgency, or delirium or cognitive or behavioral changes. Treatment of symptomatic bacteriuria includes obtaining a valid urine sample to culture using a sterile catheter (polymicrobial bacterial biofilms on the lumen of the in-situ catheter will otherwise contaminate the specimen), removing the catheter, and treating the patient with appropriate antibiotics or, if necessary, replacing the catheter and then treating the patient. In one randomized controlled trial to assess the impact of catheter removal and replacement versus no removal in symptomatic patients, subjects in the replacement group achieved bacteria-free status more quickly and were more likely to remain bacteria-free than the non-change group.[7]

If symptoms do not resolve after one course of appropriate antibiotic, patients should be referred to a urologist to rule out pathologic conditions such tumor, abscess, upper urinary tract damage, or bladder calculi.[8] By far the most common cause of unresolved catheter-associated infection is calculi, which begin as small encrustations on the catheter.

Bacterial biofilms and encrustation

Catheter encrustations are due to gram-negative organisms that proliferate in alkaline urine (pH >6.5) leading to formation of calcium oxalate or struvite (magnesium ammonium phosphate) crystals. Attempts to acidify the urine with oral intake of ascorbic acid have been equivocal and non-confirmatory.[9–11] Encrustations can collect in the bladder and form bladder stones that continue the cycle of bacterial growth and bladder spasms.[3,12] Understanding encrustations depends on an understanding of the bacterial biofilms that develop on the catheter.

Bacterial colonization, biofilm development, and subsequent encrustation formation is complex (refer to table 1). In the presence of the indwelling catheter, a biofilm is formed when bacteria with a planktonic phenotype adhere to and colonize the catheter.[13] An organic film supports rapid multiplication of the organisms, and they quickly cover the catheter's internal lumen, external walls, and drainage eyes.[14,15] Bacteria are linked via changes in gene expression stimulated by acetyl homoserine lactones (AHL), and these alterations lead to the formation of a sophisticated, complex structure of multiple clusters of bacteria and a primitive circulatory system. A bacterial extracellular polysaccharide matrix further shields the bacteria from mechanical dislodgement, from endogenous host defenses such as phagocytic activity, and from exogenous attack via oral or parenteral antibiotic therapy. The near-impenetrable biofilm contains proteins, glycoproteins, electrolytes, and carbohydrates and has a net negative charge that attracts more molecules.[16]

The pH of the urine and biofilm matrix rises by the action of urease on urea, especially in the presence of urease-producing bacteria, particularly *Proteus mirabilis, Proteus vulgaris*, and *Providencia rettgeri.*[17] The breakdown of urea to ammonia raises the pH above [6.8], and the alkaline urine in turn encourages the growth of organisms. Encrustation occurs when struvite (magnesium ammonium phosphate) and calcium phosphate crystals precipitate and agglomerate onto the catheter surface and biofilm.[13,15,18] The process of encrustation reaches clinical significance when it obstructs urine outflow through the catheter.

The prevalence of encrustation in catheters is reported to be 40% to 50%.[19,20] Several reports have noted that some patients are likely to be "blockers" while others are not; the typical blocker is female and immobile.[21] Obstruction can occur as frequently as every few days in blockers whereas, in non-blockers, catheters can be patent for many weeks.

Management of catheter encrustation and blockage

Prevention of encrustation and catheter blockage has been largely unsuccessful: hydration has not been effective in encrustation-prone patients;[21] alternative materials for catheter construction, such as hydrogels, have not prevented colonization with urease-producing bacteria or subsequent encrustation in the laboratory or clinical setting;[22,23] and antiseptic- or antimicrobial-impregnated catheters have

Figure 1. Dover™ Silver Coated Silicone Catheter (Covidien, Clinical Care Division)

not prevented blockage. Several investigators have noted that latex catheters, even those treated or coated with silicone, cause cytotoxicity and should be avoided.[24,25]

Irritation and inflammation of the urethra can result from catheterization and can lead to strictures or outright blockage. A 1985 controlled, randomized, prospective study showed that all-silicone catheters are less likely to cause urethritis or strictures.[26] In the study, 100 men who underwent elective cardiac surgery were catheterized, with antibiotic cover, for 48 hours. Six months after surgery, 22% of those with latex catheters had developed urethritis, compared with 2% of those in the silicone catheter group ($p < 0.01$).

Another contemporaneous study looked at men who underwent coronary artery bypass grafting.[27] Latex catheters were used in 100 subjects, and after 15–24 months the incidence of urethral stricture was 5.2%. A separate group of 117 had silicone catheters, and after 12–28 months experienced no urethral strictures.

These two studies looked at short-term use of catheters. Kunin et al. studied encrustation or blockage in long-term use, especially in patients who are blockers.[28] This crossover study used silicone, silicone-coated, TEFLON-coated, and latex catheters (18-F with 30-ml balloon) that were left in place for 14 days. Results published in 1987 revealed that nonblockers, who constituted about half the subjects, did well regardless of type of catheter material used. Blockers had significantly less formation of encrustations and blockage with silicone as compared with TEFLON-coated or latex catheters. Investigators noted that the more rapid flow time through silicone catheters appeared to be related to a larger bore.

In current clinical practice, only three strategies are effective in the management of catheter blockage: irrigation with an acidic solution, application or addition of antibacterial medications, and replacement of the catheter.[18,29]

Irrigation

Muncie and associates[30] compared daily irrigations versus no irrigation of long-term indwelling catheters in 32 subjects. There were no differences between groups in the incidence of symptomatic urinary tract infection, encrustation, or obstruction when daily irrigation with saline was added to routine catheter management. In 1978, Bruun and Digranes[31] compared twice-daily bladder irrigation with saline, acetic acid, chlorhexidine, and silver nitrate solutions in patients with indwelling catheters and known bacteriuria. Saline and acetic acid did not change the colony counts; chlorhexidine and silver nitrate solution both did. Silver nitrate, however, was painful for the patient, and the authors recommended further research on chlorhexidine irrigations. Unfortunately, later research on chlorhexidine solutions has shown that continuous long-term use does not confer any significant benefit and might, in fact, contribute to antibiotic-resistant organisms.[32]

Table 1. **Biofilms formation on indwelling urethral catheters**

1.	Protein binds on the catheter surface.
2.	Organic film develops.
3.	Urease-producing bacteria adhere to the biofilm.
4.	The bacterial biofilm community expands, supported by a matrix of bacterial exopolysaccharide.
5.	pH of urine and the biofilm matrix rises due to the action of urease on urea.
6.	Calcium and magnesium ions are attracted to the gel of the matrix.
7.	Calcium and magnesium ammonium phosphate crystals develop and are stabilized by the biofilm matrix.
8.	The alkaline urine and matrix encourage the formation of crystals, which further promotes aggregation and growth of the biofilm.

In Europe, an accepted measure for managing blocked catheters is irrigation with an acetic acid solution.[33] Although acetic acid alone does not reduce colony counts, a combined solution of 3.2% citrate, 0.38% light magnesium oxide, 0.7% sodium bicarbonate, and 0.01% disodium edetate does seem to effectively reduce *Proteus* infection and encrustation.[34] A more concentrated solution has been used following lithotripsy to dissolve struvite stones, but the solution irritates the bladder mucosa and is not recommended as a bladder irrigation solution.

RENACIDIN™, a solution of citric acid, glucono-delta-lactone, and magnesium carbonate is used for renal calculi and has been advertised as a preventive strategy for catheter encrustations; however, no research has been conducted on the product, and product information warns of potential adverse reactions, especially in patients with compromised renal function.[35] MANDELIC acid can also reduce the colony count in the catheterized bladder but is less effective against *Proteus mirabilis* than the other solutions.[32] Several other studies[18,21,36,37] indicate a potential benefit of routine irrigation with a small volume of a washout solution in indwelling catheters, but clinical trials are needed to prove the efficacy of this management strategy.

Antibacterial substances

Silver-alloy impregnated catheters might have modest benefit in controlling bacteriuria in short-term catheterized patients. To assess their effectiveness in the longer term, Verleyen et al[38] randomly assigned 215 post-urologic–surgery patients to standard or silver-coated catheters. No difference in incidence of bacteriuria was found in a subgroup of men catheterized for approximately 14 days after radical prostatectomy; in a larger group, after a mean of only 5 days of catheterization, onset of bacteriuria was delayed. Thus there appears to be a protective factor of silver alloy in the first 5 days of catheterization, but this influence disappears by approximately 14 days after catheterization.

In another randomized controlled trial of 1,309 patients requiring catheterization longer than 24 hours, there were no differences in the incidence of bacteriuria in the silver-alloy– or standard silicone-coated catheter groups.[33] Of note was a significant increase in bacteriuria in the men randomized to the silver alloy group.

A 1997 study[39] by Morris and colleagues compared the resistance of various types of indwelling urethral catheters to blockage by encrustation with mineralized P*roteus mirabilis* biofilms. In a simple laboratory model of the catheterized bladder, artificial urine was supplied to the bladder chamber at 0.5 mL/min. The bladder urine was inoculated with a clinical strain of P. mirabilis that had been isolated from an encrusted catheter. When a catheter blocked, atomic absorption spectrometry was used to assess the amounts of calcium and magnesium deposited on the catheters. Scanning electron microscopy was also used to locate and assess the degree of encrustation. None of the 18 types of catheter tested, including those coated with hydrogel or silver, was capable of resisting encrustation by *P. mirabilis* biofilm. Over all, the all-silicone catheters took longer to block than the TEFLON-, hydrogel-, or silicone-coated catheters.

A similar study reported a year later by Morris and Stickler produced similar results.[40] The mean times to blockage were 17.7 hours (silver-coated latex), 34 hours (hydrogel-coated latex), 38 hours (silicone-coated latex), and 47 hours (all-silicone).

The results of these studies suggest that clinicians should consider carefully before recommending the use of the silver-alloy catheters. Work continues on introducing differing antibiotic agents within or on catheters that will either penetrate the biofilm, eradicate the organisms, or inhibit the crystallization process.[16,41,42]

Instillation of triclosan into the catheter balloon has recently been proposed as a way to prevent bacterial adherence and subsequent encrustation. In a laboratory controlled study,

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Adverse reactions to latex in the clinical setting: *A urologic perspective — Cont'd*

assist the clinician to determine whether an individual patient is at risk for an immediate (type-1) hypersensitive response or a delayed (type-4) response. Assessment is also influenced by knowledge that specific groups are at higher risk than the general population for latex allergy (table 1). Additional risk factors should be queried including atopy, allergies to specific foods (table 2), recurring dermatitis of the hands, and frequent environmental or occupational exposure to latex products.

Confirmatory laboratory tests are indicated when the history reveals a reasonable suspicion for latex hypersensitivity.[20] An allergist may complete a patch or skin-prick test; these tests are relatively inexpensive and yield rapid results. There is no commercially available skin test in the United States, but allergists can prepare their own latex extracts from powdered latex gloves or base their evaluations on serologic findings. A skin-prick test offers the advantage of avoiding severe hypersensitivity reactions, and it is preferred in patients at risk for anaphylaxis.

Serologic testing relies on measurement of IgE-specific antibodies. Several assays may be used to detect IgE antibodies, including the radioallergosorbent (RAST) test, the DPC Immulite and ALASTAT® assays (Diagnostic Products Corporation), the CAP system FEIA and UNICAP® FEIA assays (Pfizer), and the HYTEC™ assay (Hycor Biomedical). The diagnostic specificities of these assays vary from 68%–97% while the diagnostic sensitivities vary from 75%–92% when compared to patch testing.[20] Some clinicians suggest that patients who present without a documented history of latex sensitization reactions be evaluated for latex allergy using skin-prick tests initially, with a RAST-CAP test combination as follow-up for positive skin-prick results.

Alternative assessment techniques are based on in-vivo provocation tests. For example, patients with equivocal skin-prick or patch tests may be monitored for cutaneous and pulmonary hypersensitivity after donning powdered latex gloves for two hours on three consecutive days.[21] Some investigators test for latex hypersensitivity using nasal washings or a hooded exposure chamber.

Management

Management of latex hypersensitivity focuses on primary prevention (reduction or elimination of initial latex exposure) or secondary prevention (reduction of repeated exposure). Alternatives to common products containing latex, including sterile examination gloves, should be available in all care settings. Research suggests that the greatest risk for allergen sensitization occurs within the first several years of exposure; therefore, it is particularly important that novice clinicians and technicians are educated about the risk of latex hypersensitivity so that they may protect themselves and their patients from needless exposure.[21]

Latex-free environments should be established for groups at particularly high risk for latex hypersensitivity, such as patients with spina bifida.[22,23,24] A latex-free environment requires avoidance of latex in all products, including gloves, catheters, condoms, drains, injection ports, and avoidance of any other product containing latex, latex proteins, or eluates. Diligent precautions can result in a decrease in latex sensitization and hypersensitivity reactions over time. One study showed that the prevalence of latex sensitization among spina bifida patients dropped from about 26.7% to 4.5% in children treated in a latex-free environment from birth compared with traditional controls.[25]

While the costs associated with the use of non-latex products are generally higher than for latex-containing products, these short-term costs must be weighed against the risk of adverse reactions among patients and healthcare workers.[26] Unfortunately, research delineating the costs of healthcare worker disability and morbidity due to latex hypersensitivity has not yet been solidified. Estimates of such costs seem to indicate that it would be financially advantageous for all healthcare institutions to closely reevaluate current practices and provide a safer working environment for employees.[27] There is a great need for solid epidemiological studies focusing on latex sensitization and allergies among healthcare workers. Further research should include consistent latex antigen exposure measurements, appropriate comparisons of healthcare workers to referent groups, and thorough evaluation of known risk factors that influence latex sensitization.

Latex effects in the indwelling catheter

In addition to prevention of hypersensitivity reactions, clinicians must carefully consider the clinical implications of prolonged latex exposure among patients with indwelling catheters. These considerations include issues related to cytotoxicity, local inflammation, infection risk, and encrustation.

Cytotoxicity

Cytotoxicity is a consideration whenever a foreign material remains in prolonged contact with a mucosal surface. Human urothelial-cell culture studies have been completed to assess the potential for cytotoxicity associated with urinary catheters.[6,7] Two principal techniques have been described: cell cultures may be exposed to material extracts, which analyze the presence of toxic substances leached from a catheter; or cell cultures can be exposed through direct contact, where fragments of catheters are deposited in wells containing human urothelial cells. Catheter cytotoxicity is typically determined by evaluating three criteria of cellular health: cell viability, metabolic activity, and proliferation as reflected by DNA synthesis. Latex extracts and direct contact studies exhibit toxicity to cellular viability, metabolic activity, growth, and DNA synthesis, resulting in high functional cell loss. Manufacturers have experimented with coated latex catheters to prevent toxic eluates from being absorbed by cells and to reduce direct contact between cells and allergenic latex proteins. Research indicates that the coatings slightly reduce, but do not prevent, cytotoxicity.[6]

Comparison studies examining the cytotoxicity of all silicone urinary catheters versus latex catheters suggest that silicone is biologically inert and chemically stable. Human urothelial culture studies involving both material extracts and direct-contact techniques have shown that silicone does not influence cellular viability, metabolism, proliferation, or DNA synthesis.[6,7]

Local inflammation

Local tissue inflammation (urethritis) is commonly associated with catheterization. Research has explored the contribution of catheter composition to the incidence of urethritis. For example, a prospective study of 100 males found that the incidence of urethritis upon catheterization using latex urinary catheters was 22%, compared to 2% when an all-silicone catheter was used.[8] Additional factors influence the risk of urethritis, including duration of catheterization, catheter caliber, and the type of lubricant used with insertion. More research evaluating the effects of latex allergenicity and cytotoxicity on the incidence of urethritis is clearly needed before suggesting any change in current clinical practice, but clinicians may choose to explore all-silicone urinary catheter use for decreasing catheterization-induced urethritis in patients.

Urethral stricture

Urethral stricture is another sequela as-

Table 1. **Groups at High Risk for Latex Hypersensitivity**

Group	Estimated prevalence
Spina bifida[5]	18%-72%
Spinal cord injury[15]	47% (limited to those managed with indwelling urinary catheters)
Atopy[26]	30%-80%
Occupational exposure[36]	8%-12% of healthcare workers

sociated with urinary catheterization. Anteriorly, strictures are observed at the meatus, the navicular fossa, and at the penoscrotal angle. Posteriorly, strictures are found at the membranous part and at the bladder neck. Research indicates that the cytotoxic and allergenic properties of latex proteins and eluates increase the risk of urethral stricture. Two studies found a zero incidence of urethral stricture with the use of all-silicone catheters,[7,9] and both recommended silicone urethral catheters to prevent urethral strictures.

Urinary tract infection

Hospital-acquired urinary tract infections contribute significantly to patient morbidity and mortality. "Catheter fever" has been a topic of interest since the 1800s. Current research shows that urinary catheterization contributes to 80% of nosocomial urinary tract infections.[13] Since an estimated 25% of patients admitted to hospitals around the United States are catheterized, the influence of latex composition on the occurrence of urinary tract infection is a clinically relevant issue. Research comparing classic latex catheters, various coated latex catheters, and all-silicone catheters reveals that all contribute to bacteriuria and urinary tract infections. Some studies suggest that all-silicone and coated latex catheters may offer some resistance to bacterial adherence and biofilm formation, delaying onset of bacteriuria.[13] However, more research is needed to delineate how latex allergenicity and cytotoxicity affect the incidence and morbidity of hospital-acquired urinary tract infections. Sterile lubricated catheter insertion techniques, good meatal hygiene, and hand washing by healthcare workers before and after all handling of catheters are critically important in reducing the incidence of nosocomial urinary tract infections.

Encrustation

Encrustation is characterized by crystalline deposits within the internal lumen, eyelets, and catheter retention balloon; this condition becomes critical when it blocks urine outflow and catheter drainage. Researchers have compared many types of indwelling urinary catheters in an effort to determine which resist encrustation.[14,28] While no material has been found that prevents biofilm formation or encrustation, natural rubber latex catheters have the least resistance to encrustation; specifically, in a study comparing encrustation rates in 18 different catheters, latex catheters were the first to succumb to encrustation blockage (21 hours), while all-silicone catheters resisted obstruction for 56 hours.[14] The investigators also noted that all-silicone catheter lumens are larger than their latex counterparts. Regression analysis determining the effects of lumen diameter has shown that internal lumen size is a major factor influencing blockage rates. More recent research has suggested that inflating the retention balloon of an all-silicone indwelling catheter with triclosan, an antimicrobial agent incorporated into multiple medical and household products such as toothpaste and deodorants, inhibits encrustation for an average of 7 days.[29] Inflation of the balloon allowed slow infusion of the solution into the bladder, and the all-silicone catheter was impregnated with the solution, preventing the formation of a Proteus mirabilis biofilm and subsequent encrustation.

Table 2. **Food Cross Reactivities Associated with Latex Allergy**[37]

Fruits and berries	Vegetables	Grains and nuts
Apple	Beet	Almond
Avocado	Celery	Buckwheat
Banana	lettuce	Chestnut
Fig	Potato	Hazelnut (filbert)
Kiwi	Spinach	Peanut
Papaya	Sweet pepper	Walnut
Passion fruit	Tomato	Wheat flour
Peach	Turnip	
Pear		
Pineapple		
Strawberry		
Watermelon		

Management

A number of factors should influence catheter selection, including indication for catheterization, materials, coatings, French size, retention balloon size, and anticipated duration of catheterization.[30] Because of the risk of complications, particularly urinary tract infection, catheterization should be done only in certain circumstances. Indications for short-term catheterization (anticipated to remain in place for less than 30 days) include acute urinary retention, urologic surgery, and critical illness requiring accurate measurement of urine output.[31,32] Indications for long-term catheterization are also limited and include chronic urinary retention or bladder-outlet obstruction that cannot be managed using other techniques, promotion of healing in patients with high-stage pressure ulceration, and certain palliative-care settings.

When indwelling catheterization is deemed necessary, the catheter material should be carefully considered. Selection of a latex catheter must be weighed against associated risks of urethritis, stricture, infection, and encrustation. Catheters with hydrogel coatings (designed to reduce cytotoxicity and urethritis) or bacteriostatic materials such as silver may be considered, particularly for short-term catheterization. An all-silicone catheter is particularly suitable when latex sensitivity is suspected or when long-term catheterization is contemplated. All-silicone catheters offer several potential advantages, including reduced risk of urethritis or stricture formation, and retardation of encrustation and catheter blockage.

Catheter size is also relevant. A catheter with a larger French size may appear desirable based on perception that it is less likely to block, but this must be weighed against disadvantages associated with larger sizes including discomfort[30] and an increased risk of urethritis or bladder spasm.[8] A 12–14 F catheter is adequate for most adult women and a 14–16 F catheter is adequate for most adult men. A 5-ml retention balloon is also preferred, since larger balloons may place tension against the bladder neck.

A potential disadvantage of silicone catheter use is deflation cuff formation, which hinders catheter removal. One study investigating reports from nurses revealed that silicone catheters are more likely than latex catheters to develop cuffs impeding balloon retention and catheter removal.[33] The researchers recommend use of a hydrogel-coated latex catheter when deflator cuff formation is a concern. Three techniques can be employed to prevent or overcome deflator cuff problems:[34]

- The retention balloon should be filled with the volume of fluid recommended by the manufacturer, and overinflation in an attempt to prevent catheter bypassing should be avoided.
- The retention balloon should be inflated very slowly, using a syringe, rather than rapidly deflated. This maneuver encourages the balloon to return to its original configuration and reduces the risk of cuff formation.
- If a cuff forms despite these maneuvers, rendering the catheter difficult to remove, the clinician should avoid applying brisk traction to the catheter, which can cause urethral trauma. Instead, the balloon should be re-inflated with 0.5–1.0 ml of sterile water and the catheter removed slowly. This slight re-inflation will eliminate the cuff without creating a diameter sufficient to prevent safe and effective catheter removal.

Conclusion

Since natural rubber latex continues to

be incorporated into multiple products, clinicians must remain aware of the potential for adverse reactions associated with repeated exposure. Our knowledge of latex hypersensitivity reactions continues to expand rapidly, and this has led to strategies to prevent or limit latex exposure for patients and healthcare workers—for instance, replacing latex with materials such as polyvinyl chlorides.

Latex allergy considerations are particularly relevant to the patient with an indwelling catheter. Latex urethral catheters have been associated with an increased risk for cytotoxicity, urethritis, stricture, urinary tract infection, and encrustation. Selection of an alternative material, such as 100% silicone, reduces these risks, particularly when long-term catheterization is anticipated.

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***Mikel Gray** received his BSc(Nursing) from Vanderbilt University, his MSc (Nursing) from the University of Virginia, and his PhD (Physiology) from the University of Florida. He is currently Professor and Nurse Practitioner/specialist with the University of Virginia's department of urology. Dr. Gray is past-president of the Certification Board for Urology Nurses and Associates and past-president of the Society of Urology Nurses and Associates and served on the board of the National Federation of Specialty Nursing Organizations. He is also the editor -in-chief of the* Journal of Wound, Ostomy and Continence Nursing *and author of the book,* Genitourinary Disorders.

Tanya Achmetov, RN, BSN
Tanya Achmetov earned a BS Biology at Randolph-Macon Woman's College and a BS Nursing at the University of Virginia. She has been employed since graduation at UVA's Department of Urology.

Encrustations on Indwelling Urinary Catheters — Cont'd from page 3

catheters inflated with triclosan solution and placed in an artificial bladder contaminated with *Proteus mirabilis* remained encrustation-free in a urine pH of 6.7 for more than 7 days.[17] The control catheters became encrusted within 24 hours and urinary pH rose from 6.1 to 8.6.

Even aggressive antibiotic therapy does not obliterate biofilm formation.[29] Once present, organisms survive antibiotic therapy and proliferate rapidly after discontinuation. At least three reasons are posed to explain the remarkable self-protective ability of the bacterial biofilm: the antibiotic might not completely penetrate the biofilm; some bacteria within the biofilm survive in a near-starvation mode and might not be killed by antibiotic treatment; or specific aspects of the biofilm mediated by gene expression might alter its sensitivity to antibiotics as soon as treatment is discontinued.[12,43]

Catheter replacement

Removal of the catheter eliminates the biofilm and any encrustation but also requires repeated and frequent re-catheterization with an increased risk of cost, infection, urethral trauma, and patient discomfort. Catheter changes should be based on catheter patency rather than according to fixed intervals.[2] Assessment based on the catheter life of an individual patient, with pH and encrustation monitoring when the catheter is removed, is recommended to give both nurses and patients more control of catheter changes.[44]

The studies cited above show that all-silicone catheters may require fewer replacements, taking the longest time to become blocked.

Catheter size

Large catheters (>18 F) distend the urethra and can irreparably damage the urethra and bladder neck as well as contribute to bladder spasms and leakage.[45] It is recommended that catheter size be no larger than 16 F with a 5-ml balloon inflated with 10 cc sterile water to ensure symmetry of the balloon.[8] Larger catheters are indicated only after urologic procedures when hematuria and clots are anticipated.

All-silicone catheters offer an advantage in that their walls are thinner, thus providing a larger internal diameter than other types of the same French size. For instance, in the first study[39] by Morris and colleagues cited above, the calcium and magnesium salts were mainly deposited on the 10 cm below the eye-holes of the catheters, and complete blockage generally occurred in the 2 cm immediately below the eye-hole. The investigators concluded that a catheter's internal diameter, not necessarily its composition, was a major factor in determining time to blockage. The second study, by Morris and Stickler,[40] noted that the internal diameters of the latex catheters were only 1.5 mm compared with the 2.5 mm of the all-silicone catheters.

Occasionally, suprapubic catheters are recommended for long-term management to avoid urethritis, urethral erosion, prostatitis, and orchidoepididymitis, but there are no long-term research studies to support this practice.[8]

Conclusion

Encrustation and blockage of catheters is a perennial problem in catheterized patients and costs both the system and the patient. Current management of blocked catheters is either to replace the catheter before it blocks (depending on the "catheter life" of the patient) or to routinely irrigate.

Preventing catheter-associated complications is far easier than treating the problem once it has occurred. The judicious use of catheters in individual situations, use of a 14-F or 16-F catheter with a 5-ml balloon, and adequate fluid intake can go far to delay the onset of complications. All-silicone catheters might be the best choice because of their longer mean time to blockage; however, more clinical research studies are required to assist clinicians in managing catheter encrustations.

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Katherine N. Moore*, PhD, RN, BA is an assistant professor in the faculty of nursing and an adjunct professor in the faculty of medicine (department of surgery) at the University of Alberta in Edmonton. She serves on the Canadian Continence Foundation's board of directors and is editor-in-chief of the Journal of Wound Ostomy and Continence Nursing.*

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2. Explain primary and secondary prevention interventions designed to reduce latex hypersensitivity among patients and healthcare workers.
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4. Describe factors which contribute to catheter encrustation..
5. Describe the clinical challenges associated with bacterial biofilms.

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1. In both patients and healthcare workers, latex hypersensitivity occurs when the body produces which substance in response to exposure to latex:
a. IgE antibodies
b. T cells
c. Polymorphonucleocyte
d. H. Brasiliensis

2. Which of the following patients must be managed in a latex-free environment?
a. 70-year-old woman undergoing rehabilitation for a cerebrovascular accident
b. 19-year-old man undergoing urologic testing following a T6 spinal cord injury
c. 7-year-old girl undergoing routine annual evaluation for congenital myelomeningocele
d. 32-year-old woman with known allergy to penicillin delivering a second infant

3. Which of the following materials is associated with the lowest overall incidence of urethral strictures among patients with long-term indwelling catheters?
a. Silastic
b. Latex
c. Red rubber
d. Silicone

4. Which of the following materials has been found to resist biofilm formation when placed in the colonized lower urinary tract in a patient managed by long-term indwelling catheterization?
a. Silastic
b. Latex
c. Red rubber
d. Silicone

5. Encrustation is most likely to occur when the lower urinary tract is colonized by which pathogen?
a. Escherichia coli
b. Citrobacter
c. Proteus mirabilis
d. Staphylococcus aureus

6. A 78-year old man requires ongoing catheterization for urinary retention that cannot be managed by other means. Which catheter represents the best choice for this patient?
a. 8 French polyurethane catheter with 3 ml retention balloon
b. 12 French silastic catheter with 5 ml retention balloon
c. 16 French all silicone catheter with 5 ml retention balloon
d. 24 French latex catheter with 30 ml retention balloon

7. Which is a true statement about bacteriuria in long term catheterized patients:
a. regular changing of the catheter will prevent bacteriuria
b. bacteriuria will occur in all patients by 30 days of catheterization
c. antibiotic prophylaxis should used in catheterized patients
d. silver impregnated catheters will prevent bacteriuria in patients catheterized longer than 30 days

8. Urine cultures in catheterized patients should be collected:
a. routinely on a monthly basis
b. when the catheter is changed
c. if the urine becomes cloudy but patient is asymptomatic
d. if the patient has symptoms of a urinary tract infection

9. Symptoms which may indicate that the patient has an infection or bladder calculi include:
a. hematuria, bladder spasms
b. fever, chills, low back pain
c. cognitive or behavioral changes
d. all of the above

10.The most common cause of unresolved urinary tract infection in catheterized patients is:
a. calculi
b. bladder tumor
c. perinephritic abscess
d. urinary fistula

11. Calculi and catheter encrustations may form in susceptible patients when:
a. urine pH is acidic
b. urine pH rises above 6.8
c. bacteria such as E. coli are present
d. fluid intake is excessive

12. Catheter surfaces which may inhibit encrustation are:
a. hydrogel
b. silver impregnated
c. silicone coated latex
d. 100% silicone

13. A potentially effective prevention for catheter blockage due to encrustations is irrigation with:
a. normal saline
b. antibiotic solution
c. sterile water
d. acetic acid

14. Biofilm eradication on catheters is challenging because:
a. antibiotics may not completely penetrate the biofilm
b. bacteria in the biofilm have remarkable survival modes
c. the biofilm gene expression may cause mutations and antibiotic resistance
d. all of the above

15. Compared to latex or latex coated catheters, silicone catheters offer the advantage of:
a. larger internal lumen
b. reduced adherence of encrustations in the short term
c. less likelihood of urethral strictures
d. all of the above

Mark your answers with an X in the box next to the correct answer

	A	B	C	D
1	☐	☐	☐	☐
2	☐	☐	☐	☐
3	☐	☐	☐	☐
4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐
11	☐	☐	☐	☐
12	☐	☐	☐	☐
13	☐	☐	☐	☐
14	☐	☐	☐	☐
15	☐	☐	☐	☐

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Participant's Evaluation

1. What is the highest degree you have earned (circle one)? 1. Diploma 2. Associate 3. Bachelors 4. Masters 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	
1. Discuss latex hypersensitivity and its application to care of the patient with an indwelling urinary catheter.	1	2	3	4	5	6
2. Review primary and secondary prevention interventions designed to reduce latex hypersensitivity among patients and healthcare workers.	1	2	3	4	5	6
3. Outline potential adverse events when managing a latex indwelling catheter.	1	2	3	4	5	6
4 Describe factors which contribute to catheter encrustation.	1	2	3	4	5	6
5. Understand the clinical challenges associated with bacterial biofilms.	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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