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SHORT COMMUNICATION

Efficacy of VeinViewer in pediatric peripheral intravenous access: a randomized controlled trial

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Abstract Peripheral venous access in infants and children is technically challenging, because their veins are small and located deep in subcutaneous tissue, which makes them difficult to palpate or visualize. The VeinViewer® (Luminetx Corporation, Memphis, TN, USA) is a near-infrared light device that delineates the running course of subcutaneous veins. In this study, we investigated whether the use of the VeinViewer® in infants and children facilitated peripheral venous access, especially in difficult cases. This study was a randomized, controlled trial of a convenience sample of pediatric patients between the ages of 1 month and 16 years who required peripheral venous access in the pediatric ward. Prior to randomization, difficult intravenous access (DIVA) score, a four-variable clinical prediction rule for first-attempt success, was estimated. We compared the first-attempt success rates and procedural times between the VeinViewer® group and a control group. We evaluated 111 patients: 54 in the VeinViewer® group and 57 in the control group. Patient demographics and factors related to the success of vein access were similar for both groups. The overall first-attempt success rate was 69.4%: i.e., 77/111 in the VeinViewer® group and 38/57 in the control group, a difference that was not statistically significant. However, the first-attempt success rate increased from 5/20 in the control group to 14/24 in the VeinViewer® group for difficult veins with a DIVA score greater than 4 (p=0.026). There were no significant differences in procedural time between the two groups. Conclusion: The VeinViewer® facilitated peripheral venous access for pediatric patients with difficult veins, which enhanced first-attempt success rates.

Keywords Child · Peripheral catheterization · Vascular access · Near-infrared light

Introduction

Peripheral venous access is usually required for administration of fluids or medications in hospitalized children. Even for experts, peripheral venipuncture in infants and adolescents is difficult because of small and deeply-located veins. Several devices adjunct to vein identification and catheter insertion have been devised in the attempt to optimize peripheral catheterization [1, 2, 4, 6, 8, 9, 11]. The VeinViewer® (Luminetx Corporation, 2006) is the latest of such devices and was designed to facilitate vascular access by using near-infrared light (NIR) [1, 4, 9]. NIR emitted from the device is absorbed or scattered in the forward direction by blood, whereas it is scattered in all directions in skin and subcutaneous fat. The light reflected from the vein is detected with a video camera. The resulting image is processed by a computer and then projected back onto the skin, showing veins as black lines against a green background.

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Only a few studies exist regarding the efficacy of the VeinViewer®, and these reports have shown conflicting results [1, 4, 9]. In this study, we sought to compare the first-attempt success rates for peripheral venous access between traditional methods and the VeinViewer®-assisted method. We hypothesized that first-attempt success rate would improve with the use of the VeinViewer®, particularly in children with difficult intravenous access.

Methods

This was a randomized, controlled trial of a convenience sample of children between the ages of 1 month and 16 years who required peripheral vascular access in the pediatric ward at an urban, academic tertiary care center. We enrolled eligible patients between April 1, 2011 and May 31, 2011. Patients were included if the intravenous access was scheduled during the daytime and when research staff members (MJK, NGL, and SMJ) were available. Patients whose primary care nurses were participating in the study were approached for enrollment. The exclusion criterion was the necessity of emergency resuscitation precluding the possibility of obtaining informed consent. The hospital's institutional review committee approved the study.

Nurses who had at least 3 years of experience working in pediatric wards or neonatal pediatric intensive care units were enrolled in this study. Because none had previous experience using the device, participating nurses were given two weeks of hands-on experience to become accustomed to the VeinViewer®.

All procedures were performed in a treatment room under natural light. Before starting each procedure, the difficult intravenous access (DIVA) score of the patient was evaluated [12]. DIVA score is a clinical prediction rule comprising four proportionally weighted variables (vein palpability, vein visibility, patient age, and history of prematurity) which is used to identify patients at high risk of first-attempt intravenous access failure. A DIVA score greater than 3 was reported to estimate a more than 50% failure rate at the first attempt [12]. The nurses also judged the level of intravenous access difficulty subjectively as one of the following three categories: easy, intermediate, and difficult.

Each patient was randomized to either the VeinViewer® or control group according to a computer-generated random number. The group assignment card for each patient was sealed in an opaque envelope until the assessment for the difficulty of intravenous access was completed. In the VeinViewer® group, venipuncture was conducted aided by VeinViewer® for the first attempt. If the first attempt failed, the decision about whether to use the VeinViewer® in subsequent attempts was left to the nurse's discretion regardless of the patient's allocated group.

The primary outcome measure was first-attempt success rate. During the procedure, data such as who carried out the procedure, the location of extremities at the first attempt, and the access tool (scalp needle or catheter) were documented by research staff. Each procedure was videotaped to measure the procedural time, which was subdivided by preparation time (from tourniquet application to skin puncture), manipulation time (from skin puncture to vein puncture), and confirmation time (from vein puncture to confirmation). The procedural time was analyzed in patients who were catheterized successfully on the first attempt.

The sample size was calculated as 84 patients (42 patients per group) to detect a 31% absolute difference in first-attempt success rates between the two groups, using a two-sided α of 0.05 and a power of 0.80 [4]. We used the statistical package for the social sciences (SPSS) version 12.0 for Windows (SPSS Inc., Chicago, IL, USA). Patient characteristics and first-attempt success were compared using chi-square tests. Multivariate logistic regression was employed to investigate the main effect and interaction effect on first-attempt success. We compared procedural time between the two groups using Mann–Whitney *U* tests. All comparisons considered a *P* value of <0.05 to denote statistical significance.

Results

Patient characteristics

Among the 128 patients screened for enrollment, 15 declined to participate and 2 were exempted because of schedule cancelations. Finally, 111 patients were randomized into one of the two groups, with 54 in the VeinViewer® group and 57 in the control group. In all patients, the first attempt was performed according to the allocated group. Overall, patient demographics and characteristics were similar between the two groups (Table 1).

First-attempt success

Intravenous access was successfully achieved in 77 (69.4%) patients on the first attempt. In the VeinViewer® group, the overall first-attempt success rate was 39/54, compared with 38/57 in the control group ($p=0.526$). The first-attempt success rate was 58/67 in easy patients and 19/44 in difficult patients with a DIVA score above 4. Multivariate logistic regression with main effect (group and difficulty by DIVA score) and interaction effect was significant ($p=0.048$). In easy patients, there was no significant difference between the two groups ($p=0.485$). The first-attempt success rate of difficult patients was 14/24 in the VeinViewer® group and 5/20 in the control group ($p=0.026$) (Fig. 1).

Procedural time

We compared the procedural time of 77 patients who were successfully accessed on the first attempt. The overall

Table 1 Patient demographics and factors related to the success of vein access

Variables	Total patients (n=111)	VeinViewer® group (n=54)	Control group (n=57)	P value
Sex				0.901
Male	61	30	31	
Female	50	24	26	
Age				0.477
<1 yr	17	8	9	
1–2 yr	41	17	24	
3–6 yr	34	17	17	
≥7 yr	19	12	7	
BMI				0.413
<18.5	84	38	46	
18.5–24.9	23	14	9	
≥25	4	2	2	
Delivery type				0.109
NSVD	72	31	41	
Cesarean section	39	23	16	
Chronic disease	2	12	13	0.941
History of recent access	78	36	42	0.419
History of difficult access	50	26	24	0.522
DIVA score				0.314
0–3	67	30	37	
4–10	44	24	20	
Subjective difficulty				0.070
Easy	36	17	19	
Intermediate	28	9	19	
Difficult	47	28	19	
Access tool				0.065
Catheter	91	48	43	
Scalp needle	20	6	14	
Access site of first attempt				0.390
Upper extremities	100	50	50	
Lower extremities	11	4	7	
Nursing experience[a]				0.902
<5 yr	35	17	18	
5–9 yr	37	19	18	
≥10 yr	39	19	21	
Parental attendance	53	29	24	0.221

BMI Body mass index, *NSVD* Normal spontaneous vaginal delivery, *DIVA* Difficult intravenous access

[a]Sum of years experience working in the pediatric ward or intensive care unit

procedural time and intervals by subcategories are shown in Table 2.

Discussion

We investigated the efficacy of VeinViewer®-assisted peripheral venous access in pediatric patients. While the VeinViewer showed no significant improvement in easy veins, it enhanced the first-attempt success rate from 5/20 to 14/24 in cases of difficult veins.

Visible-light transillumination is the longest visualization technique before ultrasonography and near-infrared modalities [5, 7]. Both transillumination and ultrasonography require that a probe be held near the puncture site; ultrasonography in particular requires sterile technique because of the risk of infection related to contact. In comparison, the VeinViewer® is a standing-type device that illuminates near-infrared light from 30 cm above the skin, so there is no concern for infection, and nurses can devote both hands to the access procedure. The latest version of the VeinViewer Vision® is smaller than the previous one and

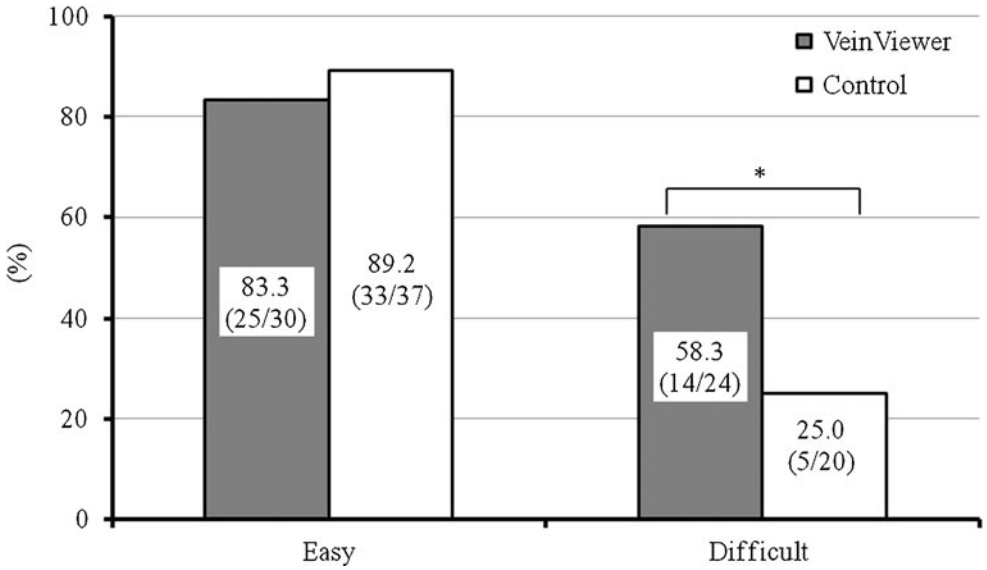

Fig. 1 Comparison of first-attempt success rate according to difficulty by difficult intravenous access (DIVA) score between the VeinViewer® group and the control group. *p=0.026

has improved portability and diminished discomfort caused by the space it occupies during the procedure. However, there were several weaknesses of the VeinViewer® as reported by the participating nurses; the magnification of the vein image made veins appear larger than their actual width, the vein image became sluggish when the patient moved his or her extremities, and the two-dimensional nature of the image makes it difficult to guess the depth of the vein. For these reasons, the VeinViewer® can be a hindrance rather than a help, especially in patients who normally would be easy to access. In the post-study survey, most participating nurses answered that they would like to use the VeinViewer® only in patients for whom they expect first-attempt failure.

Several studies have defined difficult access as two or three failed peripheral venous access attempts [2, 3]. Multiple attempts damage veins and surrounding tissues, exhausting the vein for cannulation and making subsequent trials more difficult, so it is important to establish the route of the peripheral vein successfully on the first attempt. If we can identify patients at high risk for failed catheterization, we might improve the first-attempt success rate by using ancillary equipment or by exchanging the operator for a more skilled hand in patients with expected difficulties. Clinicians need to develop and verify clinical prediction rules for screening patients with a high probability of failed peripheral catheterization, and furthermore, guidelines for difficult peripheral venous access management, especially in pediatric patients. As far as we know, DIVA score is the only clinical prediction rule available to identify children with difficult intravenous access. Recently, DIVA score was validated with an area under the receiver operating characteristic curve of 0.72 [10].

Our study was subject to the following limitations. First, the procedural time was analyzed only in patients with successful venous access on the first attempt because the time interval after the first failed attempt varied according to the operator and the situation. Second, no one has established how much training and practice are sufficient to handle the VeinViewer® proficiently. Even though nurses underwent an adaptation period of two weeks to minimize the confounding effect of the learning curve, we were unable to eliminate this influence because of individual variations in adaptability.

Table 2 Comparison of procedural time between the VeinViewer® group and the control group

Difficulty by DIVA score	Time interval	VeinViewer® group	Control group	*P* value
Easy (n=58)	Overall	36 (27,49)	39 (26,85)	0.428
	Preparation	19 (12,38)	23 (14,48)	0.131
	Manipulation	5 (3,8)	5 (4,16)	0.512
	Confirmation	8 (6,13)	6 (3,12)	0.069
Difficult (n=19)	Overall	54 (44,106)	92 (75,156)	0.056
	Preparation	34 (31,78)	73 (34,124)	0.130
	Manipulation	11 (9,15)	11 (11,34)	0.391
	Confirmation	9 (5,17)	11 (7,21)	0.444

Time shown as median (IQR) in seconds

Conclusion

The VeinViewer® was helpful in pediatric patients who were predicted to have difficult venous access, enhancing first-attempt success rate.

Conflict of interest None of the authors have any conflict of interest.

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