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Evaluating New Technology to Improve Patient Outcomes

A Quality Improvement Approach

Abstract

The nurses in the peripherally inserted central catheter (PICC) program at the University of Washington Medical Center perform ongoing data tracking to measure team and patient outcomes. Quality improvement initiatives have included the transition to microintroducer technology and ultrasound-guided placement. Used together, this technology has allowed the PICC team to increase their bedside insertion success rate to 91%. The group has also changed PICC securement methods, and use of the Statlock anchoring device has reduced the incidence of catheter migration from 6% to 1.5% of all catheter lines placed. Catheter durability also was assessed. The Pressure Activated Safety Valve PICC was compared to the Groshong PICC and the rate of catheter repair and exchange due to breakage has been reduced from 11% to 1%.

Healthcare reimbursement trends have promoted increased use of peripherally inserted central catheters (PICCs). The majority of hospital patients require infusion therapy, and increasing numbers of patients are discharged with ongoing needs for infusion therapy in outpatient settings. Both patient groups benefit from use of PICCs and many medical centers are creating nursing teams to manage the volume as a lower cost alternative to sending patients to interventional radiology (IR) for placement. The vascular access industry has likewise responded with product design enhancements intended to improve patient outcomes associated with prolonged venous access.

Integrating this new technology into an established program can be a challenging task. Data gathering systems must be designed and criteria established to measure the performance of new products. Obtaining patient outcomes can be overwhelming when resources are limited and patients are discharged to a wide variety

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of settings. Nevertheless, strategies can be designed to provide data that guide decision-making. This article describes quality improvement strategies used at the University of Washington Medical Center (UWMC), and discusses the improvements made.

• BACKGROUND

UWMC is a 450-bed tertiary care facility in Seattle, Wash. It is a teaching hospital and has never had a specialized infusion team. This began to change in 1994 when the medical center trained a small group of critical care nurses to place PICCs at patients' bedsides. Over the years, requests for PICCs and midline catheters have steadily increased. During this same time, the IR department has become increasingly busy and has supported the growth of the bedside PICC program.

In 1998, growth of the program warranted restructured leadership. Quality improvement initiatives were expanded to ensure staff development, and promote improved outcomes for patients. Currently, the program is staffed with 1 nurse 6 days per week for 8 to 12 hours per day, and routinely places 100 to 150 PICCs per month. An assistant nurse manager oversees the program, precepts new PICC nurses, and assists clinically if needed to handle outpatient requests or high volume. Several nurses share available PICC registered nurse (RN) shifts, but each has another clinical position and performs in the PICC role 1 to 2 days per week.

• OUTCOME TRACKING

A tracking log was implemented in 1998 and remains the data recording method. The tool is a paper record of PICC RN daily activities. Data from these logs are reviewed and used to track and monitor a variety of outcomes over time.

How Outcome Tracking Works

The PICC RN starts his or her shift by checking a voice mail system that staff or physicians call if they need PICC RN services, including line placement, removal, or consultation. The PICC RN notes the patient name and the department location on the log. Once all requests are recorded, the PICC RN prioritizes activities and begins visiting patients. As the PICC RN shift progresses, an outcome code is recorded for each consultation. Outcome codes are selected from a key of codes that includes line placement codes, line removal codes, and system codes.

Success codes

- P1 = Single-lumen PICC
- P2 = Dual-lumen PICC
- M1 = Midline
- M2 = Wanted PICC, could only thread to midline

Failure codes

- F1 = Failed to achieve vein access
- F2 = Vein accessed, could not thread PICC
- F3 = Assess patient, but did not attempt due to prior failure, or no veins.

FIGURE **1.**
Line placement codes. PICC, peripherally inserted central catheter.

Line Placement Codes

After a PICC RN attempts a line placement, he or she records which type of line is placed. If the placement fails, the RN records the reason. Choices of placement codes are shown in Figure 1.

Line Removal Outcome Codes

A member of the PICC team tries to be available to remove each PICC so that reason for removal can be tracked. The ideal, of course, is for lines to remain in place until therapy is complete. However, complications do occur, necessitating the removal of a PICC before therapy is finished. We capture this data to guide improvement projects. Admittedly, the PICC team does not have the resources to track all outcomes, particularly outpatient lines. Nevertheless, outcome data that are obtained are analyzed for trends and are very helpful in guiding improvement activities. Removal codes used by the PICC team are shown in Figure 2.

System Codes

There are several other activities in the course of a day that consume PICC RN time. A series of "system" codes was generated to help monitor the time required

R1 = Therapy complete
R2 = Phlebitis, suspected or actual thrombus
R3 = Suspected infection, localized or systemic
R4 = Line occlusion
R5 = Migration to unacceptable position
R6 = Leaking at insertion site (fibrin sheath)
R7 = Catheter broken (traumatic)
R8 = Other

FIGURE **2.**
Line removal outcome codes.

to perform non–insertion-related activities. Examples of system codes include consults for occluded lines, consults to identify and verify the tip placement of lines existing in newly admitted patients, and consults to repair broken catheters. The team also documents requests that cannot be managed in a given day. Recording this data has helped justify additional staffing.

Each placement, removal, and system outcome code for a specific day is recorded on a single log sheet. Data from these logs are entered onto a spreadsheet. Outcomes are analyzed on a regular basis and used to guide improvement projects. A review of projects follows.

• QUALITY IMPROVEMENT PROJECTS: IMPROVING BEDSIDE INSERTION SUCCESS RATES

Microintroducer Technology

Data from logs that were started in 1998 demonstrated that the PICC RN was successful approximately 60% to 65% of the time, and 35% to 40% of patients were referred to IR. PICC nurses used traditional, large-bore introducer needles and often referred patients immediately due to a lack of palpable, appropriately sized veins. There was a strong desire from all involved to improve success at the bedside.

The PICC team partnered with product vendors and explored the use of microintroducer technology. The hospital purchased microintroducer kits for both 4 and 5 French catheters that permit initial vein access with a 22 g safety peripheral catheter. Today, virtually all PICCs placed at the bedside are positioned using the microintroducer method.[1] The PICC team now has a bedside insertion success rate of 91% (Table 1). However, this success cannot be achieved with microintroducers alone. An essential component of current practice includes the use of ultrasound technology.

Ultrasound-guided Placement

Ultrasound-aided bedside PICC placement was pioneered at UWMC by Claudette Boudreaux, a critical care nurse who was a member of the initial PICC team. In 1997, the intensive care unit where she worked most of her shifts purchased a portable ultrasound device to assist the resident physicians in placing internal jugular central lines. After watching residents use this machine, she realized how helpful it could be in locating nonpalpable vessels in the upper arm. She began to use this technology with success placing PICCs in the basilic vein at or above the antecubital fossa.

TABLE 1

PICC Team Bedside Placement Success Rates

January	January	January
1999	2000	2001
65%	79%	91%

Today, the microintroducer technique, along with ultrasound guidance, is used to place PICCs at the bedside every day. The transition to this technique was necessitated in part by growing patient acuity: many patients do not have visible or even palpable antecubital veins. These technological advances have allowed the PICC team to refer fewer patients to IR for placement.

There is a learning curve in becoming skilled using ultrasound. Nurses must first learn to identify and assess underlying venous and arterial anatomy using the ultrasound probe. However, nurses who are already knowledgeable about traditional assessment techniques can learn assessment with ultrasound quickly. Competence in attaching the sterile sheath probe cover and maintaining sterile technique must also be developed prior to using ultrasound for the insertion procedure.

Perhaps the most difficult adjustment when using ultrasound is developing the hand–eye coordination needed to attend to both the ultrasound screen and the patient's arm. Similarly, the approach angle for accessing the basilic vein is steeper than traditional venipuncture techniques. These adjustments take varying amounts of time to master—from 20 to 50 placements, depending on the clinician. Currently, PICC RN orientation starts with the microintroducer method on patients with visible or palpable veins. Once these competencies are successfully demonstrated, ultrasound guidance techniques are added.

Over the past 3 years, approximately 10 nurses at UWMC have been trained in these techniques. Despite turnover, the team has become successful 91% of the time they attempt a line placement (Table 1). Likewise, the number of patients automatically referred to IR has dropped from 15% of patients assessed to 4% of all patients screened. The volume of patients who cannot be accessed has dropped over time from 11% to 1%. Using ultrasound to access primarily basilic veins has reduced threading difficulties from 24% to 8% (Table 2).

Besides improving success rate, ultrasound-guided placement is beneficial because it gives the patient more choices as to where the PICC will be located. Many patients prefer to have freedom of movement and want their PICC above their antecubital fossa. Ultrasound identifies underlying venous and arterial anatomy so that the ideal location for placement can be selected. Ultrasound frequently allows the nurse to offer the patient this choice.

TABLE 2

Bedside PICC Insertion Failure Rates Over Time

	January 1999	January 2000	January 2001
Cannot Access	11%	8%	1%
Cannot Thread	24%	13%	8%
Patients Auto Referred to IR	15%	10%	4%
Total Placed	61	96	139

IR, Interventional Radiology.

Microintroducers and ultrasound together have permitted the UWMC PICC team to meet increased demand for PICC and midline placements. The most dramatic increases have been seen in the successful placement of 5 French dual-lumen catheters (Figure 3). Without this technology, IR would have been required to place many more lines, increasing costs associated with venous access. Other patients would have likely required temporary, triple-lumen central venous catheters and would have been exposed to higher infection and complication risks.

• IMPROVING PATIENT OUTCOMES

Reducing the Incidence of Migration

Data from logs recorded during a 6-month period of time in 1999 demonstrated an unacceptably high rate of catheter migration. Six percent of inpatient catheters were being inadvertently pulled completely or needed to be exchanged because of partial migration out of the superior vena cava. The method for securing catheters was sterile tape and semi-permeable transparent dressings. General staff nurses were responsible for the dressing changes and standards were not consistently observed. Staff training was conducted and some improvement was noticed, although migration still occurred.

The PICC team was trained to suture lines, but this was done inconsistently primarily due to time constraints. Sutures were not placed until after the chest x-ray confirmed placement and so a second visit to the patient bedside and new sterile field was required. This additional work was not manageable due to the volume of PICC requests being addressed by a single nurse. In addition, there were infection risk concerns about placing sutures if the duration of planned therapy was not known at the time of insertion.

After education and suture training failed to significantly improve migration statistics, the hospital began to look for new technology. The Statlock anchoring

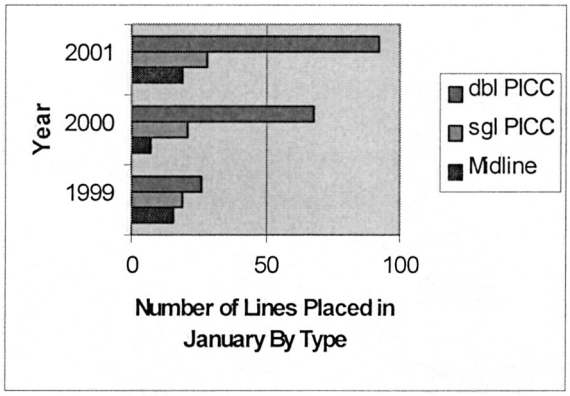

FIGURE **3.**
Types of catheter lines placed at bedside.

device (Venetech, San Diego, Calif) was tested and migration was reduced to less than 1.5% (Table 3). The Statlock is a crescent-shaped device with foam-taped backing. Small adjustable posts are mounted on the device and the wings of the PICC fit over the posts to secure the line in place (Figure 4). The Statlock is placed on the patient's arm and is changed at least once per week. Currently, migration problems almost always involve patients who are confused and pull at their lines, or patients who have had the Statlock removed. The additional cost of the Statlock is justified when compared to the materials and labor costs associated with catheter replacement.

Valved Versus Open-Ended PICCs

Over the past 3 years, data tracking has provided the necessary information to guide decision-making regarding various peripherally inserted central and midline catheters. A variety of nonpatient-related factors such as cost and staff preference have factored into decision-making; however, patient outcomes have been most important.

In 1999, UWMC stocked both silicone and polyurethane catheters. An open-ended, valveless, polyurethane catheter was preferred for critically ill patients who required high flow rates.[2] Polyurethane catheters are relatively durable and permit high flow rates, but require heparin flushing. Heparin sensitivities and the increased

TABLE 3

Premature Removal Rates Before and After Statlock

	March-August 1999	March-August 2001
Number of lines placed	486	726
Number of lines patient pulled or "fell out"	28	11
Percent	6	1.5

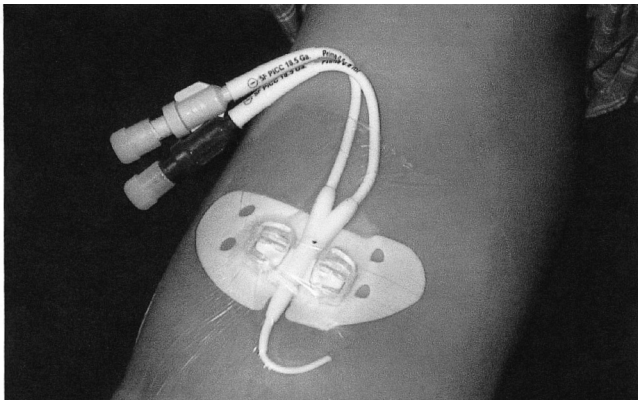

FIGURE **4.**
Statlock anchoring device and the Pressure Activated Safety Valve dual-lumen peripherally inserted central catheter.

costs associated with heparin flushing, particularly in the home infusion population, contributed to the open-ended PICC falling out of favor among users. Also, the PICC nurses anecdotally reported difficulties threading polyurethane PICCs and experienced a higher rate of internal jugular malposition after initial threading.

The Groshong PICC (Bard Access Systems, Salt Lake City, Utah) became the favored PICC at UWMC. The catheter is made of silicone and has a valve at the distal end that eliminates the need for heparin flushing.[3] The PICC was less expensive and simpler for home infusion patients to maintain. PICC nurses found threading during insertion easier because of the soft silicone design and preloaded guidewire. Hundreds of Groshong PICCs were inserted at UWMC, but log data showed an unacceptably high rate of catheter fracture due to trauma and partial occlusion. The catheter is fragile and requires a diligent dressing change technique to protect breakable hubs. Additionally, strict adherence to proper flushing must be maintained because even a partial occlusion can result in catheter rupture. Repair kits are available and were used with success, but proved time-consuming to perform. Educational efforts improved outcomes, but when another valved catheter became available, with good outcomes reported, we were eager to evaluate the product.

Reducing the Incidence of Catheter Fracture

The IR department at Harborview Medical Center in Seattle performed a trial comparing a new silicone valved catheter with a polyurethane, open-ended PICC and had favorable results.[4] Their data encouraged UWMC to test the Pressure Activated Safety Valve (PASV) PICC, (Boston Scientific, Natick, Mass). The PASV is similar to the Groshong PICC in that it is made of silicone and has valve technology that permits saline-only flushing. However, significant differences exist between the two catheters. Unlike the Groshong valve that sits at the distal tip of the catheter, the PASV PICC has a valve that rests within the catheter hub, external to the patient.

TABLE 4

Catheter Durability: Groshong Versus PASV PICC

	Sept 2000-Feb 2001 Groshong	Mar 2001-Aug 2001 PASV
Number of catheter repairs	61	7
Number of catheter exchanges due to breakage	19	6
Percent of total lines placed	11	1

The PASV PICC requires more effort to insert than the Groshong PICC. The distal end of the PASV PICC is blunt and trimmed to fit the patient before insertion. Also, the guidewire does not come preloaded into the PICC. Performing these pre-insertion procedures increases insertion time, but the added effort is worth it when patient outcomes are compared.

The external catheter extensions are very sturdy on the PASV PICC and the rate of catheter repairs and exchanges due to catheter fracture has been reduced to 1% (Table 4). It is difficult to say which valve is superior in terms of preventing occlusion. Yet clearly, the PASV is a more durable catheter. Other patient outcomes including infection, phlebitis, and thrombus rates appear the same for both types.

• FUTURE CHALLENGES

Reducing Catheter-Related Infection

UWMC is taking measures to reduce the incidence of infection. When Chloraprep (Medi-Flex, Overland Park, Kan), became available in the United States, the PICC team changed policies related to skin prepping and site care based on published data that demonstrated the persistent anti-microbial advantages of chlorhexidine in reducing bacterial counts on skin versus traditional skin prepping with povidone-iodine and alcohol.[5,6] Blood stream bacteremia rates remain low, but there is always room for improvement. Data are still being collected and analyzed, but initial indications are favorable.

Positive Displacement Adapters

Positive displacement adapters are newer products and part of a growing assortment of needleless devices. Positive displacement adapters are placed on catheter hubs and intended to reduce the incidence of catheter occlusion. They reduce occlusion by preventing reflux of

blood into the distal catheter tip after a flush syringe is removed from the catheter. They can be placed on all types of central lines and eliminate the need for heparin flushing. As of this writing, plans were underway to test three competing products at UWMC.

Expanded Vascular Access Program

A commitment to quality improvement has helped improve patient outcomes at UWMC and has illustrated the value of a dedicated group of vascular access specialists. Recording the variety of requested consultations has demonstrated that the average staff nurse does not have the skills to optimally manage the vascular access needs of the clients served at the hospital. The administration has responded with support to expand service to include more formal early assessment planning, and has increased staffing support. Future goals include mentoring less experienced nurses and providing staff coverage to ensure that patients with challenging veins have access to an expert.

• CONCLUSION

Advances in technological development of infusion devices have yielded many new products intended to improve patient outcomes and increase the efficiency of infusion therapy. As infusion nurses, we are professionally responsible for considering new methods of care and must continuously strive to improve patient outcomes.

Product evaluation is an ongoing expectation of the PICC team at UWMC and data tracking has been a valuable tool for guiding decisions. Data obtained have helped measure PICC nurse competencies and the performance of products used for PICC and midline insertion and maintenance.

The efforts at UWMC do not approach the rigor of clinical trials. Not all catheter outcomes can be realistically obtained on an ongoing basis. Percentages reported in this article are intended to show improvement over time versus absolute values of patient outcomes. We do not endorse or renounce any particular product, but hope this report of experiences and methods can assist others.

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