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Difficult Intravenous Access and Its Management

Handan Eren

Abstract

Difficult intravenous access (DIVA) may occur due to several factors, such as the demographic and clinical characteristics of the patients (age, sex, height, weight, ethnicity, IV drugs history, and medical history), health professional's experience, device characteristics, site of insertion, and vein characteristics. Difficult intravenous access leads to repeated insertion attempts that might prove to be uncomfortable for the patients, frustrating and challenging for the health professionals, and expensive for the health institutions. The practitioners must develop the awareness of the factors capable of increasing the difficulty of defining the appropriate vein for cannulation through their varied experiences with vein location and vascular access.

Keywords: difficult cannulation, patient, practitioner

1. Introduction

Difficult intravenous access (DIVA) is defined as a catheter insertion condition when the catheter cannot be entered into the vein in one attempt [1]. A published systematic review and meta-analyses reported a failure rate of up to 30% on the first attempt of peripheral intravenous cannulation [2]. Other research identifies a failure rate ranging from 10%–40%, which is consistent with the findings from a study by Witting (2012), who reported that 39% of first time attempts at peripheral intravenous cannulation (PIVC) failed [3, 4].

DIVA may occur due to several factors and lead to multiple repetitive attempts to gain peripheral venous access, which causes the patients to experience pain and anxiety and the healthcare professionals to feel inadequate [1]. In addition, as the number of materials used in the repetitive attempts increases and the treatment plan for the patient is delayed, the patient care costs also increase [5, 6]. Therefore, it is crucial for healthcare professionals to be aware of the factors that may lead to this condition, including several negativities, to understand how to manage it [7, 8]. The guidelines available for peripheral intravenous insertion mainly focus on site selection and insertion, and there is a lack of established guidelines on how to recognize or manage DIVA [1, 9–11]. In this context, the present study was aimed to provide basic information regarding the risk factors for difficult peripheral intravenous cannulation and its management.

2. Individual factors

The individual risk factors associated with DIVA are age, gender, ethnicity, body mass index, health status, medical history, and vein characteristics of the patients [7, 12–14].

2.1 Age

The age of the individual might affect the intravenous catheter insertion. With increasing age, the vein diameter expands, thereby increasing the visibility and palpability of the veins [13, 15]. Therefore, it could be relatively difficult to determine the appropriate vein in neonates and children. According to the literature, the success rate of catheter insertion in the first attempt observed in the pediatric clinics varies between 44% and 86% [15, 16]. However, similar rates are observed in older ages. This might be because of the decreased elasticity of the blood vessels at an advanced age, which could contribute to DIVA. In the studies conducted by Van Loon et al. with 3586 participants and by Armenteros-Yeguas et al. (2017) with 135 participants, no relationship between the age of the individuals and DIVA was observed, although DIVA was observed to be related to the presence of chronic disease and medical treatment. The increased possibility of chronic diseases in advanced age would result in a medical treatment history, leading to DIVA [12, 13].

2.2 Gender

Studies have reported that gender is a risk factor for difficult venous access. Jacobson and Winslow (2005) reported that catheter insertion procedure is more difficult in women compared to men. This could be explained by the smaller caliber of peripheral veins in women [17]. Piredda et al. (2019) also reported gender as one of the risk factors for difficult venous access and that the procedure could be relatively difficult in women. In the same study, 99.4% of the women who underwent lymph node dissection experienced DIVA, suggesting an association; the multivariate analysis conducted in the study revealed that lymph node dissection did not exert a statistically significant effect on difficult cannulation [7].

2.3 Ethnicity

Individuals with different ethnicities may have different skin colors, and peripheral intravenous cannulation (PIVC) might be difficult in certain individuals of particular skin color. A narrative review published in 2010 by Sabri et al. reported an association between skin color and DIVA [18]. Jacobson and Winslow (2005) also reported that catheter insertion was more difficult in individuals with dark and/or tough skins [17].

2.4 Body mass index

Body mass index (BMI) is a measure of body fat based on the height and weight of the individual. An increase in weight may cause an increase in the adipose tissue and, therefore, a decrease in the visibility of the veins, rendering the catheter insertion difficult [14, 17]. Several studies have reported body mass index as a risk factor for difficult catheter insertion [7, 13, 14]. Sebbane et al. (2013) reported that underweight patients (BMI < 18.5 kg/m²) face a higher risk of DIVA. They stated that this

result may be related to vein mobility [19]. However, Lapostolle et al. (2007) found no association with BMI and IV failure [20]. Fields et al. (2014) also did not find an association between obesity and DIVA [21]. This results may be related to patients characteristic.

2.5 Patient's health conditions

It is reported that the physiological and psychological conditions of the individuals exert an effect on their venous structure [12, 14]. It is elucidated that certain chronic diseases may cause the deterioration and hardening of the vascular structure, rendering the catheter placement process difficult. Cancer, diabetes mellitus, and vascular diseases are among the conditions that render vein access difficult [7, 13, 14]. Intravenous chemotherapy treatment or surgical procedure/dissection of the lymph nodes associated with breast cancer reduces the visibility and palpability of the veins. Furthermore, circulation problems, which are among the advanced complications of diabetes mellitus, and conditions such as coronary artery disease and the associated medical treatments, may directly cause the deterioration of the vein structure [7, 8, 12, 17]. Loon et al. (2019) reported that diabetes mellitus and chemotherapy treatment were associated with forced catheter intervention [13]. Piredda and colleagues (2019), as well as Carr and colleagues (2016), stated that the treatments of diabetes, venous disease, and cancer are closely associated with the difficult catheter intervention as they cause the reduction of blood vessel diameter [7, 17].

Dehydration is another risk factor for difficult catheter insertion as it causes the blood volume to decrease and the venous pressure to decrease, thereby rendering the detection of veins and consequently catheter insertion difficult. Dehydration is reported to lead to repeated catheter interventions [22]. However, in the study conducted by Sharp et al. (2018), a decrease of 0.57 mm in the diameter of the median cubital vein and 0.33 mm in the diameter of the cephalic vein was observed after oral rehydration. This could be related to the fact that drinking water may stimulate the sympathetic nervous system, which would then decrease the vessel diameter [23].

Emotional conditions of the individuals may also affect catheter intervention. Anxiety may lead to peripheral vasoconstriction, thereby increasing the difficulty of cannulation [24]. Having the patient lie in the during catheterization, using the muscle tensing technique, informing the patient regarding the procedure, and gaining the patient's confidence are a few factors that may reduce anxiety in the patients prior to the procedure, enabling better cannulation [25].

2.6 Patient's medical history

Medical histories of the individuals, particularly the previous history of difficulty with punctures or insertion of catheters, may be the risk factors for DIVA due to their effect on the vascular structure [13, 14]. Intravenous chemotherapy treatment is one of the most serious causes of the disruption of the vascular structure. Chemotherapy drugs (vesicants, irritants) cause complications such as phlebitis, infiltration, extravasation, thrombophlebitis, and septicemia, manifesting as pain, redness, ulceration, and necrosis along the vein, and stimulate the sympathetic nervous system, thereby causing the vessels to contract and decreasing their fullness and visibility [26]. Similarly, fluids with high osmolality, the blood, and the blood products may damage the vascular endothelium. Repeated attempts of these treatments may be a risk factor for DIVA [27].

2.7 Vein characteristics

The vascular structure may differ from individual to individual. The diameter, visibility, palpability, and superficiality (or depth) of the vein are important factors to be considered when determining the appropriate vein for PIVC [8]. A vein with a wide diameter is easily visible and palpable. Van Loon et al. reported that non-palpable invisible veins and the veins less than 3 mm in diameter after tourniquet application lead to DIVA [13]. Jacobson and Winslow (2005) reported that failed IV insertions were associated with higher degrees of difficulty arising from vein a variable, such as vein rolled or vein was resistant to puncture.

3. Factors related to health professionals

It is reported that difficult peripheral intravenous cannulation affects 10%–24% of all hospitalized adults and is associated with higher rates of catheter failure. This situation may lead to several complications, such as phlebitis, extravasation, hemorrhage, catheter-related infection, and sepsis [6, 18]. In order to prevent these complications, healthcare professionals must be aware of the risk factors for DIVA. The practitioners' knowledge and skill regarding catheter insertion and their clinical experience are the health professional-related factors for difficult cannulation [7, 14]. The literature states that the experience of the practitioner with catheter insertion is associated with forced catheter intervention. Rippey et al. (2016) reported that the practitioner's experience influenced the success of catheter placement in a single attempt [28]. Van Loon et al. (2019) reported that the prediction that the practitioner might have a difficult catheter intervention was associated with DIVA [13]. Rodriguez-Calero et al. (2020) reported no relationship between the clinical experience of the practitioners and DIVA and stated that catheter insertion could only be associated with the patients and their treatment [14].

The success of vascular access and conducting the procedure in a short duration are important for patient safety and satisfaction. Determining the appropriate vein, using the appropriate materials, and placing the catheter with the right technique would make the procedure convenient for both patient and the healthcare professional. Therefore, the practitioners must possess adequate knowledge and skills of cannulation [29, 30].

4. Management of difficult venous access

PIVC is expected to be performed in a single attempt. In the cases where the catheter cannot be inserted in a single attempt, it is recommended to limit the number of insertions by a single practitioner to two [29]. However, this is not possible in certain cases. Therefore, determining the appropriate vein and the appropriate catheter and using the most appropriate technique to access the vein is important for the prevention and control of DIVA caused due to factors related to either the patient or the practitioner [8, 11, 14, 18].

4.1 Assessment of the appropriate vein in difficult venous access

Determining the appropriate vein prior to catheter insertion is important for performing the procedure conveniently. Plump veins are distinctly visible and palpable, and therefore, easier to detect. In order to determine if the catheter insertion procedure would be challenging, the veins should be graded. Certain vein

grading scales have been developed for application in adults and pediatric patients [13, 31, 32]. The Adult Difficult IntraVenous Access (A-DIVA) scale developed and updated by Van Loon et al. (2019) includes a known history of difficult intravenous access, an expectation of difficult intravenous access by the practitioner prior to the intravenous cannulation, the inability to detect a dilated vein through palpation and/or visualization of the extremity, and a target vein diameter of less than 3 mm. A higher score on the A-DIVA scale indicates a higher risk of difficult intravenous access [13] (**Table 1**). In the vein grading scale developed by Lenhardt et al. (2002) the following factors were included: 1) The veins are completely invisible and not palpable; 2) The veins are visible although not palpable; 3) The veins are hardly visible although palpable; 4: The veins are visible and palpable; 5) The veins are distinctly visible and palpable. This scale may be used to evaluate the veins, although access to the veins rated 1 on this scale could be rather difficult [32].

Vein grading/assessment scales for small patient groups are different. The Difficult IntraVenous Access (DIVA) scale developed by Yen et al. (2008) included the visibility and palpability of the vein, and the age, skin color, and premature status of the patients as evaluation parameters. The obtained scores ranged from 0 to 11. If the obtained score was four or higher, it indicated difficult vascular access with a 50% probability of failure [31]. The scale was reviewed by Riker et al. (2011) who reduced the parameters to only 3, namely visibility of vein, palpability of vein, and age of the patient. The scale has also been adapted to the Turkish population by removing the parameter of skin color. The prediction of whether the procedure would be difficult prior to the PIVC is crucial as it prevents possible complications (**Table 2**) [31, 33]. Therefore, it is recommended that healthcare professionals use these scales [29].

The more visible and more palpable the vein preferred for PIVC, the more convenient the procedure would be. Dorsal metacarpal veins, basilica, and cephalic veins are the frequently preferred ones for PIVC. In particular, for ongoing intravenous treatments, the IV entry site should be located distal to the arm, and each attempt should be further proximal compared to the next attempt. Leg and foot veins should be avoided as much as possible due to the risk of lower extremity embolism involved [34]. However, this order of vein preference may change in the cases where veins are not easily visible and palpable. If there is a possibility of difficult cannulation, the upper arm basilica vein should be preferred because of its larger diameter. However, since this vein might be deep-seated, its visibility could be low; in which case; the procedure should be performed using palpation or vein imaging systems [35].

Another frequently preferred vein to avoid difficult venous access is the ante-cubital vein. The large diameter and the superficial location of this vein render it easily visible or palpable. However, with this vein, catheter stabilization could be difficult as this vein is located in the elbow joint [34]. Panebianco et al. (2009) reported that, with an increase in the diameter of the veins (92% success at 0.6 cm)

Factor	Score
Is there a known history of a difficult intravenous access?	1
Do you expect a failed first attempt or a difficult intravenous access?	1
Is there an inability to identify a dilated vein by palpating the upper extremity?	1
Is there an inability to identify a dilated vein by visualizing the upper extremity?	1
Has the largest dilated vein a diameter less than 3 millimeters?	1

Table 1.
The additive A-DIVA scale [13].

Predictor variable	Score		
Visibility	Visible = 0		Not visible = 2
Palpability	Palpable = 0		Not palpable = 2
Age	≥36 months = 0	12–35 months = 1	<12 months = 3
Prematurity	Not premature = 0		Premature = 3
Skin shade	Light = 0	Dark = 1	

Table 2.
DIVA score [33].

and within the vein depth range of 1.2 to 1.4 cm, the success of catheter placement increases. An ultrasound device should be used to determine the diameter and the depth of the veins [36].

4.1.1 Techniques to increase vein visibility in difficult venous access

The literature recommends the use of ultrasound and vein imaging devices for the detection of veins with low visibility and palpability. Information regarding the diameter and the depth of the veins may be obtained using the ultrasound technique. Previous studies have demonstrated that the use of an ultrasound device increased the rate of successful catheter placement at the first attempt, particularly in difficult venous access [16, 37]. Moreover, it is reported that the use of vascular imaging devices, which enables the visualization of the veins using infrared rays, prior to the procedure is particularly effective in pediatric patients and the individuals with impaired vascular structure receiving intravenous chemotherapy treatment (**Figure 1**) [1, 18, 30]. Eren (2018) reported that the use of a vein imaging device in patients with difficult venous access significantly shortened the time to determine the appropriate vein compared to the use of a tourniquet and fist-clenching techniques [30]. In a study carried out by Caglar et al. (2019) with preterm infants, it is found that success of the first attempt was significantly higher in the infrared and transilluminator groups than in the control group ($p \leq .05$). It is also found that time to successful cannulation was significantly lower for the infrared group (8.70 ± 2.56 seconds) than for the transilluminator group (45.27 ± 30.83 seconds) and the control group [38]. Considering the patient outcomes of studies conducted using the ultrasound device, ultrasound guidance increases the likelihood of successful peripheral cannulation in difficult access patients. Ultrasound guided peripheral IV catheter placement has a greater success rate with fewer skin punctures, decreased time for IV catheter placement, and fewer complications [39, 40]. Chiriloco et al. (2015) reported that first attempt success was 85% with using ultrasound at 200 patients with DIVA. They also said that patient satisfaction was higher in ultrasound guided vascular access group than traditional peripheral venous catheter insertion group [41]. In summary, ultrasound guided insertion significantly improved first attempt success rates and demonstrated higher patient satisfaction scores when compared to conventional venous catheter use.

Besides these techniques, tourniquet application, hot application, topical vasodilator application, fist-clenching, holding the arm below the chest level, hitting the vein, and massaging may be used to make the veins fuller for easier vein determination [30, 32, 34, 38, 42–44]. Tourniquet application is one of the most commonly used techniques for vein determination. The literature recommends the use of a sphygmomanometer rather than a tourniquet for the individuals with sensitive/fragile veins and those with a risk of difficult venous access. It is suggested to inflate

Figure 1.
PIVC used with vein imaging device.

the manometer to the level of the individual's diastolic blood pressure [38, 43]. Nitroglycerin, a topical vasodilator, increases the visibility of the vein, although it may not be suitable for every patient as it is absorbed into the skin [45]. Another technique, named hot application, assists in expanding the veins to make them fuller. Studies have demonstrated that hot application facilitates vein detection and catheter insertion in patients with DIVA [43, 46].

4.2 Determination of the appropriate catheter and vein entry angle in difficult venous access

The size of intravenous catheters [14, 15, 18, 21, 23, 25] is referred to as the gauge. The diameter and the length of the cannula vary with the size of the catheter. As the number/size of the catheter increases, the cannula diameter decreases. In addition, different lengths are available for the catheters of the same size [29, 34]. Generally, a 20-gauge to a 24-gauge catheter is preferred for peripheral catheterization. Peripheral catheters larger than 20 gauge in size are more likely to cause phlebitis. A 22 to 24 gauge catheter for neonates, pediatric patients, and older adults generally minimizes the insertion-related trauma. A 20-gauge to 24-gauge catheter should be used based on the vein size for blood transfusion; when rapid transfusion is required, a larger-size catheter gauge is recommended [29].

The catheter should be placed at an angle of 10–30 degrees to the skin, and after entering the vein at the PIVC, the angle should be reduced. However, the veins that are superficial, thin, slippery, and present a risk of difficult venous access should be entered at an angle of 30–45 degrees to the skin, from the lower side of the entry

point and parallel to the vein, and immediately after entering the vein, the angle should be reduced to 15 degrees [34]. In the process of catheter placement with the assistance of the ultrasound technique, if a vessel is 16 mm deep and is entered at a 45° angle to the vein, then a catheter with a minimum length of 23 mm is required to reach the vessel. At a 30° angle, the catheter would have to be 32 mm to reach the anterior wall of the vessel [36].

5. Conclusion

Difficult venous access is characterized by non-visible and non-palpable veins and is caused by the various patient- and practitioner-related factors, such as age, obesity, history of chemotherapy, and vein characteristics of the patients, and the clinical experience of the practitioners [1, 7, 8, 12]. Understanding these factors for DIVA may facilitate the management of difficult venous access and improve patient outcomes in this population. In difficult intravenous catheter intervention, determining the appropriate vein and placing the catheter with the appropriate technique is required. Evaluation of veins before catheter insertion is crucial in determining the appropriate vein. For this, vein grading scales should be used [31, 32, 47]. Techniques to increase vein fullness (e.g. fist clenching, hot application, topical vasodilator, tapping) can be used to determine the vein, or ultrasound and vein imaging devices can be used to view veins [2, 23, 30, 35, 43, 46]. In addition, difficult venous access guidelines, which are limited in the literature, need to be developed.

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