# The Promise of Novel Technology for the Prevention of Intravascular Device–Related Bloodstream Infection. II. Long-Term Devices

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**Intravascular devices (IVDs) are widely used for vascular access but are associated with a substantial risk of IVD-related bloodstream infection (BSI). The development of novel technologies based on our understanding of pathogenesis promises a quantum reduction in IVD-related infections in an era of growing nursing shortage. Infections of long-term IVDs (most are in place for ⩾10 days), including cuffed and tunneled central venous catheters (CVCs), implanted subcutaneous central venous ports, and peripherally inserted central catheters (PICCs), are primarily due to microorganisms that gain access to the catheter hub and lumen. Novel securement devices and antibiotic lock solutions have been shown to reduce the risk of IVD-related BSI in prospective randomized trials. The challenge for the future will be to identify new preventative technologies and to begin to more-widely adapt those technologies that have already been shown to be efficacious and cost effective.**

Long-term intravascular devices (IVDs), such as cuffed Hickman- and Broviac-type catheters, cuffed hemodialysis central venous catheters (CVCs), subcutaneous central venous ports, and peripherally inserted central catheters (PICCs), are indispensable for the care of patients who require prolonged parenteral nutrition or frequent transfusion of blood products or intravenous medications. Historically, the risk of infection associated with the use of these devices has been expressed as the number of BSIs per 100 devices used. However, the Centers for Disease Control and Prevention (CDC) now recommends that rates of IVD-related (IVDR) bloodstream infection (BSI) be expressed per 1000 IVD-days. This recommendation is logical, because it takes into account widely varying risks of IVDR BSI over time for different types of IVDs—for example, in general, although the rates of IVDR BSI per 100 IVDs used are usually higher for long-term devices, the risk per 1000 IVD-days is usually considerably lower than that for short-term IVDs, such as noncuffed, nontunneled CVCs (table 1) [1, 2].

The risk of IVDR infection, its pathogenesis, general strategies for prevention, and the promise of novel technology engineered to reduce the risk of IVDR BSIs associated with short-term IVDs were reviewed in the first part of this 2-part series [3]. The present article complements and completes our review by examining novel technology for the prevention of IVDR BSIs associated with long-term devices.

## PATHOGENESIS

As described in the first part of our review [3], microorganisms usually must first adhere to the intraluminal or extraluminal surface of the IVD before infection of the bloodstream can occur. In contrast to the situation for short-term IVDs, contamination of the catheter hub and lumen appears to be the predominant mode of BSI associated with long-term, permanent IVDs (most of which have been in place for ⩾10 days) [4–8]. In general, basic infection-control practices that have been shown to be effective for the prevention of IVDR BSIs associated with short-term IVDs (most of which have been in

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**Table 2. Meta-analyses of prospective, randomized clinical trials of novel technologies for prevention of intravenous device (IVD)–related (IVDR) bloodstream infections (BSIs) involving long-term IVDs.**

| | | No. of IVDR BSIs/ no. of IVDs studied | | | |
|---|---|---|---|---|---|
| Technology | No. of trials | Study technology | Control device | RR (95% CI) | P |
| Silver-impregnated cuff | 3 | 40/181 | 43/205 | 1.05 (0 66–1 71) | .80 |
| Securement device | 2 | 1/144 | 13/135 | 0.07 (0 00–0.78) | <.01 |
| Chlorhexidine sponge dressing | 1 | 12/314 | 11/341 | 1 18 (0.39–4 06) | 83 |
| Silver-impregnated CVC | 1 | 4/47 | 6/44 | 0.62 (0.05–4 12) | .51 |
| Antibiotic lock | 6 | 13/257 | 40/267 | 0 34 (0 18–0 62) | < 01 |
| Prophylactic thrombolysis | 2 | 75/396 | 97/393 | 0.77 (0.59–1.00) | .06 |

**NOTE.** Data are only from prospective, randomized trials that involved long-term, centrally placed IVDs (i.e., cuffed and tunneled central venous catheters [CVCs], peripherally inserted central catheters, and subcutaneous central venous ports) and that reported IVDR BSI as an outcome.

## Novel Securement Devices

Recently, a novel sutureless device for securing noncuffed vascular catheters became available (StatLock; Venetec International). In a randomized trial of the device, premature loss of pediatric and adult PICCs due to accidental extrusion and PICC-associated thrombosis were significantly reduced [26, 27]. Furthermore, in an adult PICC study population, the incidence of catheter-related BSI was significantly reduced with the use of the novel securement device (table 2) [26]. The potential for this device to reduce infection may derive from the elimination of festering skin suture wounds that are contiguous to the newly inserted catheter and from minimization of the to-and-fro pistoning of the catheter, which may promote invasion of the tract by cutaneous microorganisms through capillary action [28].

## Novel Dressings

Garland et al. [29] examined the utility of the chlorhexidine sponge dressing in a multicenter trial that involved 6 neonatal intensive care units; 75% of the catheters studied were PICCs. The study showed that the novel dressing, replaced weekly, yielded results similar to those of gauze and tape combined with periodic cutaneous disinfection with 10% povidone-iodine, with regard to the prevention of cutaneous colonization and catheter-related BSI (table 2). Although they were well tolerated by full-term infants, use of the chlorhexidine dressing in low-birth-weight (i.e., <1000 g) neonates was associated with a 15% incidence of dermatotoxicity. Additional studies are required before the chlorhexidine sponge dressing can be recommended for routine use with long-term IVDs.

## Silver-Coated Catheters

In contrast to the extensive research that has gone into the study of novel surfaces for short-term devices, very little data have been published on novel surfaces for long-term devices. In a single study of long-term, tunneled hemodialysis catheters, Trerotola et al. [30] found no difference between silver-coated catheters and control catheters with regard to the rates of BSI (table 2).

## Antibiotic Lock Solutions

The prophylactic use of systemic antibiotics at the time of IVD insertion or implantation has not proven to be effective in reducing the incidence of IVDR BSI [31–33] and is strongly discouraged in the new Hospital Infection Control Practices Advisory Committee (HICPAC) draft guideline [9]. However, studies of continuous infusion of vancomycin incorporated into total parenteral nutrition admixtures have shown reduced rates of coagulase-negative staphylococcal BSI in low-birth-weight infants [34, 35]. Unfortunately, this form of prophylaxis results in prolonged low levels of vancomycin in blood and tissue, a milieu conducive to promoting vancomycin resistance.

The antibiotic lock is a novel form of local antibiotic prophylaxis in which an antibiotic solution is instilled into the catheter lumen and allowed to dwell for a defined period of time (usually 6–12 h), after which it is removed. Messing et al. [36] first examined the utility of antibiotic lock solutions for the treatment of device-related BSIs associated with long-term IVDs. Subsequent small, uncontrolled studies involving long-term CVCs that were infected with gram-positive cocci (other than *Staphylococcus aureus*) or gram-negative bacilli have also shown benefit [36–41]. The success of continuous vancomycin infusions in the prevention of IVDR BSIs, as well as

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**Selected Quotes from Dr. Maki's Presentation**

Dr. Maki states "Technology is the application of basic science to better our lives."

"I feel positive about the StatLock because there is good data that it works. It has two huge advantages.

One, it prevents pistoning back and forth. I detest having to put a suture on here [slide of catheter hub] to immobilize this [the catheter hub]. That suture festers and is a huge reservoir of organisms and this obviates the need to do that. It's a very clever idea. Its far more effective at preventing pistoning, that I am convinced is a major risk factor promoting invasion of organisms down the [catheter] track.

The second advantage is that it eliminates an important sharp in the field that somebody can stick themselves. I bet I have seen at least a dozen house officers stick themselves sewing in a catheter. After the catheter's been put in, now you put your sutures in, they're particularly rookies, they haven't been putting them in [very long], they end up sticking themselves. I want to take the darned thing away from them and do it, but they have to learn how to do it, and no matter how careful, people end up sticking themselves. This obviates that risk.

The evidence is clear from the studies that have been done, is that the StatLock will significantly reduce premature loss of PICCs, and will significantly reduce the risk of infection. So I think it is a major advance."

Dr. Maki further states "Our goal is to constantly apply what works...using solid data that shows a new technology is safe and works, and ideally is cost effective."

During the post-presentation Question and Answer period, a nurse asked:
"I have a question about a typical ICU patient who as a triple lumen, they're high risk for bloodstream infection, however they're dependent on the line, you can't stop them, you can't [heparin/saline] lock them, what would you suggest with this type of patient?"

Dr. Maki's reply: " For the ICU setting, I'm convinced that the best thing is Chlorhexidine on skin; using an anti-infective catheter or a biopatch or both; and a good securement device. And obviously maximal barrier precautions when its [the catheter] put in the first time. Using all, or combinations of those, I don't think there's any question that we'll get substantial benefit. A lot of infections are extra luminal down the track. We need to have strategies that prevent organisms from going down that track when is pistons or moves. I think that's going to give us much more bang for the buck."