

Infection Control Resource

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Prevention Strategies for IC Practitioners and Professional Nurses

In this issue

Intravascular catheters are indispensable in modern-day medical practice. Although these types of catheters provide necessary vascular access, they can put patients at risk for local and systemic infectious complications, including local site infection, catheter-related bloodstream infections (CRBSI), septic thrombophlebitis, endocarditis, and other metastatic infections. CRBSI is the most life threatening of all healthcare-acquired infections and accounts for significant medical costs, estimated at approximately \$2.3-billion annually. The introduction of microorganisms (and biofilm) during insertion and use of vascular catheters is ubiquitous. Effective skin antiseptics and application techniques remove most but not all organisms.

Catheter-flushing procedures that result in a sudden onset of fever and chills could be causing the release of cell clusters from biofilm. Catheter flushing is much more than injecting some fluid through the catheter lumen. Clinical outcomes depend upon the entire system working together. In her article, Ms. Hadaway discusses infection prevention techniques, including proper catheter flushing techniques with single-use flushing containers, adequate cleaning of the needleless surface before each connection, and careful attention to hand hygiene.

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Flushing vascular access catheters: Risks for infection transmission

by Lynn Hadaway, RN, C, MEd, CRNI

It has long been accepted that the process of flushing vascular access catheters is a primary method for maintaining catheter patency, although there is very little clinical research on the practice. Ideally, the catheter should flush freely without offering any resistance to the fluid flow. All vascular access devices should yield positive blood return when aspirated and are considered to be non-functioning when blood return cannot be obtained.

Catheter-related bloodstream infections (CRBSI) take a very large toll on clinical and financial resources in U.S. healthcare. Approximately 87% of bloodstream infections are associated with the presence of some type of intravascular device.¹ CRBSI is the most life-threatening of all healthcare-acquired infections and accounts for significant medical costs, with total costs estimated as high as \$2.3-billion annually.²

The connection between bloodstream infections and flushing procedures is becoming a serious area of concern. The technology of vascular catheters, pieces added on to the catheter, flush-solution containers, syringe design, and techniques being used must work together effectively as a system. Without a systems approach, you will find that changing one piece may not alter your problems with catheter patency, and the risk of infections associated with flushing procedures will be greater.

Zero tolerance for healthcare-acquired infections is now the goal, with several national initiatives focused on reducing or eliminating these infections, including catheter- and

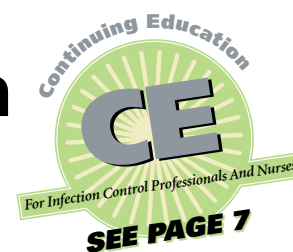
Approximately 87% of bloodstream infections are associated with the presence of some type of intravascular device.

infusate-related bloodstream infections. The 100,000 Lives Campaign from the Institute for Healthcare Improvement, the National Patient Safety Goals from the Joint Commission for Accreditation of Healthcare Organizations, the Committee to Reduce Infection Deaths, the SAVE That Line! campaign from the Association for Vascular Access, and mandates from many state legislatures for mandatory public reporting of healthcare-acquired infections are actively promoting attention to this problem among hospital administrators, all levels of healthcare workers, and patients and their families.

To understand how flushing procedures affect the risk of bloodstream infections we must first explore the major cause of such infections: biofilm.

Catheters and biofilm

The introduction of microorganisms during insertion and use of vascular catheters is ubiquitous. As the catheter passes through the skin during insertion, it is exposed to organisms in



the deep layers of the epidermis. About 80% of resident organisms reside in the top five layers of the epidermis, and the remaining 20% live in biofilm in deep epidermal layers, sebaceous glands, and hair follicles.¹ Effective skin antiseptics and application techniques remove most but not all organisms, allowing some to attach to the catheter on insertion. In addition, as the catheter hub is used for medication administration, flushing, tubing and cap changes, and blood sampling, other organisms enter and cling to the catheter's internal wall. Catheters that have been used for a few days have more biofilm on the external wall, while those indwelling for longer periods have more biofilm on the internal wall.¹

When organisms simply touch the catheter surface, adhesive materials are produced that firmly attach them to the catheter wall. Once the catheter enters the bloodstream, a conditioning process begins with proteins also attaching to the catheter surface, followed by platelets and white blood cells. Within five minutes, the amount of attached proteins is about equal to the amount in the circulating blood. The normal coagulation process causes the development of a fibrinous layer on the catheter that is commonly a depth of 1 millimeter within 24 hours of catheter insertion.¹

After attachment to the catheter's internal and external surfaces, organisms grow and multiply to form cell clusters or mushroom-shaped colonies while also producing an exopolymer substance or glycocalyx, a self-protecting slime. The biofilm surface is uneven and is composed of about 10% to 25% organism cells, with the remaining 75% to 90% being the slime.¹ The biofilm contains channels that allow essential nutrients and oxygen to reach the cells within and the waste of cell metabolism to flow out. Biofilm can also trap various particles such as minerals, red blood cells, and platelets.³

Research now indicates that glucose increases the growth of biofilm. In-vitro tests by Shin et al.⁴ have shown that several *Candida* species can easily grow in dextrose-containing broth. Non-*C-albicans Candida* species grew more readily in the broth containing 8% dextrose, suggesting a connection between biofilm formation and candidemia in patients receiving parenteral nutrition. In this study, the isolates obtained from clinical specimens taken for diagnostic purposes were subjected to laboratory biofilm pro-

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duction methods and were then correlated to the clinical findings. The presence of central venous catheters and infusion of parenteral nutrition were the clinical factors associated with laboratory-developed biofilm.

Many studies have shown heparin to support the growth of organisms both in solution and in biofilm. For example, Root et al.⁵ removed a tunneled central venous catheter, growing *Staphylococcus epidermidis*, from a septic bone-marrow transplant patient and subjected the catheter to numerous laboratory tests to determine what solution would inhibit the organism's growth. Catheter segments were incubated in four separate solutions: disodium ethylenediaminetetraacetic acid (EDTA) 20 mg/mL, heparin 10 U/mL, vancomycin 6.7 µg/mL, and a combination of those same doses of vancomycin and heparin. Quantification of the biofilm growth in the four solutions showed >8 log₁₀ colony-forming units/mL at 24 hours in the heparin-only solution, the largest growth for all four fluids.

Raad et al.⁶ implanted catheters into jugular veins of rabbits; they then inoculated the catheters with *S epidermidis* and flushed them with only heparin for two days. The rabbits were then randomly divided into three groups: five rabbits undergoing 0.5 mL flushes of heparin (100 U/mL); five undergoing 0.5 mL flushes of 3 mg vancomycin in 100 U heparin; and eight undergoing 0.5 mL flushes of 3 mg minocycline and 30

mg of EDTA in 1 mL distilled water. Beginning on day 3, catheters in all groups were flushed once every 24 hours with the respective solutions for 5 days. Quantitative blood cultures taken from all 18 rabbits on day 3 showed *S epidermidis*. For those undergoing vancomycin-heparin flushes, 3 out of 5 showed complete resolution of bacteremia by day 7; those undergoing minocycline-EDTA flushes had 100% resolution of the bacteremia by day 7.

In-vitro tests by Shah et al.⁷ inoculated catheters with broths growing *S aureus*, *S epidermidis*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and *C albicans*, and then treated them with either a heparin flush of 5000 U/mL or a taurolidine (1.35% [wt/vol]) and citrate (2.61% [wt/vol]) solution flush. The inoculated organisms grew in the heparin-treated catheters while the catheters treated with taurolidine citrate did not support growth of these organisms.

Raad et al.⁸ performed an in-vitro study of catheter segments plus 54 colonized catheter tips removed from patients. They also demonstrated that heparin can support microbial growth in fresh and mature biofilm.

A recent in-vitro study by Shanks et al.⁹ examined the mechanisms by which heparin stimulates the growth of *S aureus* biofilm. The findings suggested that heparin does not increase the attachment of organisms to the catheter surface, but it does promote cell-cell interactions, causing growth of biofilm.

Catheter-flushing protocols

Cells embedded in biofilm are known as *sessile*, while free-floating cells are called *planktonic* cells. Cells, individually or in clumps or clusters, break off from biofilm and become planktonic. This mechanism is thought to be the most important aspect of converting a biofilm to a clinical infection. Catheter-flushing procedures that result in a sudden onset of fever and chills could be causing the release of cell clusters from biofilm.

According to the Infusion Nursing Standards of Practice,¹⁰ there are two purposes for flushing a catheter: to maintain catheter patency and to prevent contact between incompatible fluids and medications. For maintaining catheter patency, 0.9% sodium chloride (normal saline) and heparinized saline lock solution are commonly used. For preventing contact between incompatible fluids, 0.9% sodium chloride is used.

The most common procedure is often called SASH—Saline, Administer medication, Saline, Heparin. The initial saline flush is used to assess catheter patency. The nurse should pay careful attention to any degree of resistance when flushing the catheter. The saline-filled syringe used for flushing is also used to aspirate for a positive blood return from the catheter, as this is the major factor in assessing the proper function of the catheter. Without a positive blood return upon aspiration, the catheter should be considered to be non-functioning, and it requires further assessment, diagnostics, or treatment before it is used.

The volume of normal saline for catheter flushing ranges from 1 to 20 mL. For a short peripheral catheter, 1 to 3 mL is most often used unless a vesicant or irritating drug requires a larger volume to adequately assess vein patency. For central venous catheters, 5 to 10 mL is most frequently used, and 20 mL is preferred after obtaining a blood sample from a central venous catheter. The Infusion Nursing Standards of Practice recommends a minimum flush volume equal to twice the internal volume of the catheter system, which includes the catheter, extension set, and/or needleless injection system added to the catheter hub.

Although the evidence linking heparin to biofilm growth is increasing, heparin still remains the solution thought to prevent clots within the catheter. Heparin, including formulations with preservatives, lacks antimicrobial activity.¹¹ Heparin is frequently omitted from the flushing procedure when the catheter or the type of needleless injection system has instructions stating that saline-only flush procedures can be used. This procedure is commonly referred to as SAS. The practice of heparin flushing could change when new flush solutions are commercially available.

The concentration of heparin flush solution ranges from 10 to 100 units, although the smallest dose that will accomplish the goal should be considered. The volume of solution should be twice the internal volume of the catheter system. For neonatal and pediatric patients, 1 U/mL may be chosen. Larger doses of 1000 or 5000 U/mL are often used on hemodialysis catheters, although these large doses must be aspirated before catheter use to avoid systemic anticoagulation. Several in-vitro studies¹²⁻¹⁴ have reported that a significant amount of fluid will spill

Practical approaches to preventing infection

Every time a catheter is flushed, there's a risk of infection. Lynn Hadaway gives *Infection Control Resource* some suggestions on reducing that risk.

What is the relationship between catheter lumen occlusion and bloodstream infection?

After a catheter has been placed, plasma proteins and platelets begin adhering to the inner wall, producing a fibrin matrix. Intraluminal biofilm forms simultaneously with the fibrin matrix, because microorganisms gain entrance to the catheter lumen each time it is manipulated.

The opportunity for infection occurs at the outset of catheter placement—for instance, during insertion, blood is aspirated to confirm the catheter's location within a blood vessel. In addition, brisk blood return is mandatory before each use of a central venous catheter, as it's one sign of patency and proper location. Each time the catheter is used to deliver a dose of medication or to obtain a blood sample, or when the administration set or needleless injection device is changed, microorganisms and blood enter the lumen. Over time, the biofilm-fibrin combination can become thick enough to partially or completely occlude the lumen. Patient activity and suboptimal flushing techniques can also cause whole blood to reflux into the lumen and to clot.

What can be done to reduce the incidence of catheter occlusion?

First and foremost, pay close attention to proper hand hygiene before each and every manipulation of the IV system. Don clean gloves immediately before touching the IV tubing, connectors, or catheter. Each time you must administer medication, use a new alcohol pad to scrub the connector surface for 10 to 15 seconds. Alcohol is a good disinfectant, but physical scrubbing reduces the level of contamination just as much as the disinfectant. For the SASH procedure, this means using four alcohol pads, one before each of the four steps in the procedure.

Reducing blood reflux requires attention to the syringe and awareness of the type of needleless injection system in place. If you're flushing a catheter and not using a prefilled syringe designed to eliminate syringe-induced reflux, don't flush all the fluid from the syringe; this will prevent the rubber gasket on the plunger from being compressed and then rebounding and promoting reflux into the catheter lumen. Know the type of needleless injection device being used—negative, positive, or neutral displacement—and use the appropriate flushing technique after each IV administration; this will reduce the amount of blood left to reside in the catheter lumen.

Needleless injection devices are known to grow biofilm and cannot be used indefinitely.

When in constant use, they must be changed at the same time as IV administration sets. When infusion therapy is given intermittently, the needleless device must be changed at least once every seven days.

What impact does patient activity have on reflux of blood into the catheter lumen?

Any time the catheter is compressed, the fluid used to lock the catheter will be forced into the bloodstream. When the compression is relieved, blood is pulled into the catheter lumen to fill the space vacated by the locking fluid.

Compression occurs with many types of catheters. For instance, the muscles of the upper arm affect a PICC. Normal muscular contraction helps to move blood back to the heart by compressing peripheral veins. If muscular contraction is excessive, it can compress the soft, flexible catheter inside the vein. Patients should be taught to avoid excessive, strenuous activities while a PICC is in place.

Patients sometimes develop a habit of pinching or rolling external catheters (i.e., twiddler's syndrome), which can also cause catheter compression.

When catheters are inserted in the medial subclavian vein, pinch-off syndrome is a distinct possibility. The catheter can be compressed between the clavicle and the first rib. Not only does this promote reflux into the lumen, but it also causes a great risk of catheter fracture and embolization, because the bone movement exerts a scissor action against the catheter.

What effect does heparin have on these issues of blood reflux? Is heparin still necessary to maintain catheter patency?

This is a controversial issue, and we definitely need well-designed, randomized clinical trials to address it. Heparin supports the growth of biofilm, and there is growing concern about the incidence of thrombocytopenia caused by exposure to small amounts of heparin.

Flushing solution may have no effect on lumen occlusion when blood reflux is caused by mechanical actions such as catheter compression. Flushing technique may have more impact on lumen patency when blood reflux is due to the type of needleless device.

Our expanding knowledge of biofilm and fibrin formation seems to indicate that the ideal solution will be one that decreases the development of both substances. There are many questions remaining to be answered, yet it appears that an anticoagulant with antimicrobial properties is needed. At present, in the USA, there is no commercially available alternative to heparin-based flushing solutions.

out of the catheter lumen after it is locked with the heparin flush solution. At present, it is unknown what implications these studies have for clinical practice; however, this leakage of heparin from the catheter lumen into the bloodstream should be considered when choosing the heparin concentration. This would be especially important when a hemodialysis catheter is locked with large concentrations of heparin. It would be possible for this leakage to affect coagulation times.

Several drugs are incompatible with normal saline and require flushing with 5% dextrose in water. Dextrose left to reside in the catheter lumen provides nutrients for cells within biofilms; for this reason, the dextrose in water should be followed by a saline flush and heparin, if indicated. Also, heparin should be diluted in normal saline instead of dextrose in water.

The frequency of catheter flushing depends upon the clinical setting. For hospitalized patients, flushing is most commonly performed after each intermittent infusion or at 8- or 12-hour intervals if the catheter is not being used routinely. For home-care patients, the frequency of infusion is less than during hospitalization, and the catheter may be flushed only once per day. For patients receiving infusion therapy in an outpatient clinic, the catheter is flushed only on the days when the patient visits the clinic to receive therapy. A literature review¹⁵ of flushing protocols for tunneled central venous catheters recommended 5 mL of 10 U/mL of heparin once or twice per week when the patient was not receiving infusion but emphasized that more study is required to completely answer this question. This recommendation correlates with the Infusion Nurses Society standard of practice that recommends using the lowest concentration of heparin so as not to negatively impact coagulation factors.¹⁰

As shown in the studies discussed above, several alternative solutions are being investigated. These include EDTA and taurolidine citrate. Earlier research combined EDTA with minocycline; however, intravenous minocycline is no longer available on the U.S. market. Later studies using 40 mg EDTA alone may prove it to be equally effective.^{16,17} Clinical questions yet to be answered involve the dosage and the length of time required for the flush solution to be locked in the catheter lumen for maximum effectiveness. In vitro studies¹⁸ have reported exposure times of 21 and 24 hours with EDTA; however, this

Current recommendations, guidelines, and national standards of practice strongly favor the use of single-dose containers for flush solutions.

may be difficult to achieve when frequent use of the catheter is required.

Ethanol and multiple antibiotics have also been used as catheter-locking solutions. At present these solutions are used to treat catheter-related bloodstream infections rather than as a routine prophylactic catheter-flushing or -locking solution. Some brands of polyurethane catheters have warnings about exposing the catheter to alcohol; therefore it is imperative to read the catheter's instructions for use.¹⁸

Flush solution containers

Current recommendations, guidelines, and national standards of practice strongly favor the use of single-dose containers for flush solutions. The Infusion Nursing Standards of Practice,¹⁰ Joint Commission for Accreditation of Healthcare Organizations,¹⁹ and the Centers for Disease Control and Prevention² strongly endorse the use of single-dose flush containers. The Institute for Safe Medication Practices reports frequently on the risk associated with multidose vials.

Multidose vials of 0.9% sodium chloride contain benzyl alcohol as the preservative, yet contamination is reported to be as high as 23% of vials.²⁰ Benzyl alcohol is bacteriostatic, not bacteriocidal; it has no effect on fungi and viruses, and gram-negative bacteria are the least sensitive to it. For adults, the maximum dose of bacteriostatic 0.9% sodium chloride is 30 mL in a 24-hour period.²¹ When 10 mL of bacteriostatic normal saline is used before and after each medication dose, the maximum amount of preserved saline is exceeded with only two medication doses per day. Contamination of multidose saline vials is reported to be responsible for nosocomial transmission of hepatitis B, hep-

atitis C (HCV), human immunodeficiency virus (HIV), and malaria.

DeBaun has reported on the problem of disease transmission with multidose vials.²² There are additional published reports that focus on catheter-flushing solutions and disease transmission; for example, Silini et al.²³ reported on the transmission of HCV in a hematology unit. From August 1997 to August 1998, there were 13 cases of HCV seroconversion among 294 patients admitted to this nursing unit. Eleven of the 13 patients had central venous catheters, and 12 received blood transfusions. Transmission from transfusions and staff was ruled out, and molecular data suggested a patient-to-patient mode of transmission. In September 1998, the staff discontinued the use of multidose vials, monitored the HCV status on admission, and admitted patients for high-dose chemotherapy to a private room. As of December 2001, no additional cases had been identified. The authors point out the lack of an established cause and effect but they do note that these preventive measures proved successful in stopping disease transmission.

Kokubo et al.²⁴ have reported on 11 hemodialysis patients with nosocomial transmission of HCV. While they could not conclusively establish the mode of transmission, retrospective analysis suggested that it was the sharing of multidose vials of heparinized saline for catheter flushing.

Another study of HCV, among pediatric oncology patients, was conducted by Widell et al.²⁵ They identified 10 patients with acute HCV. All patients had implanted subcutaneous ports with attached vascular catheters and received many infusions. Due to correlation of the same genotype and the timing of infusions among two patients, and a high number of used vials of saline found in the medication room, the authors concluded that multidose vials were a primary mode of transmission.

Another report, from Lagging et al.,²⁶ about 3 patients with HCV following percutaneous cardiac catheterization, concluded that the multidose vials of saline used for catheter flushing were the most likely mode of transmission.

Krause et al.²⁷ have described three patients who were hospitalized on the same nursing unit in a U.S. hospital and subsequently developed acute HCV. The HCV genotype plus clinical practices of using

multidose saline vials supported the theory that the transmission came from contaminated vials.

Plasmodium falciparum malaria was transmitted to 20 pediatric patients in a Saudi Arabian hospital. Abulrahi et al.²⁸ describe how nurses admitted to using the same syringe for flushing catheters of multiple patients; however, the authors could not rule out other means of transmission.

In another report, Katzenstein et al.²⁹ provided substantial genotyping and epidemiological evidence to support nosocomial transmission of HIV in an outpatient clinic. The most likely mode of transmission was use of a multidose vial.

Large-volume bags of IV solution are often used as the source of catheter-flushing fluid, and this practice has been implicated in many nosocomial outbreaks of infection. For instance, 14 patients with central venous catheters in an outpatient oncology clinic developed *Pseudomonas cepacia* bacteremia, as described by Pegues et al.³⁰ Four additional patients were asymptomatic but had *P cepacia* colonization of their central venous catheters. A 500-mL bag of 5% dextrose in water used to prepare heparin flush solution produced a positive culture of *P cepacia*. Based on the number of flushes prepared, it was estimated that this bag of fluid had been in use for 14 days. No other cultures of water, liquid soap, hand lotion, or povidone-iodine were positive for this organism.

In another situation, 7 confirmed and 4 possible cases of polymicrobial gram-negative bacteremia were reported from a single nursing unit in a community hospital. According to Chodoff et al.,³¹ all patients had either a peripheral or a central venous catheter flushed with saline taken from a bag of IV fluids. The practice was to add a dispensing pin to either a 250-mL, 500-mL, or 1000-mL bag of saline, and to discard the bag when it was empty or after 24 hours. Organisms isolated from patient blood cultures included *Enterobacter cloacae*, *Klebsiella pneumoniae*, and *Citrobacter freundii*, and analysis of the bacteria with pulse-field gel electrophoresis revealed that many had identical genetic patterns. The actual bag and dispensing pin thought to be the culprits had been discarded, but the authors were able to duplicate contamination of a similar system in the laboratory.

In the same nursing unit, 4 liver transplant patients experienced 5 episodes of

Large-volume bags of IV solution are often used as the source of catheter-flushing fluid, and this practice has been implicated in many nosocomial outbreaks of infection.

K pneumoniae bacteremia; 3 of them had central venous catheters and 1 had a midline catheter. One additional patient with a central venous catheter had a positive catheter-tip culture. As reported by Goetz et al.,³² saline for catheter flushing was taken from a 100-mL bag, with a stopcock attached, that was used until it was empty. Cultures from an empty bag and a partially used bag produced the same strain as that cultured from all the patients.

Macedo de Oliveira et al.³³ recently reported how 4 patients newly diagnosed with HCV began an investigation of practices at their hematology-oncology clinic. The practice of the clinic nurse was to use the same syringe for obtaining blood samples from central venous catheters and to access a 500-mL bag of saline for catheter flushing. This fluid bag was used for multiple patients. Testing of 486 patients revealed 99 with clinic-acquired HCV, with the same genotype identified in 95 patients. This is one of the largest documented outbreaks of healthcare-acquired HCV. The patients' investigation resulted in closure of the clinic and revocation of the oncologist's and nurse's licenses. The outbreak is currently the subject of litigation.

These cases indicate that it is imperative to follow published standards and guidelines for the use of single-dose flush containers. Busy nurses with large workloads are under pressure to meet patient needs. The task of drawing up the saline and heparinized saline into syringes adds to their burden and opens the door for serious breaches of infection prevention; nonetheless, as a 2003 report from the CDC has stated, do not use

bags or bottles of intravenous solution as a common source of supply for multiple patients.³⁴ Single-dose flush solutions are available in two forms: 10-mL single-dose preservative-free vials of saline and prefilled syringes. When the cost of labor and treatment of nosocomial infection are included, prefilled syringes are cost-effective.

Other IV system components

A significant portion of the problems with catheter patency could be related to the design of syringes used for catheter flushing. Most catheter manufacturers recommend using a large (e.g., 5- or 10-mL) syringe for catheter flushing to reduce the amount of pressure exerted against the catheter wall. Smaller syringes generate greater pressure on injection. Excessive force applied to the syringe plunger with partial occlusion in the catheter lumen from blood clots or drug precipitate can cause intraluminal pressure great enough to produce catheter rupture. In addition to syringe size, hand size and strength also add to the challenge, as these are difficult if not impossible to measure. These unknown factors cause the recommendation for larger syringes for catheter flushing.

The other challenge with syringes is the design of the traditional syringe. When all fluid is flushed from the syringe, the tip on the plunger is compressed. To detach the syringe from the catheter hub, the force on the plunger is released and the tip rebounds, pulling blood into the catheter lumen. To avoid this problem, the nurse could leave a small amount of fluid in the syringe. This technique requires learning and practicing a new process, to which busy nurses may not have time to devote attention. The other answer is to use only a prefilled syringe designed to eliminate this plunger-rebound problem.¹⁸ Currently there are 2 brands of prefilled syringes de-



MONOJECT PRE-FILL™ ADVANCED™ Syringe
(Tyco Healthcare Kendall)

signed to eliminate syringe-induced blood reflux: BD POSIFLUSH™ Prefilled Syringes (BD Medical) and MONOJECT PREFILL™ ADVANCED™ Syringe (Tyco Healthcare).

Needleless injection systems were introduced about 15 years ago as an attempt to reduce the number of needlestick injuries to healthcare workers. Currently, the Blood-borne Pathogens Standard from OSHA³⁵ mandates use of needleless devices. However, through clinical use of these devices, other issues have been revealed. The original design was a two-piece system: a blunt cannula attached to the male Luer tip of a syringe or IV tubing, and a pre-cut slit in the injection cap attached to the catheter hub. A one-piece mechanical-valve injection cap was introduced next, allowing for direct access with the male Luer tip of syringe or IV tubing. This original design is often called negative displacement because of the potential for blood to move into the catheter lumen after flushing.

The next design addressed the blood reflux that could occur with the original needleless devices. Mechanical valves with positive fluid displacement were introduced; they hold a small amount of fluid in a reservoir. Upon syringe or tubing disconnection, this fluid is forced from the reservoir into the catheter lumen to overcome the blood reflux. There are many different brands of these devices, with different amounts of fluid held in the reservoir. The latest design offers a mechanical valve with neutral fluid displacement, and there is no fluid movement in either direction when the syringe or tubing is disconnected. Several brands have instructions for saline-only flushing, and the manufacturers' directions should be followed.

Catheter lumen occlusion, with blood reflux into the lumen, is the major clinical concern. As discussed, it occurs because of both the syringe design and the type of needleless injection system being used. This reflux can easily be observed in a lab test; however, there are very few clinical data on this problem, making it almost impossible to quantify the contribution of blood reflux to catheter lumen occlusion.

The relationship of catheter-related bloodstream infection to these needleless injection devices has been the subject of growing concern over the past few years. Multiple hospitals have found a dramatic rise in rates of CRBSI after changing from a blunt-cannula/split-septum system to a mechanical

valve.³⁶⁻³⁸ Research has not answered all the questions yet, as many hospitals are using mechanical valves without any documented increase in rates of CRBSI.

There are several areas of concern. The topography of the connection surface of these devices makes it impossible to clean them adequately before use, rendering it relatively easy for organisms to contaminate the fluid pathway. A survey³⁷ of nursing practice in one hospital with an increased CRBSI rate found that 31% of nurses did not disinfect the surface before connecting the syringe or tubing. The connection surface of the needleless system must be cleaned before each connection. For the SASH procedure, this would mean cleaning four times with four alcohol pads. Although there are no studies that have examined this issue, experts have recommended a 10- to 15-second alcohol scrub of this surface before use.

Several catheter design factors have an impact on flushing procedures. Three brands of catheters have integral valves allowing for saline-only flushing. The GROSHONG™ valve from Bard Access Systems is built into midline, PICC, nontunneled, and tunneled catheters and implanted ports. The PASV™ valve from Boston Scientific is used in PICC and tunneled catheters and implanted ports. LifeValve™ from Rita Medical is available on implanted ports.

A catheter's length and internal diameter determine its internal volume, and this factor determines the minimum volume for flushing or locking catheter lumens. The exact internal or priming volume for each type and brand of catheter can be found in the instructions for use that are packaged with each catheter.

Catheter-flushing technique

The specific technique used to flush a catheter depends upon the equipment being used. Neutral-displacement needleless injection devices are not dependent on flushing technique. In the case of blunt cannulas, positive-pressure flushing technique is recommended to overcome the problem of blood reflux. There are 2 approaches that can be used:

1. As the last 0.5 to 1 mL of fluid is flushed inward, withdraw the blunt cannula from the injection cap. This results in a spray of fluid on the external cap and the hands of the nurse, mandating that gloves be used to pre-

vent exposure to blood-contaminated fluid.

2. Flush the fluid into the catheter, leaving a small amount in the syringe if using one with a traditional design. Continue to hold the plunger while closing a clamp on the catheter or extension set, and then disconnect the syringe.

If you are using a positive-displacement device, these techniques cannot be employed, as they will prevent fluid movement from the internal reservoir. If hospital policy requires that catheters be clamped, flush the catheter and detach the syringe. Allow a few extra seconds for the positive fluid displacement to occur, and then close the catheter clamp.

Another flushing technique that has grown in use is the so-called pulsatile or turbulent technique. This involves start-stop flushing in an attempt to create turbulence inside the catheter lumen and to prevent blood products from adhering to the inner catheter wall. This technique is based on the theory of fluid flow and has no in-vitro or clinical studies to support its use. Questions about it abound, including what is the amount of turbulence, if any, created by this technique; what are the differences between nurses' applications of this start-stop process; and what are the clinical outcomes seen with its use. Given the current knowledge of biofilm development inside catheter lumens, including needleless injection systems, it is conceivable that this technique may enhance the detachment of biofilm and increase the rate of CRBSI, although there is no evidence to support this theory either.

Conclusion

When all aspects are considered, catheter flushing is much more than injecting some fluid through the catheter lumen. Clinical outcomes depend upon the entire system working together. The flushing technique must match the needleless injection system design, yet many times the bedside nurse does not know what type of needleless device is being used. All brands look similar, and it is very hard to distinguish the types because they are not labeled by their fluid-displacement characteristics. Changing the type of needleless system may not produce the desired catheter patency if the syringe design is not considered. Above all, infection prevention techniques must be stressed, including adequate cleaning of the needleless surface

before each connection, choosing single-use flushing containers, and careful attention to hand hygiene. Technology must be carefully chosen to work with the appropriate techniques, as neither can address the complete problem if used alone.

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This continuing nursing education activity was approved by the Vermont State Nurses' Association Inc. (VSNA) an accredited approver by the American Nurses Credentialing Center's Commission on Accreditation.

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- Explain the development of biofilm in vascular access catheters.
- Identify the common protocols for flushing vascular access catheters.
- Describe the components of catheter flushing that increase the risk of catheter-related bloodstream infection.
- Correlate the appropriate catheter flushing technique to the needleless injection device being used.

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1. **Microorganisms attach to the catheter**
 - a. during the manufacturing process
 - b. during the packaging or shipping process
 - c. as it passes through the skin during insertion
 - d. as it resides in the bloodstream
2. **Biofilm develops because**
 - a. organisms produce adhesive material causing them to stick to the catheter
 - b. slow flow rates of iv fluid allows for easy contact with the catheter
 - c. rapid flushing techniques forces organisms against the catheter
 - d. blood flow rates are not fast enough to flush them away.
3. **Which of the following solutions supports the growth of biofilm?**
 - a. heparin and dextrose
 - b. normal saline and dextrose
 - c. heparin and normal saline
 - d. edta and heparin
4. **Bloodstream infection is caused by**
 - a. breaking of biofilm clusters which then float into the bloodstream
 - b. the volume of normal saline used to flush the catheter
 - c. the use of electronic flow control pumps
 - d. the volume of heparin used to flush the catheter
5. **The purpose of using normal saline in the flushing protocol is to**
 - a. remove the biofilm in the catheter lumen
 - b. prevent the biofilm from forming inside the catheter lumen
 - c. prevent contact between incompatible medications
 - d. maintain patency of the catheter lumen
6. **The most common volume for flushing a central venous catheter is**
 - a. 1 to 3 ml of normal saline
 - b. 25 to 30 ml of normal saline
 - c. 20 to 25 ml of normal saline
 - d. 5 to 10 ml of normal saline
7. **The minimum volume for flushing all catheters should be**
 - a. equal to the internal volume of the catheter and add-on devices
 - b. twice the internal volume of the catheter and add-on devices
 - c. three times the internal volume of the catheter and add-on devices
 - d. five times the internal volume of the catheter and add-on devices
8. **Catheter flush solutions should be obtained from**
 - a. a prefilled syringe labeled for each patient
 - b. a multiple-dose vial of normal saline stocked in the medication room
 - c. a large bag of normal saline maintained in the medication room
 - d. a multidose vial of diluted heparin supplied by the pharmacy
9. **The maximum amount of bacteriostatic normal saline for an adult within a 24-hour period is**
 - a. 100 mL
 - b. 50 mL
 - c. 30 mL
 - d. 10 mL
10. **Flushing a central venous catheter with a 3-mL syringe produces**
 - a. risk of catheter damage from high amounts of pressure in the catheter lumen
 - b. increased risk of bloodstream infection by disturbing the biofilm
 - c. risk of blood reflux into the catheter
 - d. decreased risk of catheter damage because of the small size
11. **Blood reflux into the catheter lumen is caused by**
 - a. syringe design and the type of needleless injection systems
 - b. negative and positive displacement needleless injection systems
 - c. positive-pressure flushing technique
 - d. positive and neutral displacement needleless injection systems
12. **The frequency for cleaning the connection surface on a needleless injection system should be**
 - a. once a week when it is changed
 - b. once with each medication
 - c. never as cleaning will not reduce the risk of infection
 - d. before each syringe or administration set is connected to the system
13. **Positive pressure flushing technique is required when using**
 - a. negative displacement needleless injection system (blunt cannula)
 - b. positive displacement needleless injection system
 - c. neutral displacement needleless injection system
 - d. both positive and neutral systems
14. **The pulsatile or turbulent flushing technique**
 - a. must be used on all catheters
 - b. is not supported by any scientific evidence
 - c. will decrease the formation of biofilm
 - d. will increase the formation of biofilm
15. **Heparin may be eliminated when flushing**
 - a. all brands of peripherally inserted central catheters (PICCs)
 - b. all types of central venous catheters
 - c. only when flushing an implanted port
 - d. any catheter that contains an integral valve

Participant's Evaluation

What is the highest degree you have earned (circle one)? 1. Diploma 2. Associate's 3. Bachelor's 4. Master's 5. Doctorate

Indicate to what degree you met the objectives for this program: Using 1 = Strongly disagree to 6 = strongly agree rating scale, please circle the number that best reflects the extent of your agreement to each statement.

	Strongly Disagree			Strongly Agree		
	1	2	3	4	5	6
1. Explain the development of biofilm in vascular access catheters.						
2. Identify the common protocols for flushing vascular access catheters.						
3. Describe the components of catheter flushing that increase the risk of catheter-related bloodstream infection.						
4. Correlate the appropriate catheter-flushing technique to the needleless injection device being used.						

How long did it take you to complete this home-study program? _____
 What other areas would you like to cover through home study?

Name & Credentials _____
 Position/Title _____
 Address _____
 City _____ State _____ Zip _____
 Phone _____ Fax _____

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

1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	9	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	13	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	14	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	15	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	16	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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Resource Volume 4, No.2

15