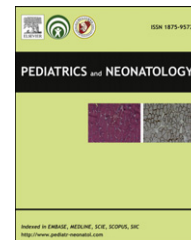


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ORIGINAL ARTICLE

Near-Infrared Light Device Can Improve Intravenous Cannulation in Critically Ill Children

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Key Words

critically ill children;
intravenous
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near-infrared light
device

Background: Vascular access in critically ill children can be a real challenge for medical staff. In order to evaluate the effectiveness of a near-infrared light vein-viewing device for critically ill children, 60 pediatric inpatients were enrolled in a randomized prospective observation trial for intravenous cannulation.

Methods: The patients' demographic data, mean time required to find the first available vessel, first-attempt success rate, mean number of attempts per patient, and the total time taken on the attempts per patient were compared.

Results: Less time was required to find the first available vessel in the near-infrared light device group compared with the control group (126.37 vs. 383.61 seconds; $p = 0.027$). In addition, the near-infrared light device group had a fewer number of attempts compared with the control group (median 1 vs. 2; $p = 0.004$), and also a shorter total time of attempts per patient compared with the control group (186.16 vs. 497.23 seconds; $p = 0.014$).

Conclusion: The use of a near-infrared light vein-viewing device for vascular access in critically ill children can decrease the total medical time and cost.

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1. Introduction

Vascular access is frequently required for patients admitted to hospitals. Fluid supplements and administration of medication are mainly dependent on vascular access. However, under some conditions it can be a real challenge to insert an intravenous cannula even for experienced medical staff. Young age, dark skin, general anxiety, a critically ill condition, and chronic illnesses are all important factors that contribute to unsuccessful cannulation.^{1–6} It has been reported that successful intravenous placement requires an average of two venipunctures over 28 minutes for children.⁷ Vascular access is more difficult in critically ill children, and nurses working in a pediatric intensive care unit (PICU) often face the challenge of difficult venous access. Failure to establish an intravenous line increases the anxiety and pain of patients. It also leads to frustration and disappointment of the nursing staff. The additional cost and time spent by the staff on difficult venous access are also negative factors.

Several strategies have been proposed to improve venous access. Recently, a near-infrared light source has been developed to view both superficial and deep veins, which reportedly reduces the number of needlesticks required to achieve venous access, although the results have been controversial (Figure 1).^{8,9} In this study, we compared the first-attempt success rate for the insertion of peripheral intravenous catheters between those placed

with and without the assistance of a near-infrared light vein-viewing device for critically ill children in a PICU.

2. Materials and Methods

This study was conducted in a PICU at Kaohsiung Chang Gung Children's Hospital over a 1-year period from April 2010 to March 2011. The study protocol was approved by the institutional review board of Chang Gung Memorial Hospital, Taiwan. Sixty patients between the ages of 3 months and 17 years who were admitted to our PICU and who required vascular access were enrolled for the study in a 3-month prospective observation period. Pediatric Risk of Mortality (PRISM) III scores were used as a prognostic score to assess the gravity of the disease.¹⁰ All patients received an intravenous cannula insertion. The indications for intravenous cannulation included the need for fluid supplements and administration of medication. After informed consent had been obtained from their parents, the patients were divided into two groups: the near-infrared light vein-viewing device group (VeinViewer; Luminetx Corporation, Memphis, TN, USA) and the control group (without the use of the VeinViewer). A physician created two random allocation sequence lists (computer generated). The exclusion criteria included patients or families who did not agree to participate in this study, a rapidly progressive condition that needed resuscitation, and any other condition that did not give the medical staff enough time to prepare for this study.

Five nurses with work experience ranging from 1 to 12 years were assigned to perform vascular access in both groups. All nurses received a 2-hour training session, and their ability to operate the device was validated by the device manufacturer. The basic clinical features and laboratory data of the patients were recorded. When performing vascular access, the nurses were asked to record the time required to find the first available vessel, the number of attempts needed to achieve success, and the total time needed to complete the procedure.

2.1. Statistics

The data presented are expressed as mean \pm standard error. The chi-square test or Fisher's exact test was used to evaluate statistical differences in parametric items. The Mann-Whitney *U*-test was used to test the differences in nonparametric items. A *p* value less than 0.05 was considered statistically significant. All statistical tests were performed using SPSS 17.0 for Windows XP (SPSS, Inc., Chicago, IL, USA).

3. Results

Sixty pediatric patients were entered into the study and randomly assigned to the control group or the study group. There were 30 patients in the near-infrared light device (study) group and 30 patients in the control group. Each nurse completed a minimum of one attempt and a maximum of 10 attempts per patient. The demographic data for the 60 patients are summarized in Table 1. There were no

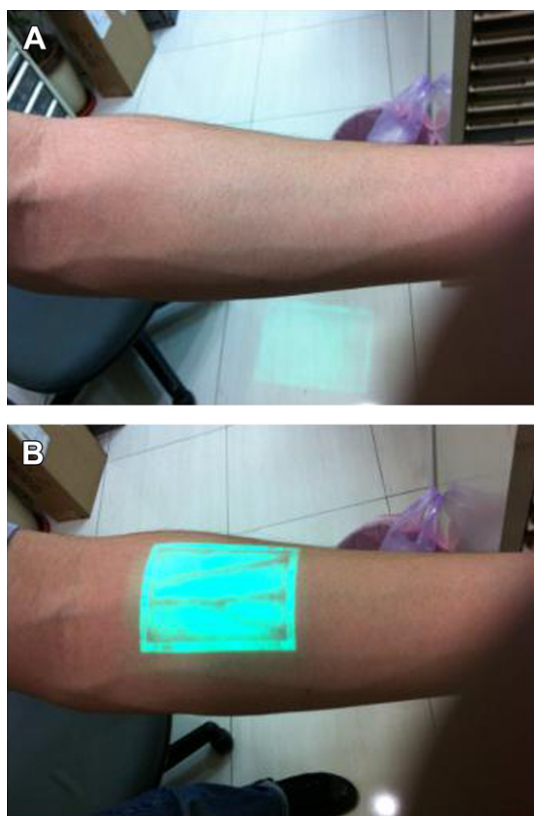


Figure 1 Visualization (A) without and (B) with the near-infrared light device (VeinViewer).

Table 1 Demographic characteristics of the patients with and without use of the VeinViewer.

Characteristic	Study group	Control group	<i>p</i>
Sex (M/F)	15/15	13/17	NS
Age (y)	4.8 ± 0.9	4.5 ± 0.7	NS
BH (cm)	103.80 ± 66.66	100.38 ± 6.82	NS
BW (kg)	18.36 ± 2.44	18.25 ± 2.78	NS
BMI	15.18 ± 0.68	15.23 ± 0.79	NS
PRISM III score	6.83 ± 0.71	6.20 ± 0.52	NS
Nurses working experience (y)	5.84 ± 3.75	6.57 ± 4.12	NS

BH = body height; BMI = body mass index; BW = body weight; PRISM III score = Pediatric Risk of Mortality III score; NS = statistically nonsignificant.

differences between the two groups in terms of basic demographic data including age, sex, body weight, body height, body mass index, and PRISM III score. Thus, body mass index and disease severity were both independent variables regarding the total time it took to achieve a successful vascular access and the success rate of vascular access.

The primary outcome measure was the mean time it took to find the first available vessel, and the time was significantly shorter in the study group compared with the control group (126.37 vs. 383.61 seconds; *p* = 0.027) (Table 2). There were also a significantly fewer number of attempts in the study group compared with the control group (median 1 vs. 2; *p* = 0.004), and a significantly shorter total time of attempts per patient in the study group compared with the control group (186.16 vs. 497.23 seconds; *p* = 0.014). The study group had a higher first-attempt success rate for the insertion of the cannula into a peripheral vein as determined by easy flush with normal saline solution or successful blood return for laboratory analysis (study vs. control group = 56.7% vs. 33.3%), although the difference did not reach statistical significance. In general, the device was well received by the patients and staff. Only one nurse reported mild eye strain after using the device for a long time.

With regard to the cost-effectiveness of the near-infrared light device, we saved NTD109.31 (US\$3.52) per patient, including a reduction of NTD57.71 (US\$1.86) in material costs and NTD51.6 (US\$1.66) in personnel costs. Therefore, in a PICU with 20 beds per ward, the total cost for peripheral intravenous line insertion is at least US\$150, thus enabling a savings of NTD16,397 (US\$528.51) per month in our medical budget.

4. Discussion

Vascular access is consistently one of the most distressing aspects of hospital admission for children. Children who are likely to be challenging for peripheral intravenous line insertion can often be identified by certain patient-related risk factors such as the patient's age (<3 years old),^{2,11,12} body weight <5 kg,¹³ prematurity (<38 weeks' gestation),² obesity,⁵ and dark skin.^{3,14} Other illness- and injury-related factors such as peripheral edema, hypothermia, dehydration, septic shock, vasoconstriction, chronic bedridden state, and long-term intravenous treatment for chronic conditions also contribute to vascular access difficulty.¹⁵

Approaches that enhance the visibility and palpability of peripheral veins have been reviewed.¹⁵ These include gentle slapping of the overlying skin, use of a proximal venous tourniquet, and warming the limb. Topical application of nitroglycerin ointment with a eutectic mixture of local anesthetics is effective in inducing local vasodilatation, improving the visibility of the veins of the hand. Veins can also be stabilized using a "trigger" method, in which the hand and index finger are used to stretch the skin and obstruct venous flow in a downward motion. All of these approaches are now widely used in clinical practice. Other techniques such as ultrasound and fluoroscopy may improve intravenous line insertion success rates; however, they have not been systematically investigated in children. Transillumination is another technology that can improve the visualization of nonpalpable, nonvisible veins in children. The VeinViewer uses near-infrared light over the patient's skin, called a vein viewer prototype (V-V-P), and has shown promising results. When comparing the results of V-V-P and ultrasound guided visualization of veins before phlebotomy, V-V-P has shown greater sensitivity in the detection of veins, and it can also aid in determining the direction of venous flux or reflux by projecting the image of refilling after compression of telangiectasias.¹⁶

Applying the near-infrared light device into clinical practice may be helpful for the patients in pediatric emergency departments (ED) and pediatric inpatient hospitalizations,⁸ and also assist in treating patients with varicose veins and telangiectasias.¹⁶ In contrast to Perry et al's⁹ study, in which the benefits of using the VeinViewer for vascular access did not reach statistical significance in pediatric ED patients, we found statistically significant benefits in critically ill children. This difference may be explained by the following reasons. First, our staff had a longer training session (2 hours vs. 1 hour) conducted by the device manufacturer. Second, our patients were recruited from a PICU (vs. pediatric ED) and were more

Table 2 Comparison between the patients with and without use of the VeinViewer.

Items	Study group	Control group	<i>p</i>
Mean time to find the first available vessel (s)	126.37 ± 26.33	383.61 ± 112.14	0.027
First-attempt success rate	56.7 % (17/30)	33.3 % (10/30)	0.059
Median of attempts per patient (range)	1 (1–5)	2 (1–5)	0.004
Total time of attempts per patient (s)	186.16 ± 38.82	497.23 ± 123.31	0.014

critically ill than those in Perry et al's study. Third, our patients were all ethnically Chinese with a relatively consistent skin color compared to Caucasians or blacks.

The major disadvantage of a near-infrared light device is the cost of the equipment. In addition, we found that some staff required a longer time to adapt to this new technique. Taking a break to relieve eye strain was also needed after long periods of use.

In conclusion, the use of a near-infrared light vein-viewing device for vascular access in critically ill children can decrease the total medical time and cost. The device was well received by our patients, their families, and staff.

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