When PICC Lines are Not Clinically Indicated: Considerations for Successful Peripheral Venous Access
When PICC Lines are Not Clinically Indicated: Considerations for Successful Peripheral Venous Access

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Introduction

Much of the time, the decision of which vascular access device (VAD) to place in a particular patient is an easy one. The woman in labor and delivery without any co-morbidities or significant medical history will likely receive a short peripheral catheter (SPC, figure 1) for delivery of fluids. The elderly cancer patient undergoing chemotherapy and parenteral nutrition needs a central venous access device (CVAD, figure 2) because of the caustic nature of the drugs being delivered. Yet there is a spectrum of patients who fall somewhere between the need for a SPC and CVAD making the choice of device unclear. Medications, patient co-morbidities, and patient history, including tolerance for VADs, all become part of the risk assessment for infusion therapy devices. In addition to patient specific considerations, healthcare facilities, which are subject to ever decreasing revenue streams, must weigh the cost of the device against the prescribed treatment regimen, adding another layer of complexity to an already difficult decision.

Knowing that CVADs such as peripherally inserted central catheters (PICCs) are only needed for certain populations and have a much higher price point compared to SPCs, it is important for healthcare providers and facilities to empower themselves to increase their success rates for SPC placement. One study found that 24% of PICCs placed were due to failed venous access with SPCs. If a PICC line is being placed solely because peripheral intravenous access has failed, this more invasive procedure can be avoided using the right tools.

During the last decade, the number of devices put onto the market to assist healthcare workers in placement of SPCs has and continues to grow. Ultrasound, transilluminators, and near-infrared (NIR) devices represent the most widely available devices that clinicians use to assist in vascular access. This paper will review the NIR-based vascular access assistive devices in context with the devices being used and the age population being served.
**Types of Vascular Access Devices**

When considering vascular access procedures for their patients, health care providers have at their disposal a wide array of catheter options. The most commonly placed vascular catheter is the short peripheral catheter (SPC, A.K.A. peripheral IV [PIV], peripheral venous catheter [PVC], peripheral intravenous catheter [PIC or PIVC], etc.). Investigators estimate that between 70% and 90% \(^2\) of hospitalized patients require SPCs during their stay which equates to approximately 15 – 20% of all patient days in acute care hospitals. \(^3\)

SPCs are placed, much as their name implies, into the peripheral anatomy. Most of the time for adults this means the top of the hand, the side of the wrist, or the forearm. For neonates and infants, in addition to the hand and forearm, the saphenous vein in the leg or the temporal or frontal veins in the head are often accessed. \(^4\) The location of SPC placement limits the types of fluids or medications that can be delivered through them, because the devices are placed into vascular areas that can be easily damaged by harsh fluids or medications. For instance, parenteral nutrition, infusates with a pH less than 5 or greater than 9, and infusates with high osmolality (>600 mOsm/L) can damage the lining of peripheral blood vessels. \(^5\) This may cause chemical phlebitis, an inflammation of the lining of vessels caused by delivery of harsh fluids \(^4\) and can lead to extravasations or infiltrations into the surrounding tissue. Extravasations/infiltrations can be devastating for the patient or their family and result in litigation expenses for the hospital facility. One of the ways to avoid this complication is the use of longer catheters that terminate in the large vessels of the chest: central catheters.

Central Vascular Access Devices (CVAD, A.K.A. central venous catheters [CVC]) come in a number of different forms, but their main function is to provide a place for harsh infusates to be diluted prior to entering the rest of the circulatory system. This means that these devices terminate in a large, central vessel such as the superior vena cava (figure 3.) or right atrium. \(^4\)

![Figure 3: Termination Points for CVADs](https://shutterstock.com)

There are three main categories of central venous access devices: non-tunneled catheters, tunneled central catheters, and implanted ports. The peripherally inserted central catheter (PICC, figure 4) is a variation on the non-tunneled central catheter. It is similar because the terminal end of a line rests in the superior vena cava, much like the other CVADs, but it differs from a typical CVAD in that the vein of interest is accessed much further down the arm (i.e., more ‘peripherally’) towards the antecubital area. PICCs are placed under a sterile field just like other CVAD devices. The health care provider feeds the catheter into either the basilic or cephalic veins at a point above the antecubital area. Ultrasound is used to verify location of the vein and also to verify that the

![Figure 4: Single, Double and Triple Lumen PICC Lines](https://shutterstock.com)
catheter has been fed correctly into the vessel. Confirmation of tip location for this and all CVADs is done using fluoroscopy, echocardiogram, or radiograph imaging (figure 5).\[6\]

Figure 5 Radiograph of a central line terminating in the superior vena cava [29]

In addition to the infusates being delivered and dwell time, specific patient-related information needs to be taken into account when selecting an appropriate vascular access device. Co-morbidities, either present or historical, have a profound impact on device selection.

One of the co-morbidities that has a significant effect on catheter selection and placement is renal insufficiency and/or chronic kidney disease (CKD). These patients may present with other significant co-morbidities that necessitate vascular access; yet, due to the fragility of their veins, it is important to preserve vasculature for near and long term access.\[7\] CKD patients commonly have arteriovenous fistulas (AVF) placed for hemodialysis purposes which have been shown to decrease mortality and morbidity in these patients. However, AVFs have high failure rates that are associated with certain types of vascular access procedures (figure 6).\[8\]

Obese patients’ anatomy and physiology changes as their weight increases making them more susceptible to vascular access failure. This patient population may require specialized access equipment to accommodate their needs.\[9\] Part of the physiological changes that occur in this patient population that is widely known is their predisposition to metabolic syndrome or diabetes. Diabetes, while being its own co-morbidity that has implications for vascular access, also carries with it a higher risk of renal insufficiency and renal disease compared with persons without diabetes.\[7\]

Patients with cancer have likely had extended sessions of vascular access and are receiving several different types of medications. The vascular infusate with the most extreme chemical characteristics in terms of pH or osmolality coupled with duration of infusion (i.e. dwell time) will dictate vascular access device needs.\[10\]

Aside from patients with significant co-morbidities, there are those that fall into a difficult venous access patient category for other reasons. Different patient characteristics like age, presence of visibly-identifiable vessels, edema, prematurity or history of prematurity\[11\], skin color, body mass index\[12\] all contribute to increased difficult venous access status. Patients who are known to be or who have had difficult venous access are a large concern because of the stress they and their healthcare provider have prior to the procedure\[12\] and the pain they experience on a routine basis. Pain from vascular access can lead to healthcare
avoidance and can affect their physiological responses.\textsuperscript{[13]}

**Cost Considerations**

The economic atmosphere in healthcare facilities is in constant flux, now so more than ever. Reimbursement from the Center for Medicaid and Medicare Services and other payers is decreasing at inpatient facilities for standardized services. Additionally, reimbursements for hospital acquired conditions have been completely eliminated as quality of care efforts have been moved to the forefront of healthcare facility assessments.

Forty years ago, the majority of reimbursement centered on a *per diem rate* paid by insurers. This was daily fee or rate that was billed by the hospitals and paid by the insurers, at that time in the U.S., Blue Cross and Blue Shield, Medicare, and Medicaid. Under this system there was no incentive for hospitals to focus on value-based care as they were paid for what they billed. As costs started to rise, the insurance companies began to implement efforts to control these costs by introducing the diagnosis-related group (DRG) system.\textsuperscript{[14]}

Under the current DRG system, hospital facilities are reimbursed a flat rate for a patient’s care instead of a daily rate for the care. This has shifted the responsibility for cost reduction to the healthcare facility as no matter what sort of treatments the patient had at the facility, the same amount of money was reimbursed.

The implications of this flat-rate payment system are that hospital facilities must focus their attention on delivering courses of treatments that maintain or improve quality of care, all while driving down the cost for those treatments. In terms of the vascular access devices that are used to deliver healthcare, the costs can multiply very quickly.

National averages for the cost to place a PICC line by a registered nurse are approximately $700\textsuperscript{[15]} between labor and material; the cost for an SPC is about 30 times less at $23\textsuperscript{[16]}. This number increases dramatically if the facility is using physician’s assistants or interventional radiologists to place PICC lines. Considering the large cost difference between SPCs and PICCs, it makes sense for facilities to institute practices that would make placement of SPCs more successful when a physician or nurse decides that this the appropriate course of treatment.

**VeinViewer Impact on PICC Placement Rates**

About 10 years ago, the first NIR-based vascular access assistive devices came onto the market. VeinViewer (Christie Medical Holdings, Inc., Memphis, TN), developed by scientists at the University of Tennessee Health Science Center, was the first NIR-based direct projection vein finding system on the market and is, to date, the market leader (figure 7).

The basic science behind VeinViewer is quite simple. Invisible, NIR light is directed from the device onto the surface of the skin at a wavelength of 850nm. The light penetrates the skin up to a depth of 15mm and hemoglobin will absorb this light. Other tissues such as skin cells,
adipose tissue, and connective tissue will reflect the light. Any light that has been reflected is detected by VeinViewer and is almost instantaneously turned into an image that is projected back onto the skin providing users with visual confirmation of vessel location (figure 8).

Peer-reviewed research has shown that VeinViewer technology helps clinicians improve first-attempt stick rates by over 60% in pediatric populations,\textsuperscript{[17]}\textsuperscript{,} \textsuperscript{[18]} improve first-attempt stick rates in difficult venous access patients,\textsuperscript{[19]} improve overall procedure time,\textsuperscript{[18]} and improve patient perception of care.\textsuperscript{[20]} In fact, VeinViewer has the most peer-reviewed literature of any NIR-based vascular access device on the market and new research continues in expanding scopes of practice.

\textit{Mercy Hospital, Oklahoma City Study}

In 2012, at the Association for Vascular Access annual conference in San Antonio, Texas members of the neonatal intensive care unit (NICU) at Mercy Hospital in Oklahoma City presented data on how VeinViewer helped them reduce the number of PICC lines being placed in their patient population.\textsuperscript{[21]} Prior to beginning their study, nursing staff noticed an uptick in IV stick attempts when placing a peripheral IV. After a certain number of failed attempts, these neonates would receive a PICC line for routine venous access. As a result, PICC usage increased in their unit along with supply costs.

During an in-service by Christie in their emergency department, the NICU staff saw VeinViewer being demonstrated and wondered if the device could help them to reduce the number of medically unnecessary PICC lines being used. Christie agreed to partner with the staff and support their efforts to improve patient care.

Baseline data was collected without VeinViewer to understand where the NICU was in terms of IV attempts per patient and the number of PICCs that were being placed when it was not a clinical necessity. After collecting data on 192 patients, the unit found that the average patient was receiving 5.27 stick attempts prior to success with six of those patients receiving double-digit (\(\geq10\)) sticks. The highest number of sticks prior to success was 17. The resulting rate of PICCs placed when they were not initially clinically indicated was 1:13. VeinViewer was then added to their current standard procedures and data was collected for 100 patients. Using the device, the average number of attempts prior to success dropped to 3.1. Additionally, the number of double-digit stick attempts decreased to just one patient who received 11 stick attempts before success. Most importantly, the rate of medically unnecessary PICC lines dropped to 1:25, an improvement of more than 30\% (table 1). Though these are interim results, the team anticipates that the final results will trend similarly by publication time.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Metric} & \textbf{Standard} & \textbf{Using VeinViewer} & \textbf{Improvement} \\
\hline
\textbf{# Attempts per patient} & 5.27 & 3.1 & $>40\%$ \\
\hline
\textbf{Double-digit attempts} & 6 & 1 & $>80\%$ \\
\hline
\textbf{Medically Unnecessary PICCs} & 1:13 & 1:25 & $>30\%$ \\
\hline
\end{tabular}
\caption{Interim Results of the Mercy Hospital PICC Reduction Study \textsuperscript{[21]}}
\end{table}
**St. Elizabeth Healthcare Study**

During the same time that the Mercy Hospital study was being conducted, another study on reducing medically unnecessary PICCs using VeinViewer technology was being conducted unbeknownst to Christie staff. Instead of addressing the needs of NICU patients, this study sought to improve the care of patients whose vasculature needed preservation due to kidney-related co-morbidities.

Patti Wilcox and her team of nurses sought to understand if VeinViewer could help in their vein preservation program. As has been discussed previously, nephrology patients’ vasculature is fragile compared to the normal population. Because of this, the amount of vascular access and the types of catheters used for vascular access has to be greatly considered. Many patients with chronic kidney disease receive dialysis treatments through an arteriovenous fistula (AVF). Peer-reviewed research has shown that patients who receive PICC lines prior to AVF surgery, prior to end stage renal disease, or, and most importantly, at any time in their life are at a higher risk for AVF failure (figure 6). Therefore, vein preservation in this population is extremely important.

For their study, the St. Elizabeth team began by collecting data on the number of PICC lines being placed per month prior to instituting VeinViewer technology during 2012. At their facility, physician’s assistants and, occasionally, physicians themselves, place PICC lines. After tracking the 2012 monthly rates, the team instituted the use of VeinViewer by their nursing staff during 2013. Purchased specifically to be used when placing short peripheral catheters, the nurses were instructed to use the device as much as possible and especially when second or third attempts were being made. No other changes to their catheter placement procedures were made. During the first 9 months of data collection in 2013 the investigator found that the number of PICCs placed from patients coming through their department had decreased by 261 versus the same timeframe in 2012 (figure 9). This data was
presented at the 2014 annual convention of the Infusion Nurses Society in Phoenix, Arizona. Combined with nationwide averages for cost of materials and cost of personnel time estimated at $700 per line \[^{[15]}\], the facility saved approximately $180,000 during this 9 month time period. More complete data which continues the trend of unnecessary PICC reduction is scheduled to be presented at the annual convention of the Association for Vascular Access in September 2014.

**INS Recommends Vein Visualization Technology**

In 2011, the Infusion Nurses Society (INS) published a revision to their Infusion Nursing Standards of Practice. \[^{[22]}\] At this time, INS only recommended consideration of vein visualization technology because there was scant published literature about these products and their efficacy in the field of vascular access. Since then, mounting literature by investigators on VeinViewer products has provided key opinion leaders and experts at INS with the evidence needed to draft the first-ever statement that, for short peripheral catheters, health care providers should “incorporate vein visualization technology as a routine strategy for patients with difficult or poor venous access” as a standard practice for improving patient safety. \[^{[23]}\]

The position statement authors continue that “visualization technology can improve success rates, decrease unsuccessful insertion attempt, and improve patient satisfaction.” This position statement echoes what researchers and clinicians are experiencing every day with this technology: VeinViewer is not a nice-to-have medical device for large hospital systems. VeinViewer technology is a must-have device that will improve placement of short peripheral catheters for small, community hospitals as well as large, multi-hospital health care systems.

**Conclusion**

The procedures that patients undergo are, most often, clinically indicated by the patient’s disease process or co-morbidities. Therefore, the risk of the procedures balances with the benefit. However, there are occasions when more invasive procedures are the result of failed less invasive procedures. Occurrences such as these begin to tip this balance towards treatments that are not commensurate with the patient’s medical history or experience and may expose them to unnecessary complications.

Placement of PICC lines that are not clinically indicated for a patient exposes the patient to increased risk of adverse events such as thrombosis, pneumothorax, CLABSIs. Patients undergoing dialysis currently or those who might be on track to have dialysis treatments later in life can experience significant complications when PICC lines are placed indiscriminately. Vein preservation programs around the country are looking for ways to combat these complications and improve their patient outcomes.

Additionally, hospital administrators, under the burden of reduced reimbursement for bundled procedures, are investigating ways of reducing costs all while improving patient satisfaction scores and increasing healthcare efficiencies. Few products on the market claim to benefit patient outcomes, satisfaction scores, and a hospital’s bottom-line and have the evidence to back up those claims.

Both sponsored and independent research has shown that VeinViewer can decrease the number of PICC lines that are not clinically indicated in pediatric and adult populations. At an average cost of $700 per PICC line \[^{[15]}\], facilities can save $7,000 if just 10 short peripheral catheters are successfully placed and PICC lines that are not clinically indicated for that patient are avoided.
This cost savings, coupled with the INS position statement on short peripheral catheters, and the supporting peer-reviewed literature provides a strong foundation of evidence that VeinViewer is no longer just a luxury device for hospitals that have extra budget for capital expenses. It proves that VeinViewer is a must-have device for facilities that want to improve patient care all while reducing healthcare costs.

About the author: Jessica Knowlton is the Associate Clinical Research Specialist for Christie Medical Holdings, Inc., manufacturer of the VeinViewer line of vascular imaging devices and accessories. Her pre-Christie background is in molecular biology focusing on fields of orthopaedics, DNA repair, and vaccine preclinical development. She holds an advanced degree in Clinical Research Administration and has conducted research trials in the fields of vascular access and ophthalmology.
Bibliography and Noted Images


[22] Infusion Nurses Society, "Infusion Nursing Standards of Practice," *Journal of Infusion Nursing*, vol. 34, no. 1S, 1011.


