Comparison of the Efficiency of Two Different Vein Visualization Devices for Peripheral Intravenous Catheter Placement in Preterm Infants: A Randomized Clinical Trial

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ABSTRACT

Aim: The aim of this study was to examine the efficacy of two vein visualization devices the infrared (AccuVein AV 400) and transilluminator (Wee-Sight) compared to conventional method during the placement of peripheral intravenous catheter (PIVC) in preterm infants.

Method: The data of the study were obtained from 90 preterm infants randomly assigned in NICU who were gestational age 32-37 weeks, vein for the first time, without analgesic, non-intubated (Infrared Group=30, Transilluminator Group =30, Control Group=30 preterm). Vital signs, pain scores, operation duration, operation success rate of the 1st try, catheter dwell time, and phlebitis scores were evaluated. Information form, Visual Infusion Phlebit (VIP) Scale and Neonatal Infant Pain Scale (NIPS) were used to collect data.

Results: There was no significant difference in body temperature and pulse rate between the 3 groups in the pre and post interventions period. Respiratory rate was significantly lower for the Infrared Group post intervention period as compared with the Transilluminator Group and control group ($p<0.05$). NIPS scores were significantly higher in the Transilluminator Group (0.60±0.855) than the Infrared Group (0.33±0.182) and control group (0.33±0.182) on during seeking appropriate vein ($p<0.001$). Operation duration was significantly lower for the Infrared Group (8.70±2.56 sec) as compared with the Transilluminator Group (45.27±30.83 sec) and control group (17.30±8.40 sec) ($p<0.001$). Operation success rate of the 1st try were significantly higher in the Infrared Group than in the Transilluminator Group and control group ($p<0.05$). Catheter dwell time were significantly higher in the Infrared Group (1.57±0.50 days) than in the Transilluminator Group (1.27±0.45 days) and control group (1.27±0.45 days).

Conclusion: The study concluded that use of infrared vein visualization device (Accuvein AV 400) was effective and reliable on operation duration, operation success of the 1st try, catheter dwell time, and pain scores during the placement of PIVC in preterm infants.

Key words: Peripheral intravenous catheterization, vein visualization device, neonatal nursing, Accuvein AV 400, Wee-Sight Transilluminator, preterm.

INTRODUCTION

The Neonatal Intensive Care Unit (NICU) constitutes a therapeutic environment to treat high-

risk newborns (Danski et al 2016). In the NICU, peripherally inserted intravenous (IV) catheters are widely used for total parenteral nutrition (TPN), medications and blood sampling for exams, especially in very low-birth-weight infants (Bashir et al 2016). In high risk newborns, the placement of peripheral intravenous catheters (PIVCs) is more difficult than in adults due to causes such as smaller vessel diameters, difficulty in palpating veins, and reduced visibility in newborns (Szmuk et al 2013). Multiple and repeated failed catheterization attempts cause pain and distress, and increase the risk of complications, such as hematoma or nerve injury (Kennedy et al 2008). 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 (Sun et al 2013). Visualization of veins that are invisible to the naked eye could be an aid to facilitate intravenous punctures (Cuper et al 2012). Improvement of the success rate with new technology represents a great opportunity (Aulagnier et al 2014). There are several devices using this technology including the infrared and transilluminator. It has been suggested that these devices, designed to detect the proper vein pathway, facilitate the health worker and cause less harm to the infant. It is stated that devices developed with advanced technology provide a clear and detailed view, providing a comfortable access to the most appropriate vessel, allowing free movement of hands and allowing the vessel to be opened with one health worker.

BACKGROUND

Inserting a PIVC is one of the invasive procedures most frequently performed by nurses. There are many factors contributing to the difficulty of IV insertion: vein difficult to thread, overall poor veins, vein “disappearance,” invisible vein, rolling vein, “blowing up” vein, IV infiltrate, vein difficult to puncture, dark skin, arm obese, tough skin, and patient movement and the nurse’s experience and an emergency context can explain some difficulties in catheter insertion (Aulagnier et al 2014, Gregg et al 2010)). Jacobson and Winslow (2005), who prospectively reported a 77% first success rate on 339 insertions performed by 34 nurses during hospital stays. Ultrasound (US) guidance in adults significantly increases the success rate of vein catheterization, with an overall success rate close to 99% and 71% at first attempt in patients with known difficult peripheral vein access in an intensive care unit (Greg et al 2010). A study conducted in the state of Rio de Janeiro proved that 99.6% of newborns used the venous via during their admittance in NICUs and from those, 49.2% were PIC (Danski et al 2016). Demir and Inal (2017) reported that the success rate of the PIVC in the group using infrared technology was 91.7% and 47.4% in the control group in the study conducted on 129 children between 3-18 years of age. Pediatric nurses should therefore use techniques that increase the success rate or shorten the duration of PIVC. Although there are only a few studies that have been conducted with both devices and demonstrated their efficacy, no studies have been published that

demonstrate efficacy in premature infants. This aim of this study was to examine the efficacy of two vein visualization devices the infrared and transilluminator compared to conventional method during the placement of peripheral intravenous catheter (PIVC) in preterm infants.

METHOD

Study design

This aim of this prospective, randomized controlled trial (RCT) was to examine the efficacy of the infrared and transilluminator to cannulate veins in preterm infants compared to conventional method in NICU. It was hypothesized that its clinical efficacy would be significantly greater in infrared and transilluminator preterm infants than in those who did not use the device. Accordingly, the research hypotheses were:

Hypothesis 1. The use of vein visualization devices during PIVC placement; vital signs, pain scores, operation duration, operation success rate of the 1st try, catheter dwell time, and pain scores are more effective than conventional method**.**

Hypothesis 2. The use of infrared visualization device during PIVC placement; vital signs, pain scores, operation duration, operation success rate of the 1st try, catheter dwell time, and phlebitis scores are more effective than transilluminator device.

Sample

The study was conducted June 2016-April 2017 in the NICU of Bakırköy Dr. Sadi Konuk Education and Research Hospital in Istanbul, Turkey. The hospitalized subjects comprised preterm infants who met the following inclusion criteria:

- Were gestational age 32-37 weeks,
- The first insertion of a vein pathway
- Currently not taking analgesics,
- Non-intubated
- Consent by the mother and father as indicated by the informed consent form.

Power analysis to estimate the sample size was based on previous research involving a large effect size. Assuming a power of 0.8 and $\alpha = 0.050$, a sample size of 90 was determined to be adequate. The preterm infants (N = 90) were assessed according to the inclusion criteria and invited to participate in the study, if found to be eligible. Overall, the research sample comprised 90 preterm infants; 30 in the infrared group, 30 in the transluminator group and 30 in the control group. The flow diagram created by the researchers was based on the information obtained from a CONSORT (Consolidated

Standards of Reporting Trials) statement (Figure 1). The groups were appointed by a computer-based random number generator.

Figure 1.

Procedure

Before starting the study, the research nurse was trained in the use of the vein visualization devices and performed peripheral intravenous catheterizations during 4 days; the infants who underwent catheterization during these training days were not included in the sample. The PIVC procedure performed by the same nurse with the 24-gauge of catheter (Introcan Safety® IV Catheter made of Teflon® B. Braun Medical Inc., Bethelehem, USA) into the metacarpal vein of the infants after their admission to the NICU. The insertion procedure for a PIVC was followed, based on examples in the literature (Canbulat Şahiner et al., 2014; Ortega et al., 2008; Savaşer et al., 2009).

The AccuVein AV 400 vein visualization device was used during peripheral intravenous catheter placement from one of the groups (n=30) (Figure 2). The AccuVein AV 400, which is an easily portable device, could be the solution. This hand-held instrument displays light from two low-power lasers, a red laser at 642 nm and an infrared laser at 785 nm. Veins are depicted as black lines on the skin because hemoglobin preferentially absorbs infrared light. Thus, the vasculature that is displayed represents the content of the vein and not its walls (AccuVein 2016).

The Wee-Sight Transilluminator vein visualization device was used during peripheral intravenous catheter placement from the other group (n=30) (Figure 3). The Wee-Sight transilluminator can help to accurately locate the tiny veins in a neonate's small limbs for improved insertion of an IV. The LED light performs as well as larger transilluminators, but does not emit heat, making it safer for delicate skin (Wee-Sight 2016).

The control groups did not use the device. The unit’s procedural protocol for attempting routine vein pathway opening was applied to the infants in the control group. The parents of the infants in all three groups were not with them during the process. All Peripheral Intravenous catheter placement procedures were carried out when the infants first arrived from the delivery room to the Newborn intensive care unit, under a radiant heater in a room where all stimuli (such as noise, light etc.) were controlled.

Data Collection Tools

Various patient demographic characteristics were collected for all groups, including gestational age, gender, weight, and lenght. Weight and height were determined using a portable digital

baby scale and a tape measure. The measurements were taken by the same registered nurse. Information form, Visual Infusion Phlebit (VIP) Scale and Newborn Pain Scale (NIPS) were used to collect data.

Visual Infusion Phlebitis Scale (VIP): Phlebitis scores, determined using a VIP scale, were recorded every eight hours until the catheters were removed. The Visual Infusion Phlebitis Scale is a valid visual tool that is used to determine the phlebitis score of patients following an IV infusion. This scale was developed by Jackson, according to which phlebitis is numerically rated based on observable symptoms, and evaluated in the study by Gallant and Schultz in 2006. A specific action for each numeric rating is recommended when using this scale. The standardized use of this scale eliminates catheter dwell time as a predominant variable when changing peripheral IV sites. Visual Infusion Phlebitis scores range from 0–5, with 0 being indicative of the absence of phlebitis and 5 signifying advanced thrombophlebitis. The internal consistency of the Visual Infusion Phlebitis scale was 0.84 in the current study. Infants in all groups was not observed phlebitis.

Neonatal Infant Pain Scale (NIPS): The NIPS is a valid behavioral tool for assessing infant (neonate to 12 months of age) response to pain (Lawrence et al 1993). The NIPS includes 6 behavioral responses to pain: breathing patterns, facial expression, arms, legs, cry, and state of arousal. The total pain scores range from 0 to 7. Validity and reliability for the Turkish version of the NIPS was validated by Akdovan in 1999. The internal consistency of the original NIPS ranged from 0.87 to 0.95, whereas the internal consistency of the Turkish version is 0.83, and in this study was 0.78 (Akdovan 1999, Lawrence et al 1993).

In our study two previously trained nurses observed and scored each infant's response to PIVC's pain. Each nurse independently assessed each infant in terms of pain scores both during seeking appropriate vein using the Turkish version of the NIPS.

Ethical considerations

Permission to conduct the RCT was received from the hospital ethics committee and institution (Number: 2015/06/01). Prior to the study, parents were informed of the purpose of the research and were assured of their right to refuse to participate or to withdraw from the study at any stage.

Data Analyses

The data were analyzed using Statistical Package for the Social Sciences® for Windows® version 21.0 (IBM Corp., Armonk, USA). The demographic (gestational age, gender, weight, length and Preprocedural pain scores) and outcome variables (Body temperature, pulse rate, respiratory rate, operation duration, operation success, catheter dwell time and NIPS scores) were analyzed using frequency distributions for the categorical variables, and means and standard deviation for the continuous variables. The NIPS scores from the two nurses were analysed for differences; and a concordance coefficient was calculated. Chi square was used to examine differences in categorical variables. Independent samples t-test was used to examine differences in continuous variables and compare mean NIPS scores. Comparisons of phelebitis (VIP scores) for five sequential times and for the three groups were conducted using analysis of variance for repeated measures ANOVA. The comparison of NIPS scores of preterm infants was used to t-test (seeking appropriate vein and placement of PIVC). Statistical significance was set at a p-value of ≤ 0.05.

Results

No significant differences were found between the infrared, transilluminator and control group for any of the demographic variables (gestational age, gender, weight and length, pre-procedural pain scores (see Table 1).

Infrared, Transilluminator and Control Groups' Physiological Parameters

There was no significant difference in body temperature and pulse rate between the 3 groups pre-intervention period (during seeking appropriate vein). Respiratory rate was significantly lower for the infrared group post intervention period (after the placement of PIVC) as compared with the transilluminator and control group (see Table 2).

Infrared, Transilluminator and Control Groups' Operation Success

Operation duration was significantly lower for the infrared group as compared with the transilluminator and control group (see table 3).

Operation success rate of the 1st try were significantly higher in the infrared group than in the transilluminator and control group (see table 4).

Catheter dwell time were significantly higher in the infrared group than in the transilluminator and control group (see table 6).

Infrared, Transilluminator and Control Groups' Pain Scores

NIPS scores were significantly higher in the transilluminator group (0.60±0.855) than in the infrared (0.33±0.182) and control group (0.33±0.182) at during seeking appropriate vein. There was no difference in post intervention period (after the placement of PIVC) NIPS Scores by group (see table 5). There was no significant differences between the two nurses' scores; and the concordance coefficient were 0.846, 0.834 for measurements times respectively.

Discussion

PIVC is a very important, difficult, pain_full procedure and is done frequently in NICU. However, often a nurse is not able to find a vein because of many hindrances. To overcome these problems, many types of vein visualization devices have been developed (Cuper ve ark 2013). The study was conducted for the purpose of determining the effect of the procedural success of infrared and transillumminator technologies developed for this purpose during PIVC placement in preterm babies between 32-37 gestational weeks in comparison with the success rate of traditional methods.

When the physiological characteristics of the infants were examined, it was observed that the body temperatures of the infants in the control group were lower, despite the fact that there were no statistically significant differences in body temperatures and pulse rates before and after the attempts for the infants in all 3 groups (36.37, 36.46, and 36.14, respectively). It is thought that this was the result of keeping the infant outside the incubator for a longer period of time while seeking a vein pathway for infants in the control group. The respiratory rates of the infants in the Transilluminator group were found to be significantly high in statistical terms during the process of attempting to find a vein pathway (while seeking an appropriate vein). This was thought to be caused by the possibility that infants whose vein paths were opened by Transilluminator may have undergone more manipulation-induced stress, since it took longer to find an appropriate vein with them.

The duration of the procedure to place the PIVC is a variable that demonstrates the efficacy of vein visualization devices. When the vein pathway opening times were examined in infants in all 3 groups, it was observed that the vein pathways for infants in Transilluminator group took statistically significant longer to open (45.27±30.83, 8.70±2.56, 17.30±8.40 seconds, respectively). The statement made by the nurse who opened the vein pathways in regards to the difficulty of finding a vein pathway by using the Transilluminator supports this finding. In a study conducted by Cuper et al (2013) using a different vein pathway visualization device, the VascuLuminator, it was reported that the average duration of the PIVC placement attempts was similar in the experimental group (162±14 sec) and the control group (143±15 sec). It is thought that the differences in results when compared to our study could be due to the fact that the VascuLuminator device displays the data through a computer, which is different than the infrared device (Accuvein AV 400). Sun et al (2013) reported that the procedure was carried out in a shorter period of time in the experimental group (126.37±26.33 sec) compared to the control group (383,61±112.14 sec) in a study they conducted by using VeinViewer in a group aged 3 months to 17 years. Hosokova et al (2010), on the other hand, reported that the duration of attempting to place a PIVC was much lower in the experimental group (47±34 sec) when

compared to the control group (68±66 sec) and that vein visualization devices shortened the procedural time among infants and children. It can be said that the naked eye and infrared technology could help both in carrying out the procedure in less time in preterm infants and in the effective use of the nurse's time

Success in the first attempt in placement of a PIVC is an important variable in demonstrating the efficacy of the vein visualization devices, since they impact the pain level of the patient and lead to demoralization resulting from failure among nurses. The study shows that the success rate in the first attempt is statistically higher in the infrared (80%) and control (86.7%) groups compared to the transilluminator group (60%). The findings by Kaddoum et al (2012) in pediatric patients are similar to our research findings, where they reported the rate of success in the first attempt was similar in the experimental group (75%) and the control group (73%) in a study they conducted using Accuvein AV 300, a sub-model of the device we used in our study. A study by Delvo-Favre et al (2014) reported that the success rate of a PIVC placement procedure using Accuvein AV-400 was 93% for the first and second attempts. A study by Demir and Inal (2017) determined that the success rate was 91.7% in the first and second attempts among children ages 3-18 who had received PIVC placement using the advanced version of the device, the Accuvein AV-400. Many studies investigating the efficacy of various vein visualization devices have determined that these devices increase the rate of success in the first attempt (Cuper et al 2013; Hosokawa et al 2010; Strehle 2010). It is thought that the similarity of the success rate between the infrared and control groups in the first attempt in our study may be due to the fact that most of the patient population consisted of preterms.

The PICV procedure is a significant medical procedure that causes pain (Inal and Kelleci 2012). It has been reported that a previous catheter placement increases the perception of pain and impacts the level of pain in subsequent procedures (Savino et al 2013). Therefore, the study included infants who were undergoing vein pathway opening for the first time. When the pain level of the infants was observed during the process of seeking an appropriate vein, it was observed that pain scores of the infrared (0.33±0.182) and control groups (0.33±0.182) were significantly lower than those in the transilluminator group (0.60±0.855). It is thought that this result was due to handling the preterms too long before the procedure, because the PIVC placement procedure is long and the success rate in the first attempt is low, as well as to using a multi-attempt procedure. A study by Demir and Inal (2017) conducted on pediatric patients using the Accuvein AV-400 indicates that average pain points in the experimental group are lower, similar to the findings of our research.

When the dwell duration of the PIVC in the vein pathway is examined, it is observed that

catheters placed by infrared (1.57±0.50 days) remain in the vein pathway for a statistically longer period than the transilluminator (1.27±0.45 days) and control (1.27±0.45 days) groups. It is thought that this might be the result of selecting the most ideal and reliable vein, due to the success rate of PIVC in the first attempt in infants in the infrared group.

Conclusion

While it has been determined that PIVC attempts carried out in conjunction with vein visualization devices reduces both multi-entry attempts and the time spent by the nurse, as well as lowering pain scores, it was seen that the use of the Transilluminator device, used in our study, is not suitable for use on preterm infants. However, the use of an infrared device is effective in reducing the number of procedures, duration, and pain. In this regard, increased use of an infrared device in preterms during the PIVC placement procedure can be recommended, due to its efficacy and reliability. However, many more studies are required regarding the efficacy of vein visualization devices in preterm infants.

Limitations

The study was conducted on infants gestational age 32-37 weeks. Hence, the findings may not be generalizable to all pediatric patients.

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