S. Etezazian MD[1]
B. Tavakoli MD[1]
A. Hekmatnia MD[2]
N. Omidifar MD[3]
M. Moradi MD[1]

Evaluation of Success Rate of Ultrasound-Guided Venous Cannulation in Patients with Difficult Venous Access

Background/Objective: We evaluated a new ultrasound-guided approach to percutaneous cephalic vein or basilic vein cannulation in patients with difficult intravenous access.

Patients and Methods: Patients who required intravenous access and were candidates for surgical approach, or central venous catheterization were enrolled into the study. They had at least three unsuccessful attempts at establishing a peripheral intravenous line. By using a 7.5-MHz ultrasound probe, the cephalic or basilic vein was identified and then cannulated with a conventional venous cannula. The time from probe placement to cannulation, the number of attempts and complications were recorded.

Results: Eighty-eight patients were enrolled; 28 (31.8%) female and 60 (68.2%) male. The intravenous (IV) drug abusers consisted of 29 patients (33%) which were all men (48% of males). The procedure was successful in 94.3% and failed in five cases (5.7%) after three attempts. The mean time of procedure was 175±153 seconds. There was a significant difference between IV drug abusers (231±203) and non IV drug abusers (149±118) regarding access time (p-value=0.012). The procedure was successful after one attempt in 61 patients (73.5%), two attempts in 20 patients (24.1%) and three attempts in two patients (2.4%). The cannula was dislodged in three cases after one hour of follow-up. No other complications happened.

Conclusion: Ultrasound-guided cephalic and basilic vein cannulation is safe and time saving, has a high success rate in patients with difficult peripheral intravenous access, and may be used as the first step in these patients before the other more invasive alternatives.

Keywords: Ultrasonography, Venous, Catheterization

Introduction

Peripheral venous access is a common procedure in hospitalized patients.[1] Soon after defining intravenous (IV) entry techniques by Escholtz (in 1665), Clysmatica Nova begins as the first infusions in human.[2] Surgical procedures were improved and became safe in the 20th century[3] after discovery of the microorganisms and related infections in the 19th century.[4]

Intravenous (IV) access may be a difficult procedure in some patients including infants, obese adults, IV drug abusers, edematous patients, or patients who have been frequently hospitalized.[5] This problem is mostly due to thrombosis or scarring of the veins in the hand and forearm, or difficulty in locating the veins as the result of subcutaneous fat or edema.

Surgical approach (venous cut-down) and central venous catheter placement are the default solutions when it is impossible to establish a conventional peripheral access. These are time consuming and need surgical exploration of the veins.

Moreover, the distal part of the used vein is usually tied off, and the vein becomes unusable after the procedure.[6] It is also hard and time demanding to prepare a central venous line[7] and a variety of morbidities such as pneumothorax,

1. Department of Radiology, Alzahra-Hospital, Isfahan University of Medical Sciences, Isfahan, Iran.
2. Associate Professor, Department of Radiology, Alzahra Hospital, Isfahan University of Medical Sciences, Medical Image and Signal Processing Research Center, Isfahan, Iran.
3. Assisstant Professor, Department of Radiology, Alzahra Hospital, Isfahan University of Medical Sciences, Isfahan, Iran.

Corresponding Author:
Babak Tavakoli
Address: Department of Radiology, Alzahra Hospital, Isfahan, Iran.
Tel: +98311 673 2922
Fax: +98311 673 2922
E-mail: tavakoli.babak@gmail.com

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thrombosis, catheter migration and infection may follow the procedure.

Deep arm veins are suitable alternatives for surgical procedures, and central venous catheterization.[5] Landmark-based approaches to these deep veins have been used, but have resulted in many complications, such as arterial puncture and catheterization failure.[8] Ultrasonographic guidance has also been used to locate these veins for catheterization.[7-9]

Brachial, basilic, and cephalic veins in the mid-arm are the alternative sites, although brachial veins are adjacent to the artery and the risk of arterial puncture is increased.[8] These veins are less likely to be used by IV drug abusers and we use these superficial veins.[5] Keyes et al. performed ultrasound-guided brachial and basilic vein cannulation in the emergency department patients and reported a 91% success rate for this procedure in the "difficult stick" patients. The result was 73% successful catheterization, 2% arterial puncture, and 1% paresthesias.[8] Sandhu et al. cannulated the basilic and cephalic veins in the mid-arm region using longitudinal ultrasonographic views.[5] In another study, Mills et al. used 15 cm, 16-gauge catheters and placed them under ultrasound guidance in an emergency department. They placed a 3.2-cm, 18-gauge catheter under ultrasound guidance, and then established the access with a 15 cm, 16-gauge catheter and Seldinger's technique. Catheters were used for up to 3 days. Twenty-three catheters were placed successfully with a median time of 3 minutes spent for initial vein cannulation and a more 4 minutes for securing the 15 cm catheter. Early infiltration in one patient was the only complication.[7] The aim of this study was to assess the safety and success rate of ultrasound-guided approach to percutaneous cannulation in patients with difficult intravenous access.

Patients and Methods

Study design and patients

This study was performed in Alzahra hospital from April 2008 to June 2009. Eighty eight patients who needed IV access, but were described as "patients with difficult venous access", (i.e. at least 3 unsuccessful attempts at establishing a peripheral intravenous line, and being a candidate for surgical approach, or central venous catheterization) were enrolled. Inclusion criteria were as follows: 1-Needing an IV Access, 2-Having at least three unsuccessful attempts at establishing a peripheral intravenous line by the same trained expert nurses (of infectious disease, internal medicine, and surgery wards), 3-Being a candidate for surgical approach or central venous catheterization after surgical consultation. The exclusion criteria were having unstable vital signs and being in a vital emergency state (It was time consuming to refer the patients to the radiology section due to the structure of the study). The procedure was described to all the patients and was performed after their agreement and consent.

Data collection

The patients were referred from departments of infectious disease, internal medicine and surgery of Al-Zahra Hospital (Isfahan University of Medical Sciences) to the radiology department.

Technique

An ultrasound device (G-50 Siemens Inc.) with its high frequency probe (7.5 MHz) was used to image the basilic or cephalic vein. The venous system of both arms, including cephalic, basilic, and brachial veins was evaluated briefly using color and spectral Doppler study. If there was at least one patent superficial (cephalic or basilic) and one patent deep (brachial) venous drainage, the limb was used.

The cannulation is performed by cleaning the mid arm using povidone iodine (betadine) solution as the starting point. We use surgical gloves as the probe sterile cover and a little more povidone iodine solution as the transmitter gel.

A tourniquet is applied high up on the arm. Both cephalic and basilic veins are visualized and their patency is tested using compression (Fig. 1).

The largest in diameter and most superficial vein is chosen at mid-arm. The brachial artery is easily distinguished with its pulsatility and non-compressibility.

A transverse image of the vein is obtained and the vein is brought into the middle of the image. The entry site is now about 5 mm distal to the middle of the transducer. An IV cannula (18 GA, 45 mm in length)

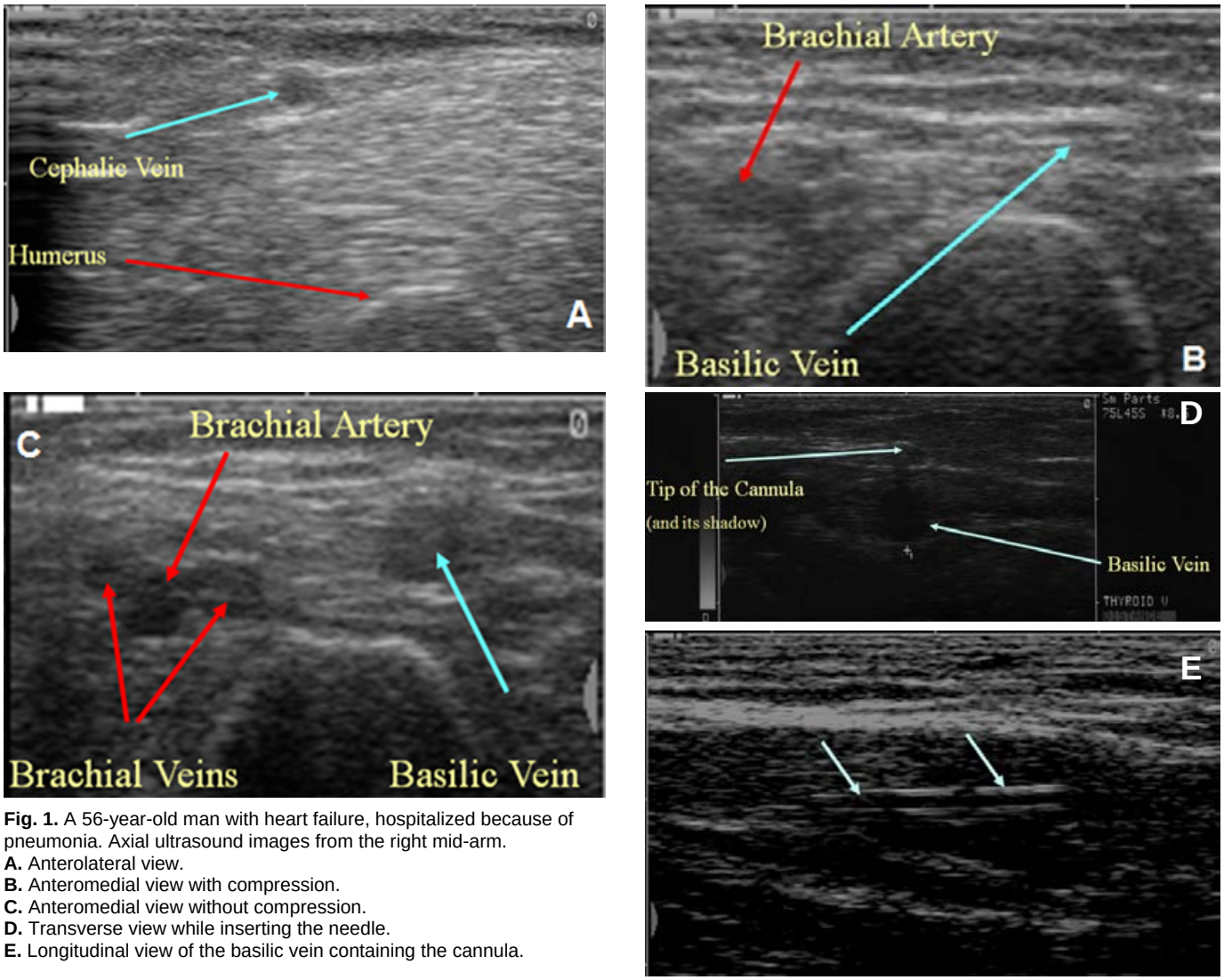

Fig. 1. A 56-year-old man with heart failure, hospitalized because of pneumonia. Axial ultrasound images from the right mid-arm.
A. Anterolateral view.
B. Anteromedial view with compression.
C. Anteromedial view without compression.
D. Transverse view while inserting the needle.
E. Longitudinal view of the basilic vein containing the cannula.

is inserted at a 45 degree angle into the skin and is visualized by real-time imaging during its advance through the superficial and deep fasciae into the vein (Fig. 1D).

The probe is rotated through 90 degrees just after the needle enters the vein to confirm the correct location of the cannula (Fig. 1E).

The venous puncture can be seen on the screen and is confirmed by the free backflow of blood. Then the mandrilis pulled back a bit and the cannula is threaded into the vein. We tried to place at least 2.5 cm of the cannula into the vein, as according to other studies, the dislodgement rate increases if this measure is less than 2.5 cm.[5]

The cannulation success rate was recorded as well as the number of attempts, the time from probe placement to cannulation and the complications.

The patient was followed for an hour to see if the cannula was dislodged.

Statistical Analysis

The statistical analysis was performed using SPSS Version 16 for Windows. Values are expressed as mean ±SD. We have used Fisher's exact test and t test to compare the success rate of cannulation and the mean time of cannulation in IV drug abusers and non IV drug abusers.

Results

The mean age was 37.8 ± 13.3 (18 to 88 years); 28 (31.8%) female, 60 (68.2%) male. Totally 29 patients (33%) were IV drug abusers, all men (48% of men).

Six patients were receiving chemotherapy (6.8%), one patient was admitted because of pneumonia in the background of being HIV positive and being af-

Table 1. Comparison Between IV-Abusers and Non IV-Abusers

	IV Drug Abusers	Non IV Drug Abusers	P Value
Success Rate	89.7%	96.6%	0.2
Mean Time of Procedure (sec)	231	149	0.012

fected by AIDS-related dementia. The procedure was successful in 94.3%, and failed in five cases (5.7%) after three attempts. One patient was an IV drug abuser with AIDS-related dementia who was not cooperative enough and another patient was under chemotherapy.

Although the procedure was more successful in non IV drug abusers (89.7% in IV drug abusers, and 96.6% in non IV drug abusers (Table 1)), Fisher's exact test showed no significant difference (p value=0.2) (Fig. 2).

The success rate was 96.4% in women and 93.3% in men with no significant difference (Fig. 3). The mean time of the procedure (sec) was 175±153. It was 231±203 in IV drug abusers and 149±118 in non IV drug abusers. Independent t test showed a significant difference here (p value=0.012).

The procedure was successful after one attempt in 61 patients (73.5%), two attempts in 20 patients (24.1%) and three attempts in two patients (2.4%).

The cannula was dislodged in three cases after one hour of follow up. We had neither arterial nor nerve injuries. No other complication occurred.

Discussion

We had a success rate of 94.3%, which means 94.3% of the cut-down/central access candidates could be managed by a far less invasive procedure. It was not much different from previous studies; a 91% success rate reported by Keyes et al.[8] It should be mentioned that we used conventional cheap IV cannulas, so there was no additional charge other than the procedure itself. The majority of the patients were IV drug abusers with potential for blood-borne diseases such as hepatitis; therefore using a less invasive method instead of cut-down or central venous catheter placement would decrease the transmission risk and cause more safety. As there was no meaningful difference between the success rates in IV drug abusers and non IV drug abusers, we concluded that the method is particularly justified in this group of patients.

The mean time of the procedure was 175 seconds, which is somehow acceptable in urgent situations.

Keyes and colleagues found 8% of catheter dislodgement or extravasation within one hour of successful cannulation[8] and we had three (3.6%) dislodgements, maybe due to the more time we spent to find a better location and the higher location we used, as there were no patent veins in the antecubital fossa in our cases.

Sandhu et al. had no dislodgment.[5] They replaced the cannula with a 13.3 cm catheter if the intravenous length was less than 2.5 cm.

Keyes and colleagues observed nerve injuries in one patient and Kramer and colleagues in 8% of the patients. Similar to Sandhu's study, no nerve injury or any arterial catheterization[5] was encountered. We also used a longitudinal view to see the entrance of the cannula into the vein, but in the former studies they just used a transverse view.

We tried to choose similar patients, but it is not possible to have patients with the exact difficulties for cannulation. On the other hand, we had to follow the ward's routines about indications of CVP or cut down

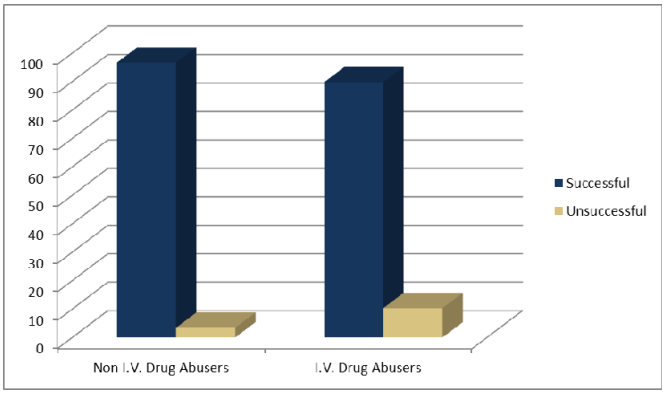

Fig. 2. IV drug abuse and result of cannulation.

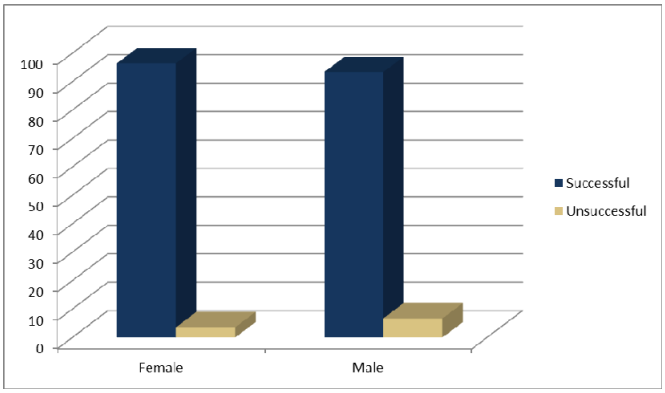

Fig. 3. Result of cannulation in men and women.

and we waited for expert surgeons to indicate patients for surgical approaches and then as mentioned above, we used our method as the last pre-operational step for those patients.

Finally, we concluded that this procedure would be a cost effective, less invasive replacement that may be used as the first line for patients with difficult venous access before other alternative procedures.

More evaluation with more cases are necessary to prove its safety and to find all the complications and their frequency. Studies are also needed to compare the success rate when the procedure is performed by different operators.

Anyway, as the procedure is cost-effective and time-saving and has high success rates and minimal complications in our study and previous studies, we recommend the procedure to be used as the first step for patients with difficult venous access before other more invasive alternatives.

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