Ultrasound Guided Peripheral Intravenous Catheter Placement Implementation in a Community Hospital

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Abstract

Problem: At a community hospital, patients were having venipuncture attempted on them, on average, every day of their hospital stay. More attempts mean more nursing time and more patient discomfort. Furthermore, according to a 2022 internal survey, the mean dwell time of peripheral intravenous catheters (PIVC) was just two days. When PIVC cannot be placed or maintained, providers then order a central line to be placed, and there are multiple initiatives in place to reduce the number of central lines placed. **Purpose:** The purpose of this project was to implement nurse placed ultrasound guided PIVCs in critical care and to implement the adult difficult venous access (A-DIVA) tool to decide which patients would benefit from the placement of an ultrasound-guided PIVC (USGPIVC). **Methods:** Eleven bedside RNs were trained to place USGPIVC by a professional trainer during 6–8-hour training sessions. The training sessions included a didactic section, practice on a vein block, and time to place USGPIVCs on patients. All staff who trained were deemed competent if they placed three USGPIVCs independently. All ICU nurses were trained to use the A-DIVA to determine which PIVC placement method should be attempted first on a patient. Higher A-DIVA scores indicate a patient will have more difficult veins to access. Scores greater than two received an USGPIVC as their first attempt. **Results:** 1.625 USGPIVCS were placed on average. 29 percent of PIVCs were USGPIVCs. Only 10 percent of patients who had access placed in the ICU had A-DIVA documentation. Of the 11 nurses trained the majority of the USGPIVCS were placed by four nurses. **Conclusions:** The interventions increased USGPIVC from none placed to a significant part of the PIVCS placed. Most studies on USGPIVC placement are set in the emergency room. This study shows USGPIVCs can be implemented in the ICU as well.

Keywords: Ultrasound, nurse, USGPIVC, PIVC, ICU, A-DIVA

Ultrasound Guided Peripheral Intravenous Catheter Placement Implementation in a Community Hospital

The doctorate in nursing practice (DNP) project took place in the intensive care unit (ICU) at a mid-size hospital, with under 250 beds. The hospital was seeking to improve the high rates of peripheral intravenous catheter (PIVC) placement failure and the high rates of central line-associated bloodstream infection (CLABSI). If a PIVC could not be obtained, then the only option at the hospital has been a central venous catheter (CVC). According to the Agency for Health Care Research and Quality (2013), CLABSIs cost $70,696 and have a mortality rate between 12 and 25% (2013). PIVC attempts cost between $28 and $35 for materials, and each PIV failure leads to a greater chance of successive PIVC failure due to trauma of the large veins (Helm et al., 2015). These costs do not include the harder to quantify costs of staff time, pain and suffering for the patient, and the risk for PIVC related bloodstream infections.

Internal evidence from purchasing from 2020 concluded that one intravenous catheter was purchased for each inpatient day. This data does not include needles used just for drawing blood. Therefore, it is reasonable to conclude that patients were having venipuncture attempted on them, on average, every day of their hospital stay. Furthermore, according to a 2022 internal survey, the mean dwell time of PIVCs was just two days, and none of the observed PIVs were placed with the correct technique that involves, choosing an appropriate site, cleaning the site for the appropriate amount of time, and not re-palpating the site before placement.

The pre-implementation process for PIVC placement in the ICU is outlined in Figure 1. Every patient must have four failed placement attempts before they are eligible for a different type of intravenous access. For any patient, but especially for those who are known to be difficult to access, this is an inappropriate number of attempts. It would be superior if the nurse identified

those patients with difficult intravenous access (DIVA) and made use of a different method of PIVC placement for the initial attempt.

These problems have many causes, (outlined in Figure 2) but one root cause is the lack of options for PIV access. There are only two options: PIVCs placed by nurses and CVCs placed by the vascular access team. With the high rate of PIVC failure and high cost of CVC complications, a third option would be helpful. The purpose of this project was to implement nurse placed ultrasound guided PIVCs in critical care and to implement the adult difficult venous access (A-DIVA) tool to decide which patients would benefit from the placement of an ultrasound guided PIVC (USGPIVC).

Available knowledge

The emergency room already had a USGPIVC placement program which was anecdotally successful but never studied. A literature review revealed four level one studies on using nurses to place USGPIVC in the ICU setting against the control of traditional landmark PIVC placement. Two of the studies were meta-analyses and two were randomized controlled trials (RCT). Both meta-analyses showed a higher success rate for ultrasound-guided PIV insertion compared to traditional methods The results of the two RCTs conducted in ICUs comparing USGPIVC to traditional PIVC placement were mixed. Bridey et al. (2018) found no difference in success rate between USGPIVC and the traditional method. Kerforne et al. (2012) found a 33% higher success rate for USGPIVC compared to the traditional method ($p=0.02$). No study found that the ultrasound group took more time or created more complications. No studies found that the traditional method was more effective than using ultrasound. Therefore, there is high-quality and reasonably consistent evidence to support practice change.

Rationale

The project utilized the Knowledge to Action framework, which links knowledge creation with adaptation and sustainability in the local context (Graham et al., 2006). The framework is diagramed in Figure 3. The center shows the knowledge creation process, and the outer circle shows the process of implementing and sustaining that evidence. The areas of the theory are to identify a problem, adapt knowledge to local context, assess barriers to knowledge use, select, tailor implement interventions, monitor knowledge use, evaluate outcomes, and sustain knowledge use (Grahm et al., 2006). These areas helped guide the project to ensure all important areas were covered. Problem identification, knowledge creation and synthesis for PIVC placement has been described in the previous section. Starting the program in the ICU where the necessary equipment is already present, and the need exists helped adapt the knowledge to the correct local context. USGPIVC placement can be difficult to learn and therefore professional trainers from the company that supplies catheters trained ICU nurses for free for 6 days. Based on their expert opinion everyone will not become proficient so there was training for more staff than was strictly necessary for the program's success. The success of the program was measured by the attainment of the program goals, which are delineated later in the paper. The intervention was sustained by the selection of nursing champions for the process, involving the manager and educator, and celebrating its success.

Methods

The context offers benefits and barriers. No new equipment was needed because the ICU already has two ultrasound machines, one that was ultimately dedicated for use by the nurses. The nurses were enthusiastic about learning USGPIVC placement with over 25 nurses volunteering before the project started. The providers were also enthusiastic about the project

because when nurses can get access independently, their services are not required, so the project should decrease their workload. This was the first formal quality improvement project implemented on the unit, so everyone was new to the process. There are not many PIVCs placed in the unit with an average of less than five placed every week so there are fewer opportunities to become and stay proficient than in the emergency room. All PIVCS were tracked for how they were placed and if A-DIVA was documented so no eligible patients were excluded.

A new process was proposed in which the A-DIVA tool was used to classify patients and, if the score was two or higher, the patient was considered to have DIVA and the nurse would then utilize the ultrasound for the first attempt. The goal was a reduction in unnecessary attempts for difficult access patients. The new process is outlined in Figure 4. To change this process, a team was gathered that included the quality improvement project leader (QIPL) with expertise in the unit and USGPIVC placement, a clinical site representative with expertise in implementing evidence-based practice, and the unit manager and the educator were responsible for helping schedule nurses for training, and provide guidance when barriers come up that required navigation. To determine which patients are a candidate for USGPIV, nurses were instructed to deploy the validated adult difficult venous access tool (A-DIVA) on all patients (van Loon et al., 2019).

The QIPL utilized various implementation strategies beyond providing education to ensure the success and sustainability of the quality improvement project. The strategies were organized utilizing the ABCDE model and listed in Table 3 (Powell et al., 2015). The USGPIVC placement training began on August 29, 2022. It started with a setback. The two weeks of training promised by the catheter company became only one initial day of training with another week of training in October. The training by the catheter company was led by a professional

trainer who worked with each nurse trainee independently during an eight-hour day. The first hour was didactic, about ultrasound fundamentals and the process of placing a PIVC under ultrasound. The second hour was hands-on training on a vein block that simulates actual patient experience. The last six hours were dedicated to practice with real patients. Nurses were considered proficient if they completed the training and obtained three USGPIVCs with minimal intervention by the trainer. To adapt to the lack of training at the beginning of the project the QIPL coordinated with the vascular access nurse to conduct the didactic portion of the training for groups of five to ten nurses in four sessions. Then the QIPL followed up with each nurse trained for six-hour hands-on training with real patients. Because the training rolled out slower than expected the QIPL strategically delayed the A-DIVA training because, if the nurses did not have anyone to place an USGPIVC when the A-DIVA score was high, the training might have been seen as irrelevant and not lead to practice change. A-DIVA training began on week six for all ICU RNs and was conducted by the QIPL via huddles, signs on the unit, and two-minute one on one sessions.

This quality improvement project did not include outcome measures because the internal data on PIVC attempts was of low quality. For example, the EMR documentation showed that, PIVC access was achieved with only one attempt for all patients, which contrasts with purchasing data, which is likely more accurate, and which shows that the hospital buys one catheter for every patient day, because it is implausible that access is achieved for every patient after the first attempt. The team concluded the staff recorded they were always successful on the first attempt even when they were not. All the project goals are listed in Table 4.

The structure goals centered on whether enough nurses were trained and obtained proficiency in USGPIVC placement. The number of nurses trained and the number of those that

obtained three successful independent USGPIVC placements was tracked using paper charting which was securely stored in the nurse educator's office. There are no standards for how many successful independent USGPIVC placements show baseline proficiency, but studies similar to this project have used three, so it was chosen (Robertson, 2021).

The process goal was that all patients should have a documented A-DIVA score during the trial period, which would serve as a proxy for effectively triaging patients to USGPIVCs or regular PIVCs. The number of USGPIVS placed was tracked in the electronic medical record. Ideally, tracking the number of attempts for ultrasound-guided lines and the number of attempts for traditional lines would be tracked but since the data was unreliable that was not done. Considering that no USGPIVCs were being placed on the unit or A-DIVA scores recorded prior to the project, it is reasonable to assume that any increase was due to the project interventions.

A run chart was used to track how many USGPIVCs were being placed every week in the ICU. The number was anticipated to increase as the nurses become more comfortable with ultrasound-guided placement and the new protocol, but the weekly data should vary naturally. If USGPIVC placement went down for multiple weeks, the QIPL planned to investigate. The data for nurses trained and nurses proficient were displayed on a bar graph so the progress towards the goal could be monitored every week. A-DIVA documentation is visualized as a bar graph and was expected to increase after the training with a possible decrease sometime after the training. Since this is a quality improvement project it was concerned with increasing the number of USGPIVC placed in the ICU and whether the protocol was being followed. There were no statistical methods deployed to determine if the intervention improved patient outcomes.

Non-human Subject's Research determination from the Human Research Protections Office (HRPO) of the University of Maryland School of Medicine Institutional Review Board

(IRB) was obtained prior to project implementation. A separate approval was obtained from the site to ensure data protection and alignment with site goals. Data collection was done in a private room utilizing HIPPA privacy protections. All data was collected onsite on a single secure computer and stored in REDCap, a secure, password-protected data set. Only the QIPL and faculty at the University of Maryland Baltimore had access. There was no use of patient identifiers. Nurse names were stored in a locked office that only the nurse educator could access. This information became part of the nurse educators record and is kept to demonstrate competency for those performing USGPIVCs. The QIPL is an employee of the site, but no conflicts of interest were identified.

Results

The goal of training twenty nurses was met in week seven. In total 26 nurses were trained. Of those 26 trained, 11 became proficient. Proficiency, calculated by the number of nurses that obtained three independent sticks compared to all nurses trained was 42% proficient. That was similar to the projected 50% proficiency rate before the project started. Some nurses needed more than the eight-hour training to become proficient. To meet this need, the QIPL followed up with an additional four-hour training for nurses that did not achieve proficiency in the first training. Because the training is very time intensive not all nurses received additional training. After a meeting with the QIPL, the professional trainers and the unit educator, it was agreed that each trained nurse should have 12 hours of training initially so more nurses would achieve proficiency.

USGPIVC placement (Figure 5) increased from the baseline of none placed, but the run chart shows no runs, shifts, trends, or astronomical data points. The most USGPIVCs placed in a week was four. There are only three data points above the goal. Considering that in some weeks

no PIVCs were placed in the ICU it makes sense that the goal of three per week was not met. Overall an average of1.625 USGPIVCs were placed per week, and 29% of PIVCs placed were USGPIVCs (USGPIVCs divided by total PIVCs placed).

The A-DIVA documentation increased from none to 18% of all PIVCs placed (PIVCs placed with ADIVA documented divided by all PIVCs placed). Details can be seen in figure 7. The goal was not met and there were no runs, shifts, trends, or astronomical data points. The highest percentage was 50% and that was only for one week. The A-DIVA is documented in a comment section of the medical record where PIVCs are documented. Going forward it would be helpful to have a specific place in the EMR where the score is calculated by asking the documenting RN questions about the patient. Without that the nurse must refer to a separate paper A-DIVA score tool (Figure 9) to know how to document the A-DIVA.

The results were affected by the fact that the ICU experienced flooding in early October that did not allow for half of the ICU rooms to be utilized for three and a half weeks. It also diverted attention from the project team as modifications to patient flow and equipment storage took precedence. The lack of ICU rooms decreased the total number of ICU patients which meant fewer patients available for placement of PIVCs and USGPIVCs. Mastery of USGPIVC placement required continued practice and while this was not being tracked by the project it was likely impeded by the nurses in training having fewer opportunities to practice their new skill than they would have had under normal unit operation.

Discussion

USGPIVCs are now a substantial part of PIVC placement in the ICU. They are being used most weeks, and 11 nurses know how to place them independently. Similar to findings from the literature this project found sufficient nurses to volunteer for training and that those who

were trained were able to learn (Bridly et al., 2018, Kerforne et al., 2012, Stolz et al., 2015, van loon et al., 2018). This project, which found that eight hours of training was sometimes insufficient, conflicts with other studies set in the ER, such as Robinson et al. (2021) in which nurses were only trained for an hour and a half and then attempted USGPIVCS to get signed off after three successful attempts. An informal post-intervention analysis by the QIPL showed that the majority of USGPIVCs were placed by four of the nurses who were trained. This points to the fact that although 11 nurses were deemed proficient by the project standards, not all of them were truly proficient in USGPIVC placement. This could be for multiple reasons, including differences in skill, differences in opportunities to practice, or differences in confidence. Discussion between the QIPL and nurses trained supports this conclusion. Six of the proficient nurses requested additional training. These findings point to a limited validity of the definition of proficiency used in the project. The nurses who obtained three independent USGPIVCs were sufficient to continue to practice placing USGPIVC but not yet proficient at the skill.

Although this project did not include a financial analysis, financial concerns did come up during implementation. The company that provides free training for catheters sells their catheters for $40/each, which is 20 times the cost of the less expensive option. To provide the training the company required the hospital to purchase 100 of those catheters which totaled over $4,000. The unit manager, who was initially supportive of the project, became skeptical of the money outlay necessary to commence training. A compromise was made to purchase 60 catheters using funds outside of the units' main budget, and although the company did not directly express this, it could have been the reason for the lack of training initially and having only one week of training when two weeks were initially promised.

The ICU owns two ultrasound machines; one is newer, and the screen has a higher-quality image. There were times during the training when both the nurses and the providers needed the ultrasound, and both were attempting to use the higher quality ultrasound. To address this a policy was made that if anyone wants to use the higher quality ultrasound, they need to notify the charge nurse, and if there was a conflict it was determined that the provider team would have preference to use the higher quality ultrasound. A policy delineating who has priority access to which machine at the beginning of the project would have avoided conflicts.

It is unclear why every PIVC was documented as placed on the first attempt. There is no punitive policy for multiple attempts. More study is needed to reveal the causes and possible solutions so that the hospital can have more accurate documentation and future PIVC projects can measure the effect on first attempt success.

There were several factors which limited the success of the project. The water damage that the ICU experienced limited ICU beds and training opportunities. The training persisted despite the water damage but the decreased opportunities to work with patients and practice USGPIVCs limited the amount of time that each nurse could improve on their own after training. The ADIVA documentation was not incorporated into the electronic medical record (EMR), which made documentation more onerous and limited compliance. Therefore, more reminders to document ADIVA scores were necessary. Also, there was less help from the catheter vendor for education which caused the project to adapt and required more of the QIPL's time which could have been focused on other areas of the project. There was also a problem with the first report from the electronic medical record that caused some PIVCs to be not counted and others to be double counted. This was because it was running the report from two databases for patients currently in the ICU and patients discharged and on other units. A new report was created with

the help of a nurse informaticist which was validated by correlating it with six hours of real-time data. The new report showed that fewer PIVCs were placed than originally expected. The original goal was that 10 USGPICs would be placed every week, but after the accurate report showed that only five total PIVCs were placed every week, the goal had to be decreased to three USGPIVCs every week.

Conclusions

Most studies on USGPIVC placement are set in the emergency room. This quality improvement project provides data to show USGPIVCs can be implemented in the ICU, not just the ER. No safety concerns were revealed during the study. The nurses were eager to learn with many still requesting training after the project period was over. The project also reveals that USGPIVC training in the ICU may require more time with each nurse than the studies set in the emergency room, because of the lack of opportunities to practice. Considering that PIVC placement ranged between 0 and 12 per week it may be advisable for future sites interested in implementing this practice change to train fewer nurses and ensure that they are truly proficient with adequate practice to maintain their skills. Training too few nurses could have the adverse effect of causing resentment among the trained nurses as they are continually asked to leave their patient assignments to help place PIVCs for other nurses. Initially, there was interest in training the charge nurses and the rapid response nurses, but those nurses did not volunteer for the training, and priority was given to willing volunteers because more nurses wanted to be trained than the intervention had the time and resources to provide. There were still many nurses asking for training after the project was over. Using volunteers for USGPIVC training was a strength of the project. Nurses trained were motivated to learn and practice. The scarce resource was trainer time and patients who required USGPIVCs.

Going forward, training resources should be focused on follow up training for the nurses who achieved proficiency per the project standards but do not feel completely comfortable placing USGPIVCs on their own. Future implementation projects should consider increasing the number of independent attempts needed to be deemed proficient to more than three, so the project definition of proficiency has greater validity.

Future projects should consider sustainability. In this project, the QIPL did a lot of the work with organizing, training, data collection, and data analysis, so as the QIPL steps back from those roles the site needs measures in place to ensure sustainability. The first step will be to allow the trained nurses to train future nurses to place USGPIVCs. With nursing turnover, if nurses are not trained periodically then the practice will stop. During the three-month project two fully trained nurses left, and one left shortly after the project was completed. Many hours of paid training were wasted from the perspective of the hospital. The site should consider training several people on the educator team to become trainers so that further training is available for current and future practitioners. Future projects should consider assessing volunteers for USGPIVC training to ensure the training is consistent with career goals. Finally, any documentation required by the nurses for the project should be integrated into the electronic medical record so that it can be documented and audited easily.

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van Loon, F. H., van Hooff, L. W., de Boer, H. D., Koopman, S. S.., Buise, M. P., Korsten, H. H.., Dierick-van Daele, A. T., & Bouwman, A. R. (2019). The modified A-DIVA scale as a predictive tool for prospective identification of adult patients at risk of a difficult intravenous access: A multicenter validation study. *Journal of Clinical Medicine*, *8*(2), 144. https://doi.org/10.3390/jcm8020144

Table 1

Evidence Review Table

Citation: Bridey, C., Thilly, N., Lefevre, T., Maire-Richard, A., Morel, M., Levy, B., Girerd, N., & Kimmoun, A. (2018). Ultrasound-guided versus landmark approach for peripheral intravenous access by critical care nurses: A randomised controlled study. *BMJ Open, 8*(6), e020220. https://doi.org/10.1136/bmjopen-2017-020220					Level and Quality: I (RCT) – A (Good quality)
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
Compare USGPIVC to the traditional method for "placement of a PIVC in upper limbs in patients with anticipated difficult PIVC access and who no longer required a CIVC." (Bridey et al. 2018)	Research: A prospective randomized, non-blinded, controlled, single center study.	Sampling Technique: Convenience sampling of all patients who were over 18, no longer needed a CVC but needed replacement access, and did not have palpable veins as determined by the RN. # Eligible: 114# Accepted: 114 # Control:57# Intervention: 57 Power analysis: 96 patients were	Control: PIVs placed by landmark technique; the way PIVs are traditionally placed. Intervention: PIVs placed with ultrasound guidance. Intervention fidelity All nurses were certified proficient in both methods before participation. Randomization was done with sealed envelopes stating which insertion technique the nurse would use. The nurse attempted a maximum three attempts per day up to three days in a row. An	DV: Number of attempts to obtain a PIV. Attempt was defined as a single needle puncture. Secondary outcome: The proportion of successful PIV placements per day, Number of CIVC's removed, and patient satisfaction on a 1 to 10 scale. No validity or reliability data was given for the	Statistical Procedures: Mann-Whitney was used for continuous variables and the Chi-squared for proportions. Results: Success on first attempt was 41% in the intervention group and 33% in the control (p=0.886). The number of attempts (2 (1-4) p=0.911) and catheter lifespan (3(1-3) days and 3(2-3) days p=0.791) were similar among the two groups. Therefore, there were no significant differences between the intervention and control on

		needed to identify a difference with a two tailed alpha at 0.05. Group Homogeneity: No P-values were provided for Table 1 but judging from mean plus standard deviation the groups were similar except for the duration of renal replacement therapy (2 for intervention 11 for control).	information pamphlet was provided to the patient by the charge nurse. Success was defined as easy flushing and no infiltration.	patient satisfaction tool.	the primary or secondary outcomes.
Citation: Stolz, L. A., Stolz, U., Howe, C., Farrell, I. J., & Adhikari, S. (2015). Ultrasound-guided peripheral venous access: A meta-analysis and systematic review. *The Journal of Vascular Access, 16*(4), 321–326. https://doi.org/10.5301/jva.5000346					Level and Quality I (Meta-analysis of RCTs)- A (High quality)
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample– Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
"The objective of this study was to determine	Research: Systematic review and	Databases used: MEDLINE, Web of Science, The Cochrane Library,	Control: Traditional method of IV access.	DV: Success rate (successful attempt/total attempts), Time to	Statistical Procedures: Pooled random effects odds ratio for success rate, with chi-squared for

through a systematic review of the literature and meta-analysis whether success rates, time to cannulation, and number of punctures required for peripheral venous access are improved with ultrasound guidance compared with traditional techniques in patients with difficult peripheral venous access." (Stolz et al., 2015).	meta-analysis	ClinicalTrials.gov, cumulative Index to Nursing, and Allied Health Literature. Results: # Found: 4,638 # Excluded: 960 for duplicates, 3,634 after title and abstract review, 57 from full text review. # Included: 6 RCT's and one prospective systematically allocated study.	Intervention: Ultrasound guided IV access Reviewers independently selected and excluded studies. Disagreements were reviewed by a third party.	cannulation, Punctures required for each technique. Measurement tool (reliability), time, procedure:	heterogeneity and tau-squared for variance. Pulled weighted mean for time to cannulation and number of attempts with Chi-squared for p-values. Results: Pulled random effects odds ratio for ultrasound vs traditional technique was 3.96 (1.75-8.94, p=0.12). Time to cannulation was -1.07 min (-4.66-2.52 min, p=0.003). Number of punctures was -.5 punctures (-1.36 – 0.35) for the ultrasound vs traditional method. The ultrasound group had more first stick success and there were no significant differences between time to cannulation between the groups.
Citation: Kerforne, T., Petitpas, F., Frasca, D., Goudet, V., Robert, R., & Mimoz, O. (2012). Ultrasound-Guided Peripheral Venous Access in Severely Ill Patients With Suspected Difficult Vascular Puncture. *Chest, 141*(1), 279–280. https://doi.org/10.1378/chest.11-2054					Level and Quality I (RCT) – B (good quality)
Purpose/ Hypothesis	**Type of Evidence**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**

	Research Design				
"In EDs, the use of ultrasonography increases successful cannulation rates in difficult-to-achieve peripheral venous access. Its value in ICU patients has never been explored in a randomized trial." (Kerforne et al., 2012)	Research: Randomized controlled, non-blinded trial.	Sampling Technique: Convenience sample of patients in the ICU of a single institution. Eligible patients were patients deemed to have no easily visible or palpable veins in both arms after tourniquet placement by the practitioner. There is no data on how many patients were eligible and how many were excluded. # Control: 30 # Intervention: 30 Power analysis: None noted	Control: Traditional landmark PIV access. Intervention: PIV placement with real-time ultrasound guidance. Intervention fidelity: A different nurse other than the one who first assessed the patient placed the PIV in the control group. If access was unable to be obtained after two attempts the patient was placed in the second group.	DV: Success of cannulation. It was not stated how this was defined.	Statistical Procedures used were not stated. Results: Significantly more PIVs were obtained via ultrasound (21 vs 11, p=0.02). 15 of the 19 who failed in the traditional group found success in the ultrasound group. Only 2 of the 9 who failed in the ultrasound group were cannulized in the traditional group.

		Group Homogeneity: All Table 1 p-vales greater than 0.2.			
Citation: van Loon, F. H., van Hooff, L. W., de Boer, H. D., Koopman, S. S.., Buise, M. P., Korsten, H. H.., Dierick-van Daele, A. T., & Bouwman, A. R. (2019). The modified A-DIVA scale as a predictive tool for prospective identification of adult patients at risk of a difficult intravenous access: A multicenter validation study. *Journal of Clinical Medicine, 8*(2), 144. https://doi.org/10.3390/jcm8020144					Level and Quality III (Non-experimental study)- B (good quality)
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
"The present study focuses on risk factors for failure upon peripheral intravenous cannulation and aims to improve the performance of the A-DIVA scale by creating a predictive scale that is externally validated and applicable to	Research: External Validation study including participants from different units at multiple Dutch Hospitals.	Sampling Technique: Nonprobability consecutive sampling with everyone meeting the criteria included until the sample size goal was met. Power analysis: 2200 participants were recruited to ensure that there were at least 10 participants with PIV failure on	Intervention: Practitioners first assess their patients using the 5-point, additive A-DIVA scale. The higher the score the harder PIV access is predicted to be. After patients were scored on the scale practitioners attempted to place a PIV. Intervention fidelity: The study only included practitioners who routinely place PIVs and have at least one year of experience. If the practitioner failed to	DV: Failed PIV placement on the first attempt. Success was defined as being able to flush the catheter without signs of infiltration. No discussion on the reliability of the metric.	Statistical Procedures: Continuous variables were compared with the Chi-squared test, discrete variables with the Fisher's exact test. Logistic regression was used toassociate scores with first attempt fail. The following A-DIVA scores were related with the following rates of first attempt success: Score 0 – 98% Score 1 – 90% Score 2 – 69% Score 3 – 55%

the total hospitalized population."		first attempt in each A-DIVA score.	obtain access after two attempts another practitioner was called on to try.		Score 4 – 14% Score 5 – 2% Higher scores on the A-DIVA tool led to lower rates of PIV first stick success.
Citation: van Loon, F. H.. van, Buise, M. P., Claassen, J. J.., Daele, A. T., & Bouwman, A. R. (2018). Comparison of ultrasound guidance with palpation and direct visualization for peripheral vein cannulation in adult patients: A systematic review and meta-analysis. *British Journal of Anaesthesia, 121*(2), 358–366. https://doi.org/10.1016/j.bja.2018.04.047					Level and Quality: I (meta-analysis of RCTs) – A (high quality)
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/Measures**	**Results/Conclusions**
"The objective of this study was to systematically review the results of studies comparing ultrasound with the traditional technique of palpation and direct visualization, with successful peripheral i.v. cannulation as	Research: Systemic review and meta-analysis	Databases: PubMed, Clinical Key, CINAHL, Cochrane Library of Clinical Trials, Trip Database, and Google Scholar. Studies comparing ultrasound guided PIV insertion to traditional methods were included. Studies were excluded if	Control: Palpation and visualization PIV placement Intervention: Ultrasound guided PIV placement. Intervention fidelity was not discussed.	DV: Success rate (successful attempts/actual attempts) Number of attempts Complications of infiltration, arterial puncture, and nerve puncture. Patient satisfaction on a subjective rating scale.	Statistical Procedures: Pooled odds ratio for categorical variables and weighted mean difference for continuous variables Results: Ultrasound guided success rate was 81% vs 70% for palpation and visualization poolded OR 2.49 (1.37-4.52, p=0.003). Ultrasound decreased the number of attempts (although without statistically significant

the outcome of interest. This meta-analysis aimed to prove the utility of ultrasound guidance during peripheral vein cannulation in terms of efficacy and efficiency in clinical practice.". (van Loon, 2018)		they did not study PIV insertion on the arms, or compared different PIV placement methods. Two reviewers independently screened eligible studies. Discrepancies were resolved by a third independent reviewer. # Identified: 1203 # Removed after Tital Screen: 1145 # Removed after full text screen: 50 # Analyzed: 8 - 5 Randomized controlled studies and 3 cohort studies.		There is no discussion of the reliability or validity of the measurements.	results) with a mean difference of 0.92 (-0.10-1.94, p=0.08). Patient satisfaction was 33% higher in the ultrasound group (22-43, P<0.001) Only two studies tracked complications and they did not show a difference between the groups (p=0.82).

Table 2

Evidence Synthesis Template

Category (Level Type)	Total Number of Sources/Level	Overall Quality Rating	Synthesis of Findings
Level 1 - Experimental study · Randomized Controlled Trial (RCT) · Systematic review of RCTs with or without meta-analysis	2 RCT's 2 Meta analyses (Bridly et al., 2018, Kerforne et al., 2012, Stolz et al., 2015, van loon et al., 2018)	A	All the USGPIV studies used success rate of PIV access as the main dependent variable. Both meta-analyses showed a higher success rate for ultrasound-guided PIV insertion compared to traditional methods The results of the two RCTs conducted in ICUs comparing USGPIV to traditional PIV placement are mixed. Bridey et al. (2018) found no difference in success rate between USPIV and the traditional method. Kerforne et al. (2012) found a 33% higher success rate for USPIV compared to the traditional method (p=0.02). No study found that ultrasound took more time or created more complications. No studies found that the traditional method was more effective than ultrasound.
Level II · Quasi-experimental studies · Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis			
Level III · Non-experimental study · Systematic review of a combination of RCTs, quasi-experimental, and non-experimental studies, or non-experimental studies only, with or without meta-analysis · Qualitative study or systematic review of qualitative studies with or without meta-synthesis	1 - Cross Sectional study (van Loon et al., 2019)	B	The study found the tool was well accepted by practitioners and increasing scores on the tool lead to decreasing rates of first stick success indicating the tool successfully predicted first stick success.
Level IV · Opinion of respected authorities and/or reports of nationally recognized expert committees/consensus panels based on scientific evidence			
Level V · Evidence obtained from literature reviews, quality improvement, program evaluation, financial evaluation, or case reports · Opinion of nationally recognized expert(s) based on experiential evidence			
Recommendations Based on Evidence Synthesis: High quality and sufficiently consistent evidence to support practice change.			

Table 3

Implementation Strategies

Strategy	Approach
Accountability	
Provide clinical supervision	QIPL will be on unit each week to assist in further training and supervision as needed with RNs trained in USGPIVCs. USGPIVCs can be difficult to learn, and it will help to have an expert on the unit (the QIPL).
Track documentation and follow-up	QIPL will follow up with trained RNs to assess barriers and re-educate as necessary, if less than 10 USGPIVs are placed every week after week five. This will allow RNs time to train and be comfortable and will be early enough in the project that changes can be made if something is missing for the RNs to succeed in USGPIVC placement.
Buy-in	
Recruit nurses before training	A signup sheet will be placed in the break room to publicly recruit nurses for training. This will publicly show that there is interest in the project by important members of the RN team. If additional nurses are needed the QIPL will personally recruit additional nurses.
Engage PAs and NPs	PA and NP place central lines and will be motivated to have nurses obtain access on difficult access patients. They can become champions and assist with further training. The QIPL will follow up with them at week 5 and week 10 to see if they have assessed barriers or changes to be made.
Collaboration, Communication and Change in structure	
Identify and prepare champions	Identify an RN champion on both day and night shift that trained nurses can turn to for assistance. These champions will be identified based on experience and popularity on the unit. They will be helpful to increase sustainability of the project after the QIPL ends full time work on it.
Communicate background evidence	Poster in break room to show evidence for USGPIVC first stick success. First stick success decreases RN time and decreases patient discomfort.
Data	
Monitor the change	Data on A-DIVA documentation and USGPIVC placement will be collected each week by QIPL. This data will assist in monitoring and determining the success of the project.
Share data	Data gathered by QIPL was displayed on a poster in the break room that shows A-DIVA documentation and USGPIVC placement week to week.
Education	
Train nurses on ultrasound	20 nurses will be trained to place USGPIVCs. See lesson plan on Appendix B
Huddle on A-DIVA	All nurses will be educated about A-DIVA during huddles.
Follow up with nurses trained	QIPL will follow up one time with each nurse that was trained to place USGPIVCs to see if additional training is needed or if they have any follow

	up questions based on the experience they gained placing USGPIVCs on their own.

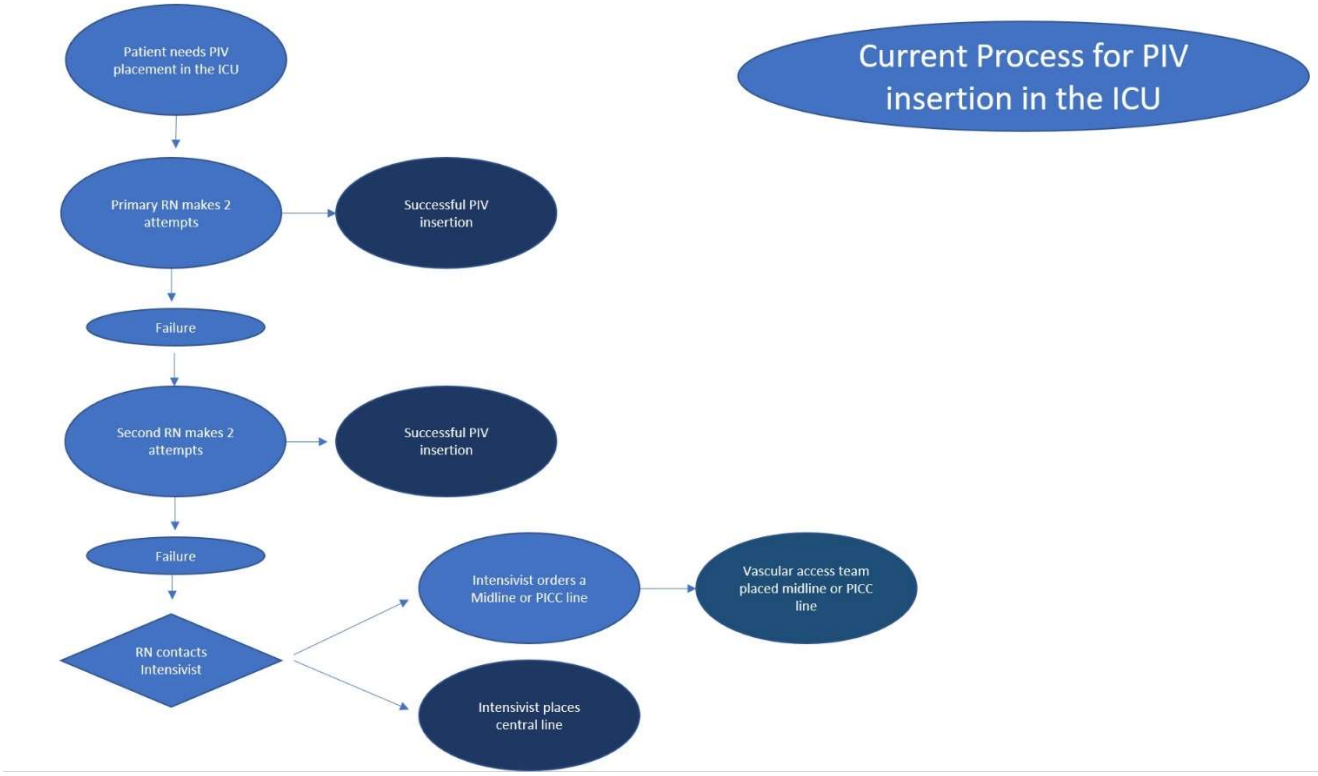
Table 4

Measurement Plan

Structure Goals	Process Goals
1.20 nurses are trained to utilize ultrasound. 2. All 20 nurses will obtain 3 independent USGPIVCs	1. 100% of patients with PIVC documentation done in the ICU should have A-DIVA documented as well. 2. 3 USGPIVCs are placed per week during the intervention.

Figure 1

Current PIVC Placement Process



Note

Each patient must have venipuncture attempted four times regardless of how difficult access appears to the RN before they can have access placed with advanced techniques.

Figure 2

Fishbone diagram of PIV access

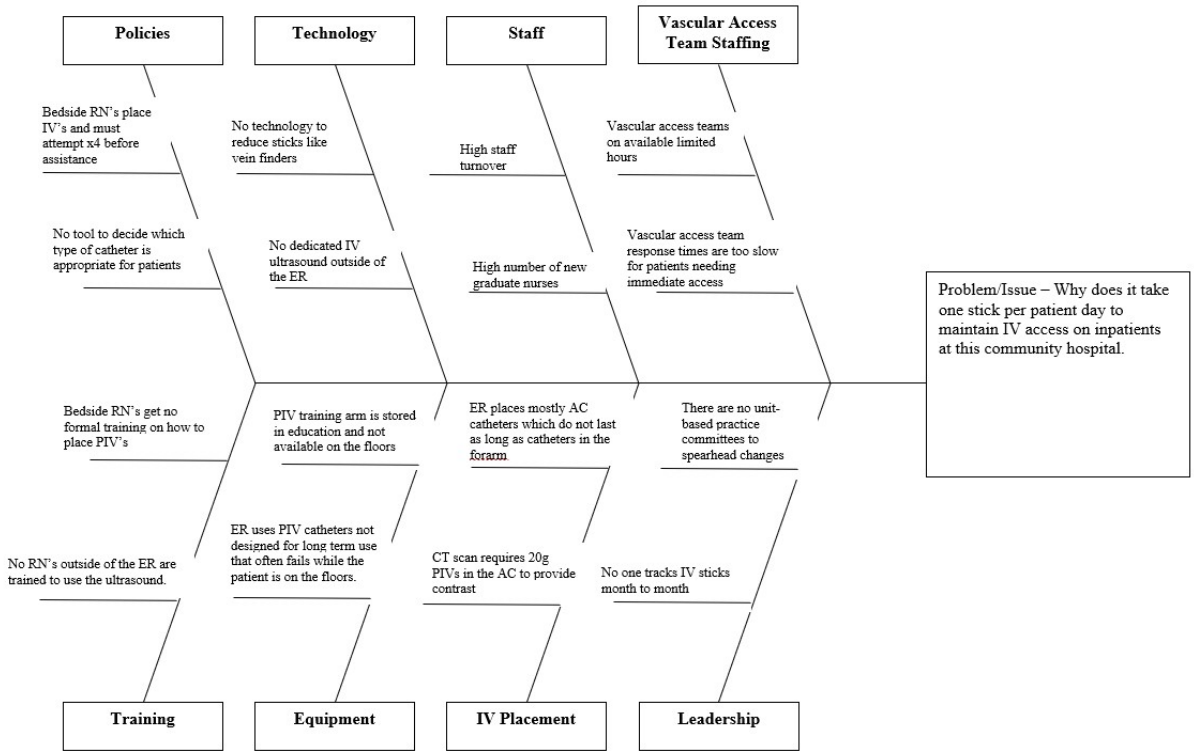


Figure 3

Knowledge to Action Framework

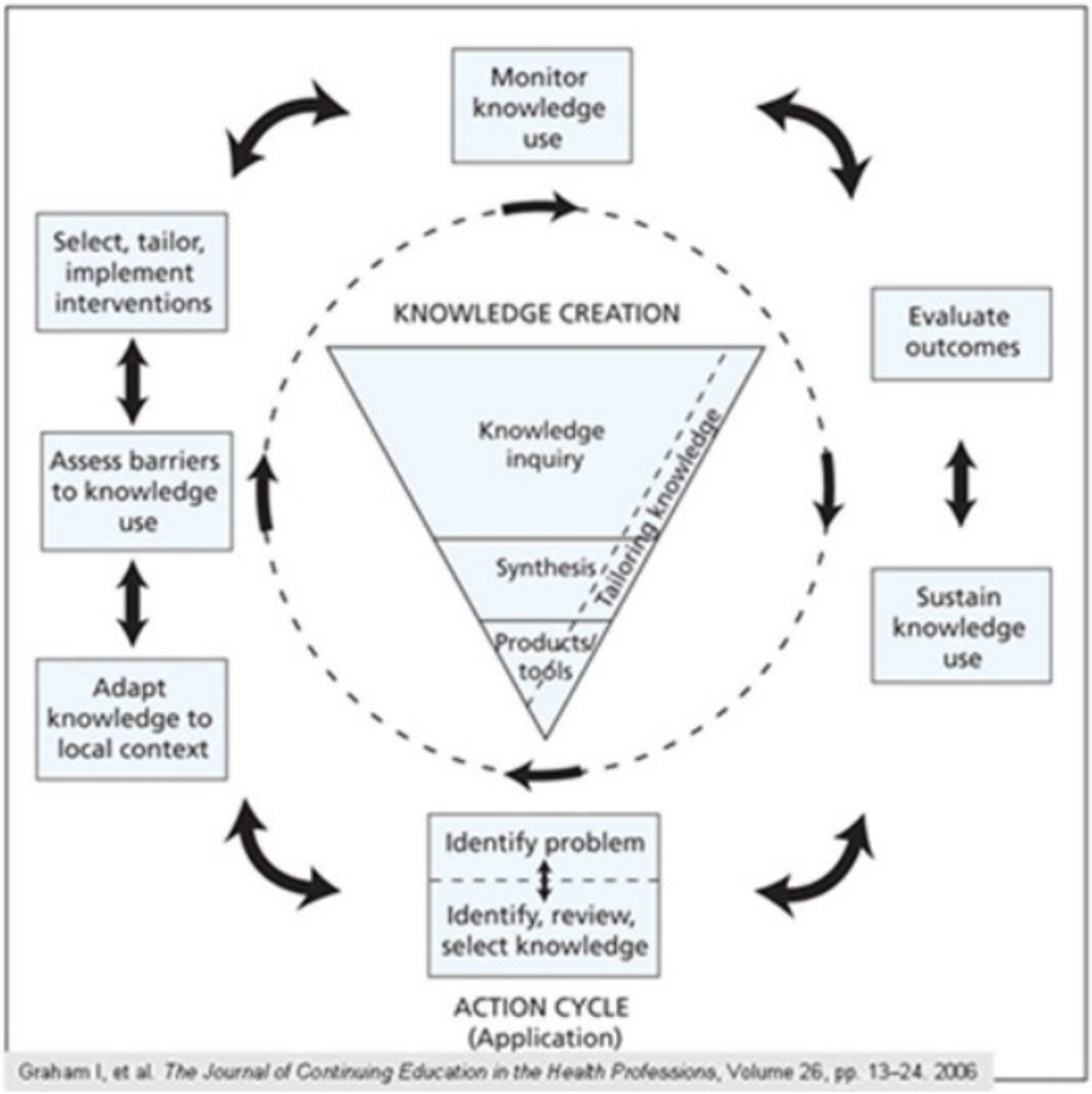
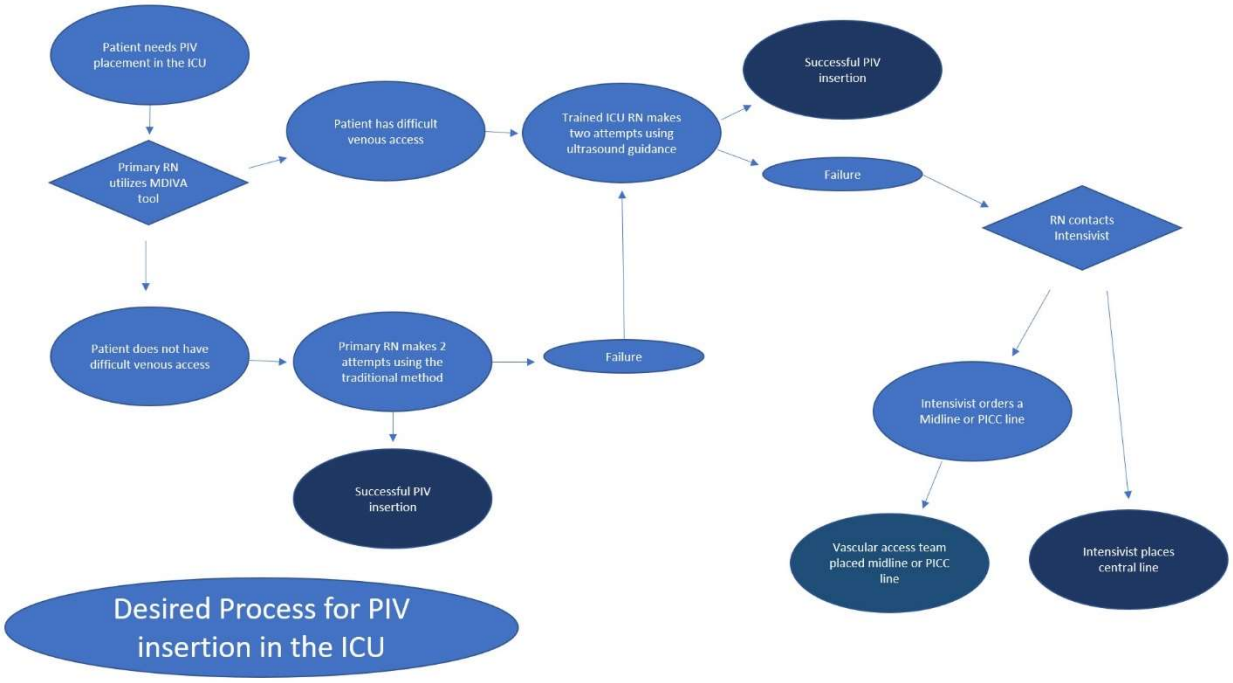


Figure 4

Proposed PIVC Placement Process



Note

In the new process patients with difficult access can benefit from the ultrasound guided technique before traditional PIV access fails

Figure 5

USGPIVCs Placed

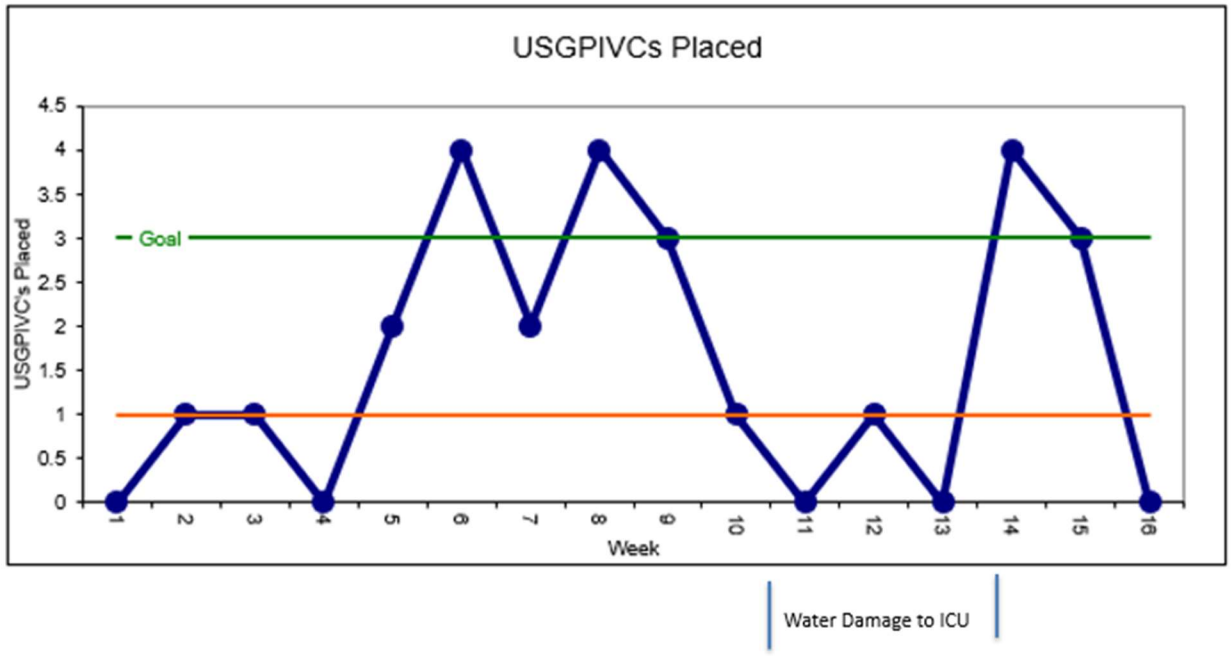


Figure 6

Percent of PIVCs Place by Ultrasound

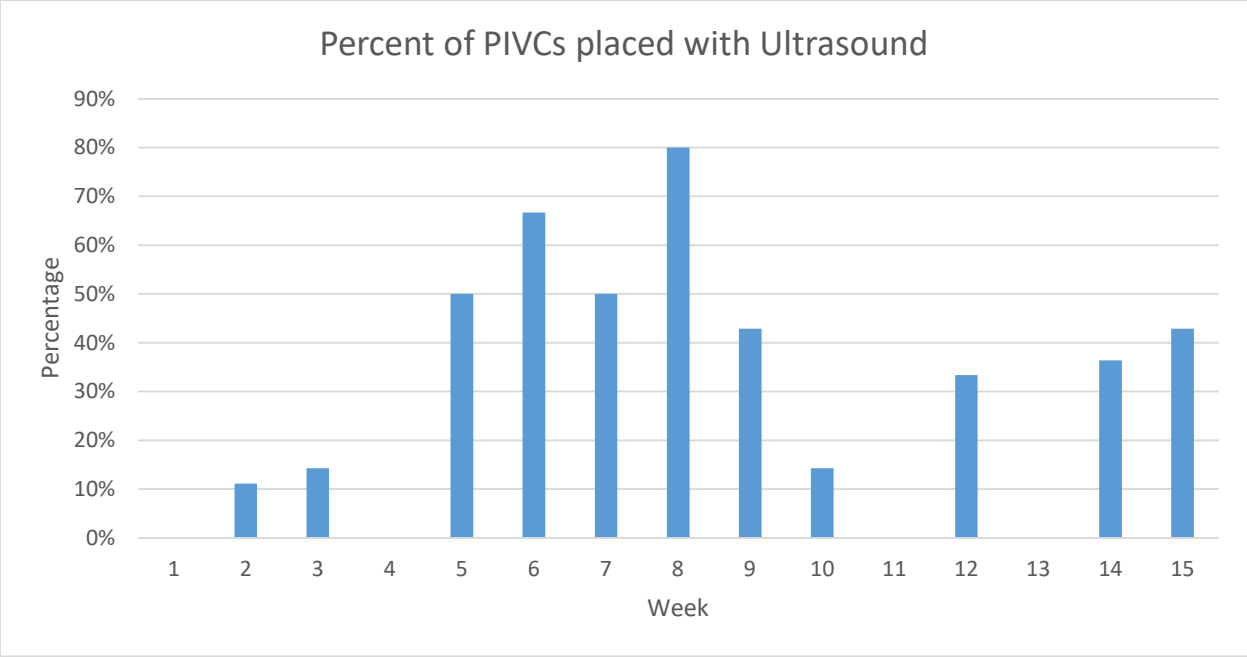
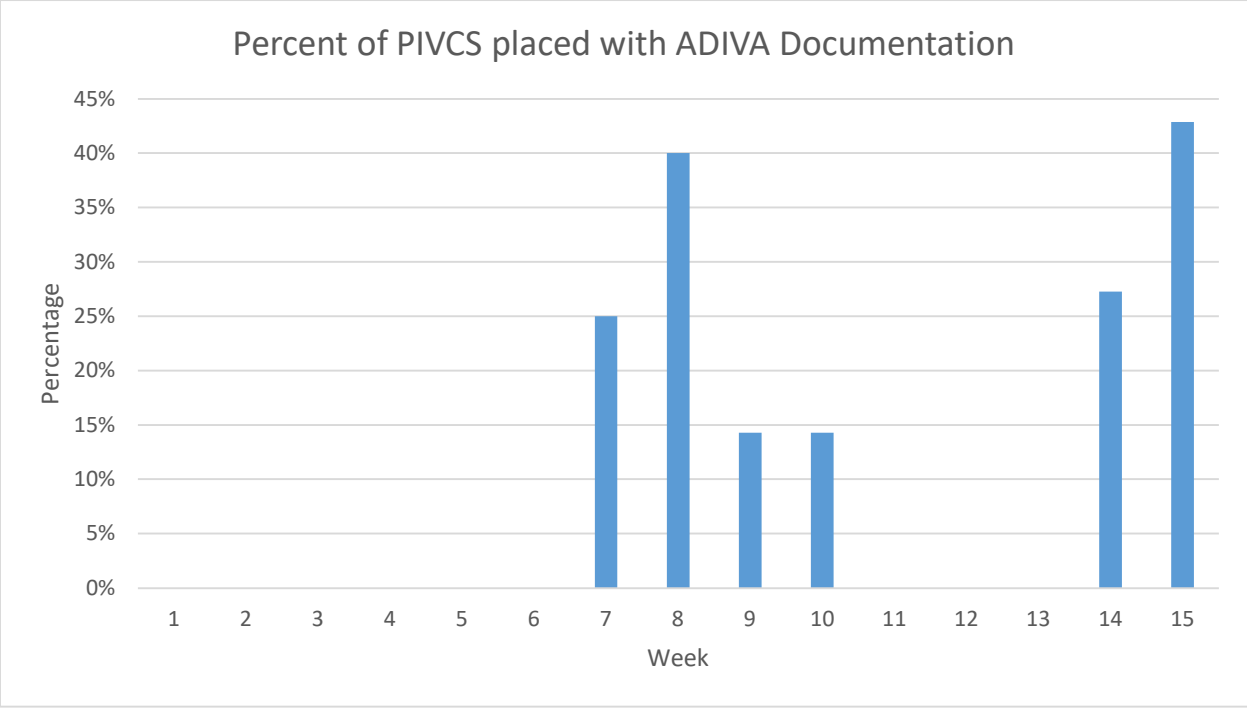


Figure 7

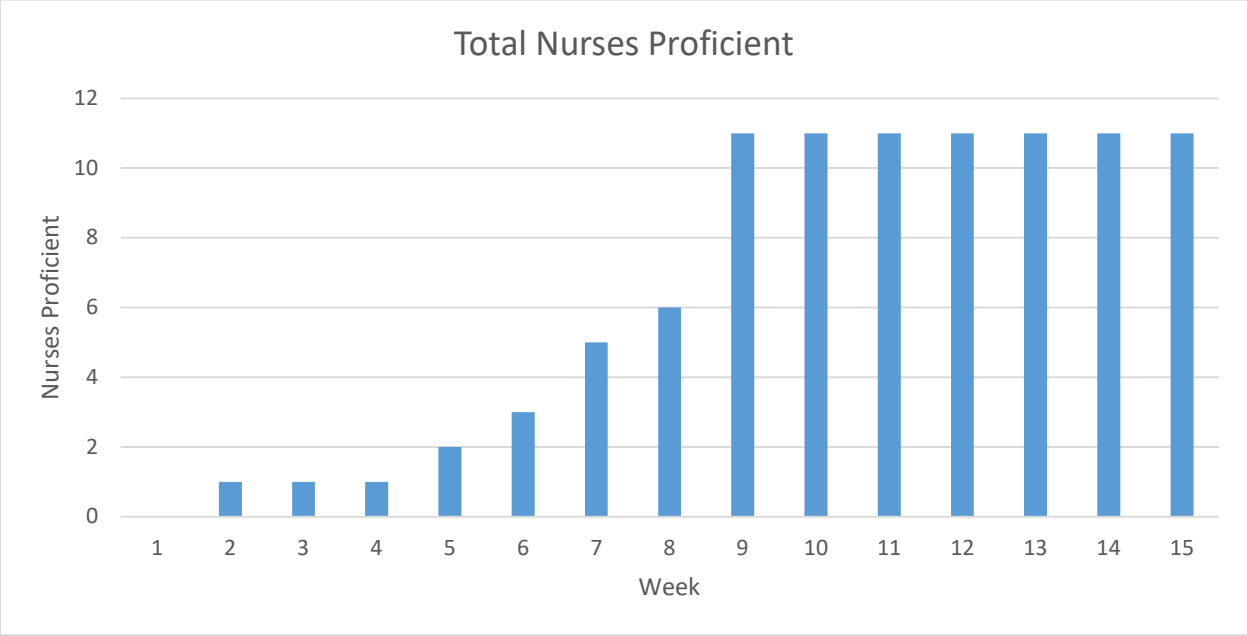
A-DIVA Documented



Note: Education did not begin until week 7. No PIVCs were placed week 11.

Figure 8

Nurses Proficient in Placing USGPIVCs



Appendix A

A-DIVA Scoring Tool

Adult Difficult Venous Access Tool (ADIVA)

Factor	Score
Is there a known history of a difficult intravenous access?	1
Do you expect a failed first attempt or a difficult intravenous access?	1
Is there an inability to identify a dilated vein by palpating the upper extremity?	1
Is there an inability to identify a dilated vein by visualizing the upper extremity?	1
Has the largest dilated vein a diameter less than 3 millimeters?	1

Add up score. Patients with scores 2 or more should get first attempt with ultrasound.

Modified from van Loon et all (2019)

Appendix B

Rick van Loon
to me

Dear Alexander,

Thank you for your interest in the A-DIVA scale. With this email, I give you the permission to use the scale in your clinical practice and for research purposes.

Best regards,
Rick van Loon

Dr. F.H.J. (Rick) van Loon
Klinisch onderzoeker | Anesthesiemedewerker

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Aanwezig op woensdag en vrijdag

Note: Permission to use A-DIVA scale