

Does the Use of a Vein Visualization Device for Peripheral Venous Catheter Placement Increase Success Rate in Pediatric Patients?

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Background: Peripheral intravenous catheterization is one of the most frequently encountered medical procedures for hospitalized children and is one that can often be painful. Pediatric nurses should therefore use techniques that increase the success rate or shorten the duration of peripheral intravenous catheterization.

Objectives: This study was performed with the objective of determining the effect of using a vein visualization device on the success of the procedure. Success was determined based on the number of attempts per patient, the duration of the procedure, and the first stick success rate.

Methods: This was a randomized, controlled experimental study on 129 children aged 3 to 18 years.

Results: The duration of peripheral intravenous catheterization was shorter in the study group (S) than in the control (C) patients (37.24 ± 20.07 vs 172.65 ± 153.21 seconds; $P = 0.001$), with fewer attempts (S, 1.08 ± 0.28 ; C, 2.23 ± 1.57 ; $P < 0.01$). The first stick success rate was higher in the control group (S, 91.7%; C, 47.4%; $P = 0.001$).

Conclusions: Peripheral intravenous catheterization using vein visualization device support reduces the number of attempts per patient and the operation duration but increases the rate of first stick success. We may therefore state that vein visualization device support improves the success of peripheral intravenous catheterization.

Key Words: peripheral intravenous catheterization, vein visualization device, nursing

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In pediatric patients, the placement of peripheral venous catheters is more difficult than in adults due to causes such as smaller vessel diameters, difficulty in palpating veins, and reduced visibility in children.^{1–4} The peripheral venous catheterization operation is sometimes only successful after several failed attempts because nurses experience difficulties in determining the vein to target using inspection and palpation.^{2,4,5} Repeated failed catheterization attempts may cause pain, anxiety, tissue injury, and vessel lesions in children.^{3,5,6} Seen from the nurse's viewpoint, unsuccessful attempts may lead to frustration, anxiety, and loss of self-confidence and damage the trust in the relationship between the patient and the nurse.⁶

To improve the quality of treatment and patient care, pediatric nurses must be able to use health care technologies effectively.^{7,8} Vein visualization technology is one of the technical fields that has been rapidly developing in recent years. In addition to reducing the pediatric patient's pain and anxiety, an increased rate of success of peripheral venous catheterization after the use of vein

visualization technology may have other positive results such as an increase in the nurses' self-confidence and a better use of time and resources.

A search of published reports yielded only few studies of the efficacy of different vein visualization technologies. Whereas some of these publications showed a positive outcome in terms of the success of the operation,^{2,6,9–12} some others reported an absence of positive influence on efficacy.^{1,3,13–18} Another study reported on the contribution of the AccuVein AV400 vein visualization technology to the efficacy of peripheral intravenous catheterization. This investigation was based on the nurses' opinion after using AccuVein AV400 on both pediatric and adult patients. These data that include only nurses' views are largely subjective in nature.

Vein visualization technology is rapidly developing and increasing in efficacy. With this in mind and because of the limited data available, we performed a study to determine the effect of vein visualization device support on the success of peripheral intravenous catheterization. Success of the procedure was evaluated based on the procedure duration, the speed of a successful first stick, and the number of attempts.

METHODS

Objective and Type of the Study

This was a controlled, randomized experimental study.

Time and Place of the Study

The study was performed in the pediatric clinic of a teaching and research hospital in Istanbul, Turkey.

Study Universe and Sample Selection

The study universe consisted of 150 pediatric patients aged 3 to 18 years hospitalized for treatment in pediatric clinics between April 1 and June 1, 2014; the sample was composed of 129 pediatric patients hospitalized in the pediatrics department of the same hospital in whom peripheral intravenous catheterization was needed and who chose to participate in the study.

The sample size was calculated using the G*Power (v3.1.7) software for power analysis. The number of patients needed in each of the 2 groups, to be able to detect a 30% difference in the time to success with an α error of 0.05 and 90% power, was calculated as 52 (ie, a minimum of 10 patients in each age group). A post hoc power analysis was also performed using the study data on the G*Power (v3.1.7) software. Taking into account the distribution of patients in the 72-patient study group and the 57-patient control group, the power for an α of 0.05 was 99.9%.

The patient selection criteria for the sample were defined as follows for the study and control group patients: being treated as inpatients in the pediatric clinic of the same hospital, being 3 to 18 years old, and having the need for peripheral intravenous

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catheterization for treatment procedures, randomized allocation of treatment for each age group (3-6, 6-19, 9-12, 12-15, and 15-18 y), the peripheral intravenous catheterization procedure performed by the same nurse, and peripheral intravenous catheterization with the same brand of catheter.

The exclusion criteria were defined as those who did not need intravenous (IV) attempt, indwelling catheter already present, diseases for which IV insertion would be contraindicated, and patients who were unwilling to be catheterized. Ten patients were excluded because there was no need for an IV attempt, and 2 patients were excluded because they were unwilling to undergo catheterization.

Data Collection Tools

Study data were collected with the help of an “interview and observation form” and the AccuVein AV400 vein visualization device.

Interview and Observation Form

This form contained a total of 6 open-ended and 7 closed-ended questions, for a total of 13 questions, developed based on the available publications.^{1,2,6,7,12,17} The first questions of these queried demographic characteristics such as race, age, sex, and body mass index (BMI), whereas the others were about the operation efficiency, including the operation duration and the number of attempts, vessel difficulty grade, and previous attempts at peripheral IV catheterization.

This interview and observation form was applied to 10 children before the start of the study. Questions that were not easily understood were edited to their final form. These 10 children were kept out of the study.

The AccuVein AV400 Vein Visualization Device

The AccuVein AV400 vein visualization device was used during peripheral intravenous catheter placement (Fig. 1). The device detects hemoglobin by reflecting it under infrared light, showing the location of the vessels.¹⁹ The AccuVein AV400 vein visualization device was held 20 cm from the extremity to be catheterized, at a 90° angle (Figs. 2, 3). More information about the device can be found on the manufacturer's Web page.¹⁹

Before starting the study, the nurse in charge of performing the peripheral intravenous catheterization was trained in the use of the device and performed peripheral intravenous catheterizations for 3 days; the children who underwent catheterization during these 3 training days were not included in the study.

Data Collection

Subjects were allocated either to the study group for venous visualization support during peripheral intravenous catheterization or to the control group for catheterization with the traditional (or standard) method. Before allocating them to either group, a preliminary interview was performed, using the interview and observation form, with the volunteering children and their parents to



FIGURE 2. Appearance of a vein before the procedure.

select the subjects responding to the selection criteria. Written informed consent was obtained from the eligible children and their parents after informing them of the study procedures.

Randomization Method

Subjects in both the study and control groups were to be stratified into 5 age groups of 3 to 6, 6 to 9, 9 to 12, 12 to 15, and 15 to 18 years. Power analysis indicated that the minimum number of patients in each group has to be 10. Each subject was only entered once into the study.

Envelopes were prepared for each eligible subject, containing 1 red chit and 1 yellow chit. The children were asked to pull 1 chit without looking. The group represented by each color had been determined in advance. Subjects who selected yellow were allocated to the study group, and those who chose red were allocated to the control group. The same procedures within the study or control groups were applied to all eligible children who required peripheral intravenous catheterization and who had volunteered to participate in the study. Subjects were randomly allocated to each of the age groups until the minimum required sample size for each group was reached.

The AccuVein AV400 vein visualization device was used during peripheral intravenous catheter placement in the study group patients, and the standard method was used in controls. Operation success was determined based on the procedure duration, the number of attempts, and the presence or absence of first stick success. The number of attempts was the number of tries made until catheter placement was successful. The procedure duration was the time from the start to the end of the procedure. It was defined as the time elapsed from the placement of a venous tourniquet to the moment a patient's venous access was assured. This definition was adopted to include the time to search for an access vein. First stick success was defined as establishing venous access at the first attempt made. If the first attempt was unsuccessful, another vein was searched, and time was kept until success.



FIGURE 1. AccuVein AV400 vein viewing system (<http://www.accuvein.com>).



FIGURE 3. Pediatric peripheral intravenous catheter placement.

Successful access was defined as blood egress from the vein in the absence of any evidence of infiltration.

The study procedure was conducted by 2 pediatric nurses, with one performing the operation and the other observing. Both of these nurses had at least 5 years of experience working in this pediatrics department and volunteered to take part in the study. To avoid subjective differences, the operation duration was measured, and first stick success was verified in each case by the same nurse. In addition, peripheral intravenous catheterization was performed by the same nurse in both the control and study groups. Both nurses underwent training on the operation before the study. All venous catheterizations in both groups used catheters of the same brand, of the caliber appropriate to patient age and vessel diameter. To help ensure data reliability, the investigator did not participate in the evaluation process of the venous catheterization. The presence of parents of both the control and study group children during the peripheral intravenous catheterization was ensured.

Before the operation, the performing nurse attributed an estimated venipuncture difficulty grade of “easy,” “intermediate,” or “difficult.” This difficulty grade was estimated by the same performing nurse on the basis of objective, published criteria.^{2,3,5,20,21} The criteria used for the grading were the presence or absence of damage to the vein, its visibility or not, and its palpability or not. All three criteria, namely, the presence of vein damage, the absence of visibility, and the absence of palpation, were classified as “difficult,” and 1 or 2 of the 3 criteria were classified as “intermediate,” whereas in the absence of all three, the vein was deemed to be “easy.”

Statistical Analysis of the Data

The Number Cruncher Statistical System 2007 and Power Analysis and Sample Size 2008 Statistical Software (NCSS, Kaysville, UT) was used for statistical data evaluation. Student *t*, Mann-Whitney *U*, Kruskal-Wallis, Pearson χ^2 , and Fisher exact tests and Yates' correction for continuity were used as appropriate for comparative statistics. Significance threshold was set at a *P* value of 0.05, and a *P* less than 0.01 was considered highly significant.

Ethical and Legal Considerations Regarding the Study

Authorization was obtained before the start of the study from the hospital and the institutional review board (ethics committee). The aim and method of the study were explained to the pediatric patients and their families; both their oral and written consent was obtained.

RESULTS

The study was performed from April to June 2014 on a total of 129 pediatric patients, with 55.8% (72) of them in the study group and the remaining 44.2% (57) in the control group.

A comparison between the 2 groups for variables that could affect the success of the procedure did not detect significant differences. There are no any correlation between BMI and success rate of IV insertion between the experimental and control groups (Table 1).

When comparing the 2 groups for efficacy, the number of attempts was significantly lower ($P = 0.001$) in the study group (1.08 ± 0.28 ; range, 1–2) than in the control group (2.23 ± 1.57 ; range, 1–8). The operation duration was similarly shorter in the study group (37.24 ± 20.07 [range, 15–83] vs 172.65 ± 153.21 [range, 40–700] seconds for the control group, $P = 0.001$). The first stick success rate was higher in the study group (91.7%) compared with the control group (47.7%; $P = 0.001$) (Table 2).

When comparing the first stick success rate according to the difficulty grade attributed to the veins, no significant difference was detected between the study (95.8%) and control (92.3%) groups among the subjects with “easy” veins ($P > 0.05$), whereas in the “intermediate” (95% in the study group vs 20% in the control group) and “difficult” (85.7% in the study group vs 14.3% in the control group) groups, the first stick success was significantly higher ($P = 0.001$) in the study group (Table 3).

Comparing the number of attempts between the study and control groups according to the difficulty grade attributed to the vein was similarly failing to show a significant difference in the “easy” vein group ($P > 0.05$), whereas the number of attempts in the study group was lower than that in the control group in the “easy” (1.05 [0.22] vs 2.27 [0.80]) and “difficult” (1.14 [0.36] vs 4.06 [1.61]) groups ($P = 0.001$) (Table 3).

DISCUSSION

This study was performed with the objective of defining the effect of the AccuVein AV400 vein visualization device support on the success of peripheral intravenous catheterization in children aged 3 to 18 years who were hospitalized in a pediatrics department. In this study, we started with children aged 3 years; neonates and very young children were not included. This age group is a separate group in terms of IV insertion difficulties. Consequently, we are planning a separate study for the 0- to 3-year age group.

Success was determined based on the number of peripheral intravenous catheterization attempts, the duration of the operation, and the first stick success rate. Comparing the study and control groups for efficacy of the procedure, it was observed that fewer attempts were needed in the study group compared with the control group and that the operation was similarly shorter in the study group, which also had a significantly higher first try success rate (Table 2). Considering the possibility that the study and control groups are similar for a number of other factors that may influence efficacy (Table 1), the study shows that the AV400 vein visualization device support improves the success of peripheral intravenous catheterization.

Some of the few published studies evaluating the effect of vein visualization technologies on operational success report a positive result, whereas some others do not. A detailed discussion regarding AV400 and AV300, its 1-level-lower version, is included here because the mentioned studies used visualization technologies different from that in our study.

A search of available publications yielded 4 reports of studies examining the efficacy of AccuVein AV300, an earlier version of the vein visualization device used in our study. Kaddoum et al (2012) concluded a controlled, randomized study of 146 pediatric

TABLE 1. Comparison of the Study and Control Groups for Variables That Could Affect Success

		Study Group (n = 72)		Control Group (n = 57)		Z/t/ χ^2	P
		Mean (SD) (Median)	Mean (SD) (Median)	Mean (SD) (Median)	Mean (SD) (Median)		
Age, y		8.51 (4.4) (7.0)	9.34 (4.54) (9.5)			Z = 0.969	0.333*
BMI, kg/m ²		17.27 (3.08) (16.6)	17.34 (2.53) (17.1)			t = 0.140	0.889†
		n	%	n	%		
Sex	Female	32	44.4	27	47.4	$\chi^2 = 0.110$	0.741‡
	Male	40	55.6	30	52.6		
Age group, y	3–6	25	34.7	17	29.8	$\chi^2 = 1.616$	0.806‡
	6–9	17	23.6	10	17.5		
	9–12	10	13.9	10	17.5		
	12–15	10	13.9	10	17.5		
	15–18	10	13.9	10	17.5		
Vessel difficulty grade	Easy	24	33.3	26	45.6	$\chi^2 = 2.355$	0.308‡
	Intermediate	20	27.8	15	26.3		
	Difficult	28	38.9	16	28.1		
Previous attempts at peripheral intravenous catheterization	Yes	51	70.8	46	80.7	$\chi^2 = 1.174$	0.279§
	No	21	29.2	11	19.3		

*Mann-Whitney U test.

†Student t test.

‡Pearson χ^2 .

§P < 0.01.

patients aged 0 to 17 years by stating that, although the device increased the visibility of veins, it was not more effective than standard methods. In a controlled, randomized study of pediatric patients aged 0 to 18 years comparing the effect on operational efficacy of 3 different vein visualization devices, namely, Vasculuminator, VeinViewer, and AccuVein AV300, no difference in the first try success rate was evidenced among the 3 devices or between each of them and the traditional method by de Graaff et al (2013). Aulagnier et al (2014), reporting a randomized study of 272 adult emergency room patients of vein visualization versus controls, concluded that the use of AccuVein AV300 did not affect peripheral vein catheterization in adult emergency patients. These results might derive from a high efficacy rate of noninstrumented venipuncture as a result of the large, evident veins of adult patients. Guillon et al (2015) conducted a controlled, randomized study of 450 patients with age from 1.8 months to 90 years, using AccuVein AV300. They concluded that vein visibility was increased in patients with

difficult venous access, a finding consistent with our results, and that pain was reduced in 39% of the cases.

Our literature survey produced 1 study performed with AccuVein AV400. In a study performed with 6 nurses, Delvo-Favre et al (2014) evaluated the efficacy of the vein visualization device in peripheral intravenous cannulation; a 93% success rate at the first or second try was reported, with 82% of nurses stating that the device improved their ability to cannulate. This report, however, did not address the operation duration or the number of attempts.

The difficulty of cannulating a vessel is one of the most important factors affecting the success of the operation and the number of attempts. The first stick success rate was significantly higher in the control group ($P = 0.001$) in our study subgroups with an “intermediate” or “difficult” vein grading, whereas the number of attempts was similarly low ($P = 0.001$) in these same subgroups. No difference with regard to the number of attempts or operation success was seen ($P > 0.05$) in the subgroup graded

TABLE 2. Comparison of the Study and Control Groups for Operation Success

		Study Group (n = 72)		Control Group (n = 57)		Z/ χ^2	P
		Mean (SD) (Median, Range)	Mean (SD) (Median, Range)	Mean (SD) (Median, Range)	Mean (SD) (Median, Range)		
No. attempts		1.08 (0.28) (1, 1–2)	2.23 (1.57) (2, 1–8)			Z = -5.859	0.001**
Operation duration, s		37.24 (20.07) (32, 15–83)	172.65 (153.21) (103, 40–700)			Z = -8.648	0.001**
		n	%	n	%		
Success at first try	Yes	66	91.7	27	47.4	$\chi^2 = 28.867$	0.001**
	No	6	8.3	30	52.6		

*Mann-Whitney U test.

†Yates' continuity correction test.

‡P < 0.01.

TABLE 3. Comparison of Success in the Study and Control Groups According to Difficulty of Vascular Access

Vessel Difficulty Grade		Success at the First Try of Peripheral Intravenous Catheterization		Success at the First Try of Peripheral Intravenous Catheterization				χ^2	P
				Study Group (n = 72)		Control Group (n = 57)			
		n	%	n	%				
Easy	Yes	23	95.8	24	92.3	0.275	1.000*		
	No	1	4.2	2	7.7				
Intermediate	Yes	19	95.0	3	20.0	17.564	0.001†‡		
	No	1	5.0	12	80.0				
Difficult	Yes	24	85.7	0	0	26.813	0.001†‡		
	No	4	14.3	16	100				

Vessel difficulty grade		Easy		Intermediate		Difficult		No. Attempts				Z	P§
								n	Mean (SD) (Median)	n	Mean (SD) (Median)		
		24	1.04 (0.20) (1)	26	1.08 (0.27) (1)	-0.519	0.604						
		20	1.05 (0.22) (1)	15	2.27 (0.80) (2)	-4.497	0.001‡						
		28	1.14 (0.36) (1)	16	4.06 (1.61) (4)	-5.939	0.001‡						

*Fisher exact test.
 †Yates' continuity correction test.
 ‡P < 0.01.
 §Mann-Whitney U test.

“easy” (Table 3). These results suggest that the use of AccuVein AV400 will be more beneficial to children with vein access of intermediate and high difficulties.

It may be stated that the study results were found to contribute to increasing procedure success and patient comfort during peripheral IV placement procedures. It should be noted that vein visualization technologies to increase the success of peripheral intravenous catheterization are not being used in Turkey. These are only now starting to be used in a few cases in only a few private hospitals. We expect the study results to contribute to a wider use of effective vein visualization technology for peripheral intravenous cannulation.

To conclude, peripheral intravenous catheterization supported by AccuVein AV400 decreases the number of attempts, reduces procedure time, and increases the rate of first stick success in pediatric patients. The efficacy of AccuVein AV400 support for peripheral intravenous catheterization is greater in children with veins considered to be of intermediate or high access difficulty.

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