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Intraosseous Vascular Access in the Emergency Department

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BY

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This Practice Innovation Project is approved as a credible and independent investigation by a candidate for the Doctor of Nursing Practice degree and is acceptable for meeting the project requirements for this degree. Acceptance of this practice innovation project does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Abstract

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Current guidelines and recommendations from the American College of Surgeons Advanced Trauma Life Support and the American Heart Association (AHA) include intraosseous (IO) access as a second-line alternative when delayed or failed peripheral vascular access occurs in emergent or trauma situations. IO access is underutilized in the emergency department (ED) due to registered nurses' knowledge deficit, lack of training and education, and lack of supplies (Cheung, Rosenberg, & Vaillancourt, 2014). The National Association of EMS Physicians (NAEMSP) supports the use of IO access and describes IOs as a significant time saving intervention in achieving vascular access and decreasing the time to administration of medications (Infusion Nurse Society, 2009). The purpose of the practice innovation project was to increase the knowledge, competency, and comfort level of registered nurses in assessing and utilizing the IO device as a second-line alternative to achieve vascular access in emergency trauma patients. The overall results of the IO education program were determined to be beneficial in improving a knowledge deficit on IO insertion. There was an increase in registered nurses completing IO access after the educational program, which is clinically significant for this ED.

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Chapter I

Development of the Clinical Question and Problem Identification

Introduction

Emergency departments and trauma centers depend significantly on obtaining reliable and rapidly achievable vascular access through peripheral intravenous (PIV) cannulation in critically ill patients (Cheung et al., 2014). Often in emergent or trauma situations, healthcare professionals, including registered nurses and physicians fail to obtain peripheral vascular access for the delivery of blood products, antibiotics, fluids, analgesics, anesthesia, and withdrawal of blood for serum analysis due to the collapse of the peripheral vein (Paxton, 2012). When peripheral intravenous access is delayed or fails, a physician may attempt to obtain an IV insertion through a central or external jugular line. However, inserting a central line during an emergent situation or trauma increases the risk of serious complications including sepsis, pneumothorax, inadvertent arterial catheterization, and time constraint (Cheung et al., 2014). Often additional attempts with a peripheral vascular device are utilized until the placement of a central or external jugular line can be performed. However, this is often difficult because of peripheral vascular collapse and small veins based on the patient's body mass index (BMI) (Voigt, Waltzman, & Lottenberg, 2012). One alternative to IV access is the use of an IO approach. According to Cheung et al. (2014), the advantage of IO access is the non-collapsible intramedullary space of cancellous bone, which has demonstrated efficiency and reliability in delivery of medications, fluids, and blood products.

The IO is a method utilized in healthcare to obtain vascular access. The method of IO insertion is obtained by utilizing a battery driven device to drill a needle into the bone

to achieve vascular access through the bone marrow. Once the IO is correctly identified in the bone marrow; medications, intravenous fluids, and blood products can be administered through the IO device to reach systemic circulation. There are several approved bone sites for the insertion of the IO device. All of these sites have been approved for IO technique in achieving vascular access.

Vascular access in trauma and critically ill patients can be difficult to establish even under the best circumstances. According to Paxton (2012) first-time success rate for placement of a PIV catheter by a healthcare professional is 34-75%. Due to the difficulty of placing PIVs in unstable patients, one in ten of these patients will still be without vascular access after two PIV attempts (Paxton, 2012). In addition, a variety of factors can play a role in making PIV access even more challenging. This includes dehydrated patients, patients in shock or with edema, patients following chemotherapy, obese patients, or IV drug users (Leidel et al., 2012). According to Leidel et al. (2012), IV access in the emergency department (ED) often results in failure 10-40% of the time with an average time needed to start the IV between 2.5 and 16 minutes.

New recommendations from the American College of Surgeons Advanced Trauma Life Support and the AHA include IO access as the second-line alternative when delayed or failed PIV access occurs in emergent or trauma circumstances. Healthcare providers in ED underutilize IO access due to knowledge deficit, lack of training and education, and lack of supplies (Cheung et al., 2014). Over the past 12 months, only 40 IO devices were utilized in the ED at my health care facility. During the three months prior to the IO educational program presented in this project, only six IOs had been utilized in ED. On average, the ED of this facility has a trauma patient five to seven times

per week. Thus, based on the current recommendations, an educational project addressing the underutilization of the IOs in trauma and critically ill patients was necessary.

Significance of Problem

Emergency vascular access is imperative in the ED because of a variety of circumstances including cardiopulmonary arrest, shock, sepsis, burns, major trauma, and status epilepticus (Voigt et al., 2012). A variety of alternative routes to peripheral intravenous catheters exist including endotracheal (ET), oral, subcutaneous (SC) and intramuscular (IM) (Paxton, 2012). However, these alternative routes are not always feasible and often are controversial in emergencies due to the unpredictable plasma concentrations and unknown optimal dose of medication required to stabilize the patient (Leidel et al., 2012).

Central venous catheter (CVC) placement is a common second alternative for administering medications, IV fluids, and blood products in emergent situations; however, this method often takes significantly longer to establish and poses a high risk for many life-threatening complications (Paxton, 2012). In addition, CVC placement can often interfere with other resuscitation interventions due to time constraint, the ability of the physician to place a CVC in an unstable patient, and the interruption of life-saving measures during cardiopulmonary resuscitation (CPR) (Day, 2011).

Recommendations from the AHA, the American Academy of Pediatrics, the Emergency Nurses Association (ENA), and the American Association of Critical-Care Nurses (AACN) suggest that IO cannulation is a simple, fast, and effective alternative to PIV in establishing vascular access in pediatric and adult patients (Hunsaker, 2013).

Despite these recommendations, healthcare providers such as physicians often discourage the use of IO access and pressure other healthcare providers to avoid IO access. In a recent healthcare survey, findings showed that healthcare providers had negative attitudes towards IO access (Cheung et al., 2014). According to Cheung et al. (2014), physicians who often perceived the nursing staff as incompetent in obtaining IO access were less likely to support the use of IO access. Additionally, nursing staff that lacked confidence in performing IO access had less intent to start an IO access (Cheung et al., 2014).

According to Phillips et al. (2010) an IO access has received considerable attention due to the rise in the inability of healthcare professionals to achieve vascular access after failed PIV attempts. If PIV route was not established, several more attempts occur until a physician is available to place a CVC or an external jugular catheter. The options of placing an external jugular, peripheral central catheter, and non-tunneled percutaneous central catheters in an unstable patient are time consuming and expensive due to the radiographic confirmation of the tip placement in these devices. IO route is more time efficient and cost effective in the initiation of care for these patients. Currently, the Center for Disease Control and Prevention (CDC) recommends selecting intravenous catheters and insertions sites with lowest complication rates to achieve the overall best treatment for the patient (Phillips et al., 2010). IO access has a long history of low complication rates and is the current recommendation for alternative vascular access to peripheral vascular access (Phillips et al., 2010).

The traditional standard of placing central lines when PIV placement has failed is a time-consuming alternative with potentially serious complications. Researchers in a

study of American Emergency Medicine (EM) Residency training programs stated that failure to obtain emergent peripheral venous access warranted placement of a CVC as the next technique of choice and IO technique was only considered as the fourth option (Cheung et al., 2014). If current medical residents are being taught that IO access is a limited technique in obtaining safe and reliable vascular access, further IO use will continue to be avoided. In addition, attitudes and beliefs about the success of IO access in emergent situations will continue to be negative.

P.I.C.O.T. Question

In emergency department trauma and critically ill patients (P), what was the effect of an education program on the number of IO insertions (I) compared to previous IO insertions (C) after nurses' completion of the education program (O) over three months time (T)?

Purpose of the Project

The purpose of this practice innovation project was to show healthcare professionals could deliver better emergent health care by introducing and utilizing IO vascular access as an alternative method in establishing vascular access in the ED. Currently, registered nurses lack the confidence, experience, and dedication to attempt IOs in emergent situations (Cheung et al., 2014). Registered nurses fear the implementation of the IO device due to these circumstances. In addition, healthcare provider's support in placement of IO is minimal and often overturned by placement of a CVC. An education program implemented within a practice innovation project supported registered nurses in utilizing IOs as a safe, reliable, and effective method in obtaining vascular access in critically ill patients in the ED.

This educational program directed registered nurses in potential improvement of patient outcomes through the following: establishing safe, effective, and faster intravascular access and decreasing potential central line infections or complications by utilizing IOs as the second alternative to stabilize the patient prior to transferring to the intensive care unit (ICU).

Definitions

Intraosseous space. "The IO space refers to the spongy, cancellous bone of the epiphysis and the medullary cavity of the diaphysis, which are connected. The vessels of the IO space connect to the central circulation by a series of longitudinal canals that contain an artery and a vein. The Volkmann's canals connect the IO vasculature with the major arteries and veins of the central circulation" (Infusion Nurses Society, 2009, p. 1).

Intraosseous access device: "A device placed in the IO space" (Infusion Nurses Society, 2009, p. 1).

Emergency Department: A department of the hospital that provides medical and surgical care to patients in need of immediate healthcare (Medicine Net, 2014).

Trauma patients: Patients who present to an emergency department from all different age groups, socioeconomic class, ethnicity, race, or geographic areas that meet trauma inclusion criteria of the healthcare facility; often requiring immediate assistance to stabilize severe or life-threatening injuries (Medicine Net, 2014).

Peripheral intravenous access: Intravenous catheter placed by a needle into the peripheral vascular system to deliver fluids, medications, blood products, analgesics, anesthesia, and withdrawal of blood for serum analysis (Medicine Net, 2014).

Central venous catheters: Intravenous catheter placed and inserted through a

vein to the thoracic portion of the vena cava or in the right atrium of the heart (Medicine Net, 2014).

Chapter 2

Review of Literature and Model of Evidence-Based Care

Introduction

The search engines utilized in this literature search were Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, EBSCO, and Wiley's Online Library. The keywords utilized in this search were intraosseous vascular access, emergency department, trauma, central venous catheter, and intraosseous devices. The John Hopkins Nursing Evidence Based Research and AGREE II Score appraisal tool were utilized in the literary search to grade the evidence accumulated to support the use of IO access. The AGREE II Score appraisal tool focuses on several evaluation domains and includes the following: scope and purpose; stakeholder involvement; rigor of development; clarity of presentation; applicability; editorial independence; and overall guideline assessment. The John Hopkins Research Evidence Appraisal assesses the strength of the study design by evaluating the sample size, randomization, involvement of intervention and control group, interpretation and analysis of data, and study limitation. The search resulted in the review of the following: IO vascular access in the ED and IO vascular access compared to CVC access.

Intraosseous vascular access in the emergency department. Recent advances in the technology of the IO access devices have increased the value of utilizing the IO device in emergency departments. This alternative route accesses the intramedullary space in the bones of the humerus or tibia allowing a direct outlet to the circulatory system. The highly vascular and non-collapsible access has now been supported as a standard quick access with high success rates (Voigt, Waltzman, & Lottenberg, 2012).

The Infusion Nurse Society (2009) developed a position paper on the role of the registered nurse in the insertion of IO access devices. The advances in the field of vascular access have resulted in an increase in scope of practice for registered nurses. The first use of the IO device dates back to 1922 in World War II. Since then IO access has transitioned into the clinical pediatric setting. Not until 2005, did the AHA recognize IO cannulation as an equivalent method of achieving vascular access to central venous access. Current guidelines for cardiopulmonary resuscitation and emergency cardiovascular care have now expanded IO access from a nonemergent clinical setting to a second alternative to PIV access in emergent clinical situations (Infusion Nurses Society, 2009). The NAEMSP states, "Intraosseous access may provide a significant time saving which may benefit critically ill patients, both by decreasing time to achieve access and by decreasing the time to administration of indicated medications" (Infusion Nurses Society, 2009, p. 1).

The position statement indicates that emergent and nonemergent IO access is crucial when IV access cannot be obtained and when there is a risk for morbidity or even mortality if vascular access is not achieved. The position statement addresses the importance of specific training for every registered nurse in order to demonstrate competence and proficiency (Infusion Nurses Society, 2009). Clinical competency can be obtained through validation of "safe insertion knowledge and skills through demonstrated clinical experience; demonstrated ability to provide appropriate care and maintenance of the IO access device; and ability to recognize complications of IO access" (Infusion Nurses Society, 2009, p. 3). These recommendations and guidelines conclude that a

qualified registered nurse who is proficient in skills can appropriately insert, maintain, and remove IO devices (Infusion Nurses Society, 2009).

Luck, Haines, and Mull (2010) developed a position statement to address vascular access as a paramount intervention in care of critically ill patients. This position statement scored a five on the AGREE II scale. An AGREE II scale is a rating scale of acceptance on the topic of interest. A five on the AGREE II scale suggests a strong overall acceptance of the literature on the use of IO access. General indications, complications, and contradictions for IO access and the focus of new insertion devices in all patients were discussed. The IO device was introduced in World War II to aid in the battlefield casualty resuscitation. In the 1980's, the IO device gained increased attention in providing safe delivery of fluids and drugs in the pediatric population. The American Academy of Pediatrics and the Pediatric Advanced Life Support course (PALS) recommended the use of IO in children younger than 6 years of age with difficult intravenous access. In 2000, this recommendation was extended to patients older than 6 years of age and currently is considered the standard alternative to PIV in Advance Cardiac Life Support (ACLS) and PALS courses (Luck et al., 2010).

Luck et al.'s (2010) literature review focused on IO vascular access as a rapid alternative to PIV in life-threatening conditions. Results of blood gas analysis including blood type, electrolyte panel, drug screen, and complete blood count drawn from a bone marrow aspirate through the IO device is comparable in values to samples obtained from a PIV. In addition, a variety of sites are available for healthcare professionals to establish IO access including the sternum, clavicle, distal radius and ulna, ilium, and medial malleolus, which have all been successful in adult patients. The success rates of these

insertion sites vary between 75-100% with successful infusion achieved within 30-120 seconds in most patient cases. Another benefit of the IO access in emergent situations is the risk of complications is less than 1% in overall incidences (Luck et al., 2010).

Voigt et al., (2012) conducted a Level I, quality A meta-analysis to determine if IO vascular access is a viable primary alternative in patients requiring emergent care. The primary outcome measures focused on the success rates, time to access, complications, pharmacokinetics, cost, and current clinical guidelines. The literary review found significant evidence that supports the underutilization of IO access in United States ED. First, lack of proper equipment was found to be a problem in 48% of the emergency departments with 42% of the emergency departments lacking guidelines on how to implement IO access. In up to 47% of the healthcare professionals, prior training or lack of knowledge was a concern, thus, resulting in underutilization. Second, if a PIV was unobtainable in an unstable patient, ED programs were using CVC as the second or third line alternative. Results of the literature review concluded that IOs were only being used 24% of the time and often the fourth option to failed PIV attempts. Finally, 74% of healthcare professionals admitted in an ED survey of being aware of IO access, but only 7% used the technique in their practice (Voigt et al., 2012). The analysis of data in this survey concludes that a lack of knowledge, training, education, confidence, and guidelines are all significant reasons registered nurses do not implement the IO procedure.

In Voigt et al.'s (2012) systematic review, clinical practice guidelines and recommendations were evaluated. The new recommendations on IO access were all supported in the guidelines from the following associations or specialties: The American

Academy of Pediatrics, American College of Emergency Physicians, Emergency Nurses Association, American College of Critical Medicine, National Association of EMS Physicians, AHA, Infusion Nurses Society, European Resuscitation Council, and the Canadian Agency for Drugs and Technologies in Health. These guidelines focused on the following recommendations: IO devices and equipment are readily available in the ED; training should be conducted so that competency is achieved; if PIV vascular access fails, IO should be the first alternative; and protocols that include specific criteria for clinical application of IO access should be available to all healthcare professionals in the emergency department (Voigt et al., 2012).

In a different study, Anson (2014) conducted a Level I, B quality meta-analysis that emphasizes the current guidelines and recommendations of IO use in cardiopulmonary resuscitation. In 2010, the AHA established new recommendations and guidelines for cardiopulmonary resuscitation. The AHA guidelines and recommendations were supported through an evidence-based literature review in PubMed and Ovid Medline databases. Anson's (2014) systematic review focused on the history of IO use; the opportunities of IO route, insertion, and devices; infection risk; drug delivery; diagnostic studies; cost effectiveness; and insertion sites. These guidelines were developed to improve achieving vascular access in shock patients with minimalizing disruption of chest compression and ACLS.

Anson (2014) found decreased survival rates in patients with ventricular fibrillation (VF) when Amiodarone administration was delayed due to failed vascular access. Thus, new AHA guidelines focused on advocating for IO use over central venous catheters or endotracheal drug administration in emergency situations. The International

Liaison Committee on Resuscitation and European Resuscitation Council supports these recommendations (Anson, 2014).

Anson (2014) discussed the success rates of IO access on 60 dehydrated children from three months to two years of age. The author found a five-minute 100% success rate in insertion of IO compared to 67% success rate of a PIV. In the adult population, the results showed a 90% first attempt achievement with IO compared to 60% first attempt with CVC. In another simulation study found in Anson's (2014) systematic review, the rate of insertion of an IO in the pre-hospital setting could be established 84.8% of time in an ambulance traveling 35mph. These results suggest even a higher percentage of successful IO access in a more controlled environment such as the ED. Finally, a trial of emergency medicine residents concluded that placing an IO in a cardiac arrest patient resulted in faster placement times with IO taking 49 seconds versus central line taking 194.6 seconds (Anson, 2014).

Mac Kinnon (2009) developed a position statement on the use of IO devices in a hospital ED. This position statement was scored as a five on the AGREE II scale. Currently, the hospital utilizes PIV access as the first safe and cost-effective method to establish intravascular access. Recent technology advancements of the IO device have provided the staff with an easy and effective alternative to failed PIVs. The hospital ED now uses the EZ-IO, battery-powered device, to establish IO access. The placement of these devices has been traditionally done by physicians or paramedics and not routinely by ED registered nurses. However, with the advancement of the new IO insertion devices and the recommended guidelines by the AHA, this ED changed the protocol on IO use (Mac Kinnon, 2009). Now, all ED registered nurses are well trained in utilizing IO

devices to infuse fluids, administer medications, and transfuse blood through the site. A specific advantage was the variety of placement options for the IO device. Currently, most registered nurses are using the tibia for insertion, which is sufficiently distant from the sites of other resuscitative efforts in cardiac arrest patients. Thus, providing interventions and efforts to save the patient's life can be carried out simultaneously. This position statement states that the use of IO devices improves the quality of the patient care by providing vascular access to the most critical patients (Mac Kinnon, 2009).

Intraosseous vascular access compared to central venous catheter access. The Current European Resuscitation Council developed guidelines for the use of the IO access in the delivery of drugs during resuscitation of patients. Leidel et al., (2012) conducted a level II and B quality study to investigate the success of IO access in adults. The study focused on the comparison of IO access versus CVC in adult patients undergoing resuscitation who had previous failed attempts to obtain a PIV. The study was conducted for two years in an ED with a Level I trauma center. The criteria included patients over the age of 18 who presented to the ED with the need for ACLS. During the initial resuscitation, the nursing staff had a maximum of three attempts to establish PIV or a maximum of two minutes. Otherwise, two independent healthcare professionals such as an anesthesiologist or general surgeon were assigned to place a CVC and an IO. The study then focused on the success rates and time to establish vascular access with CVC and IO placement (Leidel et al., 2012). Results of the study favored the high success rates and fast times to establish access through the IO route. The first attempt success rate was 85% for IO access compared to 60% for CVC access. In addition, the IO route was six

minutes faster in achieving access compared to CVC. The results demonstrated a median time of two minutes to place an IO compared to eight minutes to establish CVC access.

According to Leidel et al. (2012), complication rates for the CVC placement are reported around 15-20% in the patient population and include the following: malposition, arterial puncture, hematoma, pneumothorax, venous thrombosis, and catheter related infections. One of the main and growing concerns in the hospital is the associated-central line infections. On average, 12-25% of patients with CVC catheters result in mortality with an estimated 250,000 cases occurring per year in the United States resulting in $25,000 per central-line infection patient case. In this study, on average 33 per 1000 catheters placed per day in the emergency department alone did result in a central line infection (Leidel et al., 2012).

Due to the decreased infection control in the ED compared to inpatient units such as ICUs, a bridging intervention such as the IO access can subsequently decrease central line infections. For example, attempting CVC access in emergent situations results in reduced time to set up for proper infection control measures or the use of ultrasound guidance to place the CVC. According to this study, ultrasound-guided CVC placement increases success rates and decreases complications. Therefore, if IO access can be established in the emergency department in an effective and timely manner, the patient can be transferred to the ICU for CVC placement in a more controlled environment (Leidel et al., 2012).

The IO vascular access was found to be a safe, reliable, and rapid alternative to failed PIV attempts in emergency departments. In addition, IO cannulation was more

successful in first attempts and requiring less time compared to the classic CVC alternative. Supportive evidence shows very low complications rates for IO access and ensures this vascular device as a superior bridging intervention in emergency departments.

The literary review concluded that IO devices in the ED are underutilized. The current guidelines and recommendations support the use of IO devices as the second-line alternative to peripheral venous access in critically ill or trauma patients. The IO device has been proven to be a safe, reliable, and cost-effective alternative to a PIV (Leidel et al., 2012). In addition, the use of IO devices compared to CVCs has been demonstrated to be more effective in successful first-time attempts and faster in placement of the vascular route (Leidel et al., 2012). Evidence-based guidelines support and recommend the use of IO devices and the need for an IO guideline in the ED was warranted.

Registered nurses and learning methods. Registered nurses are responsible for delivering evidence-based care throughout his or her clinical practice. The practice of teaching to nursing students involves the preparation of students to operate effectively and efficiently and apply nursing theory to clinical practice. The use of the following teaching paradigm facilitated the learning of registered nurses in the implementation and operation of IO devices.

The role of the teacher is to acknowledge individual student learning styles and consider a variety of learning methods to facilitate student learning. These learning styles can be distinguished as utilizing different senses such as visual, auditory, and tactile. Often role modeling is achieved through formal lectures in large group setting. Role modeling is a concept utilized to provide learning, motivation, inspiration, and allowing

students to develop his or her own concept of role modeling. More than just modeling good practice as an educator, it is important for the role model to demonstrate good practice as a nurse. In addition to role modeling, active learning strategies such as collaborative groups and nursing laboratory simulations can be beneficial. These learning strategies build student confidence and allow the student to demonstrate his or her learning into clinical practice. Finally, once the learning activities have occurred, feedback is necessary to improve future practice and troubleshoot problems (Davis, 2013).

It is important to provide a safe environment for the students to allow for feedback to occur. In addition, the teaching and learning environment should be warm, open, and engaging for the students and the teacher should allow for asking questions and offering opinions. The use of these concepts of role modeling, demonstration of clinical skills, and feedback has proven to be a benchmark for teaching and learning paradigms in actions and contexts (Davis, 2013). The benchmark of role modeling, demonstration of clinical skills, and student feedback was utilized throughout the teaching process of IO access in the emergency department.

Gaps in the Evidence

Several gaps exist in the literature. The first gap in the evidence is the lack of higher quality studies that conducted research on the use of IO devices in EDs and in-patient hospital settings. Randomized controlled studies or meta-analysis (Level 1 or 2) that compare the different vascular access methods including a PIV or CVC to the IO access are needed. Randomized-controlled studies including larger number of participants would add to the evidence supporting the use of IOs in the ED. Currently, a variety of

research has been conducted on the use of IO devices in pre-hospital settings used by emergency personnel, but research on IO used by registered nurses in ED is minimal (Voigt et al., 2012).

The second gap in evidence is the lack of high quality studies comparing central and IO access in terms of insertion speed and accuracy. Other important factors to include in future research are the comparison of infection risks between the two routes and the mortality rates in patients resuscitated with either a CVC or IO access. In addition, long-term follow-up studies on the use of IO route and long-term complications are absent in the literature. Currently, studies on the use of IO and long-term complications are only being conducted in animal studies. New literature and research needs to focus more on the effect of the IO in the ED and critically ill patients, the long-term effects of IO use, and the comparison of IO devices to other vascular access in emergency settings (Anson, 2014).

The final gap in evidence is the lack of studies focusing on the use of IO devices within the registered nurses population. Currently, there is only one study examining IO insertion by ED nurses. Further studies need to be conducted on IO insertion rate, accuracy, types of devices utilized, and placement sites. Current guidelines focus on implementing protocols to aid registered nurses in using IOs, however, only one study exists to support this recommendation.

Model of Evidence-Based Care

The model for this study is the Ace Star Model of Knowledge Transformation. See Figure 1. This model is an evidence-based practice model utilized in this practice innovation project to aid in the implementation of guidelines for the use of IO devices in

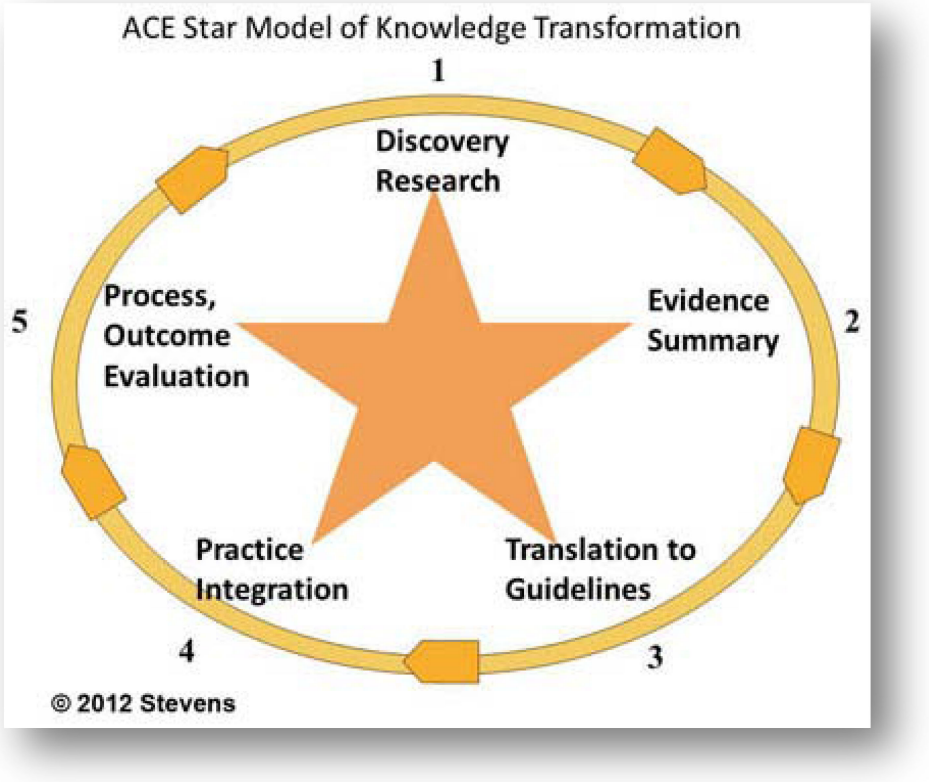
the ED. The model's framework focuses on several sequences of evidence and how to integrate it into practice. This tool consists of five stages and includes the following: knowledge search; evidence summary; translation to guidelines; practice integration; and process, outcome evaluation (Melnyk & Fineout-Overholt, 2011). The first stage of the model is knowledge discovery and this stage consists of new research knowledge. In the practice innovation project, IO vascular access was the primary interest. Research data was accumulated in the knowledge discovery stage to support the purpose of the project. The second stage, evidence summary, is an important stage in determining the strength of evidence accumulated in the first stage of the model (Melnyk & Fineout-Overholt, 2011). This stage of the ACE Star Model was utilized in determining the strength of evidence in the literature review of the IO vascular access in the ED.

The third stage, translation, is the end of the evidence summary and the start of the clinical recommendations (Melnyk & Fineout-Overholt, 2011). In this stage, the implementation of clinical practice guidelines on IO devices is supported in the literature by several organizations including the following: AHA, International Liaison Committee on Resuscitation Council, Infusion Nurses Society, National Association of EMS Physicians, Emergency Nurses Association, and the American Association of Critical-Care Nurses (Gordon, 2011). The current recommendations in ACLS courses include utilizing the IO device as an alternative method rather than numerous attempts of the PIV route in the ED (Gordon, 2011).

The fourth stage, implementation, is utilizing the accumulated literature research and integrating it into clinical practice. The key to this stage is planning and considering all factors involved including cost, efficiency, timeliness, and usefulness by staff (Melnyk

& Fineout-Overholt, 2011). In addition, careful selection of stakeholders will ensure effective planning and implementation of the practice innovation project. The final stage, evaluation, is important in determining the success of the entire project and the involvement of evidence-based practice. The application of the ACE Star Model was a successful tool and guide to implement a clinical practice guideline on the use of IO vascular devices in the ED.

Figure 1



(Melnyk & Fineout-Overholt, 2011).

Blooms Taxonomy

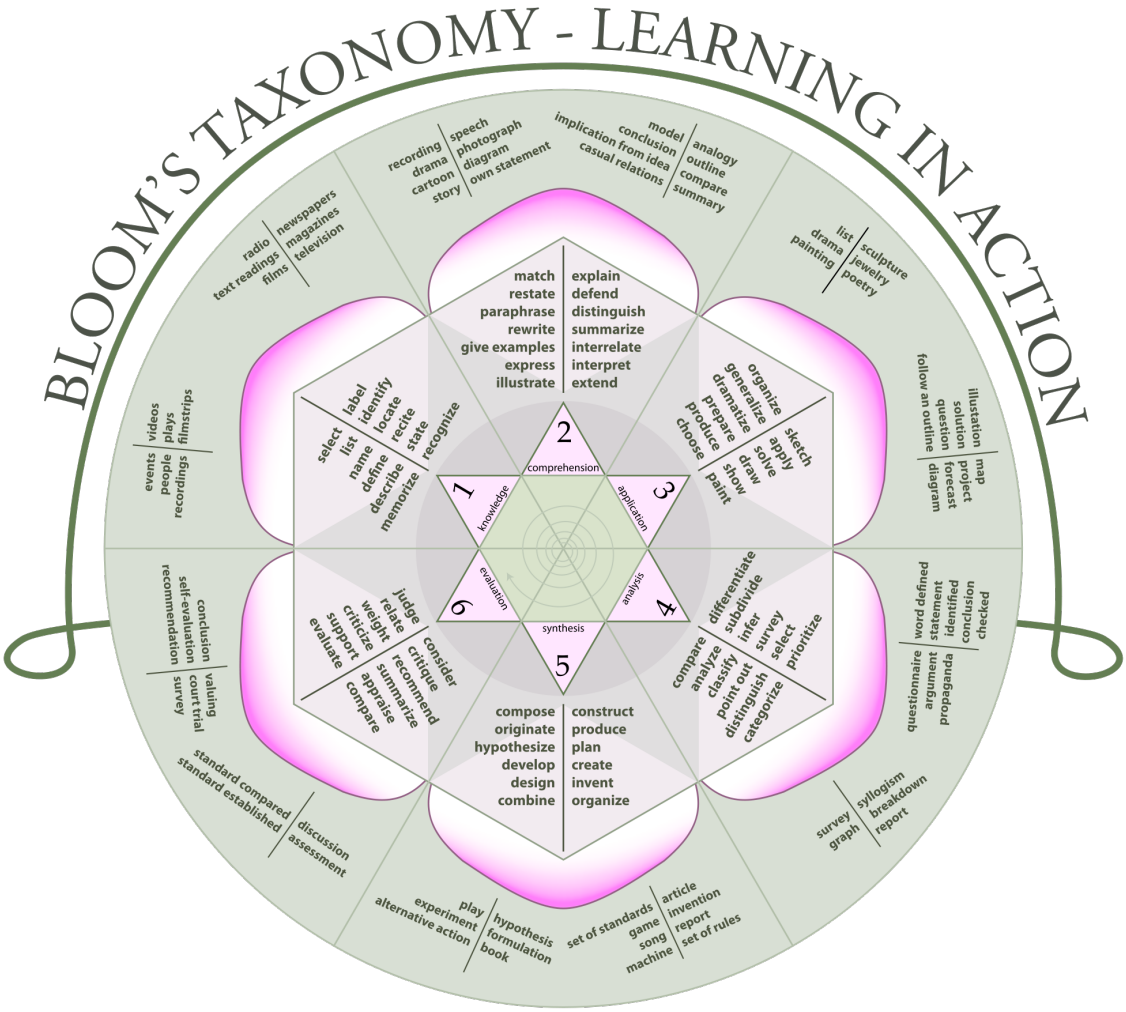
The theoretical framework that guides this practice innovation project is Blooms Taxonomy. This taxonomy was created in 1956 and is utilized as a behavioral paradigm in promoting a higher level of learning and thinking. Bloom identified the importance of

analyzing and evaluating different concepts, processes, procedures, or principles rather than just remembering the facts. The paradigm identifies three different domains that consist of specific objectives. Cognitive, affective, and psychomotor are the three domains where the learning can take place. The most widely used domain, cognitive, includes the following categorizing levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. Advancement among the levels of learning is dependent on the attainment of knowledge acquired in the level before it (Clark, 1999). However, to promote a holistic educational program, all three domains of Blooms Taxonomy were incorporated.

To promote a higher level of learning and knowledge during the educational program, all three domains were taken into consideration. The cognitive domain allowed for attainment of knowledge and acquiring of intellectual skills on the IO procedure. The traditional teaching on the purpose of the IO procedure, the use of IO device in the emergency department, and benefits of utilizing the IO were discussed. The registered nurses were able to recall the information on IOs and understand the meaning of the information being presented. Once the knowledge and comprehension objectives were met, the RNs were able to apply this knowledge to certain circumstances in the ED. Finally, the RNs were able to synthesize the data and evaluate their overall understanding and knowledge of the IO procedure. The importance of the IO procedure in promoting better patient health outcomes impacted their attitude and affective domain. The psychomotor domain took place when the RNs were practicing the IO procedure and completing the placement of the IO correctly. The process of learning through Bloom's Taxonomy promoted a better understanding and application of the IO procedure in the

emergency situation. At the end of the educational program, the goal was that every participant had acquired a new set of knowledge on the use IOs and was able to apply this teaching into his or her practice.

Figure 2



(Bloom, Englehart, Furst, Hill & Krathwohl, 1956)

Change Theory

According to Parker and Smith (2010), change is continuous and reflective within healthcare. Change within a healthcare organization can fluctuate from organized to

disorganized creating a healthcare organization that is more complex (Parker & Smith, 2010). In order to integrate a positive and significant change within the practice innovation project within the emergency department, Kurt Lewin's Theory of Change was used. This three-step process guided the planned change in the ED (McGarry, Cashin, & Fowler, 2012).

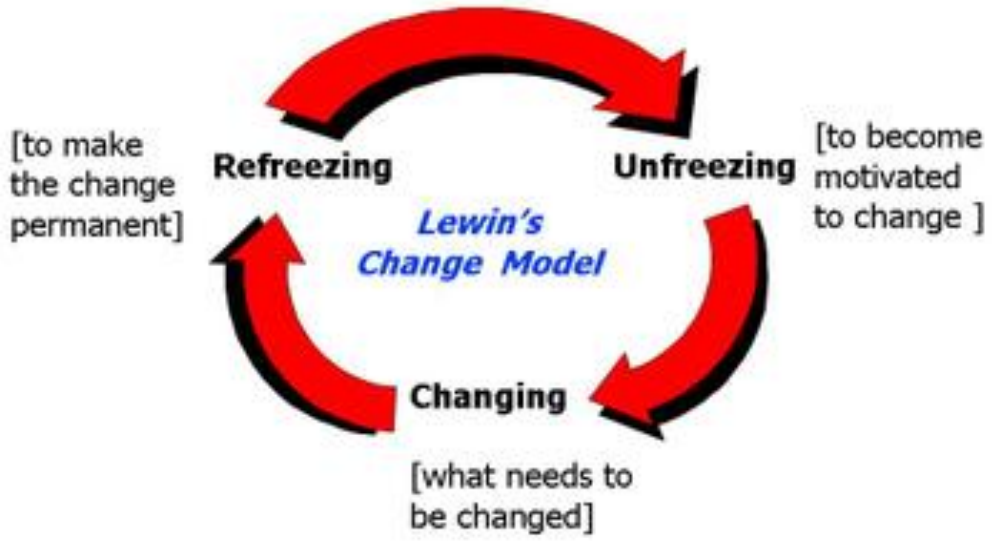
The three-step model consists of three important steps: unfreezing, transitioning, and refreezing. The first step, unfreezing, occurred when project participants were able to acknowledge the benefits to adapting a new practice of IO insertion. The unfreezing stage prepared the project participants in overcoming the fear or anxiety associated with implementing a new procedure. The ED registered nurses needed to overcome the fear of utilizing IOs in emergent and trauma situations and mentally prepare themselves to incorporate this tool into their practice (McGarry et al., 2012).

The second step of the Lewin's three-step model, movement or transitioning, focuses on incorporating new behaviors in implementing the practice innovation project. Participants not only needed to accept IO use, but implement IO use through a behavior change or action. Support from the fellow participants and healthcare professionals are important during this step. This will encourage consistency in utilizing the IO device as the standard alternative method for intravascular access (McGarry et al., 2012).

The final step, refreezing, is considered the re-establishment of the equilibrium or balance (McGarry et al., 2012). This step is imperative in restoring the balance of the ED and establishing the new procedure as a standard practice of care. Currently, IOs are being underutilized due to the lack of equipment, resources, guidelines, and support (Cheung et al., 2014). The Lewin's Theory of Change provided a framework to guide the

innovation project through implementing an educational program that inspired and promoted the use of IO access in the ED. Thus, in the refreezing step, this IO procedure was recognized as a consistent tool utilized by registered nurses and part of the ED culture.

Figure 3



Chapter 3

Project Design and Methodology

Introduction

According to the Cochrane Collaboration (2014), evidence-based practice is utilizing the best available evidence from summaries of systematic reviews that assist healthcare providers in making the best healthcare decisions. Evidence-based practice is the incorporation of three significant factors and includes the following: best research evidence; clinical expertise; and patient values and preferences. The best available evidence is the most recent research data that supports a specific area of healthcare that will aid healthcare professionals in implementing highly appraised evidence-based research and methodology. Individual clinical expertise or practitioner expertise is defined as the healthcare provider using the best available evidence, in consultation with the patient, to determine the best course of treatment (Cochrane Collaboration, 2014).

The literature review and evidence-based practice has supported the development of this project. The following areas of the project are addressed in this chapter: population; environmental and organizational context; project design; methods; and the analysis. In addition, the Ace Star Evidence-Based Model, Kurt Lewin's Theory of Change, and Bloom's Taxonomy were incorporated to guide the implementation of the project.

Population

The educational project was conducted in a Level II trauma center and emergency department in an urban area. A Level II trauma center is capable of providing 24-hour immediate coverage of care by general surgeons and specialties including orthopedic

surgery, neurosurgery, anesthesiology, emergency medicine, radiology, and critical care. The Level I trauma center also includes education on prevention and continuing education to staff and incorporates a comprehensive quality assessment program (American Trauma Society, 2014). The educational program was presented during the emergency department monthly meeting. The participant population consisted of all registered nurses that currently work in the healthcare facility's ED. All of these registered nurses have completed a bachelor's or associate degree in nursing from an accredited college or university. There are no restrictions on age, socioeconomic status, race, ethnicity, or gender to participate in the educational program.

Environmental and Organizational Context

The Level II trauma center and emergency department is a 29-bed unit. The facility is a non-profit organization that provides healthcare to various surrounding rural areas and the urban area it resides in. The philosophy and mission of this healthcare organization is dedicated to the work of health and healing. The mission focuses on improving the health of every patient through innovation, discovery, and exceptional health care. The faculty of the organization incorporates five different values into his or her work environment and includes the following: courage, passion, resolve, advancement, and family. This practice innovation project correlates with the philosophy of the organization and encompasses the mission statement to implement innovation into health care practice.

There are approximately 80 registered nurses employed in the ED and who work at various shifts throughout the day. The ED is fully staffed with a total of nine nurses during its busiest hours between 4 p.m. and 10 p.m. A clinical care coordinator leads the

shifts with a director and clinical manager available for assistance during the day shifts, which run from 7 a.m. to 7 p.m. The clinical manager is in charge of all practice improvements projects for the emergency department. The clinical manager and director of the ED support the purpose and implementation of the educational program. High turnover rates have introduced a variety of new staff into the ED over the past year. An educational program that focused on a step-by-step process of implementing the innovative tool, IO vascular access, and assisted new and old staff in improving patient outcomes in the ED was implemented.

Design/Approach

A quasi-experimental pre-test, post-test design was used. The advantages of this design included the following: the feasibility given the time constraint and logistical restraints; it was beneficial in this setting due to inability to obtain randomization; and the pre-posttest measurement allows the researcher to determine the effect of the intervention. The disadvantages of the quasi-experimental design included the following: decreased control over variables. The independent variable of the design was the educational program and the dependent variable was the number of successful IO procedures completed after the implementation of the project.

Anticipated Barriers

The underlying values of this practice innovation project focused on improving the safety of delivering intravenous medications, fluids, and blood products, decreasing time and stress for healthcare professionals to obtain vascular access, decreasing complication risks associated with CVC placement, and improving patient care. Anticipated facilitators of the implementation of this project included the emergency

department flight team, clinical manager, and director of the emergency department. The clinical manager and the clinical nurse educator were stakeholders in the implementation and success of the practice innovation project.

Anticipated barriers to implementation included inspiring the healthcare providers and registered nurses to attend the education program, retain information on the IO procedure following the educational program, and utilizing the technique in critically ill or trauma patients. All registered nurses in the ED are trained and certified from the ACLS and PALS course to place and utilize IO vascular access. However, the knowledge and confidence in placement of the IO device may be limited due to the underutilization of the IOs in the ED. In addition, the content in the PALS course regarding IO placement is only a small part of the course and not reinforced following completion of the PALS curriculum.

PIV and CVC access have been the gold standard for achieving vascular access in the ED in my healthcare facility. Thus, physicians and other healthcare professionals may lack the support needed to encourage registered nurses to implement the guideline. A substantial challenge in proposing this project was receiving an overall consensus from the physicians in initiating the use of an IO route. A copy of the educational program PowerPoint® presentation on the available evidence that supports the use of IO device as a standard second alternative to PIV and associated complications with the placement of central lines hopefully inspired physicians to accept the new guideline and policy change.

Finally, implementing change into a work environment always poses a challenge. Resistance to implementation of the innovative tool will occur and in order to promote change, it will be the innovative leader's responsibility to inspire, integrate available

evidence, and present the benefits to all healthcare professionals involved in the practice innovation project. Promoting Lewin's Theory of Change enabled registered nurses and other healthcare professionals to feel comfortable in the use of an IO route. This theory allowed individuals to recognize the potential obstacles, but in return adjust and allow for the growth of the innovation project within the ED.

Methods

The purpose of the educational program was to educate registered nurses on the AHA current guidelines and recommendations of IO access. The student learning outcomes focused on understanding the purpose and importance of utilizing the IO device in the ED and explaining and demonstrating the correct placement of the IO device. (See Appendix E). A 30-minute educational program was conducted at the monthly staff meeting. Every registered nurse is required to attend half of the monthly meetings conducted throughout the year. The registered nurses were encouraged to attend this monthly staff meeting by promoting the presentation of the IO procedure by flyers placed throughout the ED. (See Appendix G).

An anonymous pre-test survey consisting of five Likert 3-scale questions was given to the participants to complete prior to the program (See Appendix F). The program included a presentation on the use of IO devices in the ED: the evidence-based literature on IO access; current guidelines and recommendations; the purpose of using IOs in the ED; and explanation of IO placement content (See Appendix E).

Once the presentation concluded, a demonstration of the IO procedure was conducted. The first step was to identify the two demonstration sites for IO insertion for training purposes. The two sites presented to the participants during the educational

program were proximal humerus and distal tibial IO sites. The second step was finding the correct humeral site and tibial site for IO placement on themselves or another participant. The third step was utilizing the IO drill on a practice mannequin bone to allow demonstration of IO needle insertion. In addition, education and a visualization of all of the appropriate supplies were provided throughout the demonstration. The supplies utilized during the demonstration were the same equipment utilized by staff in the emergency department. Once every registered nurse had correctly identified the humeral and tibial site, he or she was allowed to perform the IO procedure on a mannequin bone. At the end of the educational program, the participants were allowed to ask questions or offer opinions pertaining to the overall presentation. After completion of the program, a post-test survey with the same questions was given to the participants to complete. The post-survey assisted in evaluating the overall impact of the educational program.

Impact of Project

The implementation of the IO device will have an impact on the financial budget of the ED. Every ED will need to be supplied with an IO device, needles, and IO kit. The size of the ED will determine the number of devices needed. The cost of the IO devices and needles should be compared to the cost of central line kits, ultrasound evaluation, and the human resources required to place central lines (Phillips et al., 2010). In addition, central lines are associated with increased infection rates and length of hospital stays. Hospital-acquired infections have been placed on the “never events” by Centers for Medicare and Medicaid Services (CMS), thus, CMS will not reimburse hospitals for the catheter related infections (Phillips et al., 2010).

The effect of cost and quality of health care in rural or underserved populations may result in a positive outcome. Rural communities are at a disadvantage of not having additional assistance in placement of vascular access. For example, rural communities lack access to anesthesiologists, flight team medics and flight registered nurses, or additional healthcare providers who could place a CVC. In addition, rural healthcare facilities often do not have all the necessary staff on site during evening shifts, but instead are on-call. The lack of trained professionals in rural healthcare facilities warrant the use of the IO device as a second-line alternative for registered nurses in achieving vascular access.

The cost of having an EZ-IO access device in the ED is roughly $500. The EZ-IO is usable for 100 insertions before expiration. The cost of EZ-IO device needles cost around $115 per needle set. The cost of a central venous catheter kit is roughly $400-500 per patient. The utilization of an IO device is a significant cost-effective device to be utilized in all emergent situations.

Protection of Human Subjects

The U.S. Department of Health and Human Services has issued The Health Insurance Portability and Accountability Act (HIPAA) to protect the patient's healthcare record and to assure complete privacy. Any statistical data collected in the study was protected and remained in the healthcare organization. The educational program was voluntary and did not cause any harm to any patients or participants. The project proposal was submitted to the healthcare organization and the university Institutional Review Board (IRB). See Appendices B and C. Both committees approved the practice innovation project.

Instruments

The instruments utilized in this study included an EZ-IO battery device and IO kit during the educational program. "The powered drill is a handheld, battery-operated device that inserts the needled in the intraosseous space with a high-speed rotary motion" (Infusion Nurses Society, 2009, p. 2). The FDA has cleared this device for use in both the proximal and distal tibia and the humeral head (Infusion Nurses Society, 2009). There are three different sizes of IO devices and needles that can be utilized during an IO procedure depending on the patient's size. All participants had an opportunity to practice with the three different sizes of IO devices. The emergency department provided the IO devices and supplies.

Analysis

The analysis of the practice innovation project was completed to demonstrate improved patient outcomes by achieving safe, fast, and effective vascular access in the ED. Data on how many IO devices were inserted three months prior to the educational program were obtained. This data was collected through the documentation of the ED's charging database. Once the educational program was completed, data was again collected for the following three months to evaluate the effectiveness of the program as measured by the number of IO procedures performed after completion of the educational intervention.

The focus of the practice innovation project was to implement an educational program that aids in delivering reliable, safe, and cost-effective healthcare. This project was important to improve patient outcomes and assure healthcare organizations are implementing evidence-based practice guidelines within the ED. The purpose of the

project correlates with the purpose of pursing a doctorate of nursing practice (DNP). Nurse practitioners strive to improve healthcare outcomes and patient satisfaction in every area of his or her expertise. The emergency department is underutilizing a beneficial intervention that can improve patient centered outcomes and satisfaction; thus, the IO educational program is a purposeful practice innovation project.

Chapter 4

Outcomes & Impact of Practice Innovation Project

Introduction

A total of 17 registered nurses participated in the education and training. The education program was a voluntary program for registered nurses that work in the ED. A PALS course was being conducted the same day as the IO presentation. The overall turnout of registered nurses for this project may have been decreased due to the two educations programs being conducted on the same day. All participants received the educational presentation and all had the opportunity to participate in the hands on portion of IO site identification and placement of the IO devices.

An anonymous pre-test survey consisting of five Likert 3-scale questions was completed prior to the education program and demonstration. A post-test survey was completed at the end of the demonstration to review the benefits of the overall education program. Data on the number of IO insertions in the ED was accumulated three months prior to the educational program and three months after to determine if there was an increase in IO insertions in the ED.

Discussion of outcomes

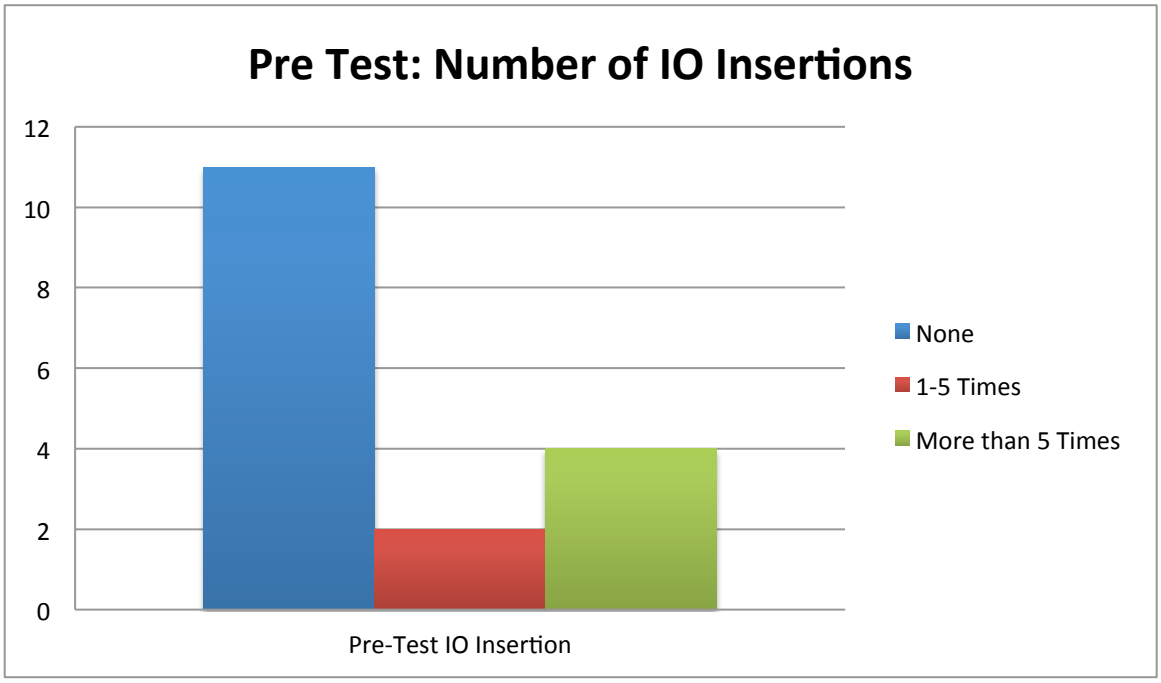
The pre-test survey consisted of five Likert-3 scale questions and included the following: the number of times each participant had completed an IO insertion during his or her nursing practice; how confident the participant was in his or her knowledge about IO use; how confident each participant was in placing an IO; how important he or she believes the IO insertion is as an alternative to IV access; and what is the likelihood of the participant completing an IO in his or her nursing practice. A total of 17 participants

completed the pre-test survey and only 12 participants completed the post-test survey. This did disrupt the overall results of the pre-post test survey. However, despite five participants not completing the post-test survey, there were still increases in knowledge and confidence regarding IO insertion.

1) How many times have you performed intraosseous (IO) insertion in your nursing practice?

The results of the pre-test survey for question one showed 11 participants had never placed an IO in his or her nursing practice; two had placed an IO between 1-5 times; and four had placed an IO more than five times. See Figure 4. The post-test survey results did not change for this question.

Figure 4



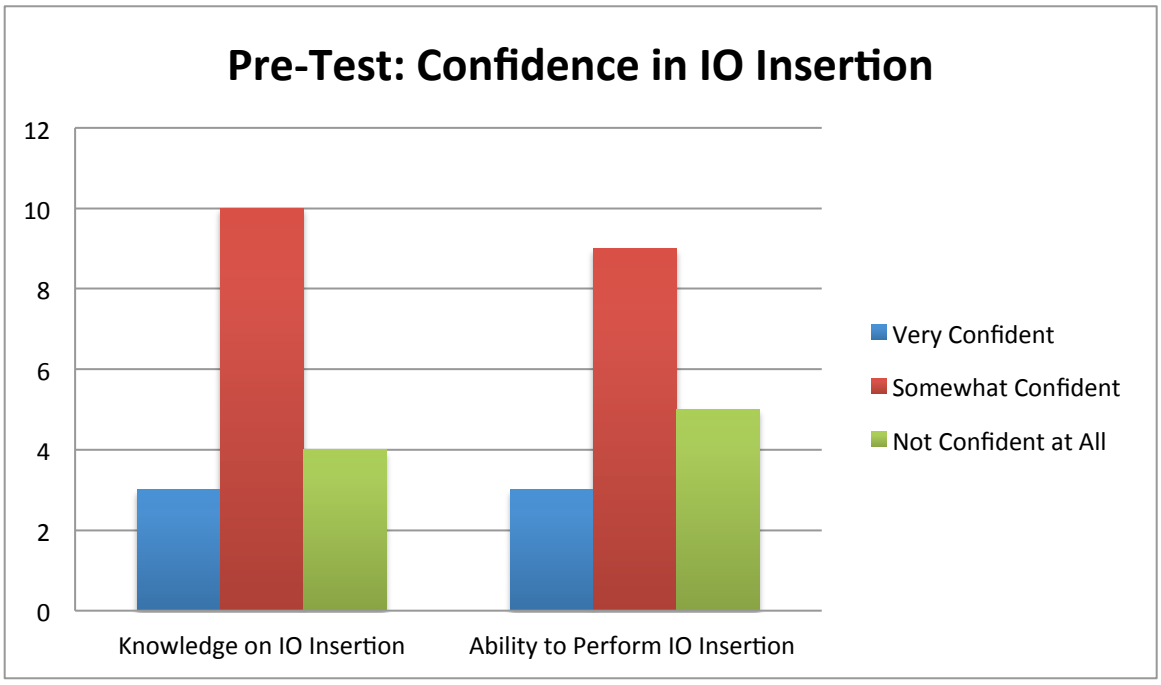
2) How confident are you in your knowledge about IO insertion?

The results of the pre-test survey for this question showed three participants were very confident in his or her knowledge about IO insertion; 10 participants were somewhat confident; and four participants were not confident at all. See Figure 5. The post-survey showed an increase of participants that were very confident in his or her knowledge about IO insertion and no participants said they were not confident at all after the educational program.

3) How confident are you in your ability to perform IO insertion?

The results of the pre-test survey for this question showed three participants were very confident in performing IO insertion; nine participants were somewhat confident; and five were not confident at all in IO insertion. See Figure 5. The post-test survey showed an increase in the number of participants that were very confident in his or her ability to perform IO insertion and a substantial decrease in participants that were not confident at all. The trend for question two and three showed an increase in confidence with knowledge on IOs and ability to perform an IO after the completion of the educational program.

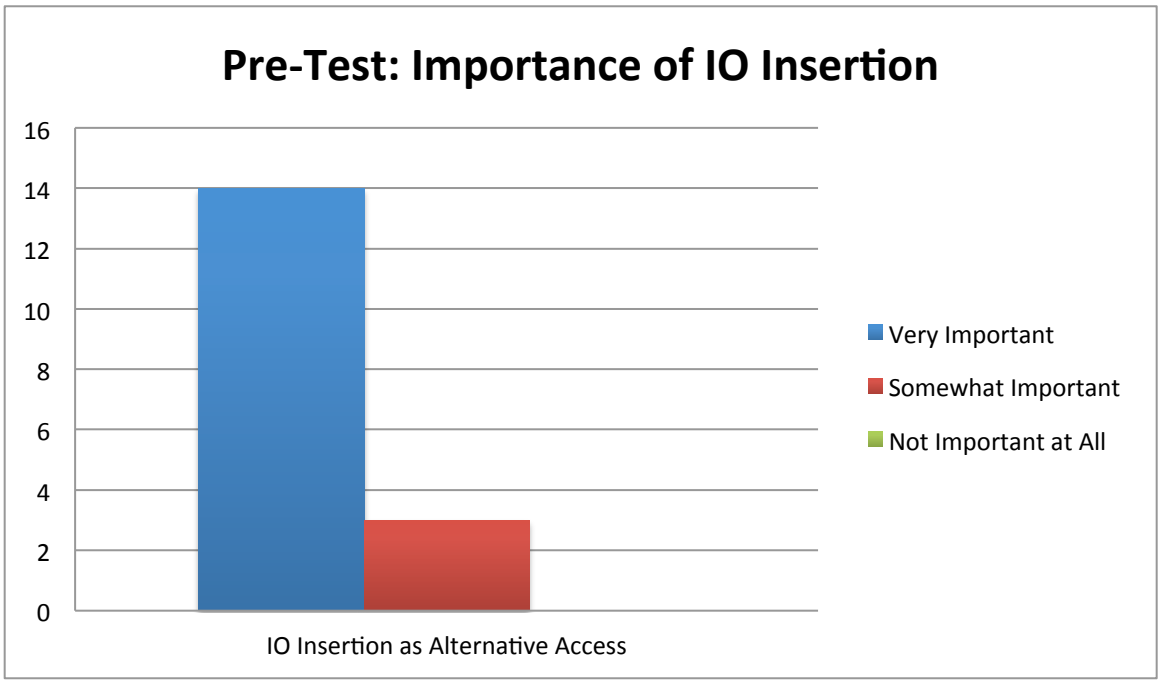
Figure 5



4) How important do you believe it is to use IO insertion as an alternative to intravenous (IV) access in your nursing practice?

The results of the pre-test survey for this question showed 14 participants thought utilizing IO insertion as an alternative to IV access was very important and three participants thought it was somewhat important. No participants thought it was not important at all. See Figure 6. The post-test survey results showed a decrease in overall importance of IO insertion, but this could have been altered due to five participants not completing the post-test survey.

Figure 6



5) What is the likelihood of you completing IO insertion in your nursing practice?

Finally, the pre-test survey for this questions showed 11 participants thought it was very likely he or she would use an IO in the nursing practice; five participants thought it was somewhat likely; and one participant thought it was not likely at all. See Figure 7. The post-test survey showed a decrease in participants that thought it was somewhat and very likely he or she would complete an IO insertion during his or her nursing practice. These results could have been altered due to the five participants not completing the post-test survey. The results of the pre-test and post-test survey were broken down with each score for each question. See Table 1.

Figure 7

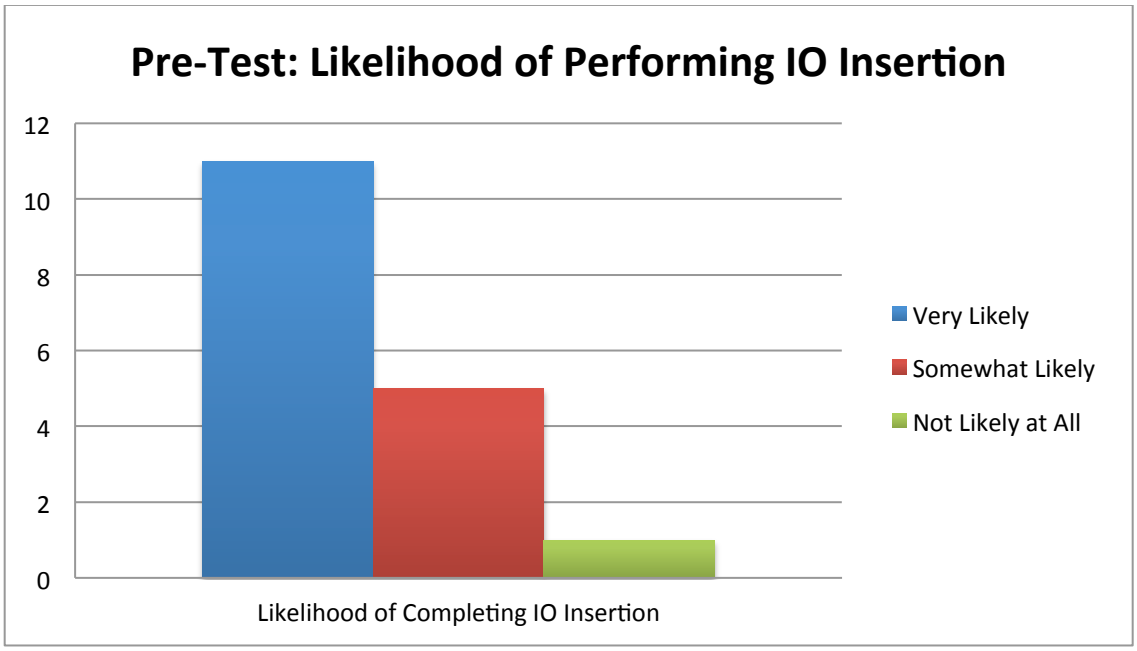

Pre-Test: Likelihood of Performing IO Insertion
12
10
8
6
4
2
0
Likelihood of Completing IO Insertion
Very Likely
Somewhat Likely
Not Likely at All

Table 1

Pre-Post Test Likert Survey					
Pre-Test			**Post-Test**		
Question #	Category	Responses	Question #	Category	Responses
1	None	11	1	None	11
	1 - 5	2		1 - 5	2
	More than 5	4		More than 6	4
2	Very Confident	3	2	Very Confident	5
	Somewhat Confident	10		Somewhat Confident	7
	Not Confident at All	4		Not Confident at All	0
3	Very Confident	3	3	Very Confident	4
	Somewhat Confident	9		Somewhat Confident	7
	Not Confident at All	5		Not Confident at All	1
4	Very Important	14	4	Very Important	9
	Somewhat Important	3		Somewhat Important	3
	Not Important at All	0		Not Important at All	0
5	Very Likely	11	5	Very Likely	9
	Somewhat Likely	5		Somewhat Likely	2
	Not Likely at All	1		Not Likely at All	1

Short Term Results

The results of the pre-test compared to the post-test showed positive trends implicating the educational program to be beneficial. Despite not having all of the participants complete the post-test survey, there was still an increase in confidence in the knowledge of IOs and ability to perform an IO after the completion of the educational program. No participants lacked confidence in IO knowledge and there was a decrease in registered nurses not feeling confident at all in performing IOs after the educational program. The overall results of the study were altered due to low participation numbers

and not all of the participants completing the post-survey. The participants may have not completed the post-test survey due to time constraint, unfamiliar with the post-test survey, or the choice not to participate. Despite the results being altered, positive trends in the pre-post test data still showed the educational program to be a beneficial method to implement change and promote better patient outcomes.

Medium Term Results

Data was accumulated for three months after the completion of the IO education program to determine if there was impact on IO insertions in the ED. A total of six IOs had been placed between November 1st, 2014 and January 26th, 2015 compared to a total of 14 IOs placed between January 26th, 2015 and May 1st, 2015. A 133% increase in IOs was implemented after the completion of the educational program. This increase in IO insertions was a clinically significant result for the impact of the educational program on IO insertions in the ED.

Ultimate Impact

IO insertion is a safe, fast, and effective method in achieving vascular access in an emergent situation or trauma. The goal of the IO education program and training was to allow ED registered nurses to gain practical knowledge and experience on IO insertion, thus providing them with the ability to provide effective patient care. The ultimate impact of the IO education program was to educate ED registered nurses on IO insertion, therefore, implementing current recommendations and guidelines on IO access into his or her nursing practice. The positive trends of the pre-post test data showed the IO educational program to be a significant method to educate, motivate, and facilitate the implementation of IOs in the ED.

Chapter 5

Summary

Conclusions

The overall results of the IO education program determined the program to be beneficial in improving a knowledge deficit on IO insertion. There was an increase in registered nurses completing IO access after the educational program, which is clinically significant for this ED. The participant turnout for the educational program was less than expected. The educational program occurred on the same day as PALS re-certification. In addition, the educational program may have lacked participation due to the learning program being voluntary. Inferential statistics were not completed due to small numbers of participants.

The educational program on IO insertion increased awareness of the ED registered nurses on the current guidelines, recommendations, and the effectiveness of IO access. The increased awareness encouraged staff to attempt IO insertions when indicated in emergent or trauma situations. Despite the decreased participant turnout for the educational program, I believe the marketing of the IO educational program had an impact on the registered nurses in the ED. After the completion of the program, I had several nurses ask questions about IO insertion and the importance of this device in the ED. I believe this educational program was a stepping-stone in the right direction for the utilization of IO access. In the future, a mandatory educational program should be implemented to assure all registered nurses are qualified and prepared to insert IO access when necessary. The educational program will allow nurses to practice beneficence by implementing evidence-based recommendations in the ED.

The Quasi-Experimental design allowed me to determine if the educational program had the intended effect on the population. The advantages of this project design was the feasibility given the time constraints; beneficial in the population setting due to inability to obtain randomization; and pre-post test helped determine the effect of the intervention. The disadvantages of this project design included threats to internal and external validity. Threats to internal validity included decreased control over cofounding variables and differential selection. Threats to the external validity included not having a t-test and level of significance due to small numbers; self-selections bias or volunteerism; no sampling frame; and sampling errors including disproportionate number of inexperienced nurses vs. experienced nurses. For example, random selection from various strata of nurse's experience could have decreased the variance among the participants, thus, decreasing sampling errors. This would have been beneficial to know the experience level of the registered nurses in the ED for the conclusion of my results.

Reflections on the Practice Innovation Project

The practice innovation project was a challenging, but rewarding experience. The project gave me the opportunity to research and become invested in a healthcare project that I feel is very important in my area of work as a registered nurse. The project allowed me to form new relationships with stakeholders in my project; enhance my communication and leadership skills in healthcare; expand my knowledge on research; and improve healthcare through evidence-based practice. The impact of the educational program had a positive outcome. Since the educational program took place, there has been an increase in IO insertions in the ED. There was a 133% increase in IOs implemented after the completion of the educational program. The overall impact of the

practice innovation project on my healthcare facility's ED and my DNP program has been positive and rewarding.

Recommendations for Future Practice

The future of IO access depends significantly on increasing access to IO education and teaching and reinforcement of training on IO devices. The ED will continue to have new staff orientating to the unit and these registered nurses will need an educational program to ensure adequate training on IO access. In the future, the educational program on IO access should include mandatory attendance and offer annual continue education units (CEU). CEUs will give registered nurses incentive to attend the educational program. Multiple sessions could also be offered so that nurses have alternate times available to attend. The mandatory attendance will continue to increase awareness on the importance of IO insertion in emergent and trauma situations.

Future educational programs should also be conducted for healthcare providers to educate and motivate these providers to support the use of IOs in the ED. A knowledge deficit on IO use in the ED exists among healthcare providers; thus, implementing this practice innovation project in this population would also prove beneficial for the outcomes of the IO access. The IO access is a significant alternative to PIV access in emergent or trauma situations. The continuation of education on IO access is imperative for future registered nurses in the ED and his or her ability to implement safe and effective patient care.

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Appendix A: Consent Form

Information Sheet
Participation in a Research Project
South Dakota State University
Brookings, SD 57006

Department of Graduate Nursing Phone No. 605-310-7519
Project Director: Nicole Helsper DeVoe Date 01/27/15
E-mail: nmhelsper@gmail.com

Please read the following information:

1) This an invitation for you as a registered nurse to participate in a research project under the direction of Nicole Helsper-DeVoe, Nurse Practitioner Student.
2) The project is entitled: Intraosseous Vascular Access in the Emergency Department.
3) The purpose of the project is to increase registered nurses' knowledge and ability to recognize appropriate circumstances in the emergency department to utilize the IO procedure to improve patient outcomes.
4) If you consent to participate, you will be involved in the following process, which will take 30 minutes of your time: Education will begin with a presentation highlighting the purpose of the IO procedure; current clinical guidelines and recommendation on IO use; and the benefits of utilizing the IO device in the emergency department. Participants will also practice the IO procedure at the end of the presentation. This education will take place in Meeting Room B.
5) Participation in this project is voluntary. You have the right to withdraw at any time without penalty. If you have any question, you may contact the project director at the number listed above.
6) There are no known risks to your participation in the study.
7) The benefits to you are potential increase in knowledge and skill that can improve patient care.
8) There are PIT Crew hours given for your participation in this study.
9) Your response is strictly confidential. When the data and analysis are presented, your name, title, or any other identifying item will not link you to the data.
10) As a research participant, I have read the above and have had any questions answered. I will receive a copy of this information sheet to keep.

_____ _____
Print Name Signature

If you have any question regarding this study you may contact the Project Director. If you have questions regarding your rights as participant, you can contact the SDSU Research Compliance coordinator at (605) 688-6975 or SDSU.IRB@sdstate.edu. The SDSU Institutional Review Board and Sanford Institutional Review Board have approved this project.

Appendix B: Human Subjects Form

South Dakota State University

Office of Research
SAD Room 200
Box 2201 SDSU
Brookings, SD 57007

To: Nicole Helsper DeVoe, College of Nursing

Date: February 4, 2015

Project Title: Intraossesous Vascular Access in the Emergency Department

Approval #: N/A (approved as not research)

Thank you for contacting the Human Subjects Committee. The Sanford IRB has determined that this quality improvement activity is not human subjects research. We accept Sanford's determination. It does not fall under the federal policy, or under the purview of the Committee. We will note the file as such and keep it in accordance with SDSU records retention policies.

If I can be of any assistance, don't hesitate to let me know.

Sincerely,

Norman O. Braaten
SDSU Research Compliance Coordinator

Appendix C: Approval Letter

SANFORD HEALTH

January 9, 2015

PI: Nicole Helsper-DeVoe
Project: Intraosseous Vascular Access in the Emergency Department

The study submission for the proposal referenced above has been reviewed via the procedures the Sanford Health Institutional Review Board.

The activities described in your application are intended to contribute to quality improvement / assessment. Based on these findings, the project proposal does not meet the definition or regulatory requirements for human subject research. If in the future, you decide to collect information with the intent to develop or contribute to generalizable knowledge, you will be required to submit an application to the IRB for prospective review.

Please maintain a copy of this letter in your study file for documentation that your study does not meet the regulatory requirements for human subject's research.

Sincerely,

Deb Langstraat, CIP
Director-Sanford IRB

Sanford Health Human Research Protection Program - Route #5033 • 1305 W. 18th Street • Sioux Falls SD 57117-5039 • P 605.312.6430

Appendix D: Evidence Based Table

Citation	Level of Evidence	Participants (n), Sample Size, & Setting	Study Design/ Purpose	Intervention	Results	Limitations
Anson, J. A. (2014).	IB	Critically ill patients requiring resuscitation. Pre-hospital or emergency department setting for insertion of IO access. 18 studies were included.	Meta-Analysis Purpose was to complete a systematic review through PubMed and Ovid Medline databases to determine whether there is a role for intraosseous vascular access in critically ill patients and the importance of clinical use.	Review current evidence to determine the effectiveness of intraosseous devices in critically ill patients through various databases.	Fast insertion speed, low infection risk, useful in drug delivery, utilized in diagnostics, cost effective, available insertion devices, and significant clinical use.	In-Hospital studies comparing central line and IO access accuracy are lacking. No direct studies comparing infection risk of both lines. No studies comparing mortality data in cardiac arrest with these two lines. Long-term follow-up on IOs are lacking.
Voight, J., Waltzman, M., & Lottenberg, L. (2012).	IA	Patients in need of emergent vascular access in the emergency department. 16 studies were included.	Meta-Analysis A literature review of the evidence supporting the use of IO access. Determine the utilization of IO access as described in the literature and assess the level of specialty society support.	Review of electronic and hand searches to identify relevant articles. The Cochrane Review methodology was utilized where studies could be combined and meta-analysis could be performed.	Fast, safe, reliable access; pharmacokinetics were equivalent between IO and IV access; decreased use of IOs due to lack of proper equipment and lack of knowledge or training; and ED programs use central-lines as alternative instead of IOs.	In the level I, 2, and 5 studies identification for the inclusion criteria were of lower quality with high risk of bias.
Phillips, L., Brown, L., Campbell, T., Miller, J., Proehl, J., &Youngberg, B. (2010).	5 on Agree II	Position Paper from the United States.	Position Statement	Explore the evidence supporting IO use wherever vascular access is medically necessary or difficult to	Position statement recognized IO access as a significant and reliable time saving intervention	No limitations were discovered.

				achieve in all settings.	to patients in emergent situations.	
Leidel, B. A., Kirchhoff, C., Bogner, V., Braunstein, V., Biberthaler, P., & Kanz, K. G. (2012).	IIB	Patients undergoing resuscitation or trauma who present to the Level I Trauma Emergency Department in an urban area. Sample size was 40 participants.	Quasi-Experimental Investigate success rates on first attempt and procedure times of IO access versus central venous catheterization (CVC) in adults with inaccessible peripheral veins under trauma or medical resuscitation.	Adults under resuscitation were analyzed, each receiving IO access and CVC simultaneously. Each intervention was evaluated for success rate and time to achieve access.	IO is more successful and faster in obtaining vascular access compared to CVC, without relevant complications. 25% difference in successful IO access compared to CVC with a 6-minutes faster time of placement compared to the CVC.	Assembly bias due to the differences ins subjects based on study design. Sample size was also small and further research could include more participants. No result yielded significant findings of difference in success or times of the two different IO devices used.
Paxton, J. H. (2012).	5 on Agree II	Position statement from the United States.	Position Statement	A current literature review of intraosseous vascular access including discussion on various devices, advantages and disadvantages, comparison to other vascular access methods, complications, and current recommendations.	Beneficial use of IO in all medical situations, minimal complications, various devices available, superior to alternative routes of vascular access secondary to the PIV.	No limitations were discovered.
Cheung, J., Rosenberg, H., & Vaillancourt, C. (2014).	IIIA	Residents and attending physicians at the Ottawa Hospital from the Departments of Emergency Medicine and Anesthesia, General Internal Medicine, General Surgery, and Critical Care.	Qualitative The objective was to determine factors associated with IO access use by physicians during adult resuscitations when PIV access is not immediately achievable.	Electronic online survey was distributed to various clinical areas to determine barriers and facilitators to performing IO access during adult resuscitations when peripheral IV	68% had prior experience in inserting an IO. Median intention to use IO when PIC is not achievable was 4.67 on a five-point Likert Scale. Results concluded that increase	Voluntary basis, may introduce selection bias. Some participants had more experience or stronger beliefs about the use of IO access and results may not be

		Sample size was 205 participants.		access is not achievable.	physicians' use of IO access would occur if more educational interventions were applied to address their attitudinal, normative, and control beliefs.	generalizable to other settings as where the survey was conducted.
Luck, R. P., Haines, C., Mull, C. C. (2009).	5 on Agree II	Position Statement of the United States.	Position Statement	A current literature review of IO general indications, contradictions, and complications.	New, improved IO systems provide healthcare providers with choices beyond traditional manual IO access.	No limitations were discovered.
Mac Kinnon, K. A. (2009).	3 on Agree II	Position Statement of the United States.	Position Statement	The use of IO device in Brockton Hospital Emergency Department.	The risk of IO in emergent patient is low, whereas the benefits are many. Change was accepted in this hospital on implementing IO use.	No limitations were discovered.

Appendix E: Educational Presentation

Slide 1

Intraosseous Vascular Access

Nicole Helsper-DeVoe
South Dakota State University

Slide 2

Purpose of Program

- Educate on the American Heart Association (AHA) current guidelines and recommendations of intraosseous (IO) access.
- **Student Learning Outcomes**
  - Understand the purpose and importance of utilizing the intraosseous device in the emergency department (ED).
  - Explain and demonstrate correct placement of the intraosseous device.

Slide 3

Intraosseous History

- A technique for vascular access found in 1922 and widely used for drug administration in children (Bailey, 2014).
- Utilized widely in the 1940's during World War II to aid in battlefield casualty resuscitation (Luck et al., 2010).
- Decreased use of IO devices in 1950's and 1960's when disposable intravenous catheters were developed (Bailey, 2014).
- In the 1980's, numerous clinical reports of effective IO use in the pediatric population were published (Luck et al., 2010).
- In 2000, IO practice was extended to patients older than 6 years of age (Luck et al., 2010).
- In 2005, the AHA recognized IO cannulation as an equivalent method of achieving vascular access to a central venous catheter (CVC) (Infusion Nurses Society, 2009).

Slide 4

Evidence-Based Data

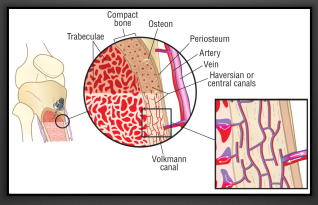
- IO placement was100% successful in patients compared to 67% success within five minutes of peripheral IV placement (Bailey, 2014).
- EZ-IO placement was achieved on the first attempt (90% versus 60%) and took significantly less time with (2 minutes versus 10 minutes) central venous access (Bailey, 2014).
- IO's risk of complications in emergent situations is less than 1% in overall incidences (Luck et al., 2010).
- Complication rates for CVC placement are reported around 15-20% and include malposition, arterial puncture, hematoma, pneumothorax, venous thrombosis, and catheter related infections (Leidel et al., 2012).
- Average of 33 per 1000 catheters placed per day in the ED resulted in a central line infection (Leidel eta l., 2012).

Slide 5

Organizations Recommend IO Vascular Access

- Air & Surface Transport Nurses Association
- American Association of Critical-Care Nurses
- **American College of Emergency Physicians**
- **American Heart Association**
- Consortium on Intraosseous Vascular Access in Healthcare Practice
- **Emergency Nurses Association**
- European Resuscitation Council
- **Infusion Nurses Society**
- International Liaison Committee on Resuscitation
- **National Association of EMS Physicians**
- Society of Pediatric Nurses

Slide 6



Intraosseous Space

IO space refers to the spongy, cancellous bone of the epiphysis and medullary cavity of the diaphysis, which are connected. The Volkmann's canals of the IO space contain vessels that connect to major arteries and veins of the central circulation (Infusion Nurses Society, 2009).

Slide 7

Indications for IO Access

- The American College of Surgeons Advance Trauma Life Support (ACLS) and the American Heart Association (AHA) recommend intraosseous access as the second-line alternative to delayed or failed peripheral vascular access in emergent and trauma circumstances (Cheung, Rosenberg, & Vaillancourt, 2014).
- Infants, children, and adults in full cardiopulmonary arrest or severe shock who do not have a readily available intravenous access should undergo IO cannulation rather than central venous line placement or surgical venous cut down (Bailey, 2014).
- IO cannulation may also be appropriate in emergent situations where reliable venous access cannot be achieve quickly including patients with shock, sepsis, status epilepticus, extensive burns, or multiple trauma (Bailey, 2014).

Slide 8

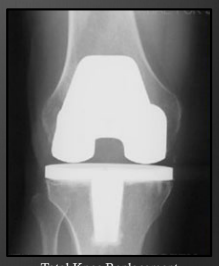
Laboratory Analysis

- Red Blood Cell Count
- Hemoglobin and Hematocrit
- Glucose
- Blood Urea Nitrogen
- Creatinine
- Blood Type and Screening
- Chloride
- Total Protein
- Albumin
- Lactate
- Sodium
- Potassium

Slide 9

Contraindications

- **Fracture**
- **Previous Orthopedic Procedures** near Insertion Site (Example: Joint Replacement)
- **Infection** at Insertion Site
- Inability to Locate Landmarks or Excessive Tissue
- IO access in targeted bone within the last 48 hours.
- Avoid with Cellulitis, Burns, or Osteomyelitis (Vidacare, 2014).



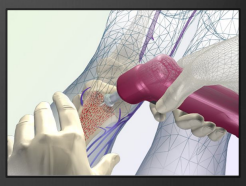
Total Knee Replacement

Slide 10

Intraosseous Access Sites

- **Proximal Tibia**
  - Adults & Pediatrics
- **Proximal Humerus**
  - Adults & Pediatrics
- **Distal Femur**
  - Pediatrics
- **Distal Tibia (Medial Malleolus)**
  - Adults & Pediatrics

EZ-IO Access



Slide 11

Proximal Humerus Insertion Site

- First position the arm for maximum proximal humerus exposure.
  - **Adduct** the patient's humerus then posteriorly locate the elbow to the same plane as the spine (laying the elbow on the bed).
  - Next place the patient's hand on the patient's abdomen near the **umbilicus**.
- Place ulnar side of hand in the axilla and the other hand perpendicular to the midline of the arm. Place both thumbs together and it will define the midline of the humerus.
- Palpate the mid-shaft of the humerus and continue palpating up to the proximal end of the humerus until you reach a protrusion **(greater tubercle insertion site).**
  - This may feel like a golf ball on a tee.

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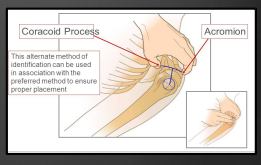
Proximal Humerus Insertion Site

- 1) With the opposite hand, consider **"pinching"** the anterior and inferior aspects of the proximal humerus while confirming the identification of the greater tubercle.
- 2) Identify the **greater tubercle** insertion site approximately two finger widths inferior to the **coracoid process** and the **acromion**.
  - Form a "T" connecting the site, coracoid process, and the acromion (Vidacare, 2014).

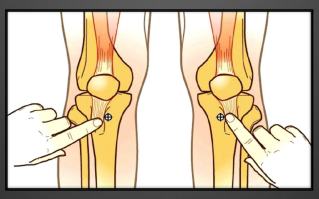


Slide13

Proximal Tibia Insertion Site

- Three Landmarks: **Tibia** (Anterior Lower Leg Bone), **Patella** (Knee Cap), and **Tibial Tuberosity** (Raised Area of Anterior Aspect).
- Extend the leg.
- Identify flat surface (insertion site):
  - 2 cm medial to the tibial tuberosity **OR**
  - Approximately 2-3cm (two finger widths) below the patella and approximately 2 cm (two finger widths) medial along the flat aspect of the tibia.

Slide 14



Proximal Tibia Insertion Site

"If You Want To Get In- Think In!" Rationale: If you want to get inside the IO space think inside (the medial aspect of the leg).

"Big Toe- Go EZ-IO" Rationale: The EZ-IO is placed on the medial side of the leg, the big toes are found on the medial aspect of the leg (Vidacare, 2014).

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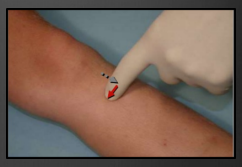
Pediatric EZ-IO

- **Pink** EZ-IO: Think **Newborn**!
- Recent FDA Approval: **Blue** EZ-IO for Pediatric Population.
- Insertion site:
  - Approximately 1cm medial to the tibial tuberosity **OR**
  - Just below the patella (approximately 1cm or one finger width) and slightly medial (approximately 1cm or one finger width) (Vidacare, 2014).



Slide 16

Intraosseous Preparation

- Equipment:
  - Iodine Solution or Similar Antiseptic
  - Non-Sterile Latex-Free Gloves
  - 10mL Syringe
  - EZ-IO Driver
  - EZ-IO Needle Set
  - EZ-IO Connection sets
  - EZ-IO Stabilizer

Slide 17

Three Size of EZ-IO Needles

- Pediatric EZ-IO (Pink)
  - 3-39kg or newborns
  - 15gauge x 1.5cm
  - Annual use in ED: 5 Units
- Adult EZ-IO (Blue)
  - >3 kg
  - 25gauge x 2.5cm
  - Annual use in ED: 19 units
- Long EZ-IO (Yellow)
  - >40 kg
  - 45gauge x 4.5cm
  - Annual use in ED: 16 units

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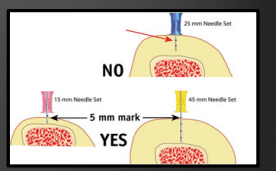
Insertion of EZ-IO

- Position EZ-IO at
  - **90** degree angle to insertion for **proximal tibial** site.
  - **45** degree angle to insertion **proximal humerus** site.
- Gently drive or manually press the needle until the tip touches the bone. Ensure that **5mm** of the catheter is visible above the skin to determine adequate needle length.



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Insertion of EZ-IO

- Squeeze the driver trigger and apply light but steady downward pressure to penetrate the bone.
  - Remember: "**Easy Does It**!" Relax your grip on the driver and "**allow the driver to do the work**!"
  - **Do not push**-instead gently guide the needle into the insertion site.
- Release the trigger to stop insertion when a sudden decrease in resistance. **Avoid recoil** – do **NOT** pull back on the driver when releasing the trigger.
  - Carefully feel a **"pop" or "give"** indicating you are in the medullary space. **STOP** when you feel the **"pop"** (Vidacare, 2014) .

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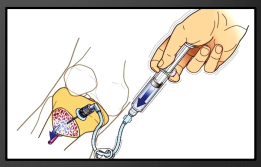
Insertion of EZ-IO

- Wait for driver to stop spinning. Hold hub and remove driver with **counterclockwise** rotation.
- Attach EZ-Stabilizer and EZ-Connect extension set and **confirm placement**.
  - Catheter feels firmly seated in bone (1st confirmation).
  - Aspirate for blood/bone marrow (2nd confirmation).
  - Drugs or fluids will flow without difficulty (3rd confirmation)
  - Connect Fluids and maintain 300mmHg (Vidcare, 2014).



Slide 21

Patients Responsive to Pain

- Prime EZ-Connect extension set with Lidocaine.
  - Note that the priming volume of the EZ-Connect is approximately 1.0 mL .
  - If primed with 2% preservative-free Lidocaine, this will be approximately 20 mg.
- Slowly infuse 40 mg of Lidocaine IO over 120 seconds (2 minutes).
  - Allow Lidocaine to dwell in IO space 60 seconds (1 minute).
- Flush the IO catheter with 5 to 10 mL of normal saline.
- Slowly administer an additional 20 mg of Lidocaine IO over 60 seconds (1 minute).
  - Repeat PRN for pain.
- Consider systemic pain control for patients not responding to IO Lidocaine (Vidacare, 2014).

Slide 22

EZ-IO Removal

- Remove EZ-IO Connection Set.
- Maintain **90 degree angle** with **tibial site** and **45 degree angle** with **proximal humerus site:**
  - **Attach** a 10cc sterile normal saline syringe (Act a longer handle for the removal process).
  - Rotate syringe and catheter **clockwise**. While rotating catheter, gently pull catheter out (Avoid excess pulling when removing).
- Minimal bleeding should occur. Apply a Band-Aid. If bleeding continues, apply pressure.
- Prophylactic antibiotic use is not recommended for EZ-IO (Vidacare, 2014).

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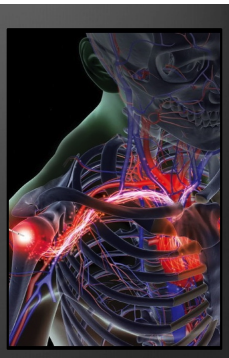
Final Four Points

1) Routinely re-confirm the EZ-IO placement.
   "No Flush = No Flow"
2) Maintain protection of insertion site against accidental bumping or dislodgment.
3) Frequently monitor the EZ-IO, fluid, and extremity.
4) Remove EZ-IO within 24 hours (Vidacare, 2014).



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Appendix F: Pre-Post Test

1. How many times have you performed intraosseous (IO) insertion in your nursing practice?

   _____ (None) _____ (1-5 times) _____ (More than 5 times)

2. How confident are you in your knowledge about IO insertion?

   a. Very confident
   b. Somewhat confident
   c. Not confident at all

3. How confident are you in your ability to perform IO insertion?

   a. Very confident
   b. Somewhat confident
   c. Not confident at all

4. How important do you believe it is to use IO insertion as an alternative to intravenous (IV) access in your nursing practice?

   a. Very important
   b. Somewhat important
   c. Not important at all

5. What is the likelihood of you completing IO insertion in your nursing practice?

   a. Very likely
   b. Somewhat likely
   c. Not likely at all

Appendix G: Educational Flyer

Intraosseous Vascular Access Education Program

Presented by Nicole Helsper DeVoe

PIT Crew Meeting
January 27th, 2015
7:30am