Original Article

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Light-emitting Diode Vein Finding Device in Facilitating Peripheral Intravenous Cannulation in Children: A Randomised Clinical Study

Anaesthesia Section

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ABSTRACT

Introduction: Peripheral venous cannulation in the paediatric age group is always a challenging task. The transillumination technique improves the visualisation of veins. The Light Emitting Diode (LED) vein finder device is based on the side transillumination principle.

Aim: To evaluate the role of transilluminating LED vein finder device (Optramed Vein-Lite), for peripheral intravenous cannulation in children with respect to ease of cannulation, time taken and number of attempts.

Materials and Methods: This randomised clinical study was conducted in Pandit Bhagwat Dayal Sharma Post Graduate Institute of Medical Sciences, Rohtak, Haryana, India, from January 2018 to January 2020. Total 130 patients, age <3 years, of either sex, and scheduled for surgery under general anaesthesia were included in the study. They were randomised into two groups. Group I (n=65), where venous cannulation was done using a transilluminating LED vein finder device, and group II (n=65) where venous cannulation was done after visualising and palpating the vein manually (conventional technique). Both the groups were compared with respect to the Difficult Intravenous Access (DIVA) score, number of attempts, ease of intravenous (i.v.) cannulation (cannulation on first or second attempt as 'easy', more than two attempts as 'difficult' cannulation) and time required for intravenous cannulation. The qualitative variables were expressed as frequencies/percentages and compared using the Chi-square test. A p-value <0.05 was considered statistically significant.

Results: The mean age of the population in group I was 17±13 months, and in group II was 15±23 months (p-value=0.5427). There was a significant variation with respect to the number of attempts; the first attempt success was 90.7% in group I vs. 63% in group II (p-value=0.0014). In group I, cannulation was easy in 95% of patients, while in group II, only 76.9% of patients had easy cannulation (p-value=0.0018). Time taken for intravenous cannulation in group I was 19.385±6.2015 sec and in group II was 22.886±11.6716 sec (p-value=0.0346).

Conclusion: Transillumination is a useful technique to improve the success rate of peripheral venous cannulation in infants and children.

Keywords: Paediatric, Peripheral veins, Transillumination

INTRODUCTION

Peripheral Intravenous Catheterisation (PIVC) is widely perceived as a routine procedure and is indeed a very crucial step in medical management. Accessing peripheral veins could sometimes be difficult in extremes of ages, neonates, children, obese patients, dark skin patients, i.v. drug abusers, patients in shock or patients treated with chemotherapy and patients with a history of long hospital stay.

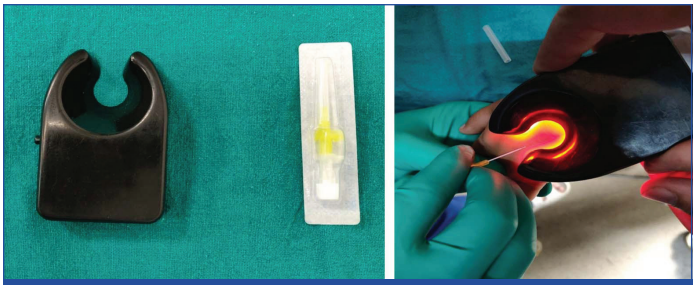
Venepuncture in paediatric patients can be tedious and time-consuming for anaesthesiologists as superficial veins may be too small to palpate or see in normal light. Children are usually more anxious and fearful of strangers. Multiple attempts at cannulation increase pain, anxiety, lifelong fear of needles and any procedure-related anxiety during subsequent procedures and towards medical care providers. Numerous punctures can increase complications like skin bruising, phlebitis, extravasation, thrombosis and nerve damage [1-3]. Moreover, these patients are generally kept Nil Per Oral (NPO) before surgery which makes it more difficult to PIVC as superficial veins get collapsed due to dehydration.

Delay in establishing venous access increases the incidence of central venous cannulation, venous cut-down and intraosseous infusions [4,5]. These procedures require greater skills, special equipment and are associated with increased morbidity and mortality [5-7]. It is better to locate and map all visible superficial and deep peripheral veins before choosing a vein for cannulation. Blind cannulation is not good, as it increases the chance of procedure failure and damages the vein and renders it unfit for further use [8].

Various techniques have been used to facilitate peripheral venous cannulation. These include the application of a tourniquet, tapping the vein, applying alcohol, clenching the hand, use of constricting bands, application of nitroglycerine ointment and local warming. Apart from these, various other modalities have been tested and tried from time to time. Colour vision glasses or filters, night vision goggles, ultrasound needles and catheters, near infrared spectroscopy, visible light transilluminator, pressure sensing needles, and heat-sensitive bands are available to ease venous cannulation in children [9,10]. There are only a few studies available in the literature, where transillumination Light Emitting Diode (LED) devices are used to assist peripheral venous cannulation.

Transillumination LED vein finder is a device that uses side transillumination to transmit circular rays of light inclined inwards at an angle such that the light is focused towards the centre of the circle and under the skin surface [Table/Fig-1]. This causes uniform transillumination of a small tissue region and increases visualisation of superficial peripheral veins [Table/Fig-2]. This device uses a cold light source of the wave length 620-660 nm which can be transmitted through hand tissue, visible to the human eye, and absorbed by haemoglobin. The cost-effectiveness, safety, portability and convenience of LED transilluminating vein finder devices make them an ideal tool in patient care areas [11,12].

The aim of the study was, to evaluate the role of transilluminating light emitting diode vein finder device (Optramed Vein-Lite), for peripheral intravenous cannulation in children. The primary outcome measures were the number of attempts and ease of intravenous cannulation. The secondary outcome measures were the time required for the procedure and the DIVA score.



[Table/Fig-1]: LED vein finder device and a peripheral venous cannula.
[Table/Fig-2]: LED vein finder device for peripheral i.v. cannulation.
(Images from left to right).

MATERIALS AND METHODS

This randomised clinical study was conducted in Pandit Bhagwat Dayal Sharma Post Graduate Institute of Medical Sciences, Rohtak, Haryana, India, from January 2018 to January 2020. Approval was obtained from the Institutional Ethics Committee (IEC/Th/18/Anst22).

Sample size calculation: A previous study by Hosokawa K et al., on infants and children <2 years of age revealed that venous cannulation was successful at the first attempt in 73% in the transillumination method compared to 49% in the conventional method [11]. Assuming these as reference values, the minimum required sample size at 5% level of significance and 80% power suggested the sample size of atleast 61 patients in each group.

Inclusion criteria: One hundred thirty patients, age <3 years, either sex, scheduled for surgery under general anaesthesia were included in the study after obtaining informed and written consent from parents/guardians of all the children.

Exclusion criteria: Patients already having an intravenous cannula, in hypovolemic shock, undergoing chronic steroid therapy, on chemotherapy and on i.v. fluid therapy within the preceding seven days, were excluded from the study.

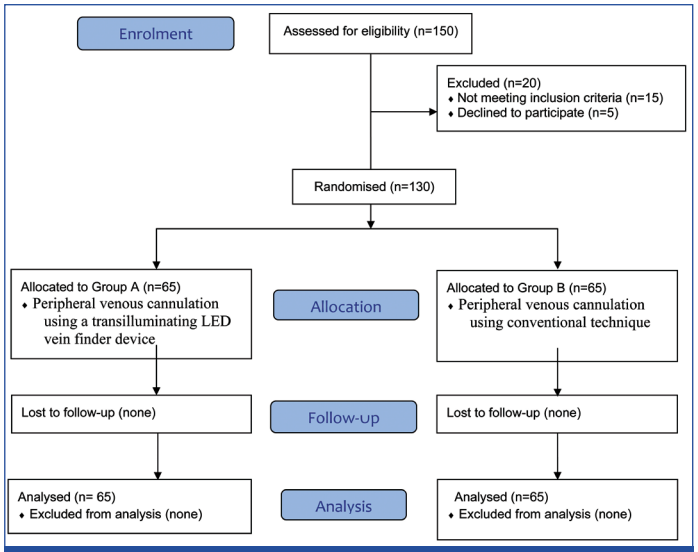
The patients were assessed a day prior to surgery. Detailed clinical history from the parents was taken and a general physical examination was carried out. Other parameters like age, sex, weight, height, skin shade, and Body Mass Index (BMI) were also noted. Skin shade was evaluated using the Fitzpatrick scale and considered dark, if shade had a scale of 5 or more [13]. All the routine investigations like haemoglobin, bleeding time, clotting time and urine complete examination were checked. Other investigations such as blood urea, blood sugar, serum electrolytes, ECG and chest X-Ray were done as per indication.

The study' flow diagram is presented in [Table/Fig-3]. Patients were randomly assigned using computer-generated random numbers to either of the following groups:

- Group I (n=65): Peripheral venous cannulation was done using a transilluminating LED vein finder device.
- Group II (n=65): Peripheral venous cannulation was done by conventional technique (by visualising or palpating the vein manually).

Study Procedure

On the day of surgery, patients were taken to the operation theatre and standard monitors like electrocardiogram and pulse oximeter were attached. Baseline vital data was noted. The patient's characteristic features pertaining to peripheral vein-like visibility and palpability as well as skin complexion were noted. All patients received general anaesthesia with inhalation induction with nitrous oxide (70%) in oxygen (30%) and sevoflurane (upto 8%) using the Jackson Rees circuit. Methods to improve venous cannulation including tourniquet application and swabbing with alcohol were used in both the groups. The predicted difficulty score for intravenous cannulation was calculated before beginning the procedure in both the groups using the DIVA score.



[Table/Fig-3]: Consolidated Standards of Reporting Trials (CONSORT) diagram of the study.

Difficult intravenous access: Score is a four-variable clinical prediction score for predicting difficulty during intravenous cannulation in children. It takes into account following variables;

- Vein visibility after tourniquet application
  - Visible=score 0
  - Not visible=score 2
- Vein palpability after tourniquet application
  - Palpable=score 0
  - Not palpable=score 2
- Age
  - >3 years=score 0
  - 1-2 years=score 1
  - <1 year=score 3
- History of prematurity
  - Not premature=score 0
  - Premature=score 3

A score of 4 or more predicts difficult intravenous cannulation in children [14].

Intravenous cannulation was attempted as per the group allocated. In group I LED device was used to locate the vein, before puncturing it and subsequently intravenous cannulation was done. In group II cannulation was performed after visualising or palpating the vein manually by the anaesthetist. Cannulation was attempted in the left hand first and if the initial three attempts in the arm failed then the right arm was considered for further cannulation. A new provider was asked to obtain venous access, if unsuccessful after six attempts and this was considered an unsuccessful intervention. An attempt was defined as a skin puncture with the chosen cannula with or without evidence of intravascular entry (blood flashback). Redirection of the needle tip while underneath the skin was counted as a separate attempt. The procedure was considered successful, if 2 mL of isotonic sodium chloride solution was infused without evidence of local infiltration. An unsuccessful attempt was defined as a skin puncture without blood flashback or resistance to i.v. fluid infusion with or without swelling at the insertion site. The rest of the procedure for anaesthesia and surgery proceeded, as planned.

Ease of cannulation: It was recorded as:

Easy cannulation on the first or second attempt OR

Difficult >2 attempts

Time taken: The time taken for peripheral i.v. cannulation was noted as the time from touching the skin for the first time, until the free flow of blood is seen in the hub of the cannula. If more than one attempt

was required then the time interval between successive attempts to further locate the vein was not counted.

STATISTICAL ANALYSIS

The quantitative variables in both groups were expressed as mean±SD and compared using unpaired t-test between groups. The qualitative variables were expressed as frequencies/percentages and compared using the Chi-square test. A p-value <0.05 was considered statistically significant. Statistical Package for Social sciences (SPSS) version 16.0 was used for statistical analysis.

RESULTS

The demographic profile including age, sex, weight and BMI were comparable in both the groups [Table/Fig-4]. In group I, 28 out of 65 patients had a visible vein while 25 out of 65 patients in group II had a visible vein [Table/Fig-5]. There was no significant statistical variation in both the groups with respect to vein visibility (p-value=0.7211). In Group I, 32 out of 65 patients had a palpable peripheral vein while 36 out of 65 patients in group II had a palpable vein [Table/Fig-5]. Both the groups showed no significant variation, with respect to vein palpability (p-value=0.5983).

Parameters	Group I	Group II	p-value
Mean age (in months)	17±13	15±23	0.5427
Sex			
Male	45	51	0.3184
Female	20	14	
Weight (kg)	9.24±7.39	9.04±11.02	0.9035
BMI (kg/m^2)	15.53±1.92	15.99±3.759	0.3813

[Table/Fig-4]: Demographic parameters.

Parameters	Group I	Group II	p-value
DIVA score			
<4	37 (57)	40 (61.5)	0.7211
>4	28 (43)	25 (38.5)	
Vein visibility			
Yes	28 (43)	25 (38.5)	0.7211
No	37 (57)	40 (61.5)	
Vein palpability			
Yes	32 (49.2)	36 (55.4)	0.5983
No	33 (50.8)	29 (44.6)	
Skin shade			
Dark (Fitzpatric scale ≥5)	31 (47.7)	33 (50.8)	0.8607
Light (Fitzpatric scale <5)	34 (52.3)	32 (49.2)	

[Table/Fig-5]: Patient's characteristic features precannulation attempt.
DIVA: Difficult intravenous access prediction score

The skin shade of the patients among the two groups was also comparable. In group I, 31 out of 65 patients had dark skin, while 33 out of 65 patients in group II patients had dark skin [Table/Fig-5]. Both the groups showed no significant variation with respect to skin shade (p-value=0.8607). In group I, 28 out of 65 patients had a DIVA score of more than 4, while, 25 out of 65 patients in group II had a DIVA score of more than 4 [Table/Fig-5]. Both the groups showed no significant variation with respect to DIVA score, with a p-value 0.7211.

There was a significant difference with regard to the time required for i.v. cannulation between both the groups with a p-value of 0.0346. Time taken in group I was 19.385±6.2015 sec, and in group II was 22.886±11.6716 sec. Both the groups showed significant variation with respect to the number of attempts (p-value=0.0014). In group I, cannulation was easy in 63, while, in group II, cannulation was easy in 50 out of 65 patients. Both the groups showed significant variation with respect to ease of cannulation (p-value=0.0018) [Table/Fig-6].

Variables	Group I	Group II	p-value
Mean time of cannulation (in seconds)	19.385±6.2015	20.886±11.671	0.0346
No. of attempts, N (%)			
1	59 (90.7)	41 (63)	0.0014
2	4 (6.15)	9 (13.8)	
3	2 (3.07)	9 (13.8)	
4	0	6 (9.2)	
Ease of cannulation, N (%)			
Easy	63 (97)	50 (80)	0.0018
Difficult	2 (3)	15 (20)	

[Table/Fig-6]: Observations recorded after i.v. cannulation.

DISCUSSION

Peripheral i.v. cannulation is a common, but essential procedure in everyday anaesthesia practice for administering fluids and medications. Securing venous access is often difficult and time-consuming in paediatric patients due to the inability to identify peripheral veins. This is so because, their superficial peripheral veins are too small to palpate, difficult to see with ambient light and at times embedded in subcutaneous fat. The first attempt success rate is also low, ranging from 53-75.6% [9]. Subcutaneous fat and tiny veins complicate the procedure in the paediatric population. Despite widespread marketing and clinical use, research evaluating the clinical utility of a transillumination LED vein finder for the visualisation of vessels for peripheral i.v. cannulation is scarce. So, the present randomised clinical trial was conducted to analyse the clinical benefits of transillumination LED vein finder in the paediatric population.

In the present study, the four variable DIVA score, suggested by Fitzpatrick TB, was used to assess the difficulty of iv cannulation [13]. It is the only available score in the literature to predict these parameters which help to decide whether or not, to use any advanced technology for establishing i.v. access. Although, it is of particular importance in emergency settings, this was calculated in order to predict difficult cannulation. Both the groups showed no significant variation and were comparable with respect to DIVA score. This implies that the distribution of patients with predicted difficult venous cannulation (i.e. who would benefit from the use of an LED vein finder) was similar in both groups.

The time taken to establish successful venous cannulation in group I was less compared to group II. This is in accordance with the study done by Hosokawa K et al., in which the mean time for securing iv access was 47±34 sec in the TM group (Transillumination group) and 68±60 sec in UM (Usual Method) group [11]. Thus, the use of a transilluminating LED device for establishing venous access in the paediatric population has made a tremendous impact on the success of the procedure. However, the mean time for establishing venous access in the present study was less than that of Hosokawa K et al., [11]. This may be because the duration of the attempt mentioned in the later study, was defined as the time taken to inspect the vein until confirmation of successful venous cannulation or tourniquet release while in the former, it was defined as time for peripheral venous cannulation as the time skin puncture with the chosen cannula with or without evidence of intravascular entry (blood flashback). Thus, tourniquet time and inspection time for the vein were not included in the present study.

In the study done by Atalay H et al., the time taken for establishing venous access is much more (5 min or 300 sec). This may be because the study population also included emergency cases. They also included the time taken for cannulation by using a saline flush, and both the groups showed significant variation with respect to the number of attempts (p-value=0.0014) [15].

The number of attempts required for establishing venous access was less in group I as compared to group II. Thus, the use of transilluminating LED device (Optramed Vein-Lite) significantly improved the success of the first attempt at venous cannulation.

Similar findings were reported by Hosokawa K et al., who concluded that venous cannulation was successful in establishing the initial first attempt in 75% of patients in the TM group [11]. Katsogridakis YL et al., also concluded that by illuminating the vein with transilluminating LED device, the i.v. placement was 2.1 times more likely to be successful in the first attempt [5]. Atalay H et al., reported that out of 100 children, transillumination helped venous access in 80 patients and a vein could be cannulated on the second attempt in less than 5 minutes [15].

In the present study, both the groups showed significant variation with respect to ease of cannulation (p-value=0.0018). Thus, the use of transilluminating LED device clearly makes cannulation in paediatric patients much easier. The results are in accordance with those of Atalay H et al., Hosokawa et al., and Katsogridakis YL et al., [5,11,15]. They also concluded that transillumination of veins has not only decreased the discomfort to the patient but also increased the rapidity of i.v. access and thus successful fluid and drug administration. Also, the frequency of i.v. establishment at uncomfortable sites like the foot or neck has decreased leading to more patient and parent satisfaction.

The LED devices can prevent unnecessary multiple cannulation as well as central venous catheterisation, thus, decreasing overall cost of procedure [5,10]. Various devices like ultrasound, infrared devices, and fibreoptic illumination have been acknowledged for facilitating i.v. cannulation [16-18]. Use of ultrasound, infrared and fiberoptic devices requires learning curve and cost of these equipment hinders use in limited resource settings [12].

Hence, the transilluminating LED vein finder device is definitely useful for successful i.v. cannulation. But an assistant is required for holding it, which is a disadvantage of its use. Also, since the veins stand out so clearly, they give the illusion of being more superficial than they are and practice is required to develop a new sense of depth perception to puncture these veins. Lastly, this light is less useful in the antecubital fossa, wherein the fat above the veins is usually too thick to allow good visualisation of the veins and it is much more difficult to immobilise the elbow adequately, during venipuncture.

Limitation(s)

Only elective cases were enrolled for the study, the age group taken was only <3 years, and only upper limb i.v. cannulations were included. Therefore, studies including emergency cases, wider age groups, and i.v. cannulation at other sites too, are recommended in future to add further knowledge.

CONCLUSION(S)

Transillumination is a useful technique to improve the success rate of peripheral venous cannulation in infants and children, which is otherwise challenging. The transilluminating LED vein finder device is a simple, economic and promising tool that can ease, the safe and rapid securing of i.v. access in minimal attempts. Thus, use of vein finder device is recommended, whenever difficult i.v. cannulation is anticipated.

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