Development of a Training Program in Peripherally Inserted Central Catheter Placement for Certified Registered Nurse Anesthetists Using an N-of-1 Method

Aaron M. Ostrowski, DNP, CRNA
Suzanne Morrison, DNP, CRNA
John O'Donnell, DrPH, CRNA

Patients wait an average of 23 hours for a peripherally inserted central catheter (PICC) in our hospital. Long waits lead to delays in discharge and medication administration. For quality improvement, development of a Certified Registered Nurse Anesthetist (CRNA) PICC line backup service was proposed. This project collected benchmarking data about the current PICC line service over 3 months. The Intravenous (IV) Nursing Unit and the Interventional Radiology Division teams insert an average of 8.1 PICC lines daily, but the demand for PICC lines is 12 insertions per day; thus, the current, combined PICC service meets 66% of its demand. The CRNAs insert IV catheters daily and are eligible to insert PICC lines. A PICC training program was developed to train a CRNA in a standardized curriculum with simulation using a partial-task trainer. Using an N-of-1 method, the CRNA inserted 10 PICCs over 3 weeks under the guidance of an IV team PICC nurse. The CRNA reached a level of competence in PICC insertion after 10 attempts, with a 70% success rate, in intervals equivalent to those of IV PICC RNs. A CRNA can be trained in a short timeframe as a resource to decrease waiting for patients needing PICC lines.

Keywords: Certified Registered Nurse Anesthetist, N-of-1 method, peripherally inserted central catheter, quality improvement, simulation.

In our nationally recognized, tertiary care hospital, patients wait an average of 23 hours for insertion of a peripherally inserted central catheter (PICC) line, leading to delays in discharge and treatment. The Intravenous (IV) Nursing Unit and the Interventional Radiology (IR) Division are the current resources for PICC insertion. The IV Nursing team experienced decreases over the past year in its full-time equivalent (FTE) allotment for PICC insertion. The IR team, which used to cover failed IV PICC insertions and any backlog of insertions from the IV Nursing team, no longer covered the backlog. The combined effort of both teams met only 66% of the demand for PICCs in our hospital.

Other types of advanced practice practitioners are found in the literature to insert central venous catheters as a component of their practice.[1-5] No evidence is found in the literature that CRNAs are inserting PICCs. Typically, CRNAs do not insert PICCs regionally, because most hospitals employ PICC teams staffed by registered nurses (RNs).

Considering the delays in PICC insertions and the lack of evidence in CRNA practice, the following healthcare improvement question was asked: Is it feasible to train CRNAs in the PICC insertion procedure to increase the available staff to meet the demand for PICC insertions? Specific aims were developed to address the important elements of this quality improvement project: (1) benchmark the current PICC insertion service, (2) analyze the costs and benefits associated with a CRNA-performed PICC service, and (3) develop a training program through which CRNAs can insert PICCs in their hospital.

Review of the Literature

• ***Advanced Practice Practitioners and PICCs.*** Evidence supports the ability of an advanced practice nurse to safely and efficiently insert central lines and PICCs with proper training. Alexandrou et al[1] reviewed 10 studies in which advanced practice nurses inserted central lines, and they commented on the implications that the nursing role combined with central venous cannulation could have for nursing practice, health policy, and research. The conclusions were that a trained specialist nurse clinician may promote efficiencies and potentially minimize adverse events of central venous cannulation.[1] Workforce shortages and compartmentalization of specialties will challenge the practice boundaries between nursing and medicine.[1]

• ***Outcomes Among Practitioners.*** Careful evaluation of outcomes among groups contrasted nursing vs medical outcomes. Yacopetti et al[2] compared the CVC insertion

outcomes of a clinical nurse consultant (CNC) group with an anesthetic medical service on multiple factors, including infection rates. There was no significant difference between the groups; however, the CNC group was equivalent in all categories except central line–associated bloodstream infections, in which the CNC rate of infection of 0.4/1,000 catheters was better than the anesthetic service's rate of 2.5/1,000 catheters.[2]

Alexandrou et al[3] explored nurse-led CVC placement services at 3 hospitals in Australia that experienced minimal insertion complications. After insertion of 760 central lines over 27 months, the complications experienced by patients included 1 pneumothorax (1.3/1,000), 5 catheter malpositions (6.6/1,000), 1 inadvertent arterial puncture (1.3/1,000), and 1 central line–associated bloodstream infection (1.3/1,000).[3]

Benham et al[4] included a radiology physician assistant (RPA) in their retrospective review of venous access device complications associated with the RPA working on a team with IR attending physicians, IR fellows, and radiology residents. Over 12 months, the RPA performed 670 venous access procedures; the IR attending physicians, 291; the IR fellows, 562; and the IR residents, 570. Although not statistically significant ($P = .7$), the overall complication rates were lowest for the RPA (0.89%), followed by the IR attending physicians (1.71%), IR fellows (1.06%), and the residents (2.46%).[4]

Park and Kim[5] conducted a review of a PICC service led by Korean clinical nurse specialists, in which 3,508 patients received 4,101 PICCs over 7 years. The results showed that the overall rate of complications was 9.03 per 1,000 catheter days, which is within the normal reported range of 2.2 to 16.0 per 1,000 catheter days.[5] With results separated by individual complications, including infection (1.34 per 1,000 catheter days) and phlebitis (3.8% to 18%), this review supported the safety of using clinical nurse specialists.[5]

Methods

The setting for this project was in multiple patient care units throughout an 801-bed tertiary care academic medical center. Approval was obtained from the institutional quality improvement committee. A small research grant was awarded through the AANA Foundation to fund this project.

The N-of-1 method, also known as single case design, has been "used in many areas of research including psychology, medicine, education, rehabilitation, social work, counseling, and other disciplines."[6] It is traditionally a model for implementing treatment for one patient with the intent to follow that patient for a long time to assess the effectiveness of a prescribed therapy.[6] Myths persist that single case studies are not true research and that the findings are not generalizable.[6] Kazdin[6] argues that there is a place for N-of-1 studies, because it is not always feasible to conduct large-sample, powered, controlled, between-groups studies.

Training a team of CRNAs in PICC insertion was not feasible because of scheduling limitations and liability concerns when the CRNAs were off duty, so the option to train a single CRNA was pursued. Grant money facilitated the reimbursement of the hospital for the CRNA's time. In this adaptation of a single case study, another CRNA, who was trained in PICC insertion, provided a vast amount of feedback during simulated and clinical training. Data were intended to be collected and recorded by a single human observer by manual entry on paper forms.

• ***Aim 1: Benchmarking the Intravenous Nursing Peripherally Inserted Central Catheter Team.*** In benchmarking the IV Nursing team, data were collected from a daily PICC logbook in which the IV Nursing Unit recorded deidentified patient data that tracked PICC insertions over 3 years. The logbook entries included the date and time of each PICC order, the insertion time, and any pertinent outcome, such as deferral to IR. Data from the IV and IR insertions provided an assessment of the hospital's capacity for PICC insertions.

A data collection assistant surveyed the legible and complete entries in the daily PICC logbook from each of the 3 prior months (August through October 2016). Order times and insertion times, and the difference between the order time (OT) from the insertion time (IT) were recorded in hours to determine the delay interval (DI) (ie, IT – OT = DI). Log entries categorized the PICC insertions according to weekdays, weekends, and times of the day, based on the date and time the PICC insertion order was written.

• ***Aim 2: Cost-Benefit Analysis of CRNA Peripherally Inserted Central Catheter Service.*** Several key factors in the cost analysis included the personnel costs of the CRNA and the IV PICC RN, reimbursement options for the procedure, and the impact of the CRNA's PICC insertion on the patient's length of stay. Costs of supplies, such as PICC kits, personal protective equipment, and draping, were equal in both groups and not considered a factor for comparison.

In 2016, the IV Nursing PICC team's average wages were $40.64 per hour (J. Yutzy, oral communication, June 2016), and the CRNA's wages were $86.36 per hour, with benefits (T. Lyons, oral communication, June 2016). The range of time for an experienced IV PICC nurse to insert a PICC was 45 to 90 minutes (J. Yutzy, oral communication, March 2015). An a priori determination was made that an experienced CRNA could meet the 45-minute interval by the end of the training program. A CRNA can bill for a reimbursement of $95 for a PICC insertion in the hospital, which could offset the personnel costs of the CRNA insertion.[7]

Assuming the time for the insertion procedure to be equivalent, the major benefit could be realized by de-

Provider	Wage (hourly), $	Benefits SVH (27%), $	Insertion time, h	Personnel cost, $	PICC cost, $	Procedure hospital, $	Medicare payment, $	Median cost of LOS per day, $	Final average cost per PICC, $
CRNA	68	86.36	0.75	64.77	200	264.77	95	0	170
IV RN	32	40.64	0.75	30.48	200	238.48	Bundled	2,000	2,238

Table 1. Cost-Benefit Analysis of a Peripherally Inserted Central Catheter (PICC) Insertion Service by a CRNA[a]
Abbreviations: CRNA, Certified Registered Nurse Anesthetist; IV RN, Intravenous Unit registered nurse; LOS, length of stay.
[a]All costs for the procedure are summarized in the "Procedure cost to hospital" column. "Final average cost per PICC" accounts for the reimbursement for the CRNA and the cost of the additional day (23 hours) to the patient's length of stay.

Theoretical content	Practical content: essential elements of PICC insertion
Historical perspective	Workup/order verification
Anatomy and physiology	Consent/timeout
Routine nursing care of CVCs	Positioning
Measuring PICC insertion depth with tape	Preparing and draping
Modified Seldinger technique of PICC insertion	Insertion
Indications, contraindications, and design of the devices	Confirmation of placement
Complications	Dressing
Safety	Cleanup/patient education
Supplies	Documentation

Table 2. Peripherally Inserted Central Catheter (PICC) Training Curriculum Derived From Infusion Nurses Society[12]
Abbreviation: CVC, central venous catheter.

creasing the patients' wait times for a PICC insertion, translating into a decreased length of stay. An increased length of stay erodes patient satisfaction and exposes patients to unnecessary risks, such as hospital-acquired infections, medication errors, deep vein thromboses, and falls.[8] Costs for treatment associated with these risks contribute to the increased costs for the length of stay. One day in a Pennsylvania hospital costs between $1,700 and $2,300 (median, $2,000), according to data from 2014.[9] If a CRNA could insert the PICC on the same day as the PICC order, a savings of at least $1,700 could be realized (Table 1).

• ***Aim 3: Development of Program to Train CRNAs to Insert Peripherally Inserted Central Catheters.*** Professional nurses on the IV team with at least 1,000 hours of IV therapy experience were eligible to train in PICC insertion in our hospital.[10] The hospital PICC policy required IV nurses eligible for PICC insertion to complete a didactic session, a demonstration of the procedure, and 2 supervised PICC insertions to establish competency.[10] Competency, proficiency, then expert is the ascending order of skill mastery, according to Benner.[11] The IV team nurses evaluated the supervised PICC insertions according to a competency checklist. According to Benner's[11] suggestion, competency was conferred to the IV nurse on successful completion of the checklist tasks. Proficiency in PICC insertion was conferred with experience and was demonstrated by the IV nurse completing the checklist tasks, but completing them as a whole, without thinking through each step.[11] Considering the baseline experience of CRNAs in our hospital, it was proposed that a CRNA could become proficient at PICC line insertion after a few insertions.

CRNAs in the hospital inserted IVs daily. Productivity of the CRNAs was defined by the billable anesthesia time per day, measured from anesthesia start time to anesthesia end time for each case. Nonproductive time, including room setup, breaks, lunches, and turnover were not billable and consumed about 40% of the CRNA's time, so 60% was the threshold productivity (H. DeFranco, personal communication, June 2015) for a full-time (2,080 hours) CRNA. On average, a CRNA produced about 1,248 hours of productive anesthesia time per year, so any CRNA with a year of job experience was qualified to insert PICCs according to the hospital's PICC policy.[10]

An Infusion Nursing Society[12] curriculum provided the framework for a didactic module followed by a simulation session. The course was designed to last 2 to 3 hours. A pretraining survey assessed the CRNA's familiarity with PICC insertion, ultrasonography, and anatomy of the arm before training. The questions were rated on a Likert scale from "hardly at all" (1 point) to "a very high degree" (5 points).

The theoretical and practical content are noted in Table 2. The didactic portion of the program contained a slide presentation (PowerPoint, Microsoft) and 2

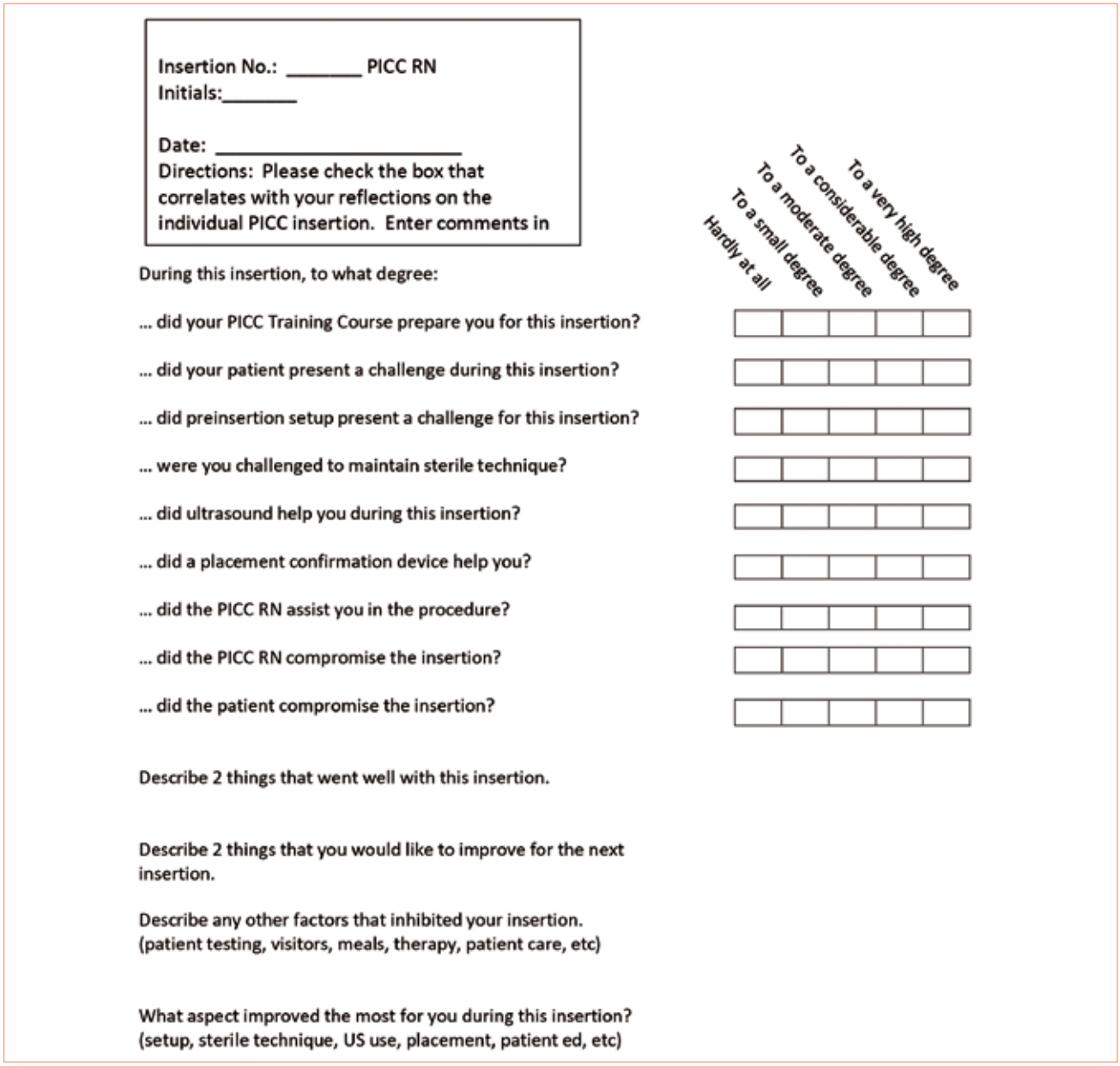

Figure 1. CRNA Evaluation of Individual Peripherally Inserted Central Catheter (PICC) Insertions

videos, 1 demonstrating ultrasonography[13] and the other showing a complete PICC insertion.[14] Both videos were vetted and approved by content experts from the IV Nursing team and conformed to the PICC competency checklist. The simulated training applied the principles of ultrasonography from the video by using a real ultrasonography machine (SonoSite, Fujifilm SonoSite Inc) to locate vessels and pass 20-gauge and 18-gauge catheters into vessels of a gel training pad (Phantom). After the CRNA developed a level of comfort with ultrasound-guided IV insertion, the CRNA performed 2 simulated insertions on a PICC partial task trainer (Peter PICC, VATA Inc). The simulated insertions also gave the data collector an opportunity to become familiar with the insertion procedure and to practice timing the events.

The CRNA evaluated the didactic and simulation program by completing a posttraining evaluation to assess the CRNA's degree of met expectations for the course, opinions on the effectiveness of the videos, slide presentation and partial task trainer, and levels of confidence regarding ultrasonography and insertion. All evaluations in this training curriculum were adapted from existing items used to gather feedback in procedural courses of the Winter Institute of Simulation, Education, and Research (WISER).

The CRNA was deployed with the IV PICC nurse after simulation training to perform at least 10 attempted PICC insertions assigned to the IV Nursing team. During

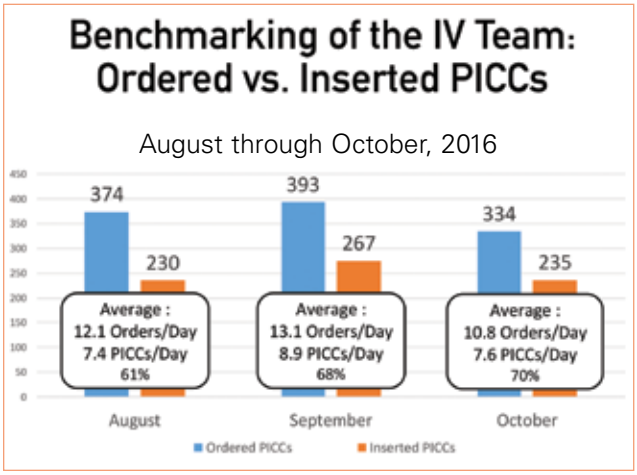

Figure 2. Orders for Peripherally Inserted Central Catheter (PICCs, blue) versus PICCs Inserted (orange), August to October 2016

the insertions, the elapsed times for each critical element of the PICC insertion and the total elapsed time of the procedure were recorded. Critical patient data were recorded on a spreadsheet from the medical record that the PICC nurse assessed for every patient. Pertinent information for PICC insertion included the indication for the PICC, hospital unit, relevant medical information, and any anatomical restrictions of the upper extremities.

The CRNA completed a self-evaluation to debrief and track changes through each PICC insertion (Figure 1). The tool assessed the CRNA's agreement on different aspects of the insertions ranging from "hardly at all" (1 point) to "a very high degree" (5 points). The questions addressed the 5 challenging elements of the insertion: the patient, setup, sterile technique, ultrasonography, and the PICC RN (as a hindrance). The rated questions also described 4 elements that could promote the success of the insertion: the PICC simulation, electrocardiography confirmation device, ultrasonography, and the PICC RN (promoting success). The structured and supported debriefing tool included open-ended questions for the CRNA to record after each insertion. At the conclusion of the series of insertions, the CRNA participated in a summary interview to reflect on the overall experience.

• ***Measures.*** One key measure of the intervention was the time required for each PICC insertion. A second key measure was the CRNA's evaluation of the PICC didactic and simulation training. A third key measure was the survey tool tracking the CRNA's progress through the insertions. Feedback on the training and insertions was important for future educational efforts to understand which factors helped and which factors hindered the trainee.

The time intervals tool addressed all the critical elements of PICC insertion. Throughout the insertion period of 3 weeks, all stakeholders from the IV Nursing team and Department of Anesthesiology were updated on the progress of the project. Consistency and accuracy in data collection was maintained by using the same personnel for each insertion.

Results

The IV Nursing PICC team employs 3 to 4 FTE staff from 6 AM to 10 PM, 7 days per week. The IV Nursing Unit covers more than 30 workload indicators, from IV-themed responsibilities to feeding tube insertion and maintenance. During August, September, and October 2016, the IV team was at its full FTE capacity, and there were 374, 393, and 334 orders for PICCs, respectively. Mondays, Thursdays, and Fridays were the highest volume days. On a daily basis, PICC orders came in at the highest rate between 9 AM and noon, when 35% of all daily orders were entered. 76% of daily orders were entered between 6 AM and 3 PM. Thirteen PICCs per day were ordered on average through the weekdays, and 9.2 PICCs per day were ordered on the weekend days. The daily demand ranged from 10.8 to 13.1 PICC orders per day.

The IV Nursing team inserted 178, 201, and 178 PICCs per month, respectively, a daily average of 5.7 to 6.7 PICCs per day, from August 1 through October 31, 2016. In the same timeframe, IR inserted 52, 66, and 57 PICCs per month, an additional 1.6 to 2.1 PICCs per day. From August through October, monthly totals of 230, 267, and 235 PICCs were inserted, ranging from 7.4 to 8.9 PICCs per day. The cumulative capacity of the IV-IR system met 66% of the demand for PICC insertions (Figure 2). The average time for a patient to wait for a PICC was 23 hours, with a range of 2 to 72 hours. Success rate of PICC insertions by the IV team for the same time interval was 557/648, or 85.9%.

The CRNA attempted 10 insertions over a 3-week period. The success rate of insertion was 7 of 10, or 70%. All 10 patients were easy to access transvenously under ultrasound guidance. The critical element that took the longest time was preparation for insertion (patient, sterile field, and kit), taking 772 seconds on average, with an SD of 234 seconds. The total elapsed time for successful insertions ranged from 2,155 seconds to 3,118 seconds (31:55 to 51:58, minutes:seconds) (Figure 3). The average insertion took 43:49 (minutes:seconds) with an SD of 6:25.

Statistical analysis of the small sample of insertions was done using a 2-sample Wilcoxon test. In correlating the intervals of time for each step of the insertion to patient factors, there was a relationship between body mass index and overall length of the procedure, although it was not statistically significant. Two patients had an implantable cardioverter-defibrillator that obstructed the advancing catheter, and 1 patient was unable to have the PICC advanced beyond the clavicle. Because the procedures were aborted after 3 insertion attempts, those procedures were excluded from analysis of the critical

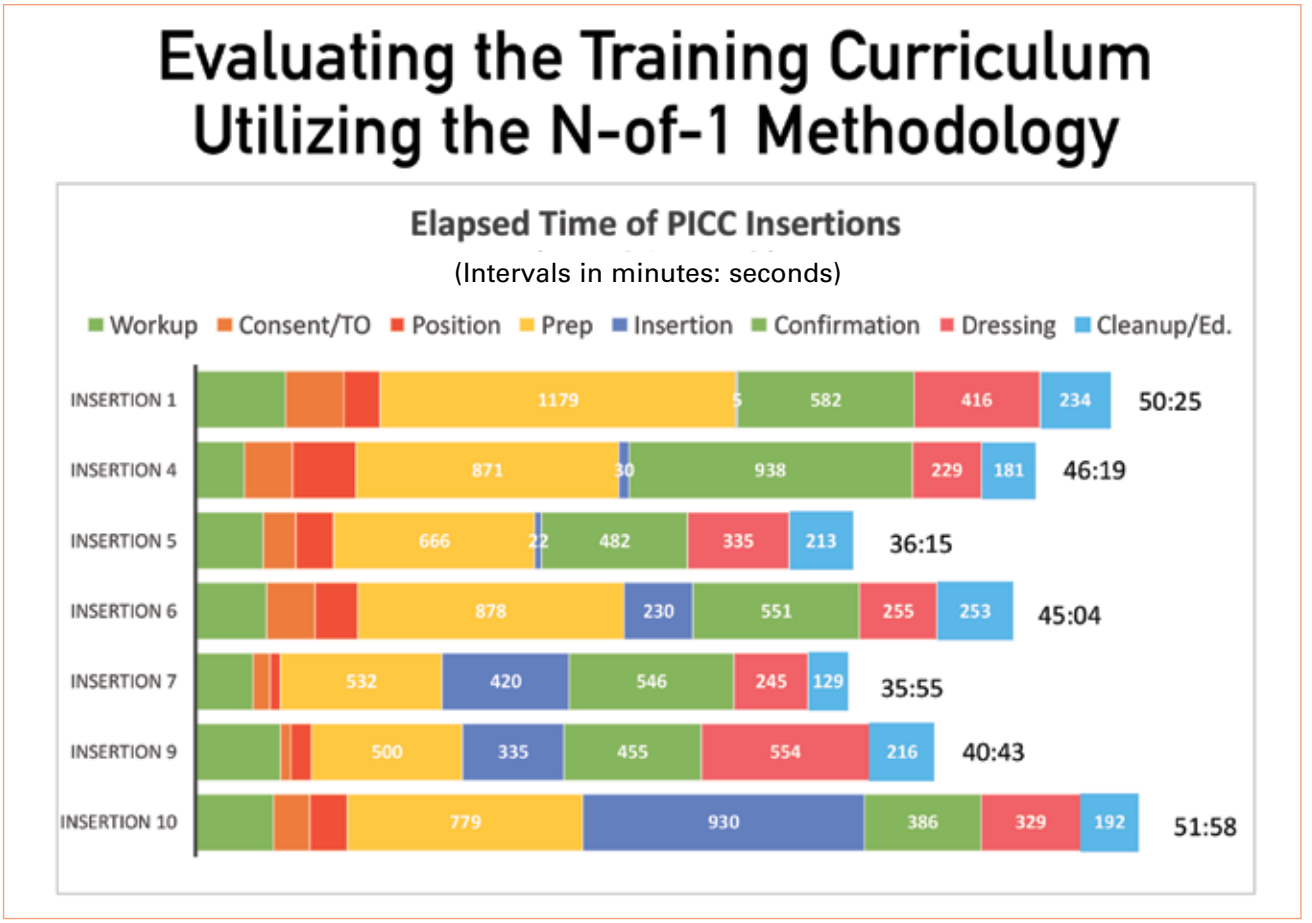

Figure 3. Time Intervals of Critical Elements of Successful Peripherally Inserted Central Catheter (PICC) Insertions by PICC CRNA

Abbreviations: CRNA, Certified Registered Nurse Anesthetist; Ed, education; Prep, preparation.

elements. There were no complications reported with any of the 10 insertion attempts.

On evaluation, the PICC training course met the CRNA's expectations. The didactic components were helpful to a moderate degree. The most effective approach to improving the CRNA's confidence in PICC insertion was practicing the insertion on the partial task trainer.

Analysis of the debriefing questions after each insertion revealed 1 negative correlation that was statistically significant. The *P* value of .001 for the PICC RN assisting the CRNA during the procedure meant that the PICC RN was helping the CRNA less and less as the insertions progressed from number 1 to 10. On average, the 5 elements that could have compromised the insertion scored as a small to moderate degree of hindrance (1 to 2.9). The 4 elements that could have promoted the success of the insertion were helpful to a moderate or very high degree (3.3 to 4.6; Figure 4).

The open-ended questions of the postinsertion survey revealed venipuncture, dressing placement, and other familiar skills "going well" in the first several insertions, but challenges included the use of the "ultrasound" and placement confirmation devices. The PICC kits were complex, as evidenced by the lengthy times spent in setup. Extra tissue in the upper arms of several patients caused difficulty in estimating the length of the catheter. On one insertion, multiple nursing student observers imposed performance pressure on the CRNA. In another, an insertion with a potentially volatile psychiatric patient in leather restraints ended successfully. As the insertions concluded, locating the vessels and coordinating the needle stick with ultrasound guidance continued to be challenging.

Overall, the clinical experience gave the CRNA a sense of accomplishment in learning a unique skill that could help meet the needs of the patients and hospital. The CRNA believed that 10 insertions were enough to acquire the skill set and become independent on any future insertions. He commented that the technique of PICC insertion is "related but not identical to" central line insertion, and there are body position adjustments, awake patients, and foreign environments to negotiate. None of the 10 insertions was done completely independently, but as the insertions progressed, the assistance was more by verbal cues.

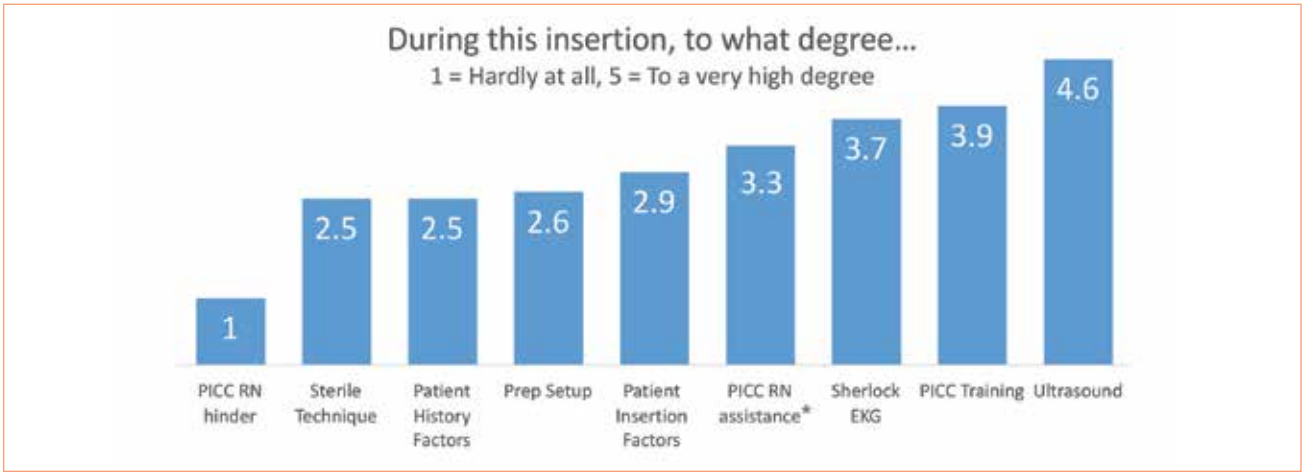

Figure 4. Average of Survey Response Values After Clinical Peripherally Inserted Central Catheter (PICC) Insertions by CRNA[a]

Abbreviations: CRNA, Certified Registered Nurse Anesthetist; RN, registered nurse.

[a]After each insertion, the CRNA rated the degree of agreement with the variables above. These are the average values of each variable and its impact on the insertions. "Sherlock EKG" refers to the electrocardiography guidance system used to confirm PICC placement.

*P value of 0.001 for PICC RN assistance demonstrated a significant but negative correlation

Discussion

The goal of this quality improvement project was to determine whether another staff resource could be trained to meet the demand for PICC line insertions. The duration of the PICC insertions was a key measure of this project. The time interval was not a measure of competency but of cost-effectiveness. If the CRNA could competently complete the PICC insertion in an equal or shorter time interval than the IV team, the costs incurred by a future CRNA PICC service could be minimized and become a viable endeavor.

Only one CRNA could be trained for this project because of organizational constraints. The PICC insertions had to be done while the CRNA was on the time-clock so that liability coverage could be maintained. The hospital's Department of Anesthesiology needed to be reimbursed for the CRNA's work time at the hourly rate plus benefits. An unintended consequence of the abbreviated timeframe demonstrated that the training could be accomplished quickly, in 2 to 3 weeks.

A larger project would need to cover a larger portion of salaries if designed the same way. A future project could examine the feasibility of training a team of PICC CRNAs to serve as a backup service for the IV Nursing PICC team. Because CRNAs were scheduled 24 hours per day, 7 days per week in the hospital, CRNAs could be a resource around the clock as long as the availability was not abused. Data from a larger scale project, with CRNAs inserting PICCs independent of the IV Nursing team, would yield the effects and potential efficiencies gained with the development of a CRNA PICC team.

The randomized, controlled trial is the gold standard method of research studies, although the N-of-1, or single case method, is an option in research and quality improvement. It is indicated for studies characterized by a heterogeneity of treatment effects, chronicity of a subject's condition, stability of treatment effect, effect onset and carryover, or a lack of adequate evidence to inform a treatment decision.[15] The N-of-1 method was applied because of organizational constraints and the paucity of literature evidence that CRNAs are inserting PICCs.

This project had several limitations. First, it produced a very small sample of PICC insertions to analyze. With such a small sample and a success rate of 70%, replications of this project may reveal that this series of insertions was more difficult than usual, considering the IV Nursing team's success rate of 86%. The sample was small, due primarily to the schedule limitations of the IV PICC team and the CRNA. Second, working with a variety of PICC RNs may have introduced inconsistent practices during PICC insertion. In the future, CRNAs could train CRNAs in a standardized curriculum of didactic, simulation, and clinical training. Third, outcomes could have been influenced during the last 2 procedures because insertion time data were collected by the PICC RN, instead of the designated assistant, because of a schedule conflict.

The N-of-1 method is arguably limited by the generalizability of its findings. To compensate, a large amount of data over a long period was intended to be collected for this project. Data from 20 or more insertions would have been preferable, but schedule limitations took precedence. A future N-of-1 project would have to build in more insertions in order to collect more data. This project was unable to evaluate the efficiency that a CRNA service would add independent of the IV Nursing PICC team. The CRNA evaluated in this project was tethered

to the PICC team's schedule and had to perform in their practice model. It serves as a foundation for a future project to examine the impact of a full CRNA PICC line service, including intervals between the PICC order and insertion, a reduced length of stay, and an evaluation of patient outcomes.

Conclusion

Patients were waiting too long for the insertion of PICC lines in our hospital. From the results of this quality improvement project, it is reasonable to conclude that a CRNA can be trained to insert PICCs in a short timeframe and provide another reliable and safe resource for the hospital to meet the needs of its patients. Although more work remains to evaluate a full CRNA PICC team, this N-of-1 project was useful to describe the hospital's option for using an alternate resource to address a problem affecting patient care.

REFERENCES

1. Alexandrou E, Spencer TR, Frost SA, Parr MJ, Davidson PM, Hillman KM. A review of the nursing role in central venous cannulation: implications for practice policy and research. *J Clin Nurs.* 2010;19(11-12):1485-1494.
2. Yacopetti N, Alexandrou E, Spencer TR, et al. Central venous catheter insertion by a clinical nurse consultant or anaesthetic medical staff: a single-centre observational study. *Crit Care Resusc.* 2010;12(2):90-95.
3. Alexandrou E, Murgo M, Calabria E, et al. Nurse-led central venous catheter insertion-procedural characteristics and outcomes of three intensive care based catheter placement services. *Int J Nurs Stud.* 2012;49(2):162-168.
4. Benham JR, Culp WC, Wright LB, McCowan TC. Complication rate of venous access procedures performed by a radiology practitioner assistant compared with interventional radiology physicians and supervised trainees. *J Vasc Interv Radiol.* 2007;18(8):1001-1004.
5. Park JY, Kim HL. A comprehensive review of clinical nurse specialist-led peripherally inserted central catheter placement in Korea: 4101 cases in a tertiary hospital. *J Infus Nurs.* 2015;38(2):122-128.
6. Kazdin AE. *Single-Case Research Designs: Methods for Clinical and Applied Settings.* 2nd ed. New York, NY: Oxford University Press; 2011:1-21.
7. Cook Medical. Central venous lines, PICCs, ports and pumps: 2018 coding and reimbursement guide. https://www.cookmedical.com/wp-content/uploads/2018/01/RG_IR_CPPPCR_RE_201801.pdf. Originally accessed May 14, 2017. Updated link accessed November 17, 2018.
8. Rosman M, Rachminov O, Segal O, Segal G. Prolonged patients' in-hospital waiting period after discharge eligibility is associated with increase risk of infection, morbidity and mortality: a retrospective cohort analysis. *BMC Health Serv Res.* 2015;15:246.
9. Ellison A. Average cost per inpatient day across 50 states. *Becker's Hospital CFO Report.* http://www.beckershospitalreview.com/finance/average-cost-per-inpatient-day-across-50-states-2016.html. Published January 13, 2016. Accessed May 8, 2017.
10. Peripherally inserted central catheter: insertion, dressing change, cap change, exchange, blood sampling, and removal. *UPMC Presbyterian-Shadyside Nursing Policies and Procedures.* Pittsburgh, PA; 2015.
11. Benner P. From novice to expert. *Am J Nurs.* 1982;82(3):402-407.
12. Bullock-Corkhill M. Central venous access devices: access and insertion. In: Corrigan A, Gorski L, Hankins J, Perrucca R, Alexander M, eds. *Infusion Nursing: An Evidence-Based Approach.* 3rd ed. St Louis, MO: Saunders-Elsevier; 2010:480-494.
13. Collins A. Ultrasound transducer manipulation. 2009. https://www.youtube.com/watch?v=RskrEsAGzec. Accessed November 1, 2017.
14. Cook Medical. Video demonstration of the placement of a peripherally inserted central catheter (PICC). https://www.youtube.com/watch?v=9FvUsjje8ic. Accessed Feburary 3, 2018.
15. Duan N, Kravitz RL, Schmid CH. Single-patient (n-of-1) trials: a pragmatic clinical decision methodology for patient-centered comparative effectiveness research. *J Clin Epidemiol.* 2013;66:S21-S28.

AUTHORS

Aaron M. Ostrowski, DNP, CRNA, is a clinical assistant professor at West Virginia University School of Nursing and a clinical CRNA at J.W. Ruby Memorial Hospital in Morgantown, West Virginia. Email: ostram20@gmail.com.

Suzanne Morrison, DNP, CRNA, is an associate professor at the University of Pittsburgh Department of Nurse Anesthesia University of Pittsburgh School of Nursing, Pittsburgh, Pennsylvania.

John O'Donnell, DrPH, CRNA, is professor and chair of the Department of Nurse Anesthesia, University of Pittsburgh School of Nursing.

DISCLOSURES

The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did not discuss off-label use within the article.

ACKNOWLEDGMENTS

The AANA Foundation supported this project through the Kay Wagner Memorial Fellowship, whose funding assisted with study implementation, data interpretation, and reporting. The authors also acknowledge Leigh Ann Clark, MSN, CRNA, and Derek Reckard, MSN, CRNA, for their assistance.