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Research Article

Evaluation Factors Affect Difficult Intravenous Access in the Prehospital Setting

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ABSTRACT

Background: Environmental factors such as the lighting of the scene, time of the day, and physical surrounding of the patient and healthcare providers in the prehospital setting can affect difficult intravenous access (DIVA). The study aimed to evaluate the association of environment, patient, and emergency medical services (EMS) technicians on the DIVA in the prehospital setting.

Methods: Six-hundred adult patients (aged ≥18 years) who necessitated prehospital peripheral IV access and were transferred to the Sina and Shariati hospitals by EMS technicians from June 2018 to October 2018 were included. There were seven research nurses for interviewing the EMS technicians. Patients were examined using the prepared checklists.

Results: Overall, there were 125 (20.83%) DIVA cases. There was a significant relationship between DIVA and the higher respiratory rate of the patients, lower the blood pressure of the patient, prior cannulation of the targeted limb, time since the last meal of EMS technician, and untidiness of the environment (Odds Ratio=1.75, 1.3, 9.4, 3.84 and 7.01, respectively).

Conclusion: The results showed fasting of EMS technicians affects DIVA and the study suggests it can be resolved by proper scheduling of the working hours of EMS technicians. Also, some risk factors of DIVA can help the paramedics to predict the DIVA and take the necessary measures.

Peripheral intravenous (IV) cannulation is a frequent procedure in hospital and prehospital emergencies [1]. Although the procedure is safe, it is not risk-free, and the risk of potential complications increases with a higher number of venipuncture attempts [2]. DIVA is defined as more than two attempts in many studies [3]. After the third attempt, the incidence of complications increases six-fold [2]. These Complications include leakage, injection site bruising, vessel thrombosis, thrombophlebitis, extravasation, local infections resulting in bacteremia and septicemia, delay in the administration of medication in life-threatening patients, and placement of central venous lines as alternative access that imposes higher risks on patients [1-2]. Also, DIVA can cause the wasting of hospital equipment such as IV cannula, gloves, dressings, etc., and increasing the length of hospital stay [4].

Studies showed that approximately one out of four patients would need more than one attempt for intravenous cannulation in the prehospital situation [5]. Outcomes failure rates of DIVA in adults vary in the studies, ranging from 10-40% in emergencies and 25-33% in non-emergent situations [1]. Also, the rate of complications in patients receiving Peripheral intravenous therapy is 10-25% [4].

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According to the prior studies, predictive factors for DIVA are poor personal hygiene of the patient, the larger caliber of the catheter, past difficulty with IV access, diabetes, sickle cell disease, history of IV drug abuse, obesity, cachexia, previous chemotherapy, burns, and limited experience of health care providers [5]. Jacobson & Winslow [6] assessed DIVA risk factors, including vein characteristics, patient movement, and dehydration. A multicenter validation study was reported an adult DIVA scale that predicts the likelihood of a DIVA in adult patients. This scale consists of five variables, including an inability to detect a suitable vein for cannulation by palpation or inspection of the extremity, a vein diameter of two millimeters or less, a known history of difficult intravenous access, and an emergency indication for surgery [7].

Environmental factors such as the lighting of the scene, time of the day, and physical surrounding of the patient and healthcare providers in the prehospital setting can affect DIVA. The study aimed to evaluate the association of environment, patient, and EMS technicians on the DIVA in the prehospital setting.

Methods

Design

This cross-sectional study was conducted from June 2018 to October 2018 on patients transferred to Sina and Shariati hospitals in Tehran. A checklist to assess the factors related to the DIVA was used.

A multidisciplinary group of two board-certified emergency physicians, two senior emergency nurses, and three senior EMS technicians have searched the literature to identify the factors related to the DIVA.

A multidisciplinary group of two board-certified emergency physicians, two senior emergency nurses, and three senior EMS technicians have searched the literature to identify the factors related to the DIVA. Then, a checklist included of these identified factors in three categories was utilized. 1. Factors related to the environment: quality of light, cannulation at night or day time, warm temperature, indoor or outdoor cannulation, 2. Factors related to the patient: Age, gender, cannulation in sitting or supine position, history of surgery on the site of cannulation, wearing much or few clothes, quality of personal hygiene, heart rate, blood pressure, respiratory rate, body temperature, oxygen saturation, Glasgow coma scale (GCS), history of chronic medical diseases, cooperation with EMS technicians, and 3. Factors related to the EMS technician: job experience, time since the beginning of the shift, time since the last meal, physical or verbal dispute with patient or guardians, and using sterile gloves.

DIVA was defined as two unsuccessful attempts in establishing IV access. An IV attempt was defined as a needle penetrating the skin. Successful IV criteria were defined as 1. Blood flow through the cannula, 2. No resistance to isotonic saline infusion, and 3. No swelling formation on the skin. Participants were categorized into two groups comprising of DIVA and non-DIVA.

The protocol was approved by the ethics committee of the Tehran University of medical sciences (Reference No: 43055300297). Informed consent was obtained from all participants, and Patients data were preserved anonymously.

Guidelines of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) for cross-sectional studies were used for reporting the research.

Participants

Six-hundred adult patients (aged ≥18 years) who necessitated prehospital peripheral IV access and were transferred to the Sina and Shariati hospitals by EMS technicians from June 2018 to October 2018 were included. EMS technicians or patients who refused to participate were excluded.

Data collection

After EMS technicians handed over the patients to the triage of a hospital, EMS technicians were interviewed by the seven nurses.

Sample size

Two university-affiliated referral urban hospitals to perform the survey was targeted.

Considering a study by Fields et al [8], the prevalence of DIVA was considered %10. Hence, with a significant level of 0.05 and a precision of %2.5, the final sample size was 576 participants. But due to more confidence, 600 cases were included. Also, the required sample size for assessing the relationship between variables was less than 100. However, assessment of DIVA prevalence was one of the secondary purposes of this study.

Data analysis

SPSS (Version 22.0, SPSS Inc., and Chicago, IL, USA) was used to analyze the data. K–S test was used to assess the normality assumption for continuous variables. Chi-square test and Fisher's exact test were used to analyse the qualitative data. The Student's t-test or the Mann-Whitney U-test was used for continuous variables. Multivariate logistic regression was performed to identify effective factors. A P value < 0.05 was considered as the level of significance.

Results

Of 600 patients included in the study, there were 125 (20.83%) DIVA cases.

Factors related to the Patient

The mean age, heart rate, and respiratory rate were significantly higher in the DIVA cases than Non-DVA (P=0.03, P=0.001, and P=0.001, respectively).

DIVA patients had lower systolic and diastolic blood pressure (P=0.001 and P=0.001, respectively). There was a significant relationship between DIVA status and sex, uncooperative patient, critical status, prior cannulation, chronic heart disease, lung disease, history of other chronic diseases, history of surgery or trauma on the

target limbs (P=0.03, 0.001, 0.001, 0.003, 0.01, 0.001, 0.001, and 0.001, respectively) (Table 1).

The mean time since the last meal of the EMS technician was 9±6 and 6±5 hours in the DIVA cases and the non-DIVA cases (P=0.004). The time since the last meal of the EMS technician was significantly longer in the DIVA group than in the non-DIVA cases (Table 2).

Table 1- Factors related to the patient in the DIVA and non-DIVA patients.

Variable	Participants n(%)		P value
	Non-DIVA 475 (79.17)	DIVA 125 (20.83)	
Age (Mean± SD)	40±12	43±25	0.03
Gender n(%)			0.03
Male	365 (76.8)	84(67.2)	
female	110(23.2)	41(32.8)	
GCS			0.08
> 13	463(97.5)	125(100)	
< 13	12(2.5)	0(0)	
Heart rate/min (Mean± SD)	84±7	98±28	0.001
Respiratory rate/min (Mean±SD)	18±3	24±7	0.001
Systolic blood pressure mmHg (Mean± SD)	130±20	100±25	0.001
Diastolic Blood pressure mmHg (Mean±SD)	80±14	65±20	0.001
Oral Temperature cc n(%)			
>37	93(19.6)	26(20.8)	0.95
36-37	375(78.5)	97(77.6)	
<36	7(1.5)	26(20.8)	
Oxygen Saturation (Mean±SD)	97±2	94±7	0.001
Patient position during cannulation n(%)			
sitting	172(36.2)	55(44)	0.11
supine	303(63.8)	70(56)	
History of surgery on the target limb n(%)	45(9.5)	5(40	0.05
Edema on target limb	37(7.8)	8(6.4)	0.06
Amount of Clothing n(%)			
Too much	24(5.1)	13(10.4)	0.05
Normal	451(94.9)	112(89.6)	
Poor hygiene	96(20.2)	17(13.6)	0.09
Cooperation during cannulation n(%)			
Cooperative	409(85.9)	72(57.6)	0.001
Noncooperative	66(13.9)	53(42.4)	
Critical status n(%)	53(11.2)	59(47.2)	0.001
Prior cannulation at target limb n(%)	71(14.9)	33(26.4)	0.003
Chronic heart disease n(%)	85(17.9)	35(28)	0.01
Chronic lung disease n(%)	36(7.6)	29(23.2)	0.001
Other chronic diseases n(%)	140 (29.5)	56(44.8)	0.001
Skin disease n(%)	6(1.3)	1(0.8)	0.55
History of trauma in target limb n(%)	152(32)	62(49.6)	0.001
Cardiac arrest n(%)	11(2.3)	6(4.8)	0.14

Table 2- Factors related to the EMS technician

Variable	Participants n(%)		P value
	Non-DIVA 475 (79.17)	DIVA 125 (20.83)	
Job experience/year(Mean ± SD)	8±6	9±7	0.92
The elapsed time of the working shift/hour (Mean ± SD)	8±7	12±10	0.07
Time since the last meal/hour (Mean ±SD)	6±5	9±6	0.004
physical or verbal dispute with patient or guardians n(%)	41(8.6)	16(12.8)	0.16
Using sterile gloves while cannulating n(%)	421(88.6)	117(93.6)	0.1

Factors related to the EMS technician

The mean time since the last meal of the EMS technician was 9±6 and 6±5 hours in the DIVA cases and the non-DIVA cases (P=0.004). The time since the last meal of the EMS technician was significantly longer in the DIVA group than in the non-DIVA cases (Table 2).

Factors related to the environment

The frequency of good lighting of the scene, cannulation at night, location of cannulation, and Untidiness of the environment was significantly higher in the DIVA patients than in the non-DIVA patients (P=0.03, 0.04, 0.001, and 0.001, respectively) (Table 3).

In a logistic regression model, the results showed that there was a significant relationship between DIVA and the higher respiratory rate of the patients, lower the blood pressure of the patient, prior cannulation of the targeted limb, time since the last meal of EMS technician, and untidiness of the environment (Odds Ratio=1.75, 1.3, 9.4, 3.84 and 7.01, respectively) (Table 4).

Table 3- Factors related to the environment

Variable	Participants n(%)		P value
	Non-DIVA 475 (79.17)	DIVA 125 (20.83)	
Lighting n(%)			
Good	326(68.6)	73(58.4)	0.03
Poor	149(31.4)	52(41.6)	
Time of the day n(%)			
Day	345(72.6)	79(63.2)	0.04
Night	130(27.4)	46(36.8)	
Location n(%)			
Indoor	127(26.7)	58(46.4)	0.001
Outdoor (subway, moving ambulance, Stand still ambulance, etc.)	190(40)	34(72.2)	
The temperature of the environment n(%)	29 (6.1)	11(8.8)	0.07
warm	446 (93.9)	114 (91.2)	
Normal or cool			
The untidiness of the environment in which cannulation was done	80 (16.8)	41(32.8)	0.001

Table 4- Multivariate logistic regression model of factors related to the DIVA

Variable	P value	Odds ratio
Reparatory rate of the patient	0.04	1.75
Blood pressure	0.04	1.3
Prior cannulation of the target limb	0.02	9.4
Time since Last meal of the EMS technician	0.01	3.84
the untidiness of the environment in which cannulation was done	0.03	7.01

Discussion

DIVA is a frequent clinical challenge for health care workers [9]. The prevalence of DIVA was reported between 1.4% to 56% [5,9-10]. In the current study, it was 20.8% in the prehospital setting. One of the most important reasons for high spectrum differences between reports is the various definition of DIVA in the studies. However, the standard definition of "more than two attempts" was used in the most previous studies [3,11-12]. Also, the prehospital or hospital setting can influence the prevalence of DIVA. The insertion of the IV line is more difficult in the prehospital setting [13].

Studies identified various factors related to DIVA, including characteristics of the veins [6,14], venipuncture attempts before the current hospitalization, and the presence of chronic conditions [15-16].

Factors such as the light of the environment, noise pollution, the mental and physical function of the healthcare provider might affect the IV line insertion. In the current study, environmental, patient, EMS technicians factors were evaluated.

The results of the current study showed DIVA was related to an older age. Studies showed elderly patients who had small, fragile blood vessels had a higher risk of DIVA [3-4]. However, likely, age is not a risk factor per se, because older age is associated with other risk factors, such as aging-associated disease [1].

Also, the female gender was associated with DIVA [6]. This finding is consistent with the current study. It might be due to a smaller vein caliber in female patients.

Furthermore, women tend to be more affected by the osteoarticular disease, and this disease was found to be significantly associated with the risk of difficult venous access [4].

Patients with DIVA had more chronic cardiac and pulmonary diseases. Maybe one of the causes of the relationship between chronic diseases like diabetes and hypertension with DIVA is the necessity of frequent medical attention as well as their direct effect on the vascular system [17-18]. Some studies considered chronic illnesses as a potential risk factor for DIVA, but without specifying the number or type of conditions [19-20].

Similar to a recent study [21], the current study showed a history of cannulation on the target limb had the highest correlation with DIVA. Studies also revealed that one of the most common reasons for DIVA is repetitive vascular trauma [3]. The prior history of catheterization to predict the difficulty of venous access in patients should be considered. Although it may not be easy to assess this history, it is a better predictor of DIVA than the current condition of the patient [8].

In the current study, DIVA patients had a higher heart rate and respiratory rate. Also, they had lower systolic and diastolic blood pressure. Vital signs, respiratory rate, and blood pressure had an independent correlation with DIVA. Some studies emphasized that fluid status (hypovolemia, hypervolemia) was moderately correlated with DIVA. Those factors influence IV access due to their impact on the visibility and accessibility of blood vessels [3]. Also, polytrauma patients and patients in shock are at an increased risk for DIVA due to hypotension and/or hypovolemia [7]. The current study found uncooperative patient can increase the possibility of DIVA, which is in agreement with other studies [8,19]. Also, the results of the current study suggest an influence of too much clothing on increasing DIVA. Other studies confirmed this finding [22].

Although the history of limb surgery was significant in univariate analysis, it was not identified as a significant factor in a multivariate analysis. In previous researches, limb edema was the factor that received high ratings by the nurses and was recognized as a significant risk factor of DIVA [1]. It is possible that in the current study, patients with a history of limb surgery, edema, or obesity, were managed by more experienced healthcare providers. Therefore, in these cases, we had a higher success rate.

In the present study, there was no significant difference between DIVA and non-DIVA patients in terms of patient position during cannulation (sitting or supine), poor patient hygiene, and history of skin diseases.

The time since the last meal of the EMS technician was significantly longer in the DIVA cases. Fatigue and decreased concentration due to the fasting can describe this association [23]. The current study showed the experience of the healthcare worker was not associated with DIVA, while many studies identified it as a significant risk factor [24-25]. For instance, Winslow and Jacobson assessed 339 IV insertions by 34 registered nurses in hospitalized patients. They found that nurses who had more years of experience were certified in a specialty and rated themselves higher in insertion skill had more successful insertions significantly than their younger and less-experienced, less-skilled counterparts [6].

Three factors, including a physical or verbal dispute with patients or guardians, using sterile gloves while cannulating, and elapsed time of the working shift, were not associated with DIVA.

In the DIVA cases, poor lighting of the scene (quality of the light during cannulation reported by participants), cannulation at night, location of cannulation (Indoor or outdoor), and untidiness of the environment were significantly correlated with DIVA, but the temperature of the scene did not influence DIVA. The only independent parameter was the untidiness of the environment that the cannulation was done.

Finding a few independent variables in the current study confirms that the relationship between the variables is complicated and does not permit a definitive conclusion.

Some limitations in the present study should be considered in future studies. One of these limitations is that we overlooked some factors that have been considered in previous studies, including catheter gauge and length, weight, and body mass index of the patients [5,7,11,26]. Another limitation that is observed in cross-sectional studies is recall and selection bias. Participants' statements can lead to a variety of reporting and even selective biases. Also, all surveys by questionnaires might be influenced by subjective selection bias [13].

Conclusion

The results showed that DIVA was correlated with higher respiratory rate and lower blood pressure of patients, history of prior cannulation in target limb, the fasting of EMS technicians, and untidiness of the environment in which cannulation was done. Also, history of prior cannulation, the untidiness of the environment, and fasting of EMS technicians had the highest relationship with DIVA in the prehospital setting.

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