Innovation in Vascular Access:

Near-Infrared Technology Revolutionizes Visualization of Blood Vessels.

Introduction

Patients who have difficult venous access (DVA) are a major challenge for modern medical care. DVA is a clinical condition that is yet to be properly defined and no severity grading system has been developed to allow for comparative research. DVA is not even typically identified in the medical record, as we do for allergies or difficult airways, to help prepare the next healthcare provider to optimize care. Still, when we are involved in the care of a patient with DVA, we are made painfully aware of their condition as we struggle to gain access.

Surprisingly, very little has been written about this issue despite the fact that clinicians spend a great deal of time and energy trying to obtain intravenous (IV) access in these patients. One can not find reliable information on the extent of the problem. We do know that nearly 90% of inpatients require peripheral intravenous catheters and 25% of these inpatients require central venous access.[1] Also, nearly 1 billion venipunctures are performed annually to obtain blood specimens for testing.[2] With a shift to more outpatient therapy, inpatients tend to be increasingly complex, often with chronic medical conditions requiring repeated venous access for monitoring and treatment over their lifetime.

Many factors contribute to DVA. A patient's level of hydration and perfusion certainly affect the ability to access their veins. A prior traumatic venipuncture or indwelling catheter could cause vessels to thrombose, leading to a reduction or even absence of the visible or palpable veins for the future. The condition is dynamic, in that some vessels can re-cannulate with time though they may not be the original size. If the patient is obese, normal cues are usually absent making venous access extremely difficult. These patients often have recurrent health problems which also bring them back to the hospital for repeated access. Pediatric patients bring their own challenges with smaller vessels and an inability to cooperate. Lastly, the clinician's skill level clearly impacts the likelihood of success.

Patient Perspective

Though it may not be identified in the medical record as such, one of the first things a patient might tell a clinician when they first meet is that they are a "hard stick". Often they will direct you to the left arm because it is the "better" one or they will tell you that "last time it took 6 sticks before they finally placed an IV". Being a DVA patient means enduring the pain of multiple needle sticks. Hospital satisfaction surveys commonly reveal that multiple needle sticks are a major factor contributing to patient dissatisfaction.

Clinician Perspective
The goal of every good clinician is to provide the best care possible. DVA frustrates this goal by delaying needed therapies and inflicting additional suffering on a patient already in need. Multiple attempts mean multiple needles will be used. This increases the risk to the health care provider of a needle stick injury. Failure to gain peripheral access may necessitate placement of a central venous catheter (CVC). Potential CVC complications of a pneumothorax, catheter related blood stream infection (CRBSI) and death are well documented.[3]

As already mentioned, the venous access skills of healthcare workers are a major factor with respect to initiating intravenous therapy. Initiating intravenous therapy is just one of a myriad of daily activities performed by nurses. Most hospitals do not have an IV team that starts ALL of the PIVs (peripheral intravenous lines) in the facility. In the majority of instances, staff nurses are required to initiate intravenous therapy on their assigned patients. As a result, there exists a shortage of practitioners that have the skills and the experience developed by repetition to properly manage the access needs of the patient population.

Making matters worse in the current healthcare demographic is the ongoing nursing shortage. Federal estimates suggest that the number of nurses who are on the front lines of healthcare will increase by a mere 6% by 2020. Simultaneously, the demand for nurses during that same time period is estimated to grow by 40%.[4]

Seeking Best Practice
One of the most challenging aspects of obtaining venous access is to be successful on the first attempt. There have been numerous studies performed over the years attempting to improve the efficiency of gaining venous access. Most of these studies provide the average number of sticks required to gain access. In a 2005 study designed to address deficits in the process of obtaining IV access, the average number of attempts to gain access was 2.4.[5] The number of penetrations in this study ranged from 1 to at least 14. In another study performed at a Medical Center in the U.S., the average attempts needed to gain intravenous access was 2.9.[6] When dealing with pediatric patients, the numbers are much more disturbing. In a pediatric study performed in 2005, the average number of attempts to obtain access was documented at 6.[7] The discomfort alone suffered by these patients is enough to demonstrate a need for either improved skill or more efficient methods. Reducing the number of attempts would ultimately result in a reduction in pain.

The Infusion Nurses Society (INS) has set the standard for obtaining intravenous access in the United States. The 2006 INS Standards of Practice includes many procedures that are proven in a clinical setting. Standard #42 recommends that a nurse attempt a maximum of two (2) peripheral attempts per patient.[8] If those attempts conclude in failure to access the vein, the nurse should stop and call on a second nurse to make an attempt. The averages point to the fact that 2 attempts is not normally enough to gain access, therefore more than 1 practitioner is usually necessary to gain intravenous access. The failure to obtain venous access on the first attempt can also result in delayed treatment in approximately 25% of patients.[9] The results of this scenario could be realized in further complications and longer hospital stays.

Although patient comfort and satisfaction are major components of any successful healthcare system, effectively managing healthcare costs are also of vital importance in maintaining the means to provide care. The costs that are associated with missed attempts are a major concern to healthcare facilities. Currently, the average cost of a single peripheral intravenous insertion attempt is approximately $32 (includes materials and labor).[10] If one were to multiply this figure by the number of missed attempts in any given healthcare setting, the figures would be staggering. According to one source, if one figured in the average cost of a peripheral intravenous attempt for a 200-bed hospital results in a total of over $350,000 in annual revenue lost.[11] Larger hospitals would of course experience an exponential increase in that figure. Needless to say, missed peripheral intravenous attempts, from a cost standpoint, are a significant concern.

Another cost that arises from poor venous access is associated with the need for central line placement and maintenance. In many instances, particularly in critical care areas, central venous catheters are placed in patients because of the inability to access a peripheral vein. The cost of a central line can range anywhere from $110 - $1,500[3,11] but is negligible when compared to the *potential* complication costs associated with the placement of a central line. One of the most costly events in the hospital setting is a Catheter-Related Bloodstream Infection (CRBSI). It has been reported that approximately half of all ICU patients have some type of Central Venous Catheter (CVC) in place. CVCs have been proven to be associated with up to 90% of all CRBSIs.[12] Some sources suggest that there are approximately 250,000 cases of CRBSIs in the United States each year.[13] The cost to treat each case of a CRBSI can range from $25,000 - $50,000.[14] The mortality associated with CRBSIs is even more significant; national data infers that over 14,000 patients die each year as a result of acquiring a CRBSI.[14]

Solutions

Given the problems faced in gaining peripheral IV access, one hopes that new technologies could make the process more successful. Several technologies have been introduced but only two have seriously dealt with improving vessel visualization. They are ultrasound and a reflective near infra-red technology. Both have the ability to visualize vessels not readily seen in real time using very different approaches.

Ultrasound uses a hand held transducer to bounce sound waves into the tissue and takes advantage of differing reflective signatures of tissues to distinguish vessels from other. With Ultrasound, one makes a fan shaped image of the tissue below and determines if vessels are present or not as the cross-sectional image is interpreted. This technology has had a big impact in improving central venous access by visualizing the needle as it enters the major vessels in the neck or elsewhere. Unfortunately for peripheral access, current Ultrasound technology has five major disadvantages. First, with more superficial vessels, it is difficult to see when the needle tip is actually entering the vessel because of a shadowing effect while trying to get the point of insertion and visualization in the same plane. Second, the view one sees is very two dimensional, so unless one follows out the course of the vessel and can remember the pattern, one cannot be confident of the course of the vessel down stream, making successful cannulation more difficult. Third, most machines require the operator to hold the transducer in one hand while inserting with the other, which can be rather awkward. Fourth, if one is attempting the insertion under sterile conditions, a sterile sleeve would also be needed. This is an added expense and would certainly drive up the cost of insertion. Lastly, the residual gel necessary for ultrasound image quality may interfere with the strength of the catheter securement, requiring extra time to clean the site. Otherwise, there may be a risk of premature loss of the catheter due to the oily surface.

The VeinViewer, a reflective, near-infrared technology, is a more recent medical innovation that has solved the problems associated with using ultrasound for peripheral access. The VeinViewer is a device that is produced by a Memphis biotech company called Luminetx Corporation. The VeinViewer technology was introduced in 2006 and has proven to aid in the location of veins used for intravenous access; thus improving vascular access overall. The VeinViewer uses Near-Infrared Light coupled with advanced technologies to display an image of superficial vasculature directly onto a patient’s skin. This patented technology is the first and only device that projects the image of one’s vasculature in exactly the same anatomical location as the vasculature itself. This image takes the “guesswork” out of finding veins and gives the clinician a “roadmap” from which to work in a way that is more efficient in gaining intravenous access. The projected image is placed on its three dimensional context (skin of patient) making it very easy to see where the vessels are going (see figure 1). With no transducer to hold, it frees up both of the clinician’s hands to deal with venous access. The resulting improved peripheral vascular access provides numerous benefits to both patients and healthcare workers.

Figure 1

VeinViewer Technology

The VeinViewer by Luminetx harnesses the abilities of near-infrared light and other various patented technologies to illuminate subcutaneous vasculature. The science behind the device itself consists of 4 specific functions. The infrared light source emits a harmless, near-infrared light (NIR) that is reflected back from tissues that surround the hemoglobin in the blood. The blood itself does not reflect the light source, therefore only the surrounding tissue creates an image. This image is then captured by a digital video camera located in the head of the VeinViewer unit. The image is processed by an image processing unit located in the base of the VeinViewer device. Once processed, a green LED is used to add contrast to the image and DLP technology is utilized to project that image back onto the surface of the skin in real-time. This "green" image is placed back onto the skin at exactly the same anatomical location of the subcutaneous vasculature just below the skin.

Clinical Benefits

The VeinViewer can be utilized in a number of different clinical areas. The primary purpose of the VeinViewer is to locate veins for phlebotomy and/or IV access.

A randomized study in a large outpatient clinic was performed in 2006 attempting to validate the presence of a vascular bed beneath the surface image projected by the VeinViewer. The VeinViewer was utilized to project a vascular image on 100 patients; this image was then verified with the SonoSite "i-Look" Ultrasound Unit. After the VeinViewer image was "mapped", the ultrasound was positioned in the exact same location. The SonoSite "i-Look" Ultrasound unit confirmed both the accuracy and reliability of the projected VeinViewer image in every instance. The superficial vascular bed was verified with 100% accuracy.

In another study performed in early 2005, the VeinViewer was tested for efficacy in patients with "known" difficult-to-find and difficult-to-access veins. Thirty patients, previously screened and rejected as blood donors, were chosen for clinical evaluation to determine the effectiveness of the VeinViewer to locate veins for access. Over a 20 day period, each of the patients were re-screened and imaged with the VeinViewer in order to locate a viable vein and attempt venous access of that vein for blood collection. The VeinViewer was 100% successful in locating a viable vein for access in each patient. In addition to successfully locating a vein in every instance, the blood center staff members had a 100% blood collection success rate with these same patients that had previously been rejected as donors due to difficult venous access. Incidentally, the greatest finding of this study was the fact that only one stick was required for venous access in all 30 patients. Given the current national average of anywhere from 2.4 to 6 sticks per IV access, this result is quite impressive.

Conclusion

Patients with DVA significantly impact limited clinical resources. The current approach to peripheral venous access is unsatisfying for everyone and results in too many sticks per successful access. The VeinViewer by Luminetx displays an accurate "vein map" to aid healthcare providers in locating viable veins. The VeinViewer has also proven to be successful in gaining venous access in "known" DVA patients. Furthermore, the technology has proven to be helpful in gaining venous access during the first attempt. In the current environment of healthcare facilities attempting to increase revenues while decreasing unnecessary costs, the VeinViewer is an extremely favorable option. Aside from the associated cost savings, there is not a price that can be placed on increased patient satisfaction. Patient satisfaction and decreased needle sticks go 'hand-in-hand'. If the VeinViewer can prove to drastically reduce the number of "sticks" needed to gain access, patient satisfaction, which is routinely linked to failed venous access attempts, will most certainly improve.

The VeinViewer by Luminetx is truly innovative in its design and approach to modern healthcare. Based on all the advantages the VeinViewer provides, it is becoming the standard of care for venous access.

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