Implementing Ultrasound-Guided Peripheral Intravenous Practices on a Multi-Service Unit

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Nurses and paraprofessionals can become proficient in using ultrasound-guided peripheral intravenous to improve catheterization success rates. Education and training can be implemented in medical-surgical settings using models for evidence-based practice.

Peripheral intravenous catheterization (PIVC) is considered the most widely performed invasive procedure in the hospital setting. It frequently is needed for the prompt diagnosis and treatment of admitted patients (Cooke et al., 2018). PIVC is required in 70%-80% of hospitalized patients (Cooke et al., 2018; Van Loon et al., 2018) and most often is indicated for medication administration, hydration therapy, diagnostic and laboratory testing, and blood transfusion (Reeves et al., 2017; Stolz et al., 2015; Van Loon et al., 2018). Initiation of IV therapy, nonetheless, may become complicated in patients who have poor vasculature or known history of difficult venous access (DVA) (10%-24% of adults, approximately 37% of children) (Kaur et al., 2019). Patients presenting with conditions, such as diabetes, drug abuse, sickle cell anemia, obesity, and shock, may pose a significant challenge to establishing PIVC (Gottlieb et al., 2017; Heinrichs et al., 2013). Multiple

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Clinical Question

Does an ultrasound-guided peripheral intravenous (USGPIV) program reduce multiple intravenous access attempts in patients with difficult intravenous access compared to traditional methods?

Evidence-Based Practice Model

The Rosswurm and Larrabee Model for Change to Evidence-based Practice (Rosswurm & Larrabee, 1999)

Patient Outcomes

Greater than 50% reduction in peripheral intravenous catheterization and blood specimen collection attempt failures in medical-surgical patients with difficult intravenous access

Search Strategy

A literature review was conducted using the following search terms: *ultrasound-guided peripheral intravenous access, difficult peripheral intravenous access patients,* and *ultrasound guidance peripheral catheterization*. Only systematic reviews with or without meta-analysis comparing the effectiveness of USGPIV practices to traditional peripheral intravenous catheterization methods were included. Full-text manuscripts in English published 2009-2019 were considered, and no limits for age were set to maximize findings related to the topic of interest.

Databases

CINAHL, EBSCO, Ovid Online, PubMed, Google Scholar, The Cochrane Library

Clinical Setting

20-bed inpatient multi-service unit with diverse patient population (age 30 days to older adult); average 300 admissions monthly

PIVC attempts may be needed in patients with poor vasculature, leading to pain and discomfort. Research has documented first-attempt success rates via traditional methods at 53%-75.6% and 76%-91% for pediatric and adult populations, respectively (Heinrichs et al., 2013). Furthermore, clinical nurses have reported an average as high as 5.5 attempts per PIVC (Reeves et al., 2017).

Physicians often resort to central venous catheter (CVC) insertions for cases of DVA, carrying a 5%-19% complication rate (e.g., local infection, bacteremia, thrombosis, pneumothorax) (Kaur et al., 2019; Liu et al., 2014; Rodriguez-Calero et al., 2018; Tsotsolis et al., 2015). The estimated cost of a single CVC-related infection in 2019 was $46,000, resulting in annual costs of $2.3 billion nationally (Haddadin & Regunath, 2019). Previous studies demonstrated implementation of an ultrasound-guided peripheral intravenous (USGPIV) catheter program by trained personnel can reduce CVC placement rates in noncritical patients by up to 85% (Au et al., 2012; Rodriguez-Calero et al., 2018; Shokoohi et al., 2013). Similarly, Duran-Gehring and coauthors (2016) documented a 46.5% reduction in the need to obtain CVC access in 830 patients with DVA.

This project explored the following evidence-based practice (EBP) question: When properly implemented, does an USGPIV program reduce multiple intravenous access attempts in medical-surgical patients with DVA compared to traditional methods?

Project Site and Reason for Change

Current population statistics indicate North America (including the United States) will remain the second oldest region in the world in 2050. An estimated 21.4% of the population will be age 65 and older (U.S. Census Bureau, 2018). This projection suggests the complexity of care and the volume of medical-surgical patients will continue to increase, placing further demand on the advancement of skill sets such as PIVC.

The multi-service unit (MSU) at Naval Hospital Jacksonville, FL, is a 20-bed inpatient unit that provides care to a variety of patients (infants >30 days to senior adults). The patient population presents unique challenges for healthcare providers due to diverse diagnoses in pediatrics, gerontology, internal medicine, obstetrics, and surgical specialties (e.g., general surgery; orthopedics; urology; ear, nose, and throat; ophthalmology). Factors contributing to successful PIVC via traditional methods on MSU compare to those reported in the literature. Kaur and coauthors (2019) described overall success rates for PIVCs of 61%-90% and associated higher cannulation success rates with having visible or palpable veins and high procedural volumes/staff experience. On average, 69% of core staff who provide direct patient care on MSU possess less than 3 years of clinical practice, making it difficult to rely on experience alone as a contributing factor for attaining successful PIVC. Keleekai and colleagues (2016) suggested PIVC first-attempt success rates are related directly to knowledge, confidence, and skills. It thus becomes critical to advocate for use of evidence-based strategies to minimize potential PIVC complications.

Summary of Literature

Eight systematic reviews/meta-analyses were found initially through database searching and other sources. After screening for eligibility, three studies were excluded for non-English language, lacking comparison of USGPIV practices to traditional methods, and evaluation of peripheral arterial USGPIV studies rather than peripheral venous. Four systematic reviews with meta-analysis and one systematic review without meta-analysis analyzing data from 12 different randomized controlled trials and three cohort studies were included for further evaluation (Egan et al., 2013; Heinrichs et al., 2013; Liu et al., 2014; Stolz et al., 2015; Van Loon et al., 2018).

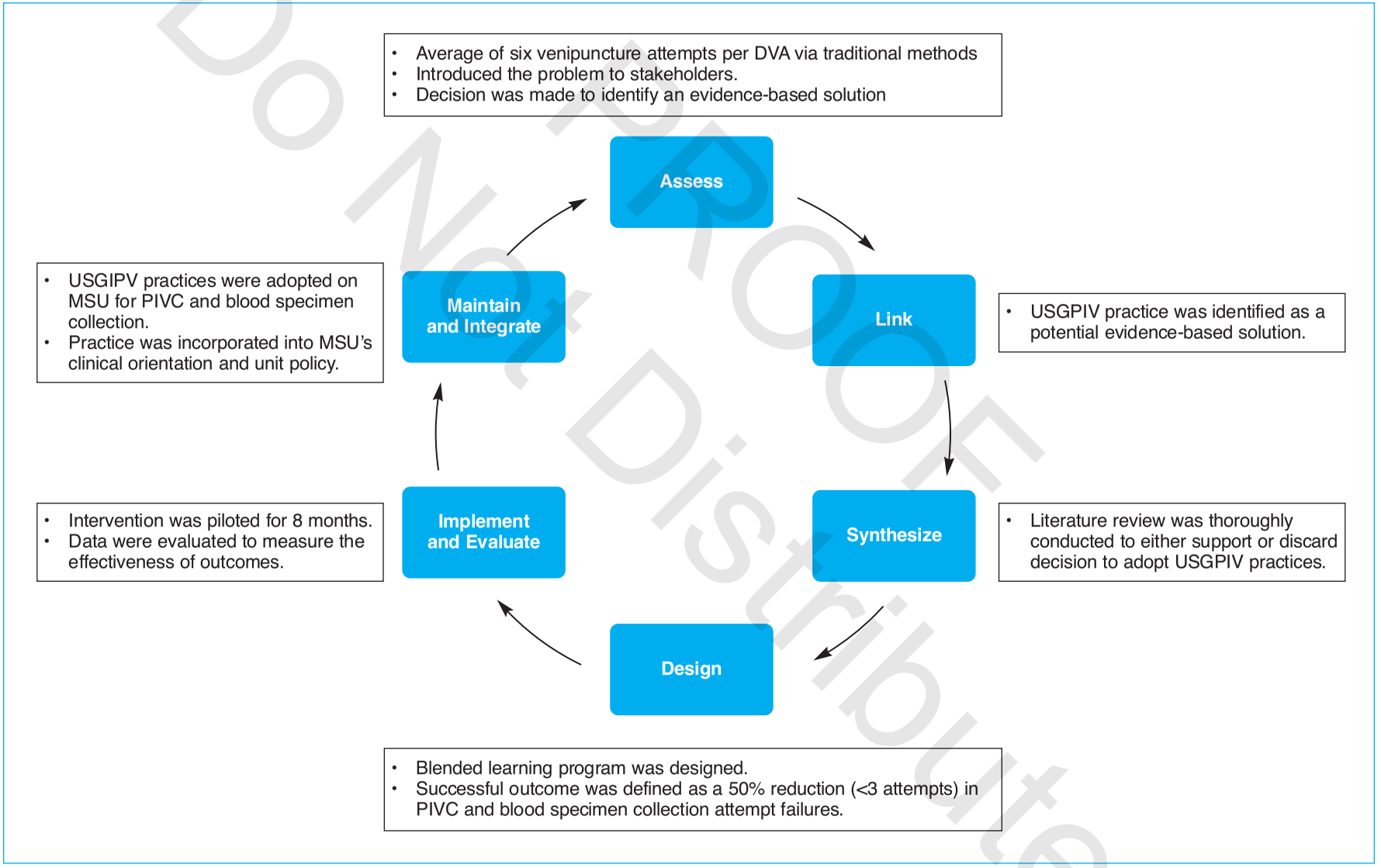
Ultrasound-guided vein cannulation was introduced in 1999 (Keyes et al., 1999) and has been well documented in the literature as an effective means for obtaining PIVC in children and adults admitted to acute care settings (Heinrichs et al., 2013; Van Loon et al., 2018; Yamagami et al., 2018). Compared to traditional methods, USGPIV techniques have demonstrated superiority in achieving first-attempt success rates and reduced needle passes (Van Loon et al., 2018). Although medical providers have been the conventional end-users of ultrasonography for purposes of obtaining PIVC, studies have found nurses also may gain proficiency in USGPIV practices through robust competency programs incorporating multi-modal learning techniques (Moore, 2013; Reeves et al., 2017; Rice et al., 2016). Despite positive findings associated with USGPIV practices, limited information exists regarding its usefulness in the medical-surgical setting.

EBP Model

The Rosswurm and Larrabee Model for Change to Evidence-based Practice (Rosswurm & Larrabee, 1999) was chosen as the organizing framework for introducing USGPIV practices on MSU (see Figure 1). Under this model, healthcare professionals are guided systematically through developing and integrating EBP in the clinical set-

Note: The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, or the United States Government.

FIGURE 1.
USGPIV Implementation Process Based on Rosswurm and Larrabee's Model for Change to Evidence-Based Practice



DVA = difficult intravenous access, PIVC = peripheral intravenous catheterization, MSU = multi-service unit, USGPIV = ultrasound-guided peripheral intravenous

Source: Rosswurm and Larrabee (1999)

ting. The model's effectiveness is well documented in the literature (Mohide & King, 2003; Pipe et al., 2005; Pipe, 2007). The model is characterized by six major tenants: Assess, Link, Synthesize, Design, Implement & Evaluate, and Integrate & Maintain (Rosswurm & Larrabee, 1999).

Answer to the EBP Question

Assess

The need for improving traditional PIVC methods and blood specimen collection practices was identified based on staff members' self-reporting an average of six needle sticks per patient with DVA. Trends in patient safety reporting to the Quality Department related to diagnosis and treatment delays also raised patient safety and satisfaction concerns. Stakeholders were introduced to the clinical problem during a monthly Nursing Professional Practice Committee meeting, and the decision was made to pursue an evidence-based solution.

Link

Use of ultrasound guidance for establishing PIVC was recognized as a possible intervention to mitigate challenges associated with DVA. This intervention was identified because of other existing USGPIV non-standardized protocols within the hospital, specifically in the intensive care unit and emergency department (ED). Due to variability in education and training methods in these two clinical areas, a secondary outcome of this project was to develop a standardized USGPIV program for adoption in any clinical setting with patients with DVA.

Synthesize

The five systematic reviews/meta-analyses that met inclusion criteria were evaluated using The Centre for Evidence-Based Medicine (2019) Systematic Review Critical Appraisal Sheet. This tool helped assess the quality of each study, ensuring questions were clear, methods were valid, and results were relevant and generalizable. Selected studies shared the same primary outcome as stated by their PICO (Patient, Problem, or Population; Intervention; Comparison; Outcome) questions: evaluation of the effectiveness of USGPIV practices in patients with DVA (Egan et al., 2013; Heinrichs et al., 2013; Liu et al., 2014; Stolz et al., 2015; Van Loon et al., 2018). All authors conducted thorough literature searches to identify relevant studies based on inclusion/exclusion criteria. However, a common element in all the systematic reviews was heterogeneity in patient populations (adults vs. pediatrics), operator experience, defining DVA, and randomization of individual studies. All but one study completed a meta-analysis (Liu et al., 2014). Consensus in all five articles was USGPIV practices significantly improve catheterization success rates and satisfaction in patients with DVA (see Table 1).

Supporting research found ultrasound guidance technique was easy to learn and could be performed safely by various healthcare providers (Van Loon et al., 2018). In a prospective study, Carter and coauthors (2015) found no statistical differences in performing successful USGPIV insertions between ED residents and nurses. Similarly, Schoenfeld and colleagues (2011) did not find any statistical differences in USGPIV success rates between experienced ED technicians and licensed healthcare personnel, such as physicians and nurses. Based on studies' favorable results, a collaborative decision was made to purchase an ultrasound machine to introduce USGPIV practices on the MSU.

Design

A blended learning program was designed before implementation of USGPIV practices on MSU. It comprised a self-paced, web-based lesson via Elsevier Clinical Skills (ECS) and one-on-one instruction that incorporated use of PIVC silicon molds. ECS was selected as the learning delivery method to integrate audiovisual teaching tools and evidence-based skills checklists. The ECS lesson contains seven sections (Quick Sheet, Extended Text, Supplies, Videos, Illustrations, Test, Competency Checklist) that could be referenced at any time by learners in preparation for the hands-on evaluation.

Knowledge validation would be achieved by successfully completing a five-question test; a minimum score of 80% was set as the standard to pass. Upon verification of test scores, initial one-on-one training was conducted by an experienced MSU clinical nurse specialist who also was certified in peripheral central catheter insertion. One-on-one training facilitated the review of vessel anatomy, PIVC sites, and ultrasound principles. Silicon molds designed specifically for PIVCs were purchased to allow learners to gain proficiency with motor-coordination skills associated with ultrasound guidance. The clinical competency's hands-on portion required demonstration of seven various USGPIV elements: gathering equipment, preparation for insertions, site selection, catheter selection, site preparation, venipuncture/insertion of catheter, and documentation. Five supervised USGPIV insertions would be evaluated before clinicians' independent practice.

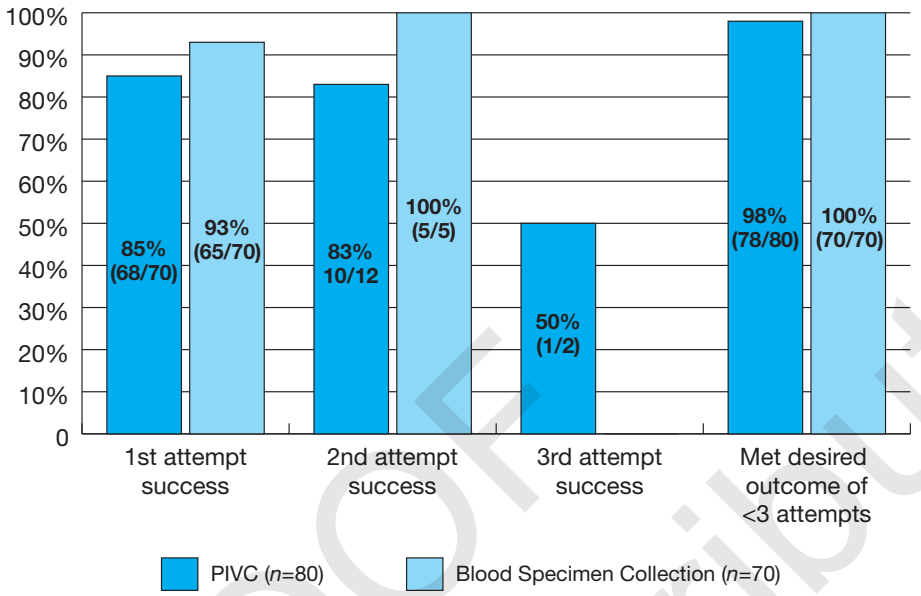
Because challenges associated with intravenous access on MSU were not unique to PIVCs, ultrasound guidance also was extended to blood specimen collections. Although the literature synthesis did not explore use of ultrasound guidance for blood specimen collections, a clinical decision was made to incorporate it into MSU's practice due to its parallel approach to PIVC. The desired outcome was defined as greater than 50% reduction in PIVC and blood specimen collection attempt failures in patients with DVA (from a self-reported average of six to less than three attempts). A logbook was created to document each patient encounter to maintain accountability of ultrasound usage. Staff members performing USGPIV procedures would be required to specify if ultrasound guidance was used for a PIVC or blood specimen collection, total number of

TABLE 1.
Table of Evidence for Systematic Reviews/Meta-Analyses

Design	Authors	Population	Outcome	Findings and Comments
Systematic review with meta-analysis	Egan et al. (2013)	7 RCTs (*N*=289): 5 adult, 2 pediatric Treatment: US guidance Control: Traditional method	Primary measures: • Rate of successful PIVC Secondary measures: • Procedure time • Number of attempts	1. Increased success rates of PIVC with ultrasound guidance in patients with DVA 2. No statistical difference in procedure time, number of attempts
Systematic review with meta-analysis	Heinrichs et al. (2013)	9 RCTs (*N*=376): 7 adult, 2 pediatric Treatment: US guidance Control: Traditional method	Primary measures: • Rate of successful PIVC • Number of attempts • Procedure time Secondary measures: • Patient satisfaction • Healthcare worker qualitative rating of effectiveness • Healthcare worker qualitative rating of visibility of peripheral veins before/after technological assistance • Parent or family satisfaction	1. Ultrasound guidance reduces PIVC attempts and procedure time.
Systematic review without meta-analysis	Liu et al. (2014)	6 RCTs (*N*=316): 4 adult, 2 pediatric Treatment: US guidance Control: Traditional method	Primary measure: • Rate of successful PIVC Secondary measure: • Number of attempts • Procedure time	1. Ultrasound guidance is beneficial in patients with nonvisible or palpable veins. 2. Greatest benefits in number of attempts, time to success found in pediatrics
Systematic review with meta-analysis	Van Loon et al. (2018)	5 RCTs, 3 cohorts (*N*=1,660): ages not specified Treatment: US guidance Control: Traditional method	Primary measure: • Rate of successful PIVC Secondary measure: • Number of attempts • Procedure time • Patient satisfaction or pain scores • Incidence of complications	1. Increased success rates of PIVC with ultrasound guidance in patients with DVA 2. Ultrasound guidance reduces PIVC attempts and procedure time. 3. Ultrasound guidance improves patient satisfaction but has no difference in complications.
Systematic review with meta-analysis	Stolz et al. (2015)	6 RCTs, 1 cohort (*N*=not specified): 5 adult, 2 pediatric Treatment: US guidance Control: Traditional method	Primary measure: • Rate of successful PIVC Secondary measure: • Number of attempts • Procedure time	1. Increased success rates of PIVC with ultrasound guidance in patients with DVA 2. No statistical difference in procedure time and number of attempts

DVA = difficult intravenous access, PIVC = peripheral intravenous catheterization, RCT = randomized controlled trial, US = ultrasound

FIGURE 2.
Peripheral Intravenous Catheterization (PIVC) and Blood Specimen Collection Procedure Success Rates



attempts, and if the invasive procedure was successful or not.

Implement and Evaluate

Fourteen staff members completed the training and competency evaluations. Six registered nurses had professional nursing experience of 0-15 years, and eight paraprofessionals (hospital corpsmen) had no more than 3 years of clinical experience. U.S. Navy Hospital Corpsmen (HMs) are enlisted medical specialists who serve in a variety of clinical settings to assist medical and dental professionals in providing care to active duty and reserve component service members, retirees, and other beneficiaries (National Museum of the United States Navy, 2019). HMs are highly qualified to work and train alongside nurses on inpatient units, and often are delegated the task of performing invasive procedures such as PIVC and blood specimen collection.

USGPIV practices were piloted on MSU. Data were collected over 8 months to evaluate impact on the number of PIVC and blood specimen collection attempts in patients with DVA (based on clinical judgment). With ultrasound guidance, 80 PIVCs and 70 blood specimen collections were attempted. Of 80 attempted PIVCs, 85% (*n*=68) were inserted successfully on the first attempt; 83% of the remainder were inserted successfully on the second attempt (*n*=10), and 50% on the third attempt (*n*=1). Of 68 first-attempt successful USGPIV insertions, one was performed on a child (<age 10). The USGPIV first-attempt success rates obtained in this project (85%) were comparable to the overall success rates reported in the literature (79%-81%) (Egan et al., 2013; Van Loon et al., 2018). For the one unsuccessful attempt, a peripherally inserted central catheter was indicated for long-term antibiotic therapy.

Of 70 blood specimen collections attempted, 93% (*n*=65) were obtained successfully on the first attempt; 100% (*n*=5) were obtained successfully on the second attempt. Two of the successful first-attempt blood specimen collections were in children (<age 10). No comparison for blood specimen collections could be found in the literature. Overall, 97.5% (*n*=78) and 100% (*n*=70) of PIVCs and blood specimen collections, respectively, met the desired outcome of being obtained in less than three attempts (see Figure 2).

Integrate and Maintain

Following successful implementation, the Ultrasound-Guided Peripheral Intravenous Access Competency was incorporated into MSU's policy through initial unit orientation and the training module in ECS. This integration ensures all MSU staff are exposed to USGPIV practices, providing an established pathway to receive one-on-one training. Clinical nurse specialists at the facility are charged with maintaining currency of training endeavors for nurses and paraprofessionals. Remaining abreast of best practices related to the use of ultrasound guidance is also critical, including infection control standards and better identification of patients with DVA.

Limitations

This project was an evidence-based initiative designed to effect change at the local level, so results are not generalizable to other institutions. PIVC and blood specimen collection success rates before implementation were not quantified beyond verbal interviews with staff, so direct pre-post comparisons

could not be made. Local PIVC success rates were consistent with those found in the literature; however, these results were self-reported by staff and not confirmed by independent observers. Moreover, identifying DVA cases defaulted solely on the clinical judgment of staff members due to lack of a decision-making algorithm. A validated tool could be introduced in future assessments to standardize how patients with DVA are identified.

Nursing Implications

An estimated one in nine patients presents to the hospital with DVA due to obesity, end-stage renal disease, sickle cell disease, IV drug abuse, peripheral vascular disease, or diabetes (Pare et al., 2019). These challenges are transposed to medical-surgical settings, where admitted patients commonly require PIVC for fluids, blood products, and medications (Williams & Hopper, 2015). These challenges affect nurses by increasing the time spent placing peripheral catheters and delaying initiation of appropriate therapies.

Implementation of an USGPIV program is viable, easy, and safe when training is executed properly. USGPIV can be equally effective when performed by physicians, nurses, or HMs (Oliveira & Lawrence, 2016). Additionally, Pandurangadu and coauthors (2016) found patient satisfaction scores increased by 20% when USGPIV was used. Data indicate USGPIV placement is safe and effective when performed at the bedside by trained personnel, can decrease time spent placing PIVC and hasten initiation of IV therapies, and has the potential to increase patient satisfaction scores.

Physicians and nurses have a shared role in developing and implementing best practices to ensure optimal patient care and outcomes. Multiple IV attempts are painful and, if peripheral cannulation fails, placement of alternative access may be required. In addition to reducing delays in patient care, USGPIV placement avoids the need for central venous catheters and potential associated complications (Duran-Gehring, 2016). Given the necessity of PIVC in the medical-surgical setting, providing quality training in USGPIV placement should become a standard of care.

Conclusion

Well-implemented USGPIV initiatives have helped minimize potential complications associated with PIVC, specifically the need for multiple venipuncture attempts. Clinical proficiency and staff experience played an essential role in identifying patients with DVA on MSU, decreasing the likelihood of attempting unnecessary use of CVCs. Establishing robust USGPIV programs may decrease delays in patient diagnosis and treatment and reduce patient discomfort, prolonged hospitalization, increased costs, and morbidity in the medical-surgical setting (Reeves et al., 2017). Providers and nurses share the responsibility of optimizing clinical outcomes associated with IV therapy and play a vital role in systematically translating evidence-based practices to the point of care. USGPIV placement can be learned through a well-designed education and training program that validates knowledge and skill demonstration. MSN

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