

Seven years of zero central-line-associated bloodstream infections

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Abstract

Many hospitals feel they have adequately addressed the issue of bloodstream infection prevention if they mandate a conventional central-line bundle. Yet central-line-associated bloodstream infections (CLABSIs) persist as a major problem in health care today. Sutter Roseville Medical Center (SRMC) in Roseville, California has achieved unprecedented success in eliminating CLABSIs by approaching the issue more broadly than most institutions. The SRMC bundle is more comprehensive and innovative than conventional bundles. It is applied by a dedicated vascular access team, and the team's efforts are supported by a safety-first culture enforced by senior leadership. All of this is accomplished without losing sight of the financial implications of infection prevention. SRMC is committed to substantial up-front investments in patient safety to realise long-term cost-effectiveness.

Key words: CLABSI ■ Central-line bundle ■ Biofilm ■ Extraluminal ■ Intraluminal ■ PICC ■ Culture of safety

Central-line bundles are an essential strategy for maximising patient safety throughout the course of IV therapy. In particular, bundles are crucial for preventing central-line-associated bloodstream infections (CLABSIs), which are fatal in 12–25% of cases (Mermel, 2000; O'Grady et al, 2011). However, bundles can give hospitals a false sense of security.

Bundles group together evidenced-based practices and technologies and other best practices. Institutions often feel that if they have a widely accepted practice or technology in their bundle in all the usual categories (e.g. skin preparation, full barrier precautions), they have done all they can to prevent bloodstream infections. This assumption seems reasonable at first glance—but it is a major reason that CLABSIs persist as a major threat to patient wellbeing in hospital settings.

Sutter Roseville Medical Center (SRMC) in Roseville, California, USA has taken a broader approach to CLABSI prevention. Outcomes reflect the effectiveness of this approach. In January 2006, SRMC implemented a central-line bundle with seven primary elements (*Figure 1*). In the nearly 7 years (as of 2012), no SRMC patient has suffered a CLABSI attributable

to peripherally inserted central catheters (PICC) inserted by the PICC team.

This success is owing to several interrelated elements. First, the central-line bundle goes beyond traditional bundles in several ways. For example, few central-line bundles address the issue of IV needleless connectors. Several of the most commonly used connector designs are associated with increased CLABSI risk, revealed by the literature search conducted before formulating the bundle. The SRMC bundle includes the use of what was researched as being the safest connector design available.

Secondly, the SRMC bundle is more comprehensive than most others. Some institutions try to find some cost/benefit middle ground that improves but does not maximise patient safety. That is, they add some preventive practices/technologies but not every one that could make a difference, in the name of saving costs. We felt this approach increases CLABSI risk, because bacteria ingress is insidious. If all possible avenues for ingress are not addressed, infections are likely to occur.

To look at this another way, many institutions claim to have a goal of zero CLABSIs. However, such a goal has little meaning if an institution is not willing to do everything in its power to prevent infections. SRMC had a goal of zero CLABSIs and everyone from senior administrators to frontline nursing staff took that goal to heart. This is not to say that cost was not a consideration. The PICC team did believe a comprehensive bundle would pay for itself in avoided infections and their associated costs. According to a frequently cited estimate, CLABSIs cost from £21300 and £35 000 to treat (Rello et al, 2000; Institute for Healthcare Improvement, 2011) so avoiding infections can save an institution hundreds of thousands of pounds annually.

This leads to the third point: the human factors. A bundle by itself is basically a collection of policies defining best practice. The human beings involved must put those policies into action. Will all clinicians faithfully carry out those policies as written? If nurses spot physicians varying from the mandated insertion/maintenance procedures, do they have the authority—which can only be granted by senior leadership—to stop those procedures by physicians? Has senior leadership made it known in other ways that patient safety has priority over all other concerns?

Fourth, even a well-designed bundle, including well-intentioned clinicians, may not result in success if the clinician has not achieved an optimal clinical and technical skill set. At SRMC, the commitment of the PICC team to the zero-CLABSI goal has been an indispensable factor in this achievement. The team takes complete responsibility for all central lines. This encompasses assessment, line insertion,

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Bundle Descriptors	2005	2006	2007	2008	2009	2010	2011
Average Monthly PICC Volume	60	131	189	187	159	160	158
Yearly PICC Volume	767	1570	2266	2243	1904	1929	1898
Insertion Success Rate	92%	98%	98%				
Interventional Radiology Rate	8%	2%	1.5%	1%			
Maximum Barrier	PICC team only	All central lines	All central lines				
Insertion Site	Antecubital	Upper Arm, Basilic Vein	Upper Arm, Basilic Vein (preferred)				
Technique	Traditional/Modified Seldinger	100% Ultrasound Guided	100% Ultrasound Guided				
Dressing	24 hour pressure gauze dressing then weekly	No pressure dressing (exception excessive bleeding) Weekly dressing change	No pressure dressing (exception excessive bleeding) Weekly dressing change				
Skin Preparation	Alchocol/Betadine	Chlorhexidine	Chlorhexidine				
Protective disk with CHG	Inconsistent	Consistent	Consistent				
Line Securement device	Inconsistent	Consistent	Consistent				
Connector	Positive Pressure Connector	Neutral Connector	Neutral Connector				
Flushing Protocol	Normal Saline followed by Heparin (positive pressure flush)	Flush 10ml NS every 8 hours and PRN use (push/pause technique)	Flush 10ml NS every 8 hours and PRN use (push/pause technique)				
RN Training	Annual In-Service Day	One-on-One Training at the bedside	One-on-One Training ,Vasc. Access Class., housewide ongoing education				
Line Monitoring	Completed q week with dressing change	Completed daily during site checks.	Completed daily during site checks.				

Figure 1. Bundle components demonstrating SRMC team's consistency in practice and bundle compliance since 2006. The red shows the time period where any problems were identified. The yellow is when the bundle was implemented and every component was evaluated with 'caution' over the year. The green is where the team saw consistency and strong outcomes.

care and maintenance, weekly dressing changes, and line discontinuation.

The PICC team also assists physicians with centrally inserted central-catheter placement. This includes setting up a maximal barrier field, and completing the appropriate dressing/securement of the line post insertion. This is another example of how the team takes responsibility for bundle compliance specifically related to pre-insertion preparation, post-insertion securement, dressings, biopatch, and accurate documentation for all central lines. It demonstrates that the PICC team has gone beyond nurse empowerment to actual collaboration with physicians (which they appreciate because the team's assistance with central lines saves them time).

Many institutions have discontinued their vascular access teams in a move to cut or streamline costs. In the author's view, this compromises their ability to eliminate bloodstream infections.

Comparison between SRMC bundle and conventional bundles

The SRMC central-line bundle is based on seven elements. It is the PICC team's view that each of these elements is critical to SRMC's zero-CLABSI rate. The team believes success is replicable by other institutions, but only if they adopt this approach in its entirety rather than picking and choosing aspects that suit them. Because CLABSI prevention

is a question of eliminating every conceivable opportunity for bacteria ingress, success requires a combination of best practices, best technologies, and committed, well-trained clinicians.

There are two refinements to these ideas that should also be mentioned:

- **Ease-of-use.** Because of both economic and social factors, nurses assume a heavier workload as there are a higher level of patient acuities than in the past. If pressed by other duties, even conscientious nurses may be tempted to 'short-cut' or skip entirely preventive practices that are too time-consuming. Hospitals are more likely to get full consistent compliance with central-line policies if they develop policies that are 'nurse-friendly' and efficient to follow. This aligns with choosing technologies that are also nurse-friendly
- **Failure-proof.** A related concept concerns choosing technologies that will work as designed, without complicated routines that need to be followed. For example, the PICC team chose a simple securement device that is the industry standard and a failure-resistant connector type.

The SRMC central-line bundle consists of three extra-luminal elements, three intraluminal elements and one other key provision.

Practice 1 (extra-luminal): maximum barrier precaution kit and related education

A team of nurses, physicians, infection control staff, and

materials management staff worked together to devise the kit. They made sure that each individual component followed recommendations by the federal Centers for Disease Control and Prevention (CDC). For antiseptic purposes, the kit includes skin-preparation solution containing the broad-spectrum antiseptic chlorhexidine gluconate (CHG) and a sponge that dispenses CHG. To protect the patient, there is a full body drape. A cap, mask, and gown for the clinician prevent bacterial transfer between patient and clinician. The PICC team also provides in-service education on both the kit's contents and their use.

The combined purpose of the components is to protect the patient by creating an aseptic environment for catheter insertion, since an invasive procedure increases the opportunity for bacterial ingress. The point of putting all the components in a kit as opposed to making them available separately is to ensure that all components are available when and where needed.

Prior to composing the kit, the PICC team had investigated concordance with maximum barrier precautions at SRMC. The team found that while the PICC team was consistently compliant, physicians and critical care nurses were not. Reasons for non-compliance included lack of knowledge about what the policy included and where the supplies were located, as well as time pressures. Besides inspiring the kit itself, the investigation provoked the team to support its policy with in-service education. This helped all clinical staff understand the importance of full compliance as well as how to properly use all kit components.

Contrast with conventional bundles

Because of their endorsement by the CDC and major organisations dedicated to infection prevention, maximum barrier precautions are a standard element in central-line bundles. Putting bundle supplies in a kit is a common, but not universal, practice. It is not part of the SHEA or Institute for Healthcare Improvement recommendations for maximum barrier precautions (although SHEA does recommend putting bundle items in a kit. It also recommends educating relevant clinicians about central-line practices and CLABSI prevention in general) (Marschall et al, 2008). Both the kit and the education provided by the PICC team are examples of how SRMC prioritises patient safety by going beyond minimum recommendations.

Practice 2 (extra-luminal): ultrasound-guided PICC placement

Before January 2006, when the bundle was implemented, PICCs were inserted with percutaneous, antecubital placement. The PICC team used the modified Seldinger Technique but not ultrasound guidance. Centrally inserted central-catheter-line insertion was carried out by clinicians relying on external anatomical landmarks. Normal human anatomical variances mean landmarks cannot be trusted for guidance in vascular selection and device insertion, and their use results in complication rates exceeding 15% including inadvertent lung and artery puncture, nerve damage, and subsequent chronic pain syndromes. PICCs are now placed in the upper arm because studies show there are far fewer bacteria in this

location (Weinstein, 1991; Safdar et al, 2004). The PICC team uses ultrasound guidance during placement, and the basilic vein is the vein of choice.

Contrast with conventional bundles

The SRMC PICC team's choice of insertion site is consistent with both SHEA and IHI recommendations (Marschall et al, 2008; Institute for Healthcare Improvement, 2011). Neither SHEA nor IHI mention ultrasound guidance, but the author's literature review revealed that this technique increases accuracy, thereby reducing placement attempts. Making fewer attempts improves patient comfort and reduces insertion-related complications such as insertion trauma. Because ultrasound guidance has been shown to save costs, it is another example of how clinical and financial considerations often complement one another, at least in the long term (Anstett et al, 2003; Moureau, 2006).

Practice 3 (extra-luminal): revised central-line dressing kit

As with maximum barrier precautions, the point of a kit is to have all supplies necessary for policy compliance available at the site where they are used. As per SRMC's current central-line dressing change policy, the kit contains the following:

- Swab sticks with a blend of isopropyl alcohol and CHG
- StatLock® Securement Devices (Bard Access Systems)
- CHG skin prep
- BIOPATCH® Protective Disk with CHG (Ethicon).

The SRMC policy formerly included a 24-hour gauze pressure dressing. The team decided to delete it because it had the drawback of potentially accommodating bacteria without providing any antimicrobial benefits.

Contrast with conventional bundles

CHG for skin antiseptics is almost universally recommended in the US, including by SHEA and IHI (Marschall et al, 2008; IHI, 2011). Neither organisation mentions securement devices as part of their basic recommendations. The PICC team uses them because considerable evidence shows they help prevent catheter migration, insertion site trauma, and extra-luminal migration of bacteria (Yamamoto, 2002).

CDC and SHEA recommend the protective disk with CHG but only at institutions where high CLABSI rates persist despite adoption of basic preventive practices (Marschall et al, 2008). The PICC team uses the disk routinely because it is supported by evidence and the concept behind it—ongoing antiseptics at the insertion site—is sound (Rohrer et al, 2010). When placed around the catheter insertion site, the foam disk secretes CHG. The protection lasts up to 7 days, providing antiseptics between dressing changes (O'Grady et al, 2011).

Practice 4 (intraluminal): zero displacement IV connector

The PICC team at SRMC mandates use of a zero fluid displacement IV needleless connector. The SRMC team uses InVision-Plus® (RyMed Technologies). Previously, a positive-pressure connector was used.

Contrast with conventional bundles

The CDC, IHI, and SHEA do not generally cover the

connector issue in their recommendations (though the US Food & Drug Administration has issued a warning about potential problems with positive-pressure connectors). SHEA advises against the use of positive displacement connectors before a thorough assessment of risks, benefits and education regarding proper use. This is because of their association with higher CLABSI rates. The literature clearly associates positive displacement, negative displacement, and split septum connectors—all of which are widely used—with higher rates of CLABSIs (Jarvis et al, 2009).

The lower CLABSI risk of zero-displacement connectors compared with other connector types is thought to originate in the simplicity of the former's design and its ease of use (Jarvis, 2010). Other connector designs have such problematic features as torturous fluid pathways with dead spaces. This makes it hard to flush them clean and creates surfaces to which blood residue can adhere. They also have internal moving parts to which blood can stick. That residue leads to fibrin build-up, a precursor to bacteria colonisation and increased CLABSI risk (Jarvis, 2010).

Many connector designs, including the positive displacement connector formerly used at SRMC, are subject to blood reflux—a backflow of blood into the connector that occurs when tubing or a syringe is either attached or disconnected. Blood reflux can be prevented but only if nurses execute a several-step process called a clamping sequence. Positive and negative displacement connectors each require a different clamping sequence. If the nurse does not remember the proper sequence for the connector type or does not know what kind of connector is being used—a common occurrence—the fluid pathway can become coated with blood (Jarvis, 2010).

The zero-displacement connector does not have any of the aforementioned design issues (Jarvis, 2010). It has a straight fluid pathway with no dead spaces and no moving parts. No blood reflux occurs whether tubing or a syringe is connected or disconnected from the connector. Therefore, no clamping sequence is required, so nurses are not burdened with having to remember the proper one (Macklin et al, 2010). Two of the team's basic principles in designing the bundle were ease-of-use and failure-proof. Use of the zero-displacement connector is consistent with this philosophy.

Practice 5 (intraluminal): consistent IV connector disinfection

It is standard practice in hospitals to disinfect the hubs of IV connectors before accessing the connector to deliver fluids or draw blood. Generally, an evidence-based method known as 'scrub the hub' is employed. The same method is employed at SRMC but it is supported by education and also closely supervised by nurses.

Contrast with conventional bundles

SHEA recommends disinfection prior to line access (Marshall et al, 2008). The USA's Joint Commission, which accredits hospitals, also requires that hospitals have a standardised protocol for disinfecting connectors before accessing IV lines (The Joint Commission, 2012). While most hospitals probably use 'scrub the hub' for this purpose, the PICC team at SRMC did not feel it was sufficient just to have it in the policy, because

the method must be performed precisely to achieve proper disinfection. The method is widely believed to be subject to variance and non-compliance, as some studies also confirm (O'Grady et al, 2011).

When connectors are not thoroughly disinfected beforehand, the act of line access can introduce bacteria into the connector's fluid pathway, adding to CLABSI risk. The ongoing education and supervision at SRMC helps mitigate this problem.

Practice 6 (intraluminal): Standardised catheter flushing protocol

SRMC central-line catheters are flushed with saline only, with the exception of ports and dialysis catheters (those are flushed with both saline and heparin). Specifically, the PICC team flushes the catheters with 10 ml of normal saline every 8 hours (or more frequently if needed) to keep them clear of fibrin buildup/blood residue (see Practice 4 for more discussion of this issue). The team also flushes central-line catheters with 20 ml of saline post blood draw.

The flushing policy mandates that all catheter lumens be checked for patency before they are used. Catheters that fail or do not have a patent blood return are evaluated to determine if patency can be re-established through interventions. The PICC team supports the flushing protocol with education in the form of a colourful educational card placed on every medication cart in every nursing station. The card relates the policy details as they pertain to each type of catheter.

Contrast with conventional bundles

While not specifically mentioned by SHEA or IHI in their central-line bundles, saline-only flushing protocols are commonplace. SRMC has gone a step beyond with education cards. Equally importantly, the connector used by the team supports its flushing policy because it eliminates the chance of blood residue/fibrin build-up even before flushing takes place (Jarvis, 2010; Macklin et al, 2010).

Practice 7: daily monitoring of all central lines

The PICC team assesses its lines daily for multiple purposes. The assessment is part of the SRMC's ongoing supervision of nursing practice in general and bundle compliance specifically. It also yields the information the PICC needs to respond if trends are spotted that could compromise patients' wellbeing.

To assist in this practice, SRMC developed a data collection tool that reveals issues with a particular patient's catheter, a nurse's placement technique, or catheter-related complications. It can also identify problems related to a particular nursing unit.

Contrast with conventional bundles

Daily monitoring of this sort is not mentioned in the central-line practices advocated by IHI or SHEA.

Conclusion

Many hospitals will recognise aspects of their own central-line practices in the SRMC bundle. Much of what is done is standard medical practice. Some of the practices that are less than conventional, are only so by a matter of degree. That is, they are the product of a more thorough than usual application of a generally accepted principle.

It is important to understand that because of the insidiousness of bacterial ingress, a bundle that employs any policy or device that is not maximally preventive is itself a veritable risk factor for CLABSIs. Simply using a positive or negative displacement IV connector, even when surrounded by impeccable preventive practices, may be enough to substantially increase CLABSI risk.

It is crucial to recognise that a bundle that replicates SRMC's might be insufficient if it was not executed by a skilled vascular access team and if that team was not supported by administrators who emphasised patient safety over all other considerations. Clinicians, materials managers, pharmacists, and every other staff member whose duties impact IV therapy in some way must know unequivocally that senior leadership always supports them to put patient safety first.

SRMC has a patients-first culture. It is not an add-on to the central-line bundle, it is the context in which that bundle occurs. It is also where other institutions should begin if their goal is to eliminate CLABSIs.

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KEY POINTS

- The experience of Sutter Roseville Medical Center (SRMC) demonstrates that hospitals may need to expand their central-line bundles beyond the conventional bundle 'categories' if they are to achieve a goal of zero central-line-associated bloodstream infections (CLABSIs)
- The use of catheter stabilisation devices and zero-displacement IV connectors are examples of unusual bundle elements that may have a profound effect on preventing CLABSIs
- The education and close supervision SRMC mandates to support its IV connector disinfection protocol is an example of a policy that goes beyond what most hospitals require, with a potentially high impact on CLABSI prevention
- By itself, even a bundle like SRMC's may be insufficient if it is not applied by a dedicated vascular access team whose efforts are supported by senior leadership
- While the up-front costs of an approach like SRMC's are certainly greater than usual, the approach is likely cost-effective in the long term because of the high treatment and other associated costs for CLABSIs

Conflict of interest: none

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