



## Emergency Nursing Resource: Difficult Intravenous Access

In emergency department patients with known or suspected difficult intravenous access, does ultrasound-guided, intraosseous, subcutaneous rehydration therapy, warming, or alternative methods improve intravenous access with fewer attempts, less pain, and/or improved patient satisfaction as compared to traditional techniques?

### **Authored by the 2011 ENA Emergency Nursing Resources Development Committee:**

Melanie Crowley, MSN, RN, CEN, MICN  
Carla Brim, MN, RN, CEN, CNS  
Jean Proehl, MN, RN, CEN, CPEN, FAEN  
Susan Barnason, PhD, RN, APRN, CEN, CCRN, CNS, CS  
Sherry Leviner, MSN, RN, CEN  
Cathleen Lindauer, MSN, RN, CEN  
Mary Naccarato, MSN, RN, CEN, CCNS  
Andrew Storer, DNP, RN, ACNP, CRNP, FNP  
Jennifer Williams, MSN, RN, CEN, CCRN, CNS

### **2011 ENA Board of Directors Liaison:**

AnnMarie Papa, DNP, RN, CEN, NE-BC, FAEN

ENA's Emergency Nursing Resources (ENRs) are developed by ENA members to provide emergency nurses with evidence-based information to utilize and implement in their care of emergency patients and families. Each ENR focuses on a clinical or practice-based issue, and is the result of a review and analysis of current information believed to be reliable. As such, information and recommendations within a particular ENR reflect the current scientific and clinical knowledge at the time of publication, are only current as of their publication date, and are subject to change without notice as advances emerge.

In addition, variations in practice, which take into account the needs of the individual patient and the resources and limitations unique to the institution, may warrant approaches, treatments and/or procedures that differ from the recommendations outlined in the ENRs. Therefore, these recommendations should not be construed as dictating an exclusive course of management, treatment or care, nor does the use of such recommendations guarantee a particular outcome. ENRs are never intended to replace a practitioner's best nursing judgment based on the clinical circumstances of a particular patient or patient population. ENRs are published by ENA for educational and informational purposes only, and ENA does not approve or endorse any specific methods, practices, or sources of information. ENA assumes no liability for any injury and/or damage to persons or property arising out of or related to the use of or reliance on any ENR.

**Publication Date:** December 2011

## Table of Contents

	Page
Background/Significance .....	1
Methodology .....	1
Evidence Table and Other Resources .....	3
Summary of Literature Review .....	3
Description of Decision Options/Interventions and the Level of Recommendation .....	11
References .....	12
Acknowledgements .....	15

## Background/Significance

Establishing vascular access is one of the most common procedures carried out in the emergency department (ED) and a high priority for the care of a critically ill and unstable patient. The condition of the patient often plays a role in the likelihood of attaining vascular access. Conditions associated with difficult vascular access include obesity, chronic illness, hypovolemia, intravenous (IV) drug abuse, and vasculopathy (Blavias & Lyon, 2006; Chinnock, Thornton, & Hendey, 2007; Costantino, Parikh, Satz, & Fojtik, 2005; Miles, Salcedo, & Spear, 2011; Nafiu, Burke, Cowan, Tutuo, Maclean, & Tremper, 2010). Patients with difficult IV access are frequently subjected to repeated attempts by multiple practitioners.

Success rate and time to vascular cannulation are crucial to the optimal resuscitation of a critically-ill patient. This can be a challenging to even the most experienced emergency nurse. Failure rates of emergent IV access vary in the literature. Leidel, Kirchhoff, Bogner, Stegmaier, Mutschler, Kanz, and Braunstein (2009) identify a failure rate ranging from 10 to 40%. Katsogridakis, Seshadri, Sullivan, and Waltzman (2008) identifies success rates in multiple attempts for admitted patients at a children's hospital ranges from 23% for physicians, 44% for nurses to 98% for IV nurse clinicians. The average time requirement for peripheral IV cannulation is reported at 2.5 to 13 minutes, with difficult IV access requiring as much as 30 minutes (Leidel et al., 2009). The number of attempts at IV cannulation for the pediatric patient ranges from 1 to 10 attempts (Katsogridakis et al., 2008). Utilization of anatomic landmarks for peripheral IV access holds a 90% success rate (Costantino et al., 2005).

Central venous catheterization (CVC) is a common alternative approach to attain cannulation in patients with difficult venous access. CVC cannulation provides vascular access for fluid resuscitation, and additionally allows for hemodynamic monitoring. It is noted, however, that CVC cannulation presents additional risks to the patient. Most common among these complications are venous thrombosis, arterial puncture, catheter associated bloodstream infection, and pneumothorax (Leidel et al., 2009). Given the time required to establish a central venous catheter, the increased risk to the patient, and the skill required of the provider, other alternatives for vascular access are often desirable.

A delay in establishing vascular access can result in a delay in the administration of a fluids and/or medications. Patients frequently experience delays in diagnosis and initiation of treatment. In addition, multiple attempts at attaining vascular access result in frustration and a loss of productivity by the treating team (Rauch, Dowd, Eldridge, Mace, & Schears, 2009).

## Methodology

This ENR was created based on a thorough review and critical analysis of the literature following ENA's [Guidelines for the Development of the Emergency Nursing Resources](#). Via a comprehensive literature search, all articles relevant to the topic were identified. The following databases were searched: PubMed, Google Scholar, CINAHL, Cochrane - British Medical Journal, Agency for Healthcare Research and Quality (AHRQ; [www.ahrq.gov](http://www.ahrq.gov)), and the National Guideline Clearinghouse ([www.guidelines.gov](http://www.guidelines.gov)). Searches were conducted using the search terms "difficult intravenous access," "tools intravenous access," "heat," "nitroglycerin," "tourniquet," "ultrasound," "light," "illumination," "subcutaneous rehydration therapy," and "hypodermoclysis," using a variety of different search combinations. Searches were limited to English language articles on human subjects from January 2003 – October 2011. In addition, the reference lists in the selected articles were scanned for pertinent research articles. Research articles from ED settings, non-ED settings, position statements and guidelines from other sources were also included in the review.

Articles that met the following criteria were chosen to formulate the ENR: research studies, meta-analyses, systematic reviews, and existing guidelines relevant to the topic of difficult IV access. Other types of reference articles and textbooks were also reviewed and used to provide additional information. The ENR authors used [standardized worksheets](#), including the Reference Table, Evidence-Appraisal Table, Critique Worksheet and AGREE Work Sheet, to prepare tables of evidence ranking each article in terms of the level of evidence, quality of evidence, and relevance and applicability to practice. Clinical findings and levels of recommendations regarding patient management were then made by the Emergency Nursing Resource Development Committee according to the ENA's classification of levels of recommendation for practice, which include: Level A High, Level B. Moderate, Level C. Weak or Not recommended for practice (Table 1).

Table 1. Levels of Recommendation for Practice

<p><b><u>Level A recommendations: High</u></b></p> <ul style="list-style-type: none"> <li>• Reflects a high degree of clinical certainty</li> <li>• Based on availability of high quality level I, II and/or III evidence available using Melnyk &amp; Fineout-Overholt grading system (Melnyk &amp; Fineout-Overholt, 2005)</li> <li>• Based on consistent and good quality evidence; has relevance and applicability to emergency nursing practice</li> <li>• Is beneficial</li> </ul>
<p><b><u>Level B recommendations: Moderate</u></b></p> <ul style="list-style-type: none"> <li>• Reflects moderate clinical certainty</li> <li>• Based on availability of Level III and/or Level IV and V evidence using Melnyk &amp; Fineout-Overholt grading system (Melnyk &amp; Fineout-Overholt, 2005)</li> <li>• There are some minor or inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice</li> <li>• Is likely to be beneficial</li> </ul>
<p><b><u>Level C recommendations: Weak</u></b></p> <ul style="list-style-type: none"> <li>• Level V, VI and/or VII evidence available using Melnyk &amp; Fineout-Overholt grading system (Melnyk &amp; Fineout-Overholt, 2005) - Based on consensus, usual practice, evidence, case series for studies of treatment or screening, anecdotal evidence and/or opinion</li> <li>• There is limited or low quality patient-oriented evidence; has relevance and applicability to emergency nursing practice</li> <li>• Has limited or unknown effectiveness</li> </ul>
<p><b><u>Not recommended for practice</u></b></p> <ul style="list-style-type: none"> <li>• No objective evidence or only anecdotal evidence available; or the supportive evidence is from poorly controlled or uncontrolled studies</li> <li>• Other indications for not recommending evidence for practice may include: <ul style="list-style-type: none"> <li>○ Conflicting evidence</li> <li>○ Harmfulness has been demonstrated</li> <li>○ Cost or burden necessary for intervention exceeds anticipated benefit</li> <li>○ Does not have relevance or applicability to emergency nursing practice</li> </ul> </li> <li>• There are certain circumstances in which the recommendations stemming from a body of evidence should not be rated as highly as the individual studies on which they are based. For example: <ul style="list-style-type: none"> <li>○ Heterogeneity of results</li> <li>○ Uncertainty about effect magnitude and consequences,</li> <li>○ Strength of prior beliefs</li> <li>○ Publication bias</li> </ul> </li> </ul>

## **Evidence Table and Other Resources**

The articles reviewed to formulate the ENR are described in the [Evidence Table](#). Other articles relevant to difficult IV access were reviewed to serve as additional resources ([Other Resources Table](#)).

## **Summary of Literature Review**

### **Difficult Intravenous Access: General Information**

Difficult intravenous (IV) access is defined as multiple attempts and/or the anticipation of special interventions being required to establish and maintain peripheral venous access (Kuensting, DeBoer, Holleran, Shultz, & Steinmann, 2009). Gregg, Murthi, Sisley, Stein, and Scalea (2010) identify predictive factors for difficult IV access as edema, obesity, and history of IV drug use. While the literature regarding factors associated with difficult IV access in adults is limited, included are chemotherapy, diabetes, and multiple prior hospitalizations (Lapostolle et al., 2007). It is further noted by Lapostolle et al. (2007), that venous cannulation at the hands of a more experienced emergency care provider was associated with an increased success rate. Smaller caliber IV catheters were more commonly associated with cannulation failure (Lapostolle et al., 2007). This finding was postulated to be due to the choice of the person inserting the IV catheter, and the anticipated ease or difficulty of insertion.

The literature on difficult IV access in children is more robust; however, there were no high quality randomized controlled trials conducted in the ED setting identified in the literature search. In the pediatric medical-surgical setting, Lininger (2003) identified that 53% of peripheral IV attempts (N = 249) were successful on the first attempt, with an increase to 91% within four attempts. This led to the implementation of a standard of practice at that institution that specified no more than four attempts at IV cannulation were to be made by RN staff. The average time for venous access in the pediatric patient is 33 minutes (Rauch et al., 2009). Nafiu et al. (2010) studied the relationship between body mass index (BMI) and the ease of venous access in children ages 2 to 18 years. Obese children (BMI greater than the 95<sup>th</sup> percentile) were more likely to have a failed attempt at first cannulation than their lean controls and more likely to have two or more attempts at cannulation (Nafiu et al., 2010).

In 2008, Yen, Reigert and Gorelick studied IV access with an objective of developing a tool to predict difficult IV access in children. In a study of 615 children, a 4-variable difficult IV access score was created using 3 points for prematurity, 3 points for younger than 1 year, 1 point for 1-2 years of age, 2 points for vein not palpable, and 2 points for vein not visible (Yen et al., 2008). Subjects with a difficult IV access score of 4 or greater were more than 50% likely to have failed IV cannulation on the first attempt. This tool is currently being validated.

### **Ultrasound-Guided Intravenous Access**

Ultrasound guidance for venous access was initially studied for central access and shown to increase success rates and decrease complications (Costantino et al., 2005; Stein, George, River, Hebig, & McDermott, 2009). The use of ultrasound-guided techniques to gain venous access is widely studied in the ED setting for both adult and pediatric populations. Ultrasound guidance provides real time 2-D

image of blood vessels that appear as compressible circular structures (Walker, 2009). Characteristics related to successful ultrasound-guided cannulation have been found to be larger vein diameter, while depth did not affect success rate for veins less than 1.6 cm deep and patient characteristics such as age, gender, race, body mass index or medical history did not impact success rate (Panebianco, Fredette, Szyld, Sagalyn, Pines, & Dean, 2009). The literature provides guidance for several parameters to consider for ultrasound-guided IV access.

### ***Educational Considerations***

Using ultrasound for IV access requires training for the user. The type and length of time for this training varies in the literature. For physicians training is incorporated into residency training with up to sixteen hours of didactic and over 100 ultrasound scans (Costantino et. al, 2005; Panebianco et. al, 2009). For nursing staff and ED technicians training sessions include at least a 1-hour didactic with additional hands-on training time (Bauman, Braude, & Crandall, 2007; Blaivas & Lyon, 2006; Chinnock et. al, 2007; Schoenfeld, Boniface, & Shokoohi, 2010; Stein et. al, 2009; White, Lopez, & Stone, 2010). White et al. (2010) recommended a 3-hour educational program to include didactic, simulation and hands-on practice prior to beginning an ultrasound-guided IV access program.

### ***Operator Characteristics***

Studies have focused on various operators (e.g., physicians, nurses and ED technicians) as well as different techniques. Two techniques used and studied include the dual-operator method in which one user handles the ultrasound probe while a second user inserts the IV catheter and the single-user method in which both activities are performed by one user. The dual-operator technique by emergency physicians resulted in a 97% first attempt success rate compare to 33% for standard technique, with a decrease in time to insertion of 13 minutes for ultrasound-guided compared to 30 minutes for control (Costantino et al., 2005). Stein et al. conducted a randomized trial using the single-operator method which did not yield a significant difference between the ultrasound-guided approach compared to traditional methods for success rate, time to cannulation or patient satisfaction with the procedure (2009).

Operator experience with ultrasound does have an impact on the rate of successful cannulation. Schoenfeld et al. (2010) demonstrated two independent factors associated with increasing success rate. The number of previous ultrasound-guided IV attempts was important, as was the operator's overall IV experience. This reflects the two skills required to successfully cannulate a vein using ultrasound-guided techniques: using the ultrasound to visually guide the catheter and successful cannulation of the vessel.

### ***Operator Techniques***

The single-operator technique performed by nurses resulted in a 97% overall success rate (Walker, 2009). Of interest, the patients had undergone an average of 6.4 attempts prior to referral to this study, and then required an average of 1.3 attempts to gain access with the ultrasound (Walker, 2009). The anterior forearm was used for 69% of the sites with basilic veins accounting for 12% (Walker, 2009).

Blaivas and Lyon (2005) studied the effect of ultrasound use on nurses' perceived difficulty of obtaining IV access. The nurses participated in a class on ultrasound-guided techniques and then completed a survey. Although not statistically significant, the success rate was 89% for short axis and 85% for long axis. However, the study did indicate that the nurse's perception of how difficult the access would be statistically improved from "very hard" to "very easy" ( $p=0.0001$ ; Blaivas & Lyon, 2005).

Chinnock, Thornton and Hendey (2007) studied the prediction of success for nurse initiated ultrasound-guided IV access. The cannulation success rate for one-person technique was 66% and 72% for two-persons. The overall cannulation success rate was 53% with a 63% success rate for ultrasound-guided technique of which 83% were successful on the first attempt. The basilic vein had a better cannulation success rate (70%) than the brachial vein (41%) (Chinnock et al., 2007).

Two studies focused on single user technique by ED technicians (Bauman et al., 2009; Schoenfeld et al., 2010). Bauman et al. (2009) found similar success rates of 80.5% using ultrasound as compared to traditional methods (70.6%). ED technicians gained access two times faster with ultrasound-guided techniques than physicians or nurses utilizing standard technique (Bauman et al., 2009). Bauman et al. (2009) also found a reduced number of skin punctures with ultrasound-guided techniques (1.6 vs. 2.6) and significantly improved patient satisfaction with the procedure increasing from 4.4 to 7.7 ( $p=0.0001$ ). The Schoenfeld et al. (2010) study resulted in a 78.5% success rate, noting that user experience significantly correlated ( $p<0.001$ ) to success rate.

### ***Pediatric Population***

Ultrasound-guided technique has been found to be useful in the pediatric population (Bair, Rose, Vance, Andrada-Brown, & Kuppermann, 2008; Doniger, Ishimine, Fox, & Kanegaye, 2009). The study by Bair et al. (2009) found the first attempt success for ultrasound-guided methods to be (35%) compared to traditional methods of (29%) with a 6% difference between the groups. Although, the crossover group who had failed traditional method had a 75% first attempt success rate with ultrasound-guided methods (Bair et al., 2008). Doniger et al. (2009) performed a randomized control study with an overall success rate of ultrasound-guided technique at 80% compared to traditional technique at 64%, although this difference was not statistically significant ( $p=0.208$ ) (2009). However, the ultrasound-guided group had statistically significant improvements in overall time to access ( $p=0.001$ ), number of attempts ( $p=0.004$ ) and number of needle redirections ( $p<0.0001$ ) compared to the control group (Doniger et al., 2009).

### ***Alternatives to Invasive Access***

The literature also described ultrasound-guided access in clinical settings other than the ED. In the pre-operative area, Certified Registered Nurse Anesthetists using the single operator technique did not find significant difference between traditional methods and ultrasound-guided methods (Aponte, Acosta, Rigamonti, Sylvia, & Austin, 2007). Gregg et al. (2010) sought to avoid CVC placement in the intensive care unit setting. The study was performed with a single physician using single operator technique and resulted in a 71% first attempt success rate (Gregg et al., 2010). Costantino, Kirtz and Satz (2010) concluded that ultrasound-guided methods are significantly superior for first attempt ( $p=0.006$ )

compared to blind external jugular access, whereas, no difference was found when the external jugular vein was visible.

### ***Ultrasound-Guided Intravenous Access Conclusions***

Ultrasound-guided IV access requires training sessions and can be performed using single-operator or dual-operator method by physicians, nurses and ED technicians. For patients with known or suspected difficult IV access, ultrasound-guided techniques improve success rate in a timely manner with improved patient satisfaction.

### **Intraosseous Vascular Access**

Intraosseous (IO) vascular access dates back as far as the 1920s when the sternum was described as a potential site for transfusions (Fowler, Gallagher, Isaacs, Ossman, Pepe, & Wayne, 2007; Horton & Beamer, 2008; MacKinnon, 2009; Paxton, Knuth, & Klausner, 2009). The IO route was later used by military medical personnel during WWII when vascular access was needed for patients in shock and IV cannulation was difficult or delayed (Fowler et al., 2007). Subsequently, the availability of plastic catheters for peripheral and central IV access resulted in a decline in IO usage. IO access has been the standard of care for over 20 years for the pediatric population when vascular access was difficult to accomplish (Horton & Beamer, 2008). There are three different types of IO needle placement methods. First, the manual needle is a hollow needle with a removable stylet. The second type is the impact driven device, of which there are two types; one is designed for sternal access, the other is a spring-loaded injector mechanism designed for the tibia. The third type is a battery-powered, drill-based technology. The recent introduction of these various IO insertion devices has made the IO route an option for vascular access in the adult population as well as the pediatric population (Langley & Moran, 2008; MacKinnon, 2009; Von Hoff, Kuhn, Burris, & Miller, 2008; Consortium on Intraosseous Vascular Access in Healthcare Practice, 2010). Leidel et al. (2009) notes there are three lengths of IO needles available for the drill device to accommodate the pediatric, adult, and obese patients.

The Consortium on Intraosseous Access in Healthcare Practice (2010) was attended by representatives of multiple organizations with a goal of reviewing the evidence supporting use of the IO access method wherever vascular access was deemed medically necessary and difficult to achieve. Among the recommendations made by the Consortium is that IO access should be considered as an alternative to peripheral or central IV access when an increase in patient morbidity or mortality is possible. Further, for patients not requiring long-term vascular access or hemodynamic monitoring, IO access should be the first alternative to failed peripheral venous access.

Frequently brought into question regarding IO access is which medications can be given via the IO route, and are dosages equivalent to those given by other routes. The IO route is effective for the administration of blood and blood products, fluid administration, drug delivery, and blood sampling (Burgert, 2009; Paxton et al., 2009; Leidel et al., 2009). The efficacy of medication route administration was studied by Von Hoff et al. (2008) in a Latin square crossover study with each subject serving as their

own control. Each subject received a dose of morphine sulfate either through an implanted IO needle or through a peripheral IV line, followed by a second dose at least 24 hours later given via the alternate administration route. Serial blood sampling followed each administration to identify morphine sulfate plasma concentrations. There were no significant differences between the IV and IO routes on plasma morphine concentration vs. sampling time or pharmacokinetics (Von Hoff, et al., 2008). There was a statistically significant difference in the volume of distribution in the central compartment thought to be due to the deposition effect near the IO needle.

The literature search revealed three studies which looked at several parameters that demonstrate the usefulness of IO access. These included success rate of the IO access on first attempt, time to insertion of the IO access, patient report of pain with insertion, and patient report of pain with fluid administration.

### ***Success Rate on First Attempt***

Horton and Beamer (2008) found a 93% first time success rate but did not the specific parameters defining success. Leidel et al. (2009) attained 90% first time success; success was measured as successful administration of drugs or infusion solutions on first effort. The success rate of the IO access on first attempt was reported by Paxton et al. (2009) as 80.6% in the proximal humerus. No determining factors for success were identified in this study.

### ***Time to Insertion***

Horton and Beamer (2008) reported an insertion time of less than 10 seconds in 80.2% of subjects. Measurement began at the time of needle to skin contact to needle placement in the IO space. Leidel et al. (2009) reported a time of  $2.3 \pm 0.8$  minutes insertion time. Timing was measured by an independent researcher who measured time from picking up the IO access device, preparing the set, prepping the site, insertion of the IO needle, and administration of the first drug or fluid. Paxton et al. (2009) reported a time of 1.5 minutes for IO insertion in the proximal humerus. Timing began with the skin preparation before insertion and ended when the person completing the insertion deemed flow of the fluid was adequate.

### ***Patient Report of Pain on Insertion***

Paxton et al. (2009) assessed pain scores utilizing a visual analogue scale (VAS) on insertion of the IO access device into the proximal humerus in adult patients with a Glasgow Coma Scale (GCS) score of 15 and reported an average score of 4.5. Horton and Beamer (2008) reported a mean pain score of  $2.3 \pm 2.8$  on IO insertion in pediatric patients with a GCS greater than 8. Leidel et al. (2009) did not study pain on insertion.

### ***Patient Report of Pain on Infusion***

Paxton et al. (2009) assessed pain scores utilizing a VAS on infusion of fluids through the IO port in patients with GCS score of 15 and reported an average score of 3.8 following lidocaine administration. All patients were given a standard dose of 40 to 100 mg of lidocaine 2% through the IO needle prior to

infusion of fluids or medications. Horton and Beamer (2008) reported a mean pain score of  $3.2 \pm 3.5$  on infusion of fluids through the IO port in patients with a GCS greater than 8, without mention of administration of lidocaine. Leidel et al. (2009) did not study pain on infusion of fluids.

### ***Intraosseous Vascular Access Conclusions***

In light of the evidence presented here, IO access provides vascular access in a timely manner when faced with difficult IV access. This conclusion is supported by the consistent first attempt success rate and rapid time to insertion.

### **Subcutaneous Rehydration Therapy**

Also known as hypodermoclysis, subcutaneous rehydration therapy (SCRT) dates back to 1913 (Spandorfer, 2011) as an alternative for rehydration in mild to moderate dehydration when oral or IV hydration is not feasible. The physiology behind SCRT stems from the sodium-potassium pump providing an osmotic gradient. The subcutaneous tissue forms a thick matrix with hyaluronic acid (Allen, Etwiler, Miller, Maher, Mace, Hostetler, Smith, Reinhardt, Hahn, & Harb, 2009, Kuensting, 2011; Spandorfer, 2011). A recent innovation in SCRT involves the administration of hyaluronidase which modifies the permeability of connective tissue, decreasing the viscosity of the cellular cement and promoting absorption of injected fluids. By injecting hyaluronidase into the subcutaneous tissue, the permeability of the matrix is increased and allows space for the infusion of fluid. The site selected for infiltration should be an area where skin and the subcutaneous tissue can be pinched. The preferred site in children is between the scapula (Kuensting, 2011) whereas in adults, the thighs, abdomen and arms can also be used (Remington & Hultman, 2007). Fluid may be infused by gravity or by pump at a rate of 20 to 125 mL/h over a 24-hour period. Absorption of fluid is dependent on the osmotic gradient, not on the rate of administration (Kuensting, 2011).

Allen et al. (2009) studied hyaluronidase facilitated SCRT in children ages 2 months to 10 years old (N=51) to analyze rehydration and possible adverse events. The initial subcutaneous catheter was placed upon first attempt 90.2% (46/51) with successful rehydration for 84.3% (43/51) patients. There was one case of cellulitis at the site. The nurses who completed the procedure considered it easy to perform for 96% (46/51) of patients with 90% (43/48) of the parents rating satisfied to very satisfied with the procedure (Allen et al., 2009).

Remington and Hultman (2007) reviewed literature on SCRT and identified eight studies. When comparing SCRT with IV administration from a safety perspective, the two were found to be comparable. It is noted, however, subjects in these studies were elderly, with a mean age ranging from 71 to 85 years. The incidence of systemic adverse effects did not differ (Remington & Hultman, 2007). Remington and Hultman showed more subjects improved clinically with IV administration than with SCRT, but the difference was not statistically significant (81% IV, 57% SCRT,  $p=0.19$ ). Site changes were necessary on average every 2 days with SCRT and 2.8 days for IV administration ( $p=0.14$ ) (Remington & Hultman, 2007; Slesak, Schnurle, Kinzel, Jakob, & Dietz, 2003). Median duration of fluid administration

was six days with both SCRT and IV routes (Slesak et al., 2003). Nurses rated the feasibility of SCRT equal with IV catheter (Remington & Hultman, 2007; Slesak et al., 2003). Nursing time to initiate SCRT was significantly lower at 3.4 minutes versus 6.1 minutes for initiation of an IV catheter. A significant difference was seen in the median volume of solution administered with 750 mL/day for SCRT and 1000 mL/day for IV administration ( $p=0.002$ ; Slesak et al., 2003).

In summary, SCRT is a useful alternative for rehydration of mild to moderately dehydrated pediatric and adult patients.

## **Warming**

The use of heat to facilitate vasodilatation for IV insertion is widely practiced. Caution must be used with this technique as burning may occur if not closely monitored and controlled. The U.S. Food and Drug Administration (FDA) issued a patient safety warning in 2002 against the practice of using forced air warmers without the blanket in a practice known as “hosing” because second and third degree burns have resulted (FDA, 2002).

Studies specific to the ED setting are limited. Lenhardt, Seybold, Kimberger, Stoiser, and Sessler (2002) conducted a randomized control study with a crossover trial of warming using a specific device to facilitate IV cannulation in adult neurosurgery and hematology patients. The study compared passive warming using a carbon fiber mitt and active warming when powered on and heated to 52°C. The initial study found that after 15 minutes of warming the success rate for IV cannulation was 94% (44/50) in the active warming group compared to 72% (36/50) in the passive warming group ( $p=0.008$ ). Additionally, the cannulation required less time with active warming, 36 seconds compared to 62 seconds for passive warming. The crossover trial applied warming for 10 minutes with a success rate of 95% for the active warming group compared to the 73% passive warming group ( $p=0.001$ ). The time required for successful cannulation was 20 seconds shorter with active compared to passive warming ( $p=0.02$ ; Lenhardt et al., 2002).

Fink, Hjort, Wenger, Cook, and Cunningham conducted a randomized controlled study to compare dry heat with moist heat (2009). Dry heat was 2.7 times more likely to result in successful IV insertion on first attempt ( $p=0.039$ ). The difference in mean insertion time between dry heat (98.5 seconds) and moist heat (127.6 seconds) was large enough to be clinically meaningful. No significant difference in patient anxiety was found between the heat modalities or between nurses or post-insertion patient reported anxiety scores ( $p > 0.54$ ). The conclusion recommended dry heat due to low cost, safety to patients and feasibility. (Fink et al., 2009)

The use of EMLA Cream™ to decrease pain for pediatric patients is common practice which may result in vasoconstriction of the vein.<sup>1</sup> Huff, Hamlin, Wolski, McClure, and Eliades evaluated the effect of heat with EMLA Cream™ to facilitate IV cannulation (2009). The vein size was measured using ultrasound technology prior to EMLA Cream™ application, one hour after application of EMLA Cream™, and 2 minutes after heat applied. The vein measurements over time were statistically significant ( $F=2.58$ ,

---

<sup>1</sup> Refer to the ENA Emergency Nursing Resource, [Needle-Related Procedural Pain in Pediatric Patients in the Emergency Department](#) (Crowley et al., 2010) for a thorough review of needle-related pain management in this population.

p=.000), indicating approximately 51% variance in vein measurement which was attributed to EMLA Cream™ and or heat when other conditions are stable. The average vein measurement at baseline was 0.243 cm, after EMLA Cream™ 0.205 cm and with heat 0.253 cm. The difference in vein visualization was also statistically significant (F=2.58, p=.000). The study had an 80% first cannulation success rate (Huff et al., 2009).

In summary, controlled warming to facilitate IV cannulation is a low-cost adjunct to improve cannulation success rate in a timely manner.

### **Alternative Methods**

Noting the frustration experienced by healthcare professionals when faced with establishing IV access in the ED, several groups have devoted time to identifying tools to assist with IV access. Near infrared light illuminates the skin without ionizing radiation and produces a 2-D image of blood filled structures (Perry, Caviness & Hsu, 2011). The literature was limited to pediatric populations. Perry et al. (2011) found the nursing staff (N=14) felt the device was beneficial for 90% for those patients who had difficult IV access. Further, 70% of the nurses surveyed found the device helpful for dehydrated patients and 80% in the chronically ill population. However, there was no significant difference in the first attempt success rate between standard IV techniques (N=62, 79%) and the infrared device (N=61, 72.1%; Perry et al., 2011).

Transillumination of veins using fiber optics in pediatric patients in another method studied (Katsogridakis et al., 2008). Transillumination did not improve first attempt success (p=0.53), rather, use of a safety catheter (p=0.01), vein visibility (p=0.01) and palpability (p=0.02) were better predictors of first attempt success (Katsogridakis et al., 2008).

A Vein Entry Indicator Device (VEID™) is a small box with a pressure sensor that fits onto an IV cannula. When a change in pressure in the needle indicates penetration of the vessel, a continuous beep sounds and reduces the likelihood of exiting the back wall of the vein. The VEID™ was studied by Simhi, Kachko, Bruckheimer, and Katz (2008) and found to help reduce the number of attempts at IV cannulation. The VEID™ is not currently available in the United States.

In summary, these alternative methods may be useful adjuncts for patients with difficult IV access.

## Description of Decision Options/Interventions and the Level of Recommendation

Conclusions and recommendations about alternatives to venous access in the patient with difficult IV access in the ED:

1. Ultrasound-Guided Intravenous Access
  - i. Ultrasound-guided IV access is a viable option for patients with known difficult access for both adult and pediatric populations. Level A – High.
  - ii. Ultrasound-guided IV access is a technique that can effectively be performed by physicians, nurses and ED technicians. Level A – High.
  - iii. Ultrasound-guided techniques may result in improved patient satisfaction. Level C – Weak.
  - iv. When the external jugular access is not visible, ultrasound-guided peripheral access is significantly more successful than external jugular access. Level C – Weak.
2. Intraosseous Vascular Access
  - i. Intraosseous venous access is significantly more expeditious than standard IV access and should be considered early when known or suspected difficult IV access exists. Level A – High.
  - ii. In alert patients, pain with intraosseous access insertions is rated as minor. Level A – High.
  - iii. Lidocaine administration prior to medication infusion reduces the pain felt by alert patients. Level C – Weak.
3. Subcutaneous Rehydration Therapy
  - i. SCRT is an alternative to peripheral IV insertion for the mildly to moderately dehydrated pediatric and elderly patients. Level B – Moderate.
4. Warming
  - i. Application of heat improves IV success rate and decreases time required to gain access. Level B – Moderate.
    - a. Dry heat may be more effective than moist heat. Level C – Weak
  - ii. For pediatric patients, heat may counteract the vasoconstriction associated with EMLA Cream™. Level C – Weak.
5. Alternative Methods
  - i. The use of infrared light, transillumination, and the VEID™ may be beneficial for pediatric patients with difficult IV access, dehydration or a chronic illness. Level C – Weak.

## References

- Allen, C. H., Etwiler, L. S., Miller, M. K., Maher, G., Mace, S., Hostetler, M. A., Smith, S. R., Reinhardt, N., Hahn, B., & Harb, G. (2009). Recombinant human hyaluronidase-enabled subcutaneous pediatric rehydration. *Pediatrics*, *124*(5), e858-867. doi: 10.1542/peds.2008-3588
- Aponte, H., Acosta, S., Rigamonti, D., Sylvia, B., & Austin, P. (2007). The use of ultrasound for placement of intravenous catheters. *American Association of Nurse Anesthetists Journal*, *75*(3), 212-216. [www.aana.com/aanajournal.aspx](http://www.aana.com/aanajournal.aspx)
- Bair, A. E., Rose, J. S., Vance, C. W., Andrada-Brown, E., & Kuppermann, N. (2008). Ultrasound-assisted peripheral venous access in young children: A randomized controlled trial and pilot feasibility study. *Western Journal of Emergency Medicine*, *9*(4), 219-224.
- Bauman, M., Braude, D., & Crandall, C. (2009). Ultrasound-guidance vs. standard technique in difficult vascular access patients by ED technicians. *American Journal of Emergency Medicine*, *27*(2), 135-140. doi: 10.1016/j.ajem/2008.02.005
- Blaivas, M. & Lyon, M. (2006). The effect of ultrasound guidance on the perceived difficulty of emergency nurse-obtained peripheral IV access. *Journal of Emergency Medicine*, *31*(4), 407-410. doi: 10.1016/j.jemermed.2006.04.014
- Burgert, J.M. (2009). Intraosseous infusion of blood products and epinephrine in an adult patient in hemorrhagic shock. *AANA Journal*, *77*(5), 359-363.
- Chinnock, B., Thornton, S., & Hendey, G.W. (2007). Predictors of success in nurse-performed ultrasound-guided cannulation. *Journal of Emergency Medicine*, *33*(4), 401-405. doi:10.1016/j.jemermed.2007.02.027
- Consortium on Intraosseous Vascular Access in Healthcare Practice: Phillips, L., Brown, L., Campbell, T., Miller, J., Proehl, J., & Youngberg, B. (2010). Recommendations for the use of intraosseous vascular access for emergent and nonemergent situations in various healthcare settings: A consensus paper. *Journal of Emergency Nursing*, *36*, 551-556. doi: 10.1016/j.jen.2010.09.001
- Costantino, T. G., Parikh, A. K., Satz, W. A., & Fijtik, J. P. (2005). Ultrasonography-guided peripheral intravenous access versus traditional approaches in patients with difficult intravenous access. *Annals of Emergency Medicine*, *46*(5), 456-461. doi: 10.1016/j.annemergmed.2004.12.026
- Costantino, T. G., Dirtz, J. F., & Satz, W. A. (2010). Ultrasound-guided peripheral venous access vs. the external jugular vein as the initial approach to the patient with difficult vascular access. *Journal of Emergency Medicine*, *39*(4), 462-467. doi: 10.1016/j.jemermed.2009.02.004
- Crowley, M., Storer, A., Heaton, K., Nacarrato, M., Proehl, J., Morte, J., and Li, S. (2010). Emergency Nursing Resource: Needle-related procedural pain in pediatric patients. Des Plaines, IL: Emergency Nurses Association. Retrieved from <http://www.ena.org/IENR/ENR/Documents/PedPainManagementENR.pdf>
- Doniger, S. J., Ishimine, P., Fox, J. C., & Kanegaye, J. T. (2009). Randomized controlled trial of ultrasound-guided peripheral intravenous catheter placement versus traditional techniques in difficult-access pediatric patients. *Pediatric Emergency Care*, *25*(3), 154-159.
- Fields, J. M., Todman, R. W., Anderson, K. L., Panebianco, N. L., & Dean, A. J. (2010). Early failure of ultrasonography-guided peripheral intravenous catheters in the emergency department: it's not just about getting the IV – it's about keeping it. *Annals of Emergency Medicine*, *56*(3), S75-76. doi: 10.1016/j.annemergmed.2010.06.277
- Food and Drug Administration (FDA), FDA Patient Safety News. (2002). Burns from misuse of forced-air warming devices. Show #9, October. Retrieved March 18, 2011 from <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/psn/printer.cfm?id=56>
- Fowler, R., Gallagher, J. V., Isaacs, S. M., Ossman, E., Pepe, P., & Wayne, M. (2007). The role of intraosseous vascular access in the out-of-hospital environment (resource document to NAEMSP

- position statement). *Prehospital Emergency Care*, 11(1), 6. doi: 10.1080/10903120601021036
- Fink, R. M., Hjort, E., Wenger, B., Cook, P. F., & Cunningham, M. (2009). The impact of dry versus moist heat on peripheral iv catheter insertion in a hematology-oncology outpatient population. *Oncology Nursing Forum*, 36(4), E198-E204. doi: 10.1188/09.ONF.E198-E204
- Horton, M. A., & Beamer, C. (2008). Powered intraosseous insertion provides safe and effective vascular access for pediatric emergency patients. *Pediatric Emergency Care*, 24(6), 347-350.
- Huff, L., Hamlin, A., Wolski, D., McClure, T., & Eliades, A. B. (2009). Atraumatic care: emla cream and application of heat to facilitate peripheral venous cannulation in children. *Issues in Comprehensive Pediatric Nursing*, 32, 65-76. doi: 10.1080/01460860902737418
- Gregg, S. C., Murthi, S. B., Sisley, A. C., Stein, D. M., & Scalea, T. M. (2010) Ultrasound-guided peripheral intravenous access in the intensive care unit. *Journal of Critical Care*, 25, 514-519. DOI: 10.1016/j.jcrc.2009.09.003
- Katsogridakis, Y. L., Seshadri, R., Sullivan, C., & Waltzman, M. L. (2008). Veinlite transillumination in the pediatric emergency department: a therapeutic interventional trial. *Pediatric Emergency Care*, 24(2), 83-88.
- Kuensting, L. I., DeBoer, S., Holleran, R., Shultz, B. L., & Steinmann, R.A. (2009). Difficult venous access in children: taking control. *Journal of Emergency Nursing*, 35(5), 419-424. doi: 10.1016/j.jen.2009.01.014
- Kuensting, L. L. (2011). Subcutaneous infusion of fluid in children. *Journal of Emergency Nursing*, 37(4), 346-349. doi:10.1016/j.jen.2011.02.011
- Langley, D. M., & Moran, M. (2008). Intraosseous needles: they're not just for kids anymore. *Journal of Emergency Nursing*, 34(4), 318-319. doi: 10.1016/j.jen.2007.07.005
- Lapostolle, F., Catineau, J., Garrigue, B., Monmarteau, V., Houssaye, T., Vecchi, I., . . . Adnet, F. (2007). Prospective evaluation of peripheral venous access difficulty in emergency care. *Intensive Care Medicine*, 33(8), 1452-1457. doi: 10.1007/s00134-007-0634-y
- Leidel, B. A., Kirchoff, C., Bogner, V., Stegmaier, J., Mutschler, W., Kanz, KG., & Braunstein, V. (2009). Is the intraosseous route fast and efficacious compared to conventional central venous catheterization in adult patients under resuscitation in the emergency department? A prospective observational pilot study. *Patient Safety in Surgery*, 3(1), 24-31. doi: 10.1186/1754-9493-3-24
- Lenhardt, R., Seybold, T., Kimberger, O., Stoiser, B., & Sessler, D. I. (2002). Local warming and insertion of peripheral venous cannulas: single blinded prospective randomised controlled trial and single blinded randomised crossover trial. *British Medical Journal*, 325, 1-4. Lininger, R.A. (2003). Pediatric peripheral iv insertion success rates. *Pediatric Nursing*, 29(5), 351-354.
- MacKinnon, K.A. (2009). Intraosseous vascular use at signature healthcare Brockton Hospital Department of Emergency Services. *Journal of Emergency Nursing*, 35(5), 425-428. doi: 10.1016/j.jen.2009.01.016
- Miles, G., Salcedo, A., & Spear, D. (2011). Implementation of a successful registered nurse peripheral ultrasound-guided intravenous catheter program in an emergency department. *Journal of Emergency Nursing*, [In press corrected proof]. doi:10.1016/j.jen.2011.02.011
- Nafiu, O. O., Burke, C., Cowan, A., Tutuo, N., Maclean, S., & Tremper, K. K. (2010). Comparing peripheral venous access between obese and normal weight children. *Paediatric Anaesthesia*, 20(2), 172-176. doi:10.1111/j.1460-9592.2009.03198.x
- Panebianco, N. L., Fredette, J. M., Szyld, D., Sagalyn, E. B., Pines, J. M., & Dean, A. J. (2009). What you see (sonographically) is what you get: vein and patient characteristics associated with successful ultrasound-guided peripheral intravenous placement in patients with difficult access. *Academic Emergency Medicine*, 16(12), 1298-1303. doi:10.1111/j.1553-2712.2009.00520.x
- Paxton J. H., Knuth T. E., & Klausner H. A. (2009). Proximal humerus intraosseous infusion: a preferred emergency venous access. *Journal of Trauma*, 67(3), 606-611. doi: 10.1097/TA.0b013e3181b16f42

- Perry, A. M., Caviness, A. C., & Hsu, D. C. (2011). Efficacy of a near-infrared light device in pediatric intravenous cannulation: a randomized controlled trial. *Pediatric Emergency Care, 27*(1), 5-10. [www.pec-online.com](http://www.pec-online.com)
- Rauch, D., Dowd, D., Eldridge, D., Mace, S., & Schears, G. (2009). Peripheral difficult venous access in children. *Clinical Pediatrics, 48*(9), 895-901. doi: 10.1177/000992809335737
- Remington, R., & Hultman, T. (2007). Hypodermoclysis to treat dehydration: A review of the evidence. *Journal of the American Geriatric Society, 55*(12), 2051 - 2055. doi: 10.1111/j.1532-5415.2007.01437.x
- Schoenfeld, E., Boniface, K., & Shokoohi, H. (2010). ED technicians can successfully place ultrasound-guided intravenous catheters in patients with poor vascular access. *American Journal of Emergency Medicine, 29*(5), 496-501. doi: 10.1016/j.ajem.2009.11.021
- Simhi, E., Kachko, L., Bruckheimer, E., & Katz, J. (2008). A vein entry indicator device for facilitating peripheral intravenous cannulation in children: a prospective, randomized, controlled trial. *Anesthesia & Analgesia, 107*(5), 1531-1535. doi: 10.1213/ane.0b013e318185cdab
- Slesak, G., Schnurle, J. W., Kinzel, E., Jakob, J., & Dietz, K. (2003). Comparison of subcutaneous and intravenous rehydration in geriatric patients: a randomized trial. *Journal of the American Geriatric Society, 51*(2), 155-160.
- Spandorfer, P. R. (2011). Subcutaneous rehydration: Updating a traditional technique. *Pediatric Emergency Care, 27*(3), 230-236.
- Stein, J., George, B., River, G., Hebig, A., & McDermott, D. (2009). Ultrasonographically guided peripheral intravenous cannulation in emergency department patients with difficult intravenous access: a randomized trial. *Annals of Emergency Medicine, 54*(1): 33-40. doi: 10.1016/j.annemergmed.2008.07.048
- Von Hoff, D. D, Kuhn, D. G., Burris, H. A., & Miller, L. J. (2008). Does intraosseous equal intravenous? A pharmacokinetic study. *American Journal of Emergency Medicine, 26*, 31-38. doi: 10.1016/j.ajem.2007.03.024
- Walker, E. (2009). Piloting a nurse-led ultrasound cannulation scheme. *British Journal of Nursing, 18*(14), 854-859.
- White, A. , Lopez, F., & Stone, P. (2010). Developing and sustaining an ultrasound-guided peripheral intravenous access program for emergency nurses. *Advanced Emergency Nursing Journal, 32*(2), 173-188.
- Yen, K., Riegert, A., & Gorelick, M. H. (2008). Derivation of the DIVA score: a clinical prediction rule for the identification of children with difficult intravenous access. *Pediatric Emergency Care, 24*(3), 143-147.

## **Acknowledgements**

ENA would like to acknowledge the following members of the 2011 Institute for Emergency Nursing Research (IENR) Advisory Council for their review of this document:

Gordon Gillespie, PhD, RN, CEN, CPEN, CCRN, FAEN

Mary Kamienski, PhD, APRN, CEN, FAEN

Anne Manton, PhD, RN, APRN, FAEN, FAAN

Lisa Wolf, PhD, RN, CEN