Central Venous Catheter Securement: Using the Healthcare and Technology Synergy Model to Take a Closer Look

Denise Macklin, BSN, RNC, VA-BC™
Paul L. Blackburn, MNA, RN, VA-BC™
Interrad Medical, Inc, Plymouth, MN

Abstract

Proper securement provides a safe vascular access device environment for both patients and health care providers. Successful securement protects central venous catheters from several sources of failure until the end of therapy by preventing central venous catheter movement during all phases of care. Movement causes vein trauma, bacterial migration, distal tip location variation, loss of dressing integrity, and even total dislodgement. Any of these events can have serious consequences, including catheter-related bloodstream infection, thrombosis, delay of treatment, catheter replacement, and potential hemorrhage, all of which can be life-threatening events, and increase costs. We review patient issues, practice issues, and the types of securement currently used in clinical settings.

Keywords: *adhesives, subcutaneous catheter securement, sutures*

Introduction

Central venous catheter (CVC) securement is central to providing safe, complication-free intravenous therapy. Catheter securement has the potential to promote a safe environment for both patients and health care providers, and stimulate successful catheter care and dressing management. To aid in this success, securement must prevent CVC movement. Any movement can cause vein trauma, bacterial migration, distal tip location variation, loss of dressing integrity, and even total dislodgment. Each of these events can have troublesome or serious consequences, including extraluminal catheter-related bloodstream infection (CRBSI), venous thrombosis, dislodgement, delay of treatment, and catheter replacement. These complications may result in increased costs and can ultimately cause life-threatening patient outcomes.[1]

The Healthcare and Technology Synergy framework represents synergy among the conceptual variables of patient, product, and practice components, with each affecting and being affected by the other. It is the combined effect or interaction of patient, product, and practice that affect health care outcomes. The best outcomes can be achieved when there is synergy among all 3 of these health care components as represented by the overlap of all 3 circles in the Figure.[2] The influence of nursing practice on patient outcome is commonly the focus for answers and change. Individualizing a plan of care demonstrates that a patient's influence on outcome is a central tenet. Often products are overlooked as a variable. Yet products that are used in providing care have issues and can affect the success or lack of success within nursing practice. Nurses develop their own so-called work arounds to solve product problems, thereby increasing their success. It is important to identify product issues and to understand how these issues in particular influence practice outcomes. A question that can be asked is, Is this practice something that is positively patient outcome-based or is it being implemented to make a product work better? Understanding the answer to this question can lead to better decision making when developing care practices. Catheter securement is a care issue that includes patient variables, practice variables, and product variables. We provide an overview of the patient, practice, and product issues that can influence successful catheter/central line securement and demonstrate how their interaction influences outcome. It is our hope that this information will foster securement-related discussions and, more importantly, CVC securement-related research.

Patient Issues

The skin is the primary site for CVC securement today, yet the skin environment is very supple and provides major challenges

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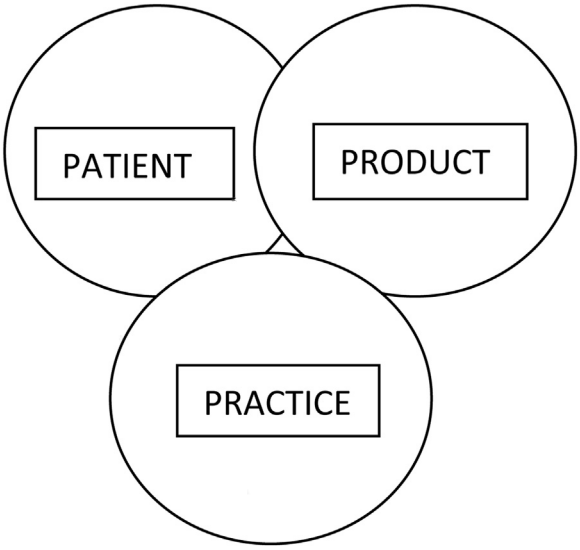

Figure. **The Healthcare and Technology Synergy Model.**

for successful CVC securement. Skin quality varies with age (ie, very young and old), comorbidities (eg, diabetes, cancer, and renal failure), hydration status, and therapeutic regimen (eg, steroids) to name a few. The epidermis is made up of basal and squamous cells. Skin's surface is actually covered in dead cells that are shed and replaced over a few weeks to a month as basal and squamous cells move to the surface. This is a continual, ongoing process. Because skin has 3 different ecosystems—dry (eg, arm), wet (eg, groin), and sebum-rich (eg, jugular and chest)—CVC insertion site plays a large role in securement success. Skin surface moisture allows bacteria to flourish and provides a medium for transit over the skin via capillary action and diffusion.[3] Skin flora type and prevalence vary depending on the ecosystem, with the lowest levels of bacteria on dry areas and highest levels, including fungi, on sebum-rich areas. Skin flora has been shown to be the most common source of CRBSI.[1] Eighty percent of transient microflora live in the first 5 layers of the skin and repopulate the skin's surface within 18 hours.[4,5] Common gram-negative bacteria that reside on the skin have cell surface receptors for fibrin/fibrinectin.[6]

The insertion site creates an opening in the skin and a direct catheter/vein link. The body's response to a puncture site is to heal it. Movement of the catheter at the insertion site causes an inflammatory response of edema and serous sanguineous fluid secretion. This is the body's attempt to reduce friction and enable healing of the insertion site. This edema can result in an enlargement of the puncture site. The enlarged, moist puncture site provides a perfect environment for bacterial migration down the extraluminal pathway.[7] The vein intimal layer promotes platelet adherence to damage on the vein wall, and this is followed by thrombus formation to promote healing. The "healing" thrombus just inside the puncture site provides the perfect location for fibrin/fibrinectin and bacteria to colonize and form biofilm. Colonization of short-term CVCs (< 15-20 days) typically occurs at the catheter exit site.[8] Initially, the thrombus occurs at the point of vein penetration. However, this response occurs wherever and whenever a vein wall is damaged by an indwelling catheter. Although we cannot see this response to friction occur on a vein wall, this interaction, over time, does occur and can lead to venous thrombosis. Additionally, the body responds to the foreign object by coating the catheter with platelets and leukocytes within minutes of placement. Patients produce small pistoning movements of the catheter in and out of the skin with normal movement.[9] The distal superior vena cava is a large vein with a flow rate of 2 L/min. This location provides drug hemodilution. Care is taken at the time of placement to position catheter tips here. It is well known that the higher the tip of the catheter is in the superior vena cava, the greater the risk of developing thrombus. Thrombus development can have a profoundly negative effect on a patient's outcome over time.

Practice Issues

Once a CVC is inserted, it is secured. From then until the CVC is removed, its care and maintenance is totally a clinical nurse's responsibility. The dressing protects the insertion site. But the catheter securement system directly influences dressing management. Movement disrupts dressing adhesion. Dressing removal is a pivotal period that can affect CVC stability. Remember, slight catheter movements—whether in and out or side to side—can increase the potential of developing securement-related problems. So if a nurse is having difficulty getting a dressing to release, or tape off the catheter, movement of the CVC is inevitable. Once the dressing is removed, in the case of sutures, complete skin antisepsis under the catheter is impossible. After removal of adhesive devices, as a nurse manipulates the CVC with 1 hand and cleans the skin with the other, preventing CVC movement at the insertion site is impossible. With pediatric and neonate populations, 2 nurses may be required to safely implement a dressing change. Even prepping with chlorhexidine gluconate (CHG) does not prevent repopulation, as previously discussed. CHG-impregnated discs and CHG gel dressings maintain significantly lower bacterial counts than skin prepped with CHG-containing skin antiseptic alone, but microflora cannot be totally eradicated.[1] Most CVC dressings remain in place for up to 7 days, allowing bacterial regrowth between dressing changes. If a patient has problematic skin or skin lesions, then use of the skin as the foundation for securement is difficult, if not impossible.

Product Issues

The Centers for Medicare and Medicaid Services reward hospitals based on the quality of care provided to Medicare patients, how closely best clinical practices are followed, and how well hospitals enhance patients' care experiences during hospital stays. Hospitals are no longer paid solely based on the quantity of services they provide.[9] The new approach of value-based purchasing (VBP) requires looking at products not only by cost alone, but also by how the product positively or negatively influences practice outcomes. Vascular access is heavily dependent on products. Any product is most effective when it helps caregivers provide safe and effective care. Securement products

Table 1. Securement Category Overview

Securement device	Pros	Cons
Suture	• Initially very secure • Initially stable during cleaning • Minimizes adhesives	• May erode through skin • Prevents complete cleaning of insertion site • May require replacement over time • Promotes bacterial migration into the suture track • Loosens over time allowing catheter movement and pistoning • May lead to needlestick injury during placement
Manufactured adhesive device	• Ease of application • Completeness of cleaning • Eliminates suture-related needlestick injuries	• Catheter is free-floating during dressing changes • Must be removed and replaced with each dressing change • May lead to skin irritation/allergic reaction • Uses adhesives to secure to skin • Allows catheter pistoning during patient movement
Subcutaneous securement device	• Ease of application • Stability during site cleaning • Completeness of cleaning • Ease of maintenance • Reduced skin surface complications • Minimizes adhesives • Decreased migration and pistoning • Eliminates suture-related needlestick injuries • Remains in place for duration of therapy	• Learning curve associated with placement and removal

fall into 3 major categories: transdermal (ie, suture/staple), cutaneous (ie, adhesive), and subcutaneous. The risks vs benefits of each product should be determined by how each interacts with patients' and practitioners' needs and safety.

Suture has been used as a CVC securement device for many years. Indeed, suture was considered to be the standard of practice for CVC securement. Initially, sutures are tied close to the catheter wing or insertion site. This configuration makes cleaning under the wing impossible. Although sutures provide initial securement, over time sutures may erode through the patient's skin, allowing the CVC to become loose and less stable. Research has shown that as a suture is being drawn through the epidermis and back to the surface, the suture material is effectively pulled through various transient flora living in the lower layers of the epidermis, thus contaminating the suture material.[10-12] Some sutures are placed near the insertion site. The practice of placing suture creates additional holes in the surface of the skin, allowing surface bacteria to move from the surface into the newly created suture holes. The contaminated suture then resides under the dressing, which provides a moist environment for bacterial growth and transience. Additionally, the risk of needlestick injury for the placing clinician is relatively high. Overall, there are 384,000 reported needlestick injuries in the United States each year.[13] Twenty-four percent of these injuries are directly related to suture needles.

Manufactured adhesive devices were developed in response to the lackluster performance of suture for CVC securement during the 7-day dressing change period and to prevent accidental needle sticks. Like suture, manufactured adhesives can also provide immediate securement. However, over time adhesive degradation and loosening may occur. Aggressive adhesives that resist moisture require specific solvents for easy removal. Incorrect solvent use may result in damage to the skin surface. The 2002 report by Yamamoto et al[14] remains the only research done on this category of securement.

Subcutaneous catheter securement has recently been developed. This technology promotes catheter stabilization through the use of securement of the catheter to subcutaneous tissue (avoids pain receptors) at the insertion site, rather than the skin. Within a short period of time, usually 48 to 72 hours, the anchor heals into place, preventing catheter pistoning and side-to-side movement. The lack of movement promotes healing of the insertion site allowing the remodeled tissue to act as a barrier to surface bacteria. Because the subcutaneous securement device is stabilized in the puncture site, the catheter can be gently lifted above the insertion site, allowing for complete insertion site cleaning. Several case studies[15-17] have been reported over the past few years, and have shown a decrease in catheter dislodgment/malposition rates, even during the anxiety provoking dressing change process.[18] These same studies noted that CRBSI

Table 2. Patient Response as a Result of Practice Compliance and Catheter Movement

Action	Implication
Accidental VAD dislodgement	Tip malposition/catheter replacement
VAD movement side to side	Vessel trauma/thrombosis
VAD pistoning	Vessel trauma/CRBSI
VAD manipulation with use	Tip migration/thrombosis/CRBSI
VAD manipulation with dressing change	Tip migration/CRBSI
Maintenance of VAD insertion site	Frequent dressing and securement device changes

VAD = Vascular access device; CRBSI = Catheter-related bloodstream infection.

Table 3. Risk Factors for Thrombosis[22]

Acute spinal cord injury	Smoking
Major trauma	Pregnancy
Brain tumor	Advanced age
Bone marrow transplant	Gynecologic malignancies
Acute pancreatitis	Lung cancer
Renal failure	Sickle cell anemia
Diabetes	Engorgement of the upper trunk
Dehydration	SVC compression by an extrinsic mass
High platelet levels	Catheter tip location in subclavian vein
History of deep vein thrombosis	Catheter malposition
Oral contraceptive use	Chronic obstructive pulmonary disease
	Left subclavian vein catheters

SVC = Superior vena cava.

levels were unaffected by the subcutaneous devices,[15-17] although a formal study on this point would be beneficial.

Outcomes based on securement products vary, which is to be expected. Although suture provides immediate securement it does not prevent CVC movement over time, it is associated with safety issues for the patient, and it may hinder skin disinfection associated with dressing changes. Manufactured adhesive securement devices eliminate the incidence of suture needlestick injury, but do not eliminate catheter movement, migration, and/or dislodgment, and must be changed with each dressing change, which may lead to tissue damage. Subcutaneous CVC securement—the newest of the 3—has been shown to eliminate suture site infections, skin erosion, suture-related needlestick injuries, and CVC cleaning challenges while providing continuous CVC securement. Because bedside clinicians are responsible for providing care that will achieve outcomes that meet or surpass reimbursement outcome metrics (ie, VBP), understanding that different products are a variable in the ways they influence patient outcomes is extremely important (Table 1).

Interaction of Patient, Practice, and Product

Three complications associated with securement are CRBSI, dislodgment (either partial or complete), and thrombosis. These complications result from the interaction of the variables of patient, practice, and the securement product.

CRBSI

CRBSI is a major CVC complication associated with morbidity and mortality. An estimated 250,000 CRBSIs occur annually with up to 20% being fatal.[7] CRBSIs increase hospital length of stay by 9.6 to 14.3 days.[1] The costs of this complication are associated with increased length of stay, additional therapeutic actions, and extended care and maintenance.[1] The combination of patient response, practice compliance, and catheter movement promote thrombus formation and both passive and active bacterial migration (Table 2). Both are the primary causes of CRBSI. Microorganisms enter into the bloodstream through the insertion site. Microorganisms then attach to the fibrin, grow, and develop a protective covering referred to as biofilm. Current medical treatment to eradicate biofilm is extremely difficult.[6] So the best intervention is to prevent microorganism entry into the system and bacterial adhesion. The Agency for Healthcare Research and Quality Keystone/On the CUSP: Stop BSI project reported that after implementing CRBSI prevention strategies that focused on identifying vulnerable patients and adhering to best clinical practices associated with insertion (extraluminal), there was a 41% reduction in CRBSIs.[19] Thus, 59% of CRBSIs could not be attributed to lapses in best practices as currently understood. This is a prime area for vascular access research.

Thrombosis

The asymptomatic rate of thrombosis approaches 40% in some studies.[20] Vein elasticity makes this complication difficult to diagnose without testing. Fluid follows the path of least resistance and is therefore shunted to collateral veins when required. This shunting decreases flow around CVCs, especially the smaller veins of the arm,[20] and only exacerbates the problem. CVC/vein friction, a result of catheter position/movement, is a cause of vein wall thrombosis.[21] Many patients are at risk for thrombosis[22] (Table 3). Peripherally inserted central catheters are associated with higher rates of deep vein

thrombosis than CVCs.[20] Catheter-related venous thrombosis is currently gaining interest in the research community.[23] As discussed above, thrombus formation is linked to infection risk because it offers the perfect medium for bacterial growth.

Dislodgment

Tip location change of a CVC—whether partial or complete—can have devastating consequences. Dislodgment/tip malposition occurs from 5% to 31% of the time.[11] This movement may lead to colonization of the external lumen of the catheter.[17] When using the skin as the foundation of securement there are numerous opportunities for catheter securement compromise, especially during catheter manipulation during dressing change procedures when accidental dislodgment can occur suddenly. Loss of dressing integrity can also be a precursor to dislodgment as well as infection. Once a CVC has migrated out with a partial dislodgment, CVC reinsertion is contraindicated. The catheter tip is now in a suboptimal location. Excessive coughing or vomiting has been associated with spontaneous dislodgements, as well.[24]

Conclusions

The interaction of patient, practice, and product variables affects securement-related outcomes. When reviewing complication rates and/or developing reduction/elimination programs, it is important to look beyond nursing practice for potential solutions. Identifying the core issues that need to be addressed and researched is 1 way to develop comprehensive solutions. Securement is a critical component of successful dressing management and complication prevention and should provide catheter stability during all phases of catheter use, including therapeutic regimen, dressing removal, and site antisepsis. It is impossible to stabilize a catheter without a securement product. Yet products are overlooked as an outcome variable.

There are 3 distinct types of CVC securement. Understanding how each securement device interacts with patients and practice to influence complication occurrence is important if complication reduction is to occur.

Proper securement offers a high level of safety for patients, practitioners, and family caregivers. To really understand the influence of a securement method on care and maintenance it needs to be clinically investigated. Comparative effectiveness research can aid in this process. Health care practitioners and researchers are the frontline persons to do this. In today's high-acuity, fast-paced clinical setting, it is paramount that securement products enhance dressing care, maintenance success, and patient safety. This will be required as VBP expands and becomes the basis for reimbursement.

Disclosures

Denise Macklin is a consultant, and Paul L. Blackburn is vice president of clinical affairs, Interrad Medical, Inc.

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