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BRIEF REPORT

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Prospective evaluation of peripheral venous access difficulty in emergency care

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Abstract *Objective:* Although frequently used and crucial in emergency care, peripheral intravenous access has been poorly documented. We examined whether criteria related to patient characteristics, underlying disease, devices, or environment were associated with difficult peripheral intravenous access. *Design and setting:* Prehospital prospective observational study. *Participants and measurements:* For each peripheral intravenous access attempt a questionnaire was filled in until final success or procedure abandonment. This questionnaire included data on the patient, operator, disease, degree of emergency, cannulation, nature of fluid infused and the use of gloves, environment, and particular medical observations such as recent peripheral intravenous access and chemotherapy. Criteria associated with peripheral intravenous access difficulty were identified comparing successful and unsuccessful attempts. A total of 671 attempts at peripheral intravenous access in 495 patients were studied. *Results:* The first attempt was successful in 368 cases (74%) and unsuccessful in 127 (26%). Final success was reported in all cases, including the use of central venous access in three cases. No abandonment was reported. Significantly correlated with a successful attempt were: the caliber of the catheter (OR 0.793), cannulation performed by a nurse specialized in emergency care (OR 3.959), lack of particular observations (OR 0.120), and a clean patient (OR 0.505). *Conclusions:* Peripheral intravenous access was achieved in 99% of the patients in out-of-hospital settings. Improved success rate was reported when attempts were performed by a nurse specialized in emergency care using a 16- or 18-G catheter in clean patients without a particular medical history.

Keywords Emergency care · Peripheral venous access

Introduction

"My kingdom for an intravenous line", Orlowski [1] once said; how right this is, particularly in the field of emergency medicine. Although very frequently used and sometimes crucially, peripheral intravenous (IV) access for patient management is still poorly documented [2]. Circumstances associated with difficult IV access remain unidentified. Consequently recommendations to optimize prompt IV access in emergency care are not available. The aim of our study was to identify whether criteria related to the patient, operator, underlying disease, devices, or the environment were associated with difficult peripheral IV access.

Materials and methods

We conducted a prospective observational study in the prehospital setting in the Seine-Saint-Denis region northeast

of Paris, an urban area with 1.3 million inhabitants. The general context for the study was the French emergency medical system [3]. In France out-of-hospital medical emergencies are managed by the Service d'Aide Médicale Urgente (SAMU). This public institution operates a permanent nationwide telephone service for contacting the regional emergency physician dispatcher of the SAMU. In cases of medical distress the dispatcher sends to the site an ambulance (mobile intensive care unit) stationed at various hospitals throughout the region, carrying an emergency physician, a nurse specialized in emergency care, a trained driver, and a student (nurse or medical). Because patient management was not altered in any way, neither specific informed consent nor ethics committee approval were required under French laws for this observational study.

During the 3-month study, 902 patients were managed in out-of-hospital settings, 583 of whom required IV access. The study was completed in 495 cases (85%). For every attempt at peripheral IV access a questionnaire was filled in. When the first attempt failed and was followed by a second attempt, a new questionnaire was filled in, and so on. This questionnaire included data on (a) the patient's age, sex, estimated weight, and height; (b) the operator's qualification (anesthesiologist, emergency physician, resident, specialized nurse in emergency care, nurse, medical student, other) and number of years of experience in emergency care; (c) the patient's clinical condition (circumstances, Glasgow Coma Scale, systolic arterial blood pressure, oxygen blood saturation, degree of emergency for IV access—classified as cardiac arrest, vital emergency, emergency, delayed emergency); (d) the caliber of the catheter and site of cannulation (hand, forearm, elbow, jugular, other); (e) the patient's location (home, outside, ambulance, other) and position (on a bed, seated, lying on the floor, other) and hygiene of the place and of the patient (spotless, clean, dirty, filthy) and its lighting (natural or artificial); and (f) particular relevant medical observations such as recent IV access and chemotherapy. Abandonment and the use of central venous access or bone venous access were considered as final failure of the peripheral venous access procedure. We recorded the duration of the procedure from application of the tourniquet until beginning the infusion or abandonment. Finally, difficulty was evaluated on a visual analogue scale ranging from "easy" to "difficult".

To identify criteria associated with peripheral IV access difficulty we compared successful and unsuccessful attempts at cannulation. Results are expressed as median and interquartile range (IQR). Quantitative data were compared using Fisher's test, and qualitative data using the Mann-Whitney test. Differences at the level of $p \leq 0.05$ were considered statistically significant. Univariate and multivariate analyses were performed using a logistic regression model (Statview 5.0, SAS Institute, Cary, N.C., USA).

Results

The first attempt at cannulation was successful in 368 (74%) cases and unsuccessful in 127 (26%). To obtain venous access in the remaining cases other attempts were performed, except in three cases for which central venous cannulation was needed. Central venous access was obtained in three patients after, respectively, two, three, and four attempts at peripheral venous access. No definitive abandonment was reported. The proportion of cannulations that were successful is reported in Table 1. No significant relationship between the order of attempt and successful cannulation was found. The median duration for IV cannulation was 2 min (1–5). The figure was 2 min (1–3) in cases of successful first attempts and 5 min (3–9) when further attempts were required ($p < 0.0001$). The median difficulty score assessed on the visual analogue scale after the first attempt was 3 (2–5) in cases of successful cannulation and 6 (3–9) in unsuccessful cases ($p < 0.0001$).

The success rate according to all the tested parameters is reported in Table 2. Particular relevant medical observations were reported in 24 cases (5%), with 70% failures at the first attempt of cannulation. These particular observations were chemotherapy in eight cases (five failures at the first attempt), diabetes in four cases (three failures at the first attempt), previous multiple hospitalizations in four cases (four failures at the first attempt), and eight other particular observations (four failures at the first attempt). Only initial Glasgow Coma Scale, qualification of the operator, caliber of the catheter, site of puncture, hygiene of the patient, and particular medical observations were significantly associated with successful attempts. Multivariate analysis was performed with the parameters significantly associated with successful IV cannulation in univariate analysis. Results are detailed in Table 3. Finally, cannulation performed by a nurse specialized in emergency care was positively associated with increased success rate; in contrast a smallest caliber of the catheter, particular medical observations and a dirty patient were associated with a decreased success.

Table 1 Proportion of successful cannulation by the number of attempts

	n	Successful attempt		Cumulative success %
		n	%	
First attempt	495	368	74	74
Second attempt[a]	127	89	71	92
Third attempt[a]	36	27	75	98
Fourth attempt[a]	8	5	63	99
Fifth attempt	3	3	100	99
Central venous access	3	3	100	–
Total	671	495	74	–

[a] Central venous access was obtained in three patients after, respectively, two, three, and four attempts of peripheral venous access

Table 2 Success rate of the first attempt at peripheral venous cannulation according to various tested parameters

	Successful	Unsuccessful	*p*
Patients characteristics			
Age (years) ($n = 488$)	60 (40–75)	60 (44–77)	0.40
Sex: M/F($n = 490$)	199 (74%)/165 (74%)	67 (26%)/59 (26%)	0.85
Body Mass Index ($n = 477$)	25.4 (22.0–29.4)	25.8 (22.2–29.3)	0.8
Glasgow Coma Scale ($n = 473$)	15 (13–15)	15 (9–15)	0.02
Systolic arterial blood pressure (mmHg) ($n = 469$)	130 (110–150)	130 (105–160)	0.95
Oxygen blood saturation ($n = 458$)	97 (92–99)	97 (90–99)	0.14
Agitation ($n = 493$)	28 (8%)	16 (13%)	0.10
Qualification of the operator ($n = 493$)			< 0.0001
Nurse specialized in emergency care	260 (82%)	55 (18%)	
Anesthesiologist, emergency physician	36 (71%)	15 (29%)	
Nurse student	20 (61%)	13 (39%)	
Resident/medicine student	31 (50%)	31 (50%)	
Other	19 (59%)	13 (41%)	
Experience in emergency care (years) ($n = 488$)	3 (0–9)	1 (0–8)	0.08
Circumstances ($n = 484$)			0.12
Cardiac disease	163 (74%)	57 (26%)	
Neurological disease	63 (68%)	29 (32%)	
Respiratory disease	56 (69%)	25 (31%)	
Traumatology	37 (82%)	8 (18%)	
Other	39 (85%)	7 (15%)	
Degree of emergency ($n = 488$)			0.55
Cardiac arrest	35 (76%)	11 (24%)	
Vital emergency	73 (69%)	33 (31%)	
Emergency	187 (75%)	62 (25%)	
Delayed emergency	67 (77%)	20 (23%)	
Caliber of the catheter ($n = 490$)			0.007
14G	8 (80%)	2 (20%)	
16G	35 (90%)	4 (10%)	
18G	185 (78%)	56 (23%)	
20G	134 (68%)	62 (32%)	
22G	3 (100%)	0 (0%)	
Site of cannulation ($n = 492$)			0.20
Hand	207 (72%)	82 (28%)	
Forearm	94 (78%)	22 (23%)	
Elbow	54 (76%)	17 (24%)	
External jugular vein	11 (92%)	1 (8%)	
Location of the patient ($n = 491$)			0.72
At home	238 (73%)	90 (27%)	
Outside	24 (75%)	8 (25%)	
In an ambulance	73 (78%)	21 (22%)	
Other	18 (82%)	4 (28%)	
Position of the patient ($n = 492$)			0.55
On a bed	210 (77%)	64 (23%)	
Lying on the floor	70 (71%)	28 (29%)	
Seated (including trapped patients)	86 (72%)	34 (28%)	
Lighting ($n = 487$)			0.12
Artificial	277 (76%)	88 (24%)	
Natural	86 (70%)	36 (30%)	
Hygiene of the place ($n = 491$)			0.07
Clean	301 (76%)	95 (24%)	
Dirty	63 (66%)	32 (34%)	
Hygiene of the patient ($n = 491$)			0.02
Clean	302 (76%)	93 (24%)	
Dirty	62 (65%)	34 (35%)	
Particular medical observations ($n = 493$)	7 (2%)	17 (13%)	< 0.0001

Table 3 Parameters significantly associated with successful IV cannulation at the first attempt in multivariate analysis

	Odds ratio	95% confidence interval	*p*
Nurse specialized in emergency care	3.959	1.778–8.813	0.0008
Caliber of the catheter	0.793	0.669–0.940	0.007
Particular medical observations	0.120	0.045–0.323	< 0.0001
Dirty patient	0.505	0.291–0.877	0.015

Discussion

Final success of peripheral IV access was achieved in 99% of the patients enrolled in this study. In the remaining patients central venous access was required, and no definitive failure was reported. The caliber of the catheter, an attempt performed by a nurse specialized in emergency care, a clean patient, and lack of particular relevant medical observations were significantly correlated with the success of peripheral IV access in this large prospective study. Interestingly, none of the parameters regarding patient characteristics, pathology, or severity of condition was significant.

Peripheral IV access is frequent in medical practice. Approximately 25 million peripheral IV lines are placed annually in France (Haute Autorité de Santé, "Recommandations pour la pratique clinique. Prévention des infections liées aux catéthers veineux périphériques", www.sfhh.net; November 2005). Nevertheless, this procedure is very poorly documented. The incidence of failed peripheral IV access is unknown in emergency settings, although venous access is vital in many cases [2]. In this study, enrolling patients managed by an emergency physician in out-of-hospital settings, venous access was considered as a delayed emergency in only 17% of the cases. Therefore Orlowski's attitude, as quoted above, is considered a rule in our practice.

The final success rate of peripheral IV access was 99% in our study. Only three central venous lines (1%) were required. Regarding assessment of the degree of emergency, such a result is excellent. A recent French prehospital study reported a similar final successful rate [4]. Lieberman et al. [5] reported a global success rate of 91.5% in 11 studies on prehospital advance life support. Furthermore, this procedure was not time consuming. The median duration of the procedure, including several attempts in 26% of the procedures, was 2 min.

According to the French emergency care organization, emergency physicians are sent into the field when required [3]. Intravenous therapies can then be initiated immediately. The lack of IV access can prohibit or delay the use of optimal emergency therapies [6]. Central venous access remains the ultimate solution. The high risk of infectious complications strongly leads to avoidance of this practice in out-of-hospital settings [7, 8]. The presence of an emergency physician and a nurse specialized in emergency care probably contributed to our high success rate. In cases of difficult or failed peripheral IV access in common sites uncommon alternative sites may be used to achieve peripheral IV access [6, 9].

Knowledge of parameters associated with an increased risk of IV access failure can contribute to optimization of the procedure. In our experience, when a nurse specialized in emergency care performs the procedure, the success rate is significantly increased. The relationship between operator qualification and the success of a procedure is common; endotracheal intubation is a classical illustration of this [10]. Initial teaching and regular practice significantly increase the success rate. Number of years of experience in emergency care was not correlated with success rate in our study. The low number of operators in each category may explain this result. The trend observed supports this hypothesis.

The caliber of the catheter was the other parameter associated with the success of the procedure. Excluding extreme calibers (14 and 22 G) that were rarely used (3%), the success rate rose significantly with increased caliber of the catheter. The most probable explanation for this paradoxical result is that the operator evaluating the predictable difficulty of venous access chose the caliber of the catheter. In other words, we can postulate that the operator chose a catheter with a higher caliber when he speculated that insertion would be easy. Our finding strongly indicates that the evaluation a priori of the predicted IV access difficulty by the operator is good. The efficiency of this subjective evaluation contrasts with the lack of significance of all the parameters tested regarding the patient.

The lack of relationship between body mass index (BMI) and peripheral venous access failure was a surprise. Obesity is regularly advocated as associated with increased venous access difficulty. This is one of the rare difficulty parameters previously studied. Juvin et al. [11] demonstrated this relationship comparing peripheral venous access in morbidly obese (BMI 46+12) and lean (BMI 23+3) patients. We did not find this relationship, probably as only 88 patients (19%) had a BMI exceeding 30 and only 40 (8%) had a BMI exceeding 40. Difficulty is probably increased only in morbidly obese patients, such as the population studied by Juvin et al. In a "real life" population with nonmorbidly obese patients this does not seem to be exact.

No parameter related to the patient or to the pathology, its severity or location, were finally correlated with peripheral IV access difficulty. Technical parameters, operator, and caliber of the catheter were statistically predominant. The relationship between particular medical observations, a dirty patient, and failure in venous access attempt is difficult to analyze. We can speculate that these specific medical observations were reported in cases of failed attempt

but were omitted successful attempts. Diabetes or recent hospitalizations were reported in eight patients as particular observation, including seven cases of failed attempts. The frequency of these two situations in our population was surely much greater. As this study tried to identify other potential situations associated with an increased risk of failed IV access attempts, they should be specifically tested in another prospective study.

Failed venous access leads to an increased number of attempts. This should increase the incidence of complications associated with peripheral venous access. Studies on central venous access have demonstrated the strong relationship between venous access difficulty and complications [12]. Mechanical complications such as pneumothorax and arterial hemorrhage are very unlikely after peripheral venous access. Infections remain the most feared complication. Although the relationship between central venous access difficulty and infectious complications has been demonstrated, a similar conclusion is very likely for peripheral IV access. Reduction in the number of infections has been demonstrated when a specialized team performs peripheral IV access [13]. The authors suggested that training was responsible for this result. We postulate that, although these complications are rare after peripheral IV access, the relationship persists.

We also believe that a study performed with many more patients would allow the identification of other parameters associated with an increased risk of peripheral IV access failure. Interference between parameters probably limited such a demonstration in this study. Similarly, parameters associated with complications after central venous access are not clearly known despite a large number of studies performed. It cannot be excluded that parameters of each procedures were associated by chance only. For example, the choice of the operator in our observational study was intuitively probably not neutral. The qualification of the operator was one of the adjustable parameters in the field. The presence of several potential operators in our team allowed this choice. No relationship was found between the order of the attempts and the success. Studying specifically the first attempt, we did not find any changes in the results, but bias cannot be excluded. Finally, choice of procedure, including choice of the operator by the team, choice of the caliber of the catheter, and choice of puncture location were not evaluated. These were probably the result of subjective evaluation of the procedures' predictable difficulty. Assessment of such parameter is a future challenge. This would lead to consider specific procedures in such situations [14–16].

Conclusion

Peripheral IV access was achieved in 99% of the patients in out-of-hospital settings. The presence of several potential operators including emergency physicians and nurse specialized in emergency care probably contributed to this result. In our experience, the success rate improved when attempts were performed by a nurse specialized in emergency care using a 16- or 18-G catheter in clean patients without a particular medical history. Parameters regarding patient characteristics, pathology, and severity were not significantly associated with IV access failure.

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