Ultrasonography-Guided Peripheral Intravenous Access: Regular Technique Versus Seldinger Technique in Patients with Difficult Vascular Access

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ABSTRACT

We sought to compare ultrasonography (US)-guided peripheral intravenous (PIV) access by regular technique using standard length catheters with a Seldinger technique using 16-cm central venous catheters in a randomized trial of adult patients with difficult intravenous (IV) access. Patients were randomized into two groups: (1) An US-guided IV access obtained through a regular technique or (2) An US-guided IV access obtained through a Seldinger technique. Outcomes measured were IV access success rates, number of attempts after enrollment, IV survival > 96 hours. As a secondary outcomes, we recorded IV complications rates and subject satisfaction. The two groups were matched in demographics, risk factors for difficult PIV access. No significant difference of clinical importance was found between the 2 groups in IV success rate or number of successful PIV catheter placement after one and two attempts. Median duration of access was 26 vs. 72 hours in regular technique group compared with Seldinger technique group, respectively. Forty one percent of IV catheters failed within 24 hours in regular technique group, most commonly due to infiltration with only 4.4 percent in Seldinger technique group. We observed low rate of immediate complications in both groups, however no infectious or thrombotic complication during the study period. Seldinger technique group had greater patient satisfaction compared with regular technique group. US-guided deep brachial or basilic vein cannulation with a 16-cm catheter offers a potentially safe and rapid alternative to central line placement in patients with difficult IV access.

Key words: *Ultrasonography, peripheral venous access, regular technique, Seldinger technique*

Ultrasonografi Eşliğinde Periferal İntravenöz Girişim: Zor Vasküler Erişim Olan Hastalarda Standart Yöntem ile Seldinger Yönetminin Karşılaştırılması

ÖZET

İntravenöz (IV) erişimi zor olan erişkin hastalarda ultrasonografi (US) eşliğinde periferal intravenöz (PIV) yolla standart uzunlukta kateterlerin kullandığı alışılagelmiş teknik ile 16 cm santral venöz kateterler kullanılan Seldinger tekniği randomize karşılaştırmayı amaçladık. Hastalar iki gruba ayrıldı: (1) US eşliğinde alışılagelmiş teknik ile IV erişim yapılan teknik veya (2) US eşliğinde Seldinger tekniği ile elde edilen IV erişim yapılan teknik. Birincil sonlanım olarak intravenöz erişim başarı oranları, girişim sayısı, 96 saatten uzun suren IV survi ölçüldü. İkincil sonlanım olarak, IV komplikasyon oranları ve hasta memnuniyeti değerlendirildi. Her iki grup demografik faktörler ve zor PIV erişim risk faktörleri açısından eşleştirilmiştir. Her iki grup arasında IV başarı oranı veya başarılı PIV kateter yerleştirilmesi açısından anlamlı fark bulunmamaktaydı. Seldinger tekniğiyle kateter yerleştirilen grupla karşılaştırıldığında standart teknik grubunda ortalama erişim süresi 26 ve 72 saat olarak tespit edildi. Standart teknikte ilk 24 saat içerisinde %41 oranında IV kateter başarısızlığı saptanırken Seldinger tekniği ile bu oran %4.4 olarak bulundu. Her iki grupta da ani komplikasyon oranını düşük oranda gözlemledik, bununla birlikte çalışma periyodu boyunca infeksiyöz veya trombotik komplikasyon tespit edilmedi. Seldinger tekniği grubunda hasta memnuniyeti standart tekniğe oranla daha yüksekti. 16 cm kateter ile US eşliğinde derin brakiyal veya bazilik ven kanülasyonu zor IV erişimi olan hastalarda santral kateter yerleştirilmesi için potansiyel olarak güvenli ve hızlı bir alternatif sunmaktadır.

Anahtar kelimeler: *Ultrasonografi, periferal venöz girişim, standart teknik, Seldinger teknik*

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INTRODUCTION

Obtaining peripheral intravenous (PIV) access can be a challenge even to experienced physicians, especially in infants, obese adults, history of injection drug use (IDU), edematous patients, or other chronic medications (1), a central venous catheter is often placed at considerable risk to the patient. Placement of a central line is associated with a greater than 15% rate of significant complications, including arterial puncture, pneumothorax, deep vein thrombosis (DVT), and infection (2). Use of ultrasonographic (US) guidance in central line placement is now widely recommended because it improves success and reduces complications (3,4). Ultrasonography has also been used to cannulate deep peripheral veins. US guided cannulation of the deep brachial or basilic vein using a standard intravenous catheter was found to be a rapid and highly successful technique in 2 previous studies (5,6). However, its drawbacks, are that intravenous catheters may dislodge and intravenous fluid infiltrates because standard length catheters may not extend far enough into the vein lumen. Mills et al (7) reported that ultrasonographically guided insertion of a 15-cm catheter into the deep brachial or basilic vein offers a potentially safe and rapid alternative to central line placement in adult patients with difficult intravenous access. We sought to compare US-guided PIV access by regular technique using standard catheters with Seldinger technique using central venous catheters.

PATIENTS AND METHODS

Patients

After obtaining approval of the Institutional Review Board/IRB and written informed consent, 45 critical care and hemodialysis patients with difficult vascular access were enrolled in a prospective, non blinded, randomized study from August 2010 to April 2011, twenty-two were underwent ultrasonography-guided PIV cannulation with regular technique using standard catheter (1.77-inch length) and 23 patients to the US-guided PIV cannulation with Seldinger technique using 16-cm central venous catheter. The inclusion criterion was inability of any available nurse/attending physician to obtain intravenous access after at least 3 attempts on a subgroup of patients who had a history of difficult intravenous access because of end stage renal disease (ESRD), obesity, history of IDU, or other chronic medical problems. Pregnant patients and children were excluded, as were those who were critically ill, in need for central line as defined by the treating physician or unable to give consent. The study was performed by the attending anesthetist, nephrologist and physician who were familiar with US-guided peripheral and central venous access. Each of the attending physicians had more than 5-years experience in placing US-guided PIV catheters. Successful venous cannulation was defined as withdrawal of 5 ml non-pulsatile blood or infusion of 5 ml of saline without evidence of extravasation. Failure of PIV access was defined as extravasation with initial infusion, inability to withdraw 5 ml of blood, inability to obtain access by the operator. Time was recorded in minutes in real time by the attending physician with time zero was chosen as the time the US probe first touched the patient's skin. The end time was marked by success or where failure criteria were met. Complications were defined as hematoma, arterial puncture, nerve injury, infection or thrombosis. Patients satisfaction with intravenous access (a Likert scale from 0-to 10 was used to gauge patient satisfaction).

Methods

Ultrasonography-guided PIV catheters were placed in real time by the attending physician using a 10-MHZ linear array probe (GE Logiq Book XP Portable Ultrasound Machine; General Electric Company, GE Healthcare – Americas, U.S.A.). A transverse image of the vein, accompanying artery and nerve is obtained, the vein is brought into the middle of the image, and the probe is rotated through 90° to visualize a longitudinal image of the vein (Figure 1). Veins were identified by their collapsibility with gentle pressure and flow can be confirmed by color Doppler.

Regular technique

The skin entry site is cleaned with Chlorhxidine antiseptic swab and infiltrated with lidocaine 1%, about 1–2 cm from the probe. The ultrasound was covered in a sterile, 4x6- in Tegaderm dressing (3M, Inc, St. Paul, Minn), and sterile lubricating jelly was applied to the probe. A tourniquet is applied high up on the arm. A 1.77-in, 18-gauge angiocatheter (BD VenflonTM; Becton Dickinson infusion therapy AB SE-251 06 Helsingborg, Sweden) was inserted at a 45° angle to the skin and visualized by real-time imaging during its advance through superficial and deep fasciae into the vein and successful venous cannulation was confirmed by aspiration of dark, nonpulsatile blood.

Table 1. Baseline characteristics of the studied groups

Characteristics	Regular technique (n:22)	Seldinger technique (n:23)	p value
Age, year; median (IQR[a])	55 (44 to 60)	58 (37 to 65)	0.699
Gender, n (%)			
Males	12 (54.5)	10 (45.5)	
Females	12 (52.2)	11 (47.8)	0.873
BMI, kg/m^2; median(IQR)	24.93 (22.88 to 28.14)	27.56 (24.76 to 31.25)	0.117
Markers of difficult PIVs[b], n (%)			
ESRD[c]	9/22 (40.9)	11/23 (47.8)	
Obesity	8/22 (36.4)	7/23 (30.4)	
Injection drug use	2/22 (9.1)	2/23 (8.7)	0.923
Other chronic disease	2/22 (9.1)	1/23 (4.4)	
Unspecified	1/22 (4.5)	2/23 (8.7)	

a, interquartile range; b, peripheral intravenous access; c, end stage renal disease, BMI: body mass index

A Luer lock was subsequently secured to the catheter hub and a 4 × 6-in Tegaderm dressing was used to secure the line.

Seldinger technique

A 2.5-in, 18-gauge introducer needle (Central Venous Catheterization set with Blue FlexTip® Catheter. Arrow International, Inc.) was inserted by technique described above, the guide wire was threaded through it into the vein, using sterile gloves and drape. The initial needle was then removed and the track was dilated by a tissue dilator and then a 16-cm single lumen catheter (14 gauge; Arrow International, Inc. 2400 Bernvile Road, Reading, PA 19605 USA), was inserted over the wire and secured with tape and transparent dressing.

Data collection and outcome measures

After successful US-guided PIV placement, the physicians performed the procedure were asked to record on the data collection sheet each patient's age, sex, reasons of difficult IV access, including, ESRD, body mass index (BMI), date and time of the procedure, IDU, patient comorbidities, the number of attempts (individual skin punctures) required for successful placement of the IV using US guidance and immediate complications, including arterial puncture (bright red, pulsatile blood return), nerve contact (sharp pain radiating up or down the arm or paresthesias), and hematoma formation. The catheter was left in place till day 4, unless the patient was discharged or a complication developed before

Table 2. Outcome measures, by groups

Variable	Regular technique (n:22)	Seldinger technique (n:23)	p value
Success rate, n(%)			
Total	20 /22 (90.9)	22/23 (95.7)	
First attempt	13/22 (59.1)	14/23 (60.9)	0.932
Second attempt	5/22 (22.7)	6/23 (26.1)	
Third attempt	2/22 (9.1)	2/23 (8.7)	
Number of attempts, median(IQR)	1 (1 to 2)	1 (1 to 2)	0.815
Time of attempt, minutes; median(IQR)	3.5 (3 to 5.25)	7 (6 to 8)	0.000*
Number of skin punctures, median(IQR)	1 (1 to 2)	1 (1 to 2)	1.0
Overall survival, n(%)	12/22 (54.6)	22/23 (95.7)	0.001*
Catheter survival time, median(IQR)	26 (13 to 72)	72 (45 to 84)	0.004*
Complications, n(%)			
Brachial artery puncture	1/22 (4.5)	1/23 (4.4)	
Hematoma	1/22 (4.5)	1/23 (4.4)	
Nerve pain	2/22 (9.1)	2/23 (8.7)	
Dislodgement	3/22 (13.6)	0/23 (0)	
Infiltration	6/22 (27.3)	1/23 (4.4)	
Thrombosis	1/22 (4.5)	0/23 (0)	
Infections	0/22 (0)	0/23 (0)	
Deep venous thrombosis	0/22 (0)	0/23 (0)	0.077
Patients satisfaction, median(IQR)	6 (5 to 7)	8 (6 to 8)	0.006*

IQR, interquartile range; *p <0.05 was considered statistically significant

Table 3. *Association of covariates with ultrasonography-guided peripheral intravenous survival time*

Variable	X^2	*P value*
Age	*0.937*	*0.333*
Sex	*2.363*	*0.124*
Body mass index	*0.002*	*0.962*

fourth day. Trained research assistants or the study investigators examined each patient's catheter site once daily to record time and date of IV removal and reasons for catheter removal, such as completion of IV therapy, the IV failed (due to catheter occlusion or infiltration of infusate into the subcutaneous tissue), a complication developed, including infection (localized cellulitis, or suppurative phlebitis requiring antibiotics), phlebitis (pain, tenderness, erythema and edema, with or without a palpable venous cord), US evidence of DVT proximal to the IV insertion site, and hematoma formation that was not recorded as an immediate complication. The primary outcomes measured were IV access success rate, time to perform successful cannulation and IV survival, which was defined as a patent catheter; catheter removal before day 4 because IV treatment was completed or the patient was discharged; any catheter changed at day 4 per hospital routine or if the patient removed the catheter. Catheter failure was defined as removal of the IV due to occlusion of the catheter, subcutaneous infiltration of infusate with associated pain and edema, infection, DVT, or dislodgement of the catheter. Secondary outcomes measured included immediate complications (hematoma formation, nerve contact, number of skin punctures, and arterial puncture) and delayed complications (catheter occlusion, catheter dislodgement, delayed hematoma formation, infiltration, infection, DVT, and the need for central line placement). Patients Satisfaction was measured on 1- to 10- point Likert scale.

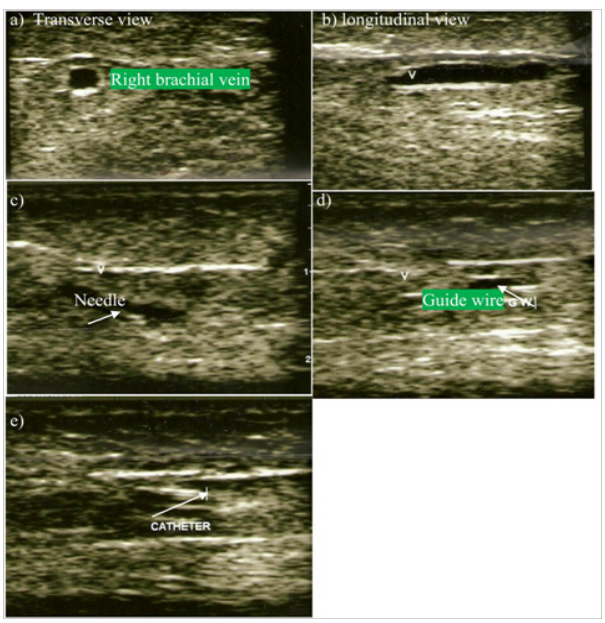

Figure 1. *Visualization of the deep brachial vein in transverse (a) and longitudinal(b) views; needle entering the lumen of the vein (c); then the guide wire (d); and the catheter(e) inside the venous lumen.*

Data analysis

Data are presented as median and interquartile ranges (IQRs). Nonparametric Mann-Whitney U analysis of variance was used to analyze significance of age, body mass index, time data, number of attempts and number of skin punctures. Frequency data significance was determined by person Chi-Square test. Cox proportional hazards models were used to describe catheter survival over time and to study continuous variables associated with early failure. A P value (two-sided in all tests) of <0.05 was considered significant. SPSS software, version 16.0, was used (SPSS Inc., Chicago, IL, USA).

RESULTS

There were no significant difference between the two studied groups of patients in age, gender, BMI, or the presence of risk factors for difficult PIV access such as (ESRD), obesity, history of IDU, or other chronic medical problems (Table 1). All patients in both groups had PIV catheter placement, except for two patients in regular technique group where US-guided cannulation couldn't be obtained after 10 minutes , despite multiple attempts, another one in Seldinger technique group, the 16-cm catheter was placed but infiltrated after 15 minutes, requiring removal. In the Seldinger group, the deep brachial vein in 12 patients was successfully cannulated, the basilic vein in 7, and the site was not recorded in 4. Meanwhile, the deep brachial vein in 14 patients was successfully cannulated, the basilic vein in 2, and the cephalic vein in 7 patients in regular technique group. Successful cannulation re-

quired one attempt (59.1% vs. 60.9%), 2 attempts (22.7% vs. 26.1%) and 3 attempts (9.1% vs. 8.7%), in regular technique compared with Seldinger technique groups, respectively. Median time for cannulation was (3.5 minutes vs. 7 minutes) in regular technique group compared with Seldinger technique group, respectively. In regular technique group the overall survival rate was 54.6% and the median survival time was 26 hours (IQR, 13 to 72). Nine (41%) US-guided PIVs failed within 24 hours, which was most commonly attributed to infiltration. Only 7 (31.8%), catheters survived more than 72 hours, the most common cause of IV failure over the course of the study was infiltration (27.3%), inadvertent dislodgement of the catheter (13.6%). Taking into consideration our small sample size, none of the studied variables (age, gender and BMI) were associated with premature catheter failure. All 22 central line catheters remained in place until IV access was no longer required and remained in place for a median of 72 hours (IQR, 45 to 84). The most common immediate complication was nerve contact (9.1% vs. 8.7%), in regular technique group compared with Seldinger technique group. At catheter removal, no patients had evidence of catheter associated hematoma, infection, or thrombosis in both groups during the course of the study (Table 2, 3). A total of 3 (6.7%) patients ultimately required central venous catheterization during their hospital course in both groups (1 in regular technique group and 2 in Seldinger technique group). Of the patients required a central line, one underwent this procedure as a direct result of US-guided PIV failure. The other 2 patients required a central line while critically ill but had functioning US-guide IVs at time of central line placement. Patients in regular technique group had a median Likert satisfaction score of 6 compared with 8 for the Seldinger technique group (p=0.006).

DISCUSSION

All physicians need to be familiar with techniques for obtaining intravenous access. Many physicians are familiar with a subgroup of patients in which intravenous access can be very difficult, because of obesity, history of intravenous drug use, or some chronic medical condition, such as patients who have ESRD and are receiving hemodialysis (6). Although some patients will still require central venous access, using ultrasonography to achieve PIVs in patients who have no other requirement for central venous access may result in decreased complications, decreased time spent obtaining intravenous access, and increased patient satisfaction. However, the longevity of ultrasonography-guided IVs has been called into question, raising concerns that the procedure may simply delay, rather than prevent, central venous access (5,7). Standard 3- to 5-cm-length intravenous catheters in the deep brachial or basilic vein tend to dislodge prematurely. In this study we prospectively studied success rate, time to perform successful cannulation and survival of US-guided PIV access using standard length peripheral catheter by regular technique compared with Seldinger technique using central line catheters (16-cm) in patients with difficult IV access. As a secondary outcome, we studied immediate and delayed complication rates and patient satisfaction. In this study there were no important differences between the groups in age, gender, BMI or in the presence of marker for difficult PIV access. All patients had successful PIV catheter placement, except for two patient in regular technique group (9.1%). No significant difference was noted between the two studied groups in percent of successful PIV catheter placement after one, two or three attempts (p> 0.05). In a prospective trial from 2005, Costantino et al (6) reported 97% success rate for US-guided peripheral IV placement not restricted to the deep brachial or basilic veins. Also, Stein et al. (8) demonstrated that US-guided technique allowed successful cannulation in 91% of the difficult IV access patients in the deep brachial or basilic vein. In concordance to our results, Dargin et al (9) reported eighty eight percent of patients had an US-guided PIV placement after 2 attempts. We found US-guided PIVs had a premature failure rate 41% in the regular technique group using standard length catheters in the first 24 hours, which was most commonly attributed to infiltration. Similarly, Dargin et al. (9) found US-guided peripheral IVs had a high premature failure rate of 47% in the first 24 hours, which was commonly attributed to infiltration. Standard PIV catheter survival rates vary considerably based on catheter, patient, and provider-related factors (10-13), but the failure rate may be as low as 2% in 24 hours and only 10% at day 4 (10). Taking into consideration our small sample size, none of the variables that we examined were associated with premature catheter failure. A previous study (5) reported an eight percent failure rate in the first hour after US-guided placement of a 5-cm catheter, which is slightly longer than the catheter used in our study

(4.4-cm). Taking this observation into consideration, Mills et al. (7) hypothesized that standard length US-guided catheters (3-5 cm in length) may be too short to adequately reach the lumen of deeper peripheral veins and therefore tend to be easily dislodged. In the Seldinger technique group, there was one case (4.4%) of early infiltration and no cases of later infiltration. The apparently improved longevity of the 16-cm catheter compared to shorter catheters suggests that this technique is well suited for patients requiring admission. A previous study has found extravasation rate of 4% in 15 minutes using a 15-cm catheter (7), in a patient after US-guided PIV placement. A longer catheter should decrease the incidence of infiltration. The immediate complication rates of US-guided peripheral IV catheters are well documented in literature, and the 8-9% rate of nerve contact, the 4.5 % arterial puncture rate that we observed are similar to that demonstrated by others (5,14). We didn't observe any infectious or DVT complications during the course of the study. Similarly, there were no infectious or thrombotic complications noted in a small study of 15-cm US-guided catheters placed in the Emergency Department (7). Multiple studies have analyzed the rates of infection and upper extremity thrombosis associated with peripherally inserted central catheters, which differ from the catheters in this study in that they extend into the central circulation and may remain in the vein for months. Rates of infection (15,16) and thrombosis (17,18) at peripherally inserted central catheter sites have been reported to be low. It is therefore not surprising that there were no cases of catheter-associated infection or thrombosis in Seldinger technique group using 16-cm central catheters in this study. A peripherally inserted central catheter is a reliable alternative to short term central venous catheters, with a lower risk of complications and possible wider range for use.

Limitations; Our study has a number of limitations. One limitation of that trial is small sample size. We did not record all of the potential patient and catheter-related factors that may have affected IV survival. The number of attempts, immediate complication rates, and the operator's intent to place a central line may be affected by reporter bias as we relied on the operator to document these immediate complications at the time of catheter placement. In addition, there was no long-term follow-up after removal of the catheter. Thus patients with delayed complications weren't detected.

In conclusion, US-guided deep brachial or basilic vein cannulation with a 16-cm catheter is a suitable and easy alternative to central venous catheterization in adult patients with difficult IV access with a low rate of short term complications.

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