Needleless Connectors for IV Catheters

How to avoid complications associated with various models and practices.

OVERVIEW: Needleless devices for connecting IV catheters, administration sets, and syringes were introduced in the early 1990s for the purpose of reducing the risk of needlestick injuries among health care providers. Although needleless connectors serve that purpose, their use has been associated with an increase in such complications as catheter-related bloodstream infection and catheter lumen occlusion. Complications may be related to design characteristics, user knowledge deficits, poor practices, or some combination thereof. The author describes the connectors in current use, how they differ in design and function, the potential complications associated with various models and practices, and the nursing interventions that can reduce the risk of these complications.

Since needleless connectors for use in IV administration were introduced in the early 1990s, a wide variety of these devices have come onto the market. Although these apparatuses are often referred to as "end caps," "injection caps," "luer-activated devices," "injection ports," and "mechanical valves," the term "needleless connector" is the most accurate, as it is the only term that includes all types and designs in this category of products. Within a single health care system, several types of needleless connectors may be in use, varying considerably in both design and function. While needleless connectors have greatly reduced the risk of needlestick injury among health care providers, they have also been associated with an increase in such complications as catheter-related bloodstream infection (CRBSI) and catheter lumen occlusion.[1-11] This article discusses the many types of needleless connectors available for use in IV systems, differences in their design features and function, potential complications that can arise if the nurse using and assessing the devices is unaware of how they vary, and nursing interventions that can reduce any associated risks.

DESIGN AND FUNCTION

Needleless connectors differ in terms of how they look and how they work.

External characteristics. The external housing of the needleless connector may be opaque and colored or clear. The external connection surface may have an angled center or be virtually flat, concave, or indented.

There are two ways to connect an IV set or syringe: the male luer tip of the IV set or syringe, or a blunt cannula attached to it, may be (1) manually pushed through a split septum or (2) directly luer-locked onto the mechanical valve. Although some split-septum devices will accept a needle, a needle should never be used in a needleless system.

Internal characteristics. Although their exterior appearance may be similar, needleless connectors have internal differences that affect the way they function.

Simple versus complex. The majority of needleless connectors fall into one of two categories: simple connectors, which have no internal moving parts, such as those with an external split septum; and complex connectors, which rely on internal moving components, such as a mechanical valve, to control the flow of fluid within the device. The internal characteristics

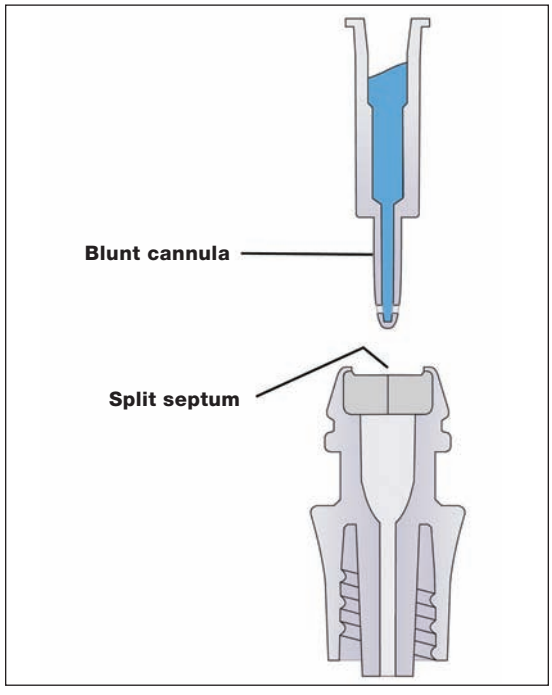

Figure 1a. Split-septum connectors are opened with a blunt cannula or male luer tip. Image courtesy of and © Becton, Dickinson and Company.

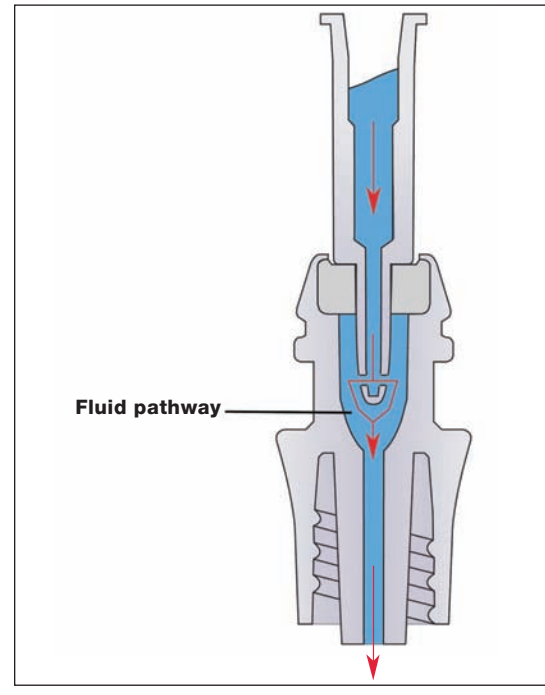

Figure 1b. Because split-septum connectors have no internal moving parts, fluid enters the lumen directly. Image courtesy of and © Becton, Dickinson and Company.

of the connectors determine the way the devices manage fluid displacement, as well as the fluid pathway (see Table 1).

Fluid displacement within the needleless connector is described by manufacturers as being either negative, positive, or neutral. Connectors with negative displacement allow blood to be pulled back, or to reflux, into the catheter lumen during connection, disconnection, or when the administration set is attached. Connectors with positive fluid displacement hold a small reservoir of fluid, so that when the IV set or syringe is disconnected, fluid is pushed into the catheter lumen to overcome the intraluminal blood reflux. Neutral fluid displacement prevents blood from moving into the catheter lumen upon connection or disconnection.

To determine fluid displacement of a needleless connector, it's necessary to refer to the product information and instructions for use. Connectors with positive or neutral displacement often highlight this characteristic in their labeling information; devices with negative displacement seldom discuss this quality. Although the term "pressure" is often used to describe connectors with positive displacement, such devices do not actually generate any pressure but merely move fluid forward within the catheter lumen.

Fluid pathway. Because split-septum connectors have no internal moving parts, they provide what is known as a "straight fluid pathway," meaning that they allow fluid to flow directly through the lumen (see Figures 1a and 1b). The blunt cannula or male luer tip used to access split-septum connectors can be relatively large, however, creating negative fluid displacement (or reflux) as it is withdrawn from the split septum.

Connectors with mechanical valves have centerpieces that open on the external connection surface. The IV set or syringe is attached when its male luer end pushes the valve's centerpiece downward, allowing fluid to enter. If the mechanical valve has negative displacement, fluid flows through the middle of the centerpiece (Figure 2); if it has positive displacement, fluid flows between the outer housing and the movable centerpiece (Figure 3). Some mechanical valves, said to have neutral displacement, contain a reversed internal blunt cannula that connects with the male luer of the IV set or syringe, allowing fluid to flow through its center (Figure 4). (Not all neutral displacement connectors have this design.)

Another device designed to achieve neutral displacement is a pressure-sensitive, cupped, slit silicone disk, which can be used with both split-septum connectors and mechanical valves. The disk closes

automatically when infusion pressure drops, preventing blood reflux into the catheter lumen (Figure 5).

ASSOCIATED RISK FACTORS

Potential risk factors for complications associated with needleless connectors fall into several categories, including device design, user knowledge deficits, inattention to the management of the entire IV administration system, and the frequency with which the connectors are changed.

Device design. Potential contamination could be associated with several connector design characteristics. For example, opaque or colored external housing makes it hard to see any residual blood or particulate matter inside a needleless connector, whereas clear external housing makes such visualization possible. Similarly, the configuration of the connection surface may affect ease of both connection and cleaning. A flat surface may make it challenging to attach the IV set or syringe, because if the male luer tip glances off the surface, it could become contaminated. A concave or indented surface may ease connection because it guides the male luer tip of the IV set or syringe into the center. The indented center, however, is difficult to adequately clean before connection.

In connectors with mechanical valves, the space between the external housing and the valve's moving centerpiece can trap microorganisms and other environmental debris, yet it is virtually impossible to clean.[12] Once organisms enter the device, they can colonize in the collapsed folds of the centerpiece or between the fluid pathway and the connector housing, where fluid may leak.[5, 13] To reduce the associated risk of infection, some manufacturers have produced needleless connectors with antimicrobial agents, such as silver or silver plus chlorhexidine, on a variety of internal surfaces. Two in vitro studies showed that needleless connectors containing silver may significantly reduce both microorganisms and downstream biofilm (the slimy substance that protects and surrounds organisms), although prospective, randomized clinical trials are needed to determine the impact of this reduction on CRBSI.[14, 15]

No specific design or type of needleless connector has been associated with greater risk of infection, but the 2011 *Guidelines for the Prevention of Intravascular Catheter-Related Infections* from the Centers for Disease Control and Prevention (CDC) advise that split-septum needleless connectors may be preferred over mechanical valves because of "increased risk of infection with the mechanical valves."[8] At this time, the U.S. Food and Drug Administration is not recommending product changes.[16] Notably, product changes within facilities have dramatically increased rates of CRBSI, causing some hospitals to return to their original needleless connectors.[5, 9]

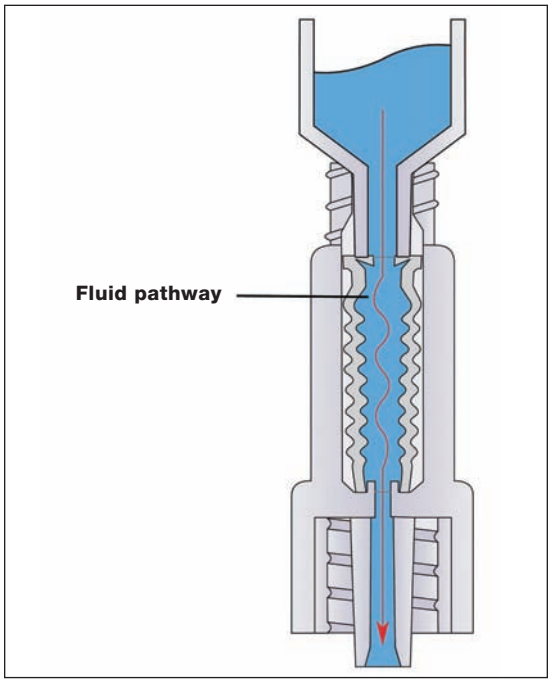

Figure 2. Mechanical valves that have negative displacement direct fluid through the middle of the centerpiece. Image courtesy of and © Becton, Dickinson and Company.

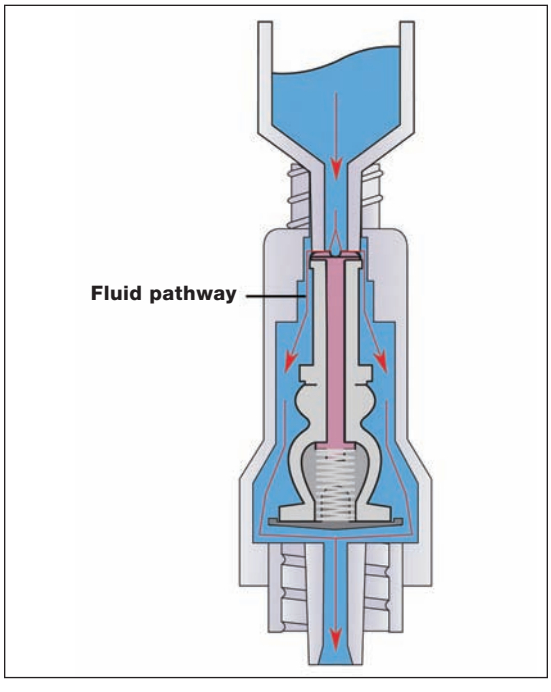

Figure 3. Mechanical valves that have positive displacement direct fluid between the outer housing and the movable centerpiece. Image courtesy of and © Becton, Dickinson and Company.

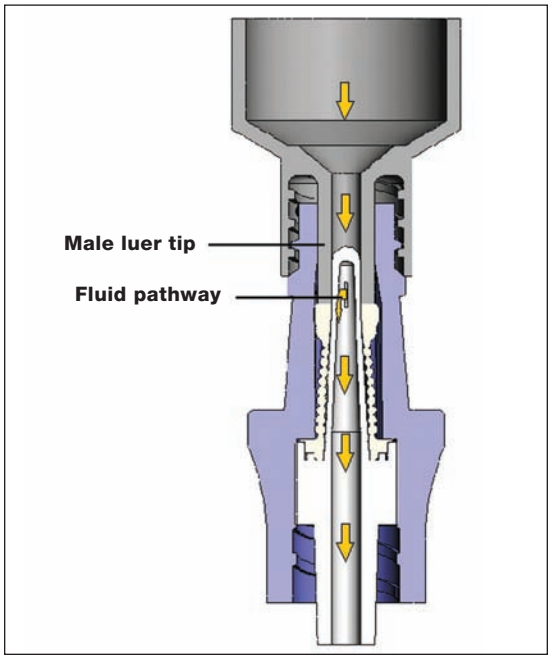

Figure 4. Some mechanical valves contain a reversed internal blunt cannula that connects with the male luer of the IV set or syringe and accepts fluid through its center. Image courtesy of Lynn Hadaway Associates, Inc.

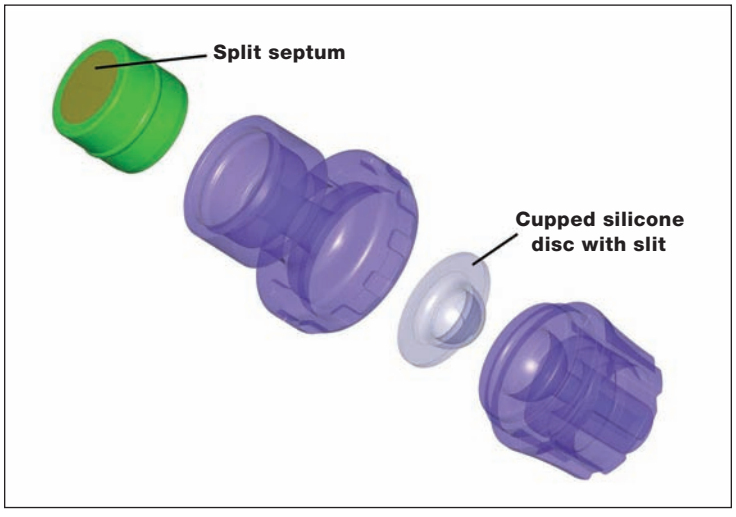

Figure 5. A pressure-sensitive, cupped, slit silicone disk closes automatically when infusion pressure drops, preventing blood reflux into the catheter lumen. Image courtesy of Lynn Hadaway Associates, Inc.

Whether blood refluxes into the catheter lumen is determined by such factors as the way the connector functions and the design of the syringe.[17] All needleless connectors, except for the pressure-sensitive, cupped slit silicone disk, leave an open pathway for blood to reflux into the catheter lumen when an IV set is connected to the catheter. With traditional syringes, filled by the nurse or pharmacy, blood reflux is produced by compression of the rubber gasket on the plunger rod. When the plunger rod is released, the gasket expands, pulling blood into the catheter lumen. Several brands of prefilled syringes are now designed to prevent this type of reflux. (All syringes are single-use items and should never be reconnected to a needleless connector or IV administration set.)

User knowledge deficits. Although it's essential that the user know the correct method for flushing and clamping the needleless connector being used, staff training is often inadequate. Moreover, few studies have investigated the most appropriate methods for cleaning and disinfecting needleless connectors. Self-reports of nurses' practices suggest that 3% to 4% of ICU and medical–surgical nurses do not routinely clean needleless connectors with an antiseptic solution before access.[18,19]

A 2011 survey sent to 4,000 health care workers in clinical practice found that 132 (25.4%) of the 554 respondents did not know the specific type of needleless connector they used with short peripheral catheters and 114 (21.9%) did not know the type they used with central venous catheters.[20] And nearly half of respondents didn't understand the correct way to flush and clamp a catheter with a needleless connector attached, even though it's essential to device performance. Self-reported practices are not the best methods by which to assess clinical practices, but no other data regarding these practices exist.

Inattention to system management. System management involves following scrupulous hygiene practices regarding handwashing and access, limiting manipulation of IV sets and components, and following current practice standards for connector changes.

The most important goal of managing IV administration sets and needleless connectors is to reduce the amount of manipulation as much as possible.

Hand hygiene. A survey of hospital policies among 10 midwestern hospitals found that 80% had written policies calling for hand hygiene prior to inserting a vascular access device (VAD), but only 36% had similar written policies calling for hand hygiene prior to accessing a VAD.[21]

Nonsterile access devices. Needleless systems are two-sided—on one side is the connection surface of the needleless connector, and on the other is the male

Table 1. Needleless Connectors for IV Catheters[a]

Manufacturer, Device	Priming Volume (mL)	Flow Rate (mL/min)	Antimicrobial Agents	Device Color	Type of Connection	Internal Mechanism	MRI Use	Power Injectable	Clamping
Negative fluid displacement									
Baxter Healthcare, Clearlink	0.25	100	No	Clear	Luer lock with IV set or syringe	Mechanical valve	Yes	Not tested	Before set or syringe disconnection
Baxter Healthcare, Interlink	0.2	525 (+/- 25)	No	Clear	Split septum accessed with blunt cannula	None	Yes	Not tested	Before set or syringe disconnection
Baxter Healthcare, V-Link	0.25	100	Yes, silver nanoparticles	Gold	Luer lock with IV set or syringe	Mechanical valve	Yes	Not tested	Before set or syringe disconnection
BD Medical, Q-Syte	0.1	533	No	Clear	Split septum accessed with male luer of IV set or syringe	None	Yes	No	Before set or syringe disconnection
CareFusion, SmartSite	0.11	133	No	White top half, clear bottom half	Luer activated	Mechanical valve	Yes	Yes	Before set or syringe disconnection
ICU Medical, Antimicrobial Clave	0.06	185	Yes, ionic silver	Blue and silver	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before set or syringe disconnection
ICU Medical, Clave	0.06	185	No	Blue	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before set or syringe disconnection
Positive fluid displacement									
B Braun Medical, Caresite	0.22	148–208	No	Clear	Luer lock with IV set or syringe	Mechanical valve	Yes	Yes	ONLY after set or syringe disconnection
B Braun Medical, Ultrasite	0.35	200	No	White	Luer lock with IV set or syringe	Mechanical valve with metal spring	Conditional, must be secured and placed outside the direct imaging area	Yes	ONLY after set or syringe disconnection

B Braun Medical, Ultrasite Ag	0.35	200	Yes, silver	White	Luer lock with IV set or syringe	Mechanical valve with metal spring	Not tested	Yes	ONLY after set or syringe disconnection
CareFusion, MaxGuard	0.28	183	Yes, silver	Blue	Luer lock with IV set or syringe	Mechanical valve	Yes	Yes	ONLY after set or syringe disconnection
CareFusion, MaxPlus Clear	0.28	183	No	Clear outer housing, blue internal mechanism	Luer lock with IV set or syringe	Mechanical valve	Yes	Yes	ONLY after set or syringe disconnection
ICU Medical, CLC2000	0.06	220	No	Blue	Luer activated	Mechanical valve	Tape down, out of field of image; starburst effect may occur	Yes	ONLY after set or syringe disconnection
Neutral fluid displacement									
Baxter Healthcare, One-Link	0.8	100	No	Clear	Luer lock with set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before or after set or syringe disconnection
ICU Medical, Antimicrobial MicroClave	0.04	165	Yes, ionic silver	Blue and silver	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before or after IV set or syringe disconnection
ICU Medical, MicroClave	0.04	165	No	Blue	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before or after IV set or syringe disconnection
ICU Medical, MicroClave Clear	0.04	165	No	Clear	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before or after IV set or syringe disconnection
ICU Medical, Neutron	0.1	100	No	Clear outer housing, blue internal mechanism	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula and a silicone slit valve	Yes	Yes	Before or after IV set or syringe disconnection

Table 1. Continued

Manufacturer, Device	Priming Volume (mL)	Flow Rate (mL/min)	Antimicrobial Agents	Device Color	Type of Connection	Internal Mechanism	MRI Use	Power Injectable	Clamping
Nexus Medical, Nexus TKO-4S	0.10	24–168	No	Green top, clear body	Luer locks to VAD hub; requires addition of another connector	Pressure-sensitive disk with slit opening	Yes	Yes	Before or after IV set or syringe disconnection
Nexus Medical, Nexus TKO-5	0.1	24–168	No	Green top, clear body	Split septum accessed with blunt cannula	Pressure-sensitive silicone disk with slit opening	Yes	Yes	Before or after IV set or syringe disconnection
RyMed Technologies, Invision-Plus	0.027	92	No	White and green	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before or after IV set or syringe disconnection
RyMed Technologies, Invision-Plus EPI (epidural catheters)	0.027	63	No	White and yellow	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Not applicable	Before or after IV set or syringe disconnection
RyMed Technologies, Invision-Plus Junior	0.022	63	No	White and blue	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Not tested	Before or after IV set or syringe disconnection
RyMed Technologies, Invision-Plus RED (arterial catheters)	0.027	92	No	White and red	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before or after IV set or syringe disconnection
RyMed Technologies, Invision-Plus/CS	0.027	92	Yes, chlorhexidine and silver	White and gray	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula	Yes	Yes	Before or after IV set or syringe disconnection
Vygon, Bionector	0.018	170	No	White and green or gray, depending on the distributor	Luer lock with IV set or syringe	Mechanical valve with internal blunt cannula and metal spring	Must be secured and placed outside the direct imaging area	Yes	Before or after IV set or syringe disconnection

MRI = magnetic resonance imaging; VAD = vascular access device.

[a] Table is based on data from manufacturers' Web sites or personal communication with manufacturers' clinical and marketing staff.

luer end of an IV set or syringe. Even if the connector is completely clean, organisms may be introduced from a contaminated IV set or syringe. CDC guidelines call for the use of only sterile devices to access the needleless connector.[8]

Although the male luer end of an intermittent IV set must be protected from contamination between uses, a variety of unsupported practices remain in use. These include leaving the luer end totally uncovered, covering it with the foil package of the alcohol pad, covering it with the tip cap from the flush syringe, or connecting it to the needleless connector higher on the same set (a practice called "looping").[20,22] The alcohol pad package and syringe tip cap are single-use items and are not designed for reuse on the male luer end of the set. No studies have been conducted on the safety of looping.

Frequent manipulation. The most important goal in managing IV administration sets and needleless connectors is to reduce the amount of manipulation as much as possible.[8] When IV administration sets are used for continuous infusion, they should never be disconnected from the catheter hub until it is time to change the set. The IV set should be luer-locked directly to the catheter hub; a needleless connector should not be used. Unfortunately, it has become common practice to attach a needleless connector to the catheter hub and then attach a continuous administration set to the needleless connector. This adds an unnecessary luer-locking connection, with the potential for organisms or air to enter the system if the connection is broken. Furthermore, the presence of a needleless connector in a continuous-infusion system could promote the disconnection of the infusion fluids during patient toileting, bathing, or ambulating. Frequent disconnection increases the risk of contamination and slows patient progress toward therapeutic goals (since while the system is disconnected the patient is not receiving prescribed fluids).

Secondary piggyback medication sets should remain connected to the primary continuous set. When there are no medication incompatibilities, one secondary set can be used for multiple medications using the backpriming method (in which the nurse flushes the secondary administration tubing with the primary IV solution to remove any residual from the first administered medication).[23]

Intermittent IV medication sets are manipulated on both ends with each medication dose. The clinical studies on IV administration sets either did not state that they included intermittent medication sets or specifically stated that these sets were excluded from the study. This means that there are no data on outcomes with the use of intermittent medication sets. Given the absence of data, the Infusion Nursing Standards of Practice recommend that an intermittent administration set should be changed every 24 hours.[23] The 2011 CDC guidelines state that the change interval for an intermittently used IV administration set is an unresolved issue, thus recognizing the absence of data on sets used in this manner.[8]

The interval between connector changes is also a confusing issue. Many manufacturers have tested their needleless connectors for a maximum of seven days or for the number of activations that could be reasonably performed within seven days. The Infusion Nursing Standards of Practice state that the optimal time for changing needleless connectors has not been established.[23] According to CDC guidelines, however, needleless connectors should be changed with the same frequency as continuous IV sets (that is, no more often than every 96 hours).[8] Studies have shown that biofilm reaches a steady state in needleless connectors within five days, at which point it grows at about the same rate as it breaks apart—when clumps of cells detach from it and float into the bloodstream, where they can produce CRBSI.[24]

EVIDENCE OF COMPLICATIONS

Infection. Shortly after their introduction in the early 1990s, needleless connectors were associated with rising rates of CRBSI.[1,2,6] Even within the past few years, there have been reports of CRBSI related to the use of needleless connectors in hospitals and in one long-term care facility.[3,5,7,9,10]

The presence of a needleless connector in a continuous-infusion system could wrongly promote the disconnection of the infusion fluids during patient toileting, bathing, or ambulating.

By contrast, in six randomized controlled clinical trials conducted between 2000 and 2007 in Europe, there was no increase in CRBSI associated with needleless connectors, and in three of those studies CRBSI rates were reduced with needleless connectors.[25-30] There is, however, a significant difference between U.S. practice and that followed in the European studies. In the latter, investigators compared a "traditional open system" (that is, a stopcock placed on the end of each catheter hub) and connectors containing mechanical valves with either negative or positive displacement. Patients were randomly assigned either to use the stopcock alone or to have a needleless connector placed on each opening of the

Table 3. Nursing Interventions to Reduce Complications Associated with Needleless Connectors[8, 17, 20, 23, 37, 41]

Goal	Intervention
To reduce contamination on the connection surface	**Thoroughly scrub the connection surface** for at least 15 seconds before each entry into the system.
To prevent blood reflux caused by gasket compression	**Use the appropriate flushing technique for the type of syringe being used.** Either use a prefilled syringe specifically designed to prevent compression of the plunger gasket or, if using a traditional syringe, leave 0.5 to 1 mL of fluid in the syringe to avoid gasket compression.
To prevent blood reflux caused by disconnection of the IV administration set or syringe	**Use the flushing and clamping sequence appropriate for the particular connector.** For a split-septum connector opened with an external blunt cannula, flush the last mL of solution while withdrawing the cannula to fill the empty space left behind. For a split-septum connector accessed with a male luer tip and all other negative displacement mechanical valve connectors, proceed as follows: • Inject the locking solution and continue to hold pressure on the syringe plunger. • Close the clamp between the connector and catheter. • Disconnect the syringe. For mechanical valve connectors with positive displacement, proceed as follows: • Inject the locking solution. • Disconnect the syringe. • Close the clamp between the connector and catheter. For mechanical valve connectors with neutral displacement, clamp before or after syringe disconnection.
To prevent contamination of the IV administration set	**Protect the ends of all administration sets used for intermittent infusions.** Immediately after disconnecting an administration set to be used for intermittent infusion, aseptically attach a new covering device (for example, an end cap or blunt cannula) to the male luer end of the IV set. Leave the empty IV fluid container attached to the intermittent IV set until the next medication dose is needed. Do NOT • allow either end of the set to remain uncovered, as this would result in a contaminated luer. CDC guidelines call for the use of only sterile devices to access the needleless connector. • attach the male luer end to another injection site on the same set. • cover the male luer end with a used syringe tip cap or with anything that does not have a tight fit, such as the foil package of an alcohol pad. Both products are single-use items and cannot be safely repurposed in this way.

To prevent contamination from excessive use	**Change the intermittent IV administration appropriately,** discarding any set after 24 hours of use or when • blood is visible in the fluid pathway. • either end is found to be uncovered. • contamination is suspected.
To reduce the risk of bloodstream infections	**Change the needleless connector on a central venous catheter as frequently as continuous IV administration sets, usually every 96 hours,** but sooner • if it was disconnected from the catheter hub for any reason. • when there is visible blood or debris inside the connector that cannot be flushed out. • before drawing a blood culture from a central venous catheter. The process to change a needleless connector is as follows: • Close the clamp between the connector and catheter. • Don clean gloves. • Detach the used connector and discard. • Clean the luer-locking threads of the catheter hub with an alcohol pad or a chlorhexidine-and-alcohol combination pad. Allow to dry thoroughly. • Aseptically attach a syringe filled with normal saline to the new connector and prime, leaving the syringe attached. • Aseptically attach the new, primed connector to the catheter hub. • Aspirate for a blood return. If obtained, flush the catheter with the remaining saline. If not obtained, further investigate catheter patency by referring the patient for radiographic studies to confirm catheter tip location or the cause of obstruction.

stopcock. In the United States, it's unusual for stopcocks to be used, except for limited periods during anesthesia and critical care, when they are placed within continuous infusion IV administration sets and not directly attached to a catheter hub.

In the United States, as nurses gained experience and overcame the challenges of using the new needleless systems, it seemed that infection was becoming less pervasive. In 2002, CDC guidelines stated that, when "used according to manufacturers' recommendations, [needleless connectors] do not substantially affect the incidence of CRBSI."[13] But then came numerous reports of CRBSI outbreaks in facilities that used needleless systems.[5,9] In 2008, the Society for Healthcare Epidemiology of America released a compendium of strategies to prevent CRBSIs in hospitals. They recommended that needleless connector use be preceded by a thorough assessment of risks and benefits, as well as education on the proper use of "positive-pressure needleless connectors with mechanical valves."[31]

New disinfecting technology. Recently, a new technology, the Site-Scrub isopropyl alcohol device (Bard Access Systems), was introduced to clean needleless connectors. A rigid plastic cap containing small finger-like sponges saturated with 70% isopropyl alcohol, the device can be positioned on top of the needleless connector, stopcock, or catheter hub. Rotation of the cap allows the sponges to clean the surfaces, including intraluminal surfaces of the stopcock or catheter hub. Clinical studies of this device are ongoing and findings are not yet available.

Another type of device in this category is the disinfection or protection cap. The SwabCap (Excelsior Medical), Curos Port Protector (Ivera Medical), EffectIV-Cap (Hospira), and DualCap (Catheter

Connections) are rigid plastic caps containing a round sponge saturated with 70% isopropyl alcohol. They are placed over the needleless connector after use and allowed to remain in place until the next use. The alcohol saturates the surface, killing organisms. The cap remains in place between uses to prevent environmental soiling. A recent clinical study of protection caps used with peripherally inserted central catheters (PICCs) found a significant reduction in intraluminal contamination and a lower density of bacteria with their use.[32] A 2012 before-and-after study of these protection caps demonstrated a significant reduction in CRBSIs. Infection rates declined from 2.3 per 1,000 catheter days during the manual scrub period to 0.3 per 1,000 catheter days during the period in which the protection caps were used.[33]

These protection caps render the connection surface clean, thereby eliminating the need for an initial scrubbing, but they are not intended to replace all scrubbing of the needleless connection surface. A single medication may require three or four connections and disconnections. So, while the first scrubbing can be eliminated, a thorough surface scrub should precede all additional attachments of a set or syringe.

Because it can confuse clinicians and lead to negative outcomes, the use of multiple brands or types of connectors in one facility is discouraged.

Catheter lumen occlusion. Early on, nurses suspected that the rising need for thrombolytic agents in patients receiving IV therapy was associated with the use of large blunt cannulas and the moving internal components of mechanical valves. Evidence of catheter lumen occlusion associated with needleless connectors is limited to sequential cohort studies[4, 11] and two randomized clinical trials (see Table 2 at http://links.lww.com/AJN/A43).[34, 35] Positive displacement connectors were developed to address the issue of occlusion, but the effect of such devices in reducing occlusion is documented only in laboratory testing by device manufacturers.

Controversies over flushing and locking practices. Catheter lumen occlusion may be linked to improper flushing and locking techniques. All VADs used for intermittent infusions must be flushed and locked after each use. Catheters should be flushed with 0.9% sodium chloride (normal saline) solution to assess patency and prevent contact between incompatible medications.[23] Locking a catheter creates a column of fluid inside the lumen to maintain patency. Manufacturers of positive and neutral displacement needleless connectors instruct clinicians to use normal saline to lock the catheter instead of the heparin lock solution. Clinical evidence for this practice, however, is limited to two recent studies that found increased lumen occlusion when normal saline was used as the locking solution.[34, 35] In one of these studies, the 6% occlusion rate associated with the normal saline lock (versus the 0% occlusion rate associated with the heparinized saline lock) made it financially unfeasible for the hospital to eliminate the use of the heparinized saline lock, given that the per PICC replacement cost was $1,900.[34] A recent systematic literature review compared outcomes in clinical studies in which central venous catheter patency was maintained with heparin, saline, or urokinase flushes; continuous heparin; heparin-coated catheters; or "pressure caps" (needleless connectors with positive displacement). The authors concluded that published studies comparing interventions to prevent occlusion were "low quality," and that current evidence is insufficient to support any particular means of maintaining patency.[36]

Because heparin is incompatible with many medications, all VADs require normal saline to be used between administrations to prevent contact and formation of intraluminal precipitate.[37] Two meta-analyses of studies involving short peripheral catheters found that catheter outcomes were virtually the same whether normal saline or a heparin locking solution were used.[38, 39] For these reasons, the 2011 Infusion Nursing Standards of Practice recommend using normal saline as the locking solution for such catheters.[23] However, because of the risks associated with the insertion of central venous catheters, a higher level of support is required before a new standard can be established for their use. According to the 2011 Infusion Nursing Standards of Practice, a heparin lock solution (10 units per mL) remains the national standard of practice for locking all central venous catheters.[23]

In vitro studies have shown that heparin enhances the growth of biofilm, but no clinical studies have investigated the potential link between heparin use and increased incidence of CRBSI.[40] Before we abandon the use of heparin locking solutions, more outcome data are needed. Studies of alternative locking solutions that combine antiinfective and anticoagulation properties are ongoing, but at this time these solutions are not commercially available in the United States.

NURSING INTERVENTIONS

To reduce the risk of infection and occlusion, it is imperative that staff be trained in the proper use of needleless connectors and syringes (Table 3 [8, 17, 20, 23, 37, 41]).

Written policies and procedures should address the specific types of connectors in use at the facility and incorporate hand hygiene for all procedures requiring injection or infusion through any type of VAD. Because it can confuse clinicians and lead to negative outcomes, the use of multiple brands or types of connectors in one facility is discouraged.[20]

Although needleless connectors are supplied in a sterile package, removing a connector from the package and attaching it to a catheter hub renders it contaminated on the external surface. This means that even newly attached connectors require a thorough scrubbing. The Joint Commission now requires an established protocol for disinfecting catheter hubs and injection ports before access.[42] In vitro studies have shown that longer scrubbing times reduce the load of microorganisms on the connection surface. With most needleless connectors, a three-to-five-second scrub with isopropyl alcohol is not sufficient to prevent organisms from entering the system.[43] In most needleless systems, a vigorous 15-second scrub of the connection surfaces with a swab pad treated with 70% isopropyl alcohol greatly reduces but does not eliminate the number of microorganisms.[41] There are few clinical studies examining the impact of cleaning agents or manual techniques on reduction of CRBSI, but these in vitro studies point to the importance of cleaning the connector before each IV set or syringe connection, which requires the use of up to four swab pads per medication.

It should be noted that a recent study of one needleless system (Interlink IV Access System, Baxter) found that a vigorous five-second scrub was sufficient to clean its external split-septum needleless connectors.[44] New connectors were either contaminated in vitro or connected to catheters of patients in critical care and then cultured either after no scrubbing or after a five-, 10-, 15-, or 30-second vigorous scrub with a 70% isopropyl alcohol swab pad. Of the 71 connectors taken from patient catheters and scrubbed for five seconds, only one (1.4%) had microbial growth. Connectors contaminated in vitro with 10^3 or 10^5 colony-forming units (CFUs) of *Staphylococcus epidermidis* were also found to be sterile after a scrubbing of approximately five seconds. Of connectors contaminated with 10^8 CFUs, two (20%) of 10 remained contaminated after a five-second scrub but were sterile after a scrub of about 10 seconds.

The intermittent IV set usually remains connected for 30 to 60 minutes and is in contact with linens, clothing, and other environmental debris. After each disconnection, there could be blood-tinged fluid remaining on the connection surface. Both of these factors make repeat cleaning necessary.

Clinicians commonly change needleless connectors immediately after drawing a blood sample, but there is no evidence to support this practice. Blood is aspirated to assess catheter patency before each dose of medication is administered; it's possible that this may bring blood into the needleless connector. Studies have shown that false-positive blood cultures may be obtained when blood is drawn from central venous catheters through contaminated connectors.[45, 46] This suggests that needleless connectors should be changed before, not after, a blood sample is drawn.[23, 45]

Clinicians should assess the amount of pressure a needleless connector can tolerate before using it for rapid-flow infusion (3 to 5 mL per second), which may be required in emergent procedures or in radiology. If anything obstructs the fluid flow, rapid infusion may produce pressures beyond those the connector can withstand. The connector's product information should state the amount of pressure it tolerates.

PRODUCT DECISIONS

Health care facilities must give adequate consideration to needleless connectors and make policy decisions appropriate for their patient populations, staff, and IV practices. Product decisions should be based on a careful analysis of risks and benefits. When product changes are made, it is essential to monitor rates of infection and occlusion because so often product changes are associated with a rise in incidence of CRBSI.

While we cannot determine the degree of risk associated with each type of needleless connector based on available evidence, we can greatly reduce known complications of infection and catheter lumen occlusion by becoming knowledgeable about and developing the skills necessary to use available connectors safely. This means that facilities need to assess staff adherence to established protocols. Well-designed clinical studies are needed to further inform practice. ▼

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