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Efficacy of Vein Visualization Devices for Peripheral Intravenous Catheter Placement in Preterm Infants

A Randomized Clinical Trial

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ABSTRACT
The aim of this randomized controlled trial was to examine the efficacy of vein visualization devices and the routine method for insertion of peripheral intravenous catheters (PIVCs) in preterm infants. The study was conducted between June 2016 and April 2017 in the neonatal intensive care unit of Bakırköy Dr Sadi Konuk Education and Research Hospital. Participants ($N = 90$) were randomly assigned to the infrared group ($n = 30$), the transilluminator group ($n = 30$), or the control group ($n = 30$). Time to successful cannulation was significantly lower for the infrared group (8.70 ± 2.56 seconds) than for the transilluminator group (45.27 ± 30.83 seconds) and the control group (17.30 ± 8.40 seconds) ($P \leq .001$). Success of the first attempt was significantly higher in the infrared and transilluminator groups than in the control group ($P \leq .05$). Dwell time of the PIVC in place was significantly higher in the infrared group than in the transilluminator and control groups ($P \leq .05$). Neonatal Infant Pain Scale scores were significantly higher in the transilluminator group (0.60 ± 0.855) than in the infrared (0.33 ± 0.182) and control groups (0.33 ± 0.182) while seeking an appropriate vein ($P \leq .001$). The use of an infrared device provides efficacy in time to successful cannulation, success of the first attempt, length of the time the catheter is in place, and technique-related pain.

Key Words: AccuVein AV400, neonatal nursing, peripheral intravenous catheterization, vein visualization device, WeeSight Transilluminator

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The neonatal intensive care unit (NICU) constitutes a therapeutic environment to treat high-risk infants.[1] In the NICU, peripherally inserted intravenous (IV) catheters are widely used for total parenteral nutrition, medication, and blood sampling for examinations, especially in very low-birth-weight infants.[2] Inserting peripheral intravenous catheters (PIVCs) is a very important, difficult, and painful procedure that is done frequently in NICUs. Danski and colleagues[1] reported that 99.6% of infants are treated intravenously in NICUs, and of those, 49.2% were treated using PIVCs. In high-risk infants, the placement of a PIVC is more difficult than in adults due to smaller vessel diameters, difficulty in palpating veins, and provided visibility in newborns.[3] Often a nurse is not able to find a vein because of these obstacles.[4] Repeated failed catheterization attempts cause pain and distress and increase the risk of complications such as hematoma or nerve injury.[5] Seen from the nurse's perspective, unsuccessful attempts may lead to frustration, anxiety, loss of self-confidence, and damage of trust in the relationship between the infant's parents and the nurse.[6] Visualization of veins that are invisible to the naked eye could be an aid to facilitate IV punctures.[4] To overcome these problems, many types of vein visualization devices (ultrasound, infrared, and transilluminator) have been developed.

BACKGROUND

Vein visualization devices are designed to detect the proper vein pathway, help healthcare professionals, and cause less harm to the infant. These devices are developed with advanced technology to provide a clear and detailed view and comfortable IV access to the most appropriate vessel. In the biomedical market, there are different visualization devices using various light sources (ultrasound, transilluminator, near-infrared, and infrared). The literature focuses on whether using vein visualization devices affect IV success rate, time to successful cannulation, and local pain of the PIVC procedure.[7] The study by Sun and colleagues[6] reported that the PIVC placement procedure was carried out in a shorter period in the infrared group (VeinViewer) (186.16 ± 38.82 seconds) than that in the control group (497.23 ± 123.31 seconds) in 3-month to 17-year-old patients. However, Cuper and colleagues[4] reported that the average duration of the PIVC placement attempts using a near-infrared vein visualization device (Vascu-Luminator) and a control group in child patients. On the contrary, Hosokawa and colleagues[8] reported that the duration of attempting to place a PIVC was much lower (47 ± 34 seconds) and shortened the procedural time in the transilluminator group compared with the control group (68 ± 66 seconds) in infants and children.

The results regarding the rate of success in the first attempt of a PIVC placement procedure, a study by Demir and Inal[9] determined that the success rate was 91.7% in the first and second attempts and pain scores were lower using the infrared advanced version of the device (AccuVein AV400) in children aged 3 to 18 years. In addition, Delvo-Favre and colleagues[10] reported that the success rate of a PIVC placement procedure using infrared technology (AccuVein AV400) was 93% for the first and second attempts. However, Kaddoum and colleagues[11] reported the rate of success in the first attempt was similar in the infrared group (AccuVein AV300) (75%) and the control group (73%) in pediatric patients.

Although there are only a few studies conducted with both devices that demonstrated their efficacy, no studies have been published that demonstrate efficacy and compare vein visualization devices in preterm infants. The purpose of this study was to examine the efficacy of vein visualization devices and the routine method for insertion of PIVCs in preterm infants.

METHODS

Design

A prospective, randomized controlled trial (RCT) design was used to determine the effects of the of the 2 vein visualization devices (infrared and transilluminator) and the routine method on physiological parameters, time to successful cannulation, success of the first attempt, dwell time, and pain intensity in preterm infants. The primary outcome was the time to successful cannulation and success of the first attempt. Secondary outcomes included dwell time of the PIVC and technique-related pain scores.

Setting and sample

The study was conducted in June 2016 to April 2017 in the NICU of Bakırköy Dr Sadi Konuk Education and Research Hospital in Istanbul, Turkey. The hospitalized participants consisted of preterm infants who met the following inclusion criteria: (*a*) were of 32 to 37 gestational weeks, (b) were not taking analgesic medications, and (c) had no previous PIVC placement. Exclusion criteria included the following: abnormalities of coagulation, hematological or oncological and allergic diseases, or any incision or scar tissue at the metacarpal area.

Power analysis to estimate the sample size was based on previous research involving a large effect size. Assuming a power of 80% and α risk of .05, a sample size of 90 was determined to be adequate. The preterm infants ($N = 90$) were evaluated 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 transilluminator group, and 30 in the control group (routine method). The groups were appointed by a computer-based random number generator.[12] The flow diagram created by the researchers was based on the information obtained from a CONSORT (Consolidated Standards of Reporting Trials) statement (see Figure 1).

Intervention

Before starting the study, the research nurse, who had experience of 10 years or more in NICU nursing, was trained to use the vein visualization devices and performed the PIVC procedure over 4 days; the infants who underwent the procedure during these training days were not included in the sample ($n = 8$). The PIVC procedure was performed by the same research nurse with a 24-gauge catheter (Introcan Safety IV Catheter made of Teflon; B. Braun Medical Inc, Bethlehem, Pennsylvania) into the metacarpal vein of the infants

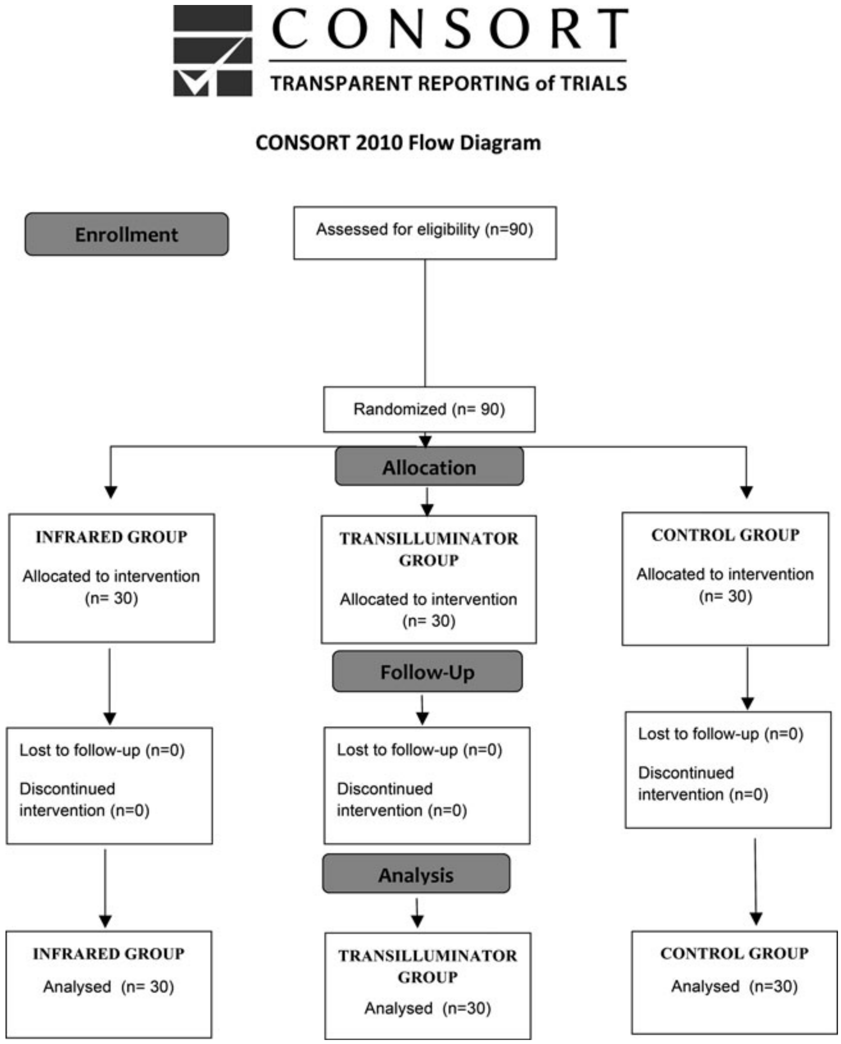

Figure 1. CONSORT 2010 flow diagram.

after their admission to the NICU during the 08:00-16:00 hour shift.

No topical anesthetic was used, as it is not the standard practice of the department. The insertion procedure for a PIVC was followed, based on examples in the literature.[13–15] After inserting the PIVC, the same research nurse applied transparent, self-adhesive, semipermeable dressings made of polyurethane film (3M™ Tegaderm™ I.V. Site Dressings, St Paul, Minnesota) for all groups.

Vein visualization devices

The AccuVein AV400 vein visualization device was used during PIVC placement for one of the groups (n = 30) (see Figure 2). The AccuVein AV400 is an easily portable device. This handheld instrument displays light from 2 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 displayed represents the content of the vein and not its

Figure 2. AccuVein AV400.

walls.[16] There is a hands-free stand that allows the device to be applied by a nurse. However, this apparatus was not used because the process was carried out by 2 nurses in all groups. The attempts guided by the AccuVein AV400 required a dual-operator technique. The research nurse performed the IV placement after selection of the optimal setting, whereas the other nurse held the device approximately 18 cm from the skin, perpendicular to the axis of the metacarpal area during the puncture. The research nurse then placed the PIVC.

The Wee-Sight Transilluminator vein visualization device was used during PIVC placement for another group ($n = 30$) (see Figure 3). The Wee-Sight Transilluminator can help accurately locate the tiny veins in an infant's palms for improved insertion of an IV catheter. The LED light performs as well as larger transilluminators but does not emit heat, making it safer for delicate skin.[17] When the Wee-Sight Transilluminator was used, the PIVC procedure was performed with 2 nurses.

In the control group, as per the routine method, the research nurse inserted a PIVC with a naked eye visualization of the vein. Routine attempts were achieved by visual inspection and palpation of the vessel. The parents of the infants in all 3 groups were not present during the process.

All PIVC placement procedures were carried out when the infants first arrived from the delivery room to the NICU, under a radiant heater where all stimuli (such as noise, light, etc) were controlled. The PIVC procedure was carried out by 2 nurses in all groups. The PIVC process carried out by 2 nurses in this clinic is a routine procedure. While a nurse is doing the invasive procedure, the other nurse helps the process and provides the baby's safety and comfort.

Data collection

Various patient demographic characteristics were collected for all groups, including gestational age, gender, weight, and length. Weight and length were determined using a portable digital baby scale and a tape measure. An information form and the Neonatal Infant Pain Scale (NIPS) were used to collect data.

Figure 3. Wee-Sight Transilluminator.

Neonatal Infant Pain Scale

The NIPS is a valid behavioral tool for evaluating infant (neonate to 12 months of age) response to pain.[18] 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 were validated by Akdovan in 1999.[19] 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.[18,19]

In our study, the 2 previously trained nurses observed and scored each infant's response to the PIVC pain. Each nurse independently evaluated each infant in terms of pain scores during cannulation of the vein using the Turkish version of the NIPS. There were no significant differences between the 2 nurses' NIPS scores, and the concordance coefficients were 0.823, 0.812, and 0.807 for measurement times, respectively.

Ethical considerations

Permission to conduct the RCT was received from the hospital ethics committee and the 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 analysis

Data were analyzed using Statistical Package for the Social Sciences for Windows version 21.0 (IBM Corp, Armonk, New York). Demographic (gestational age, gender, weight, and length) and outcome variables (physiological parameters, time to successful cannulation, success of the first attempt, dwell time of the PIVC in place, and pain scores) were analyzed using frequency distributions for the categorical variables and means and standard deviation for the continuous variables. NIPS scores from the 2 nurses were analyzed for differences, and a concordance coefficient was calculated. A χ^2 test and analysis of variance were used to determine differences among the groups to evaluate the effect of vein visualization devices on outcome variables. In this study, a P value of .05 or less was considered statistically significant.

RESULTS

No significant differences were found among the infrared, transilluminator, and control groups for any of

Table 1. **Comparison of demographic characteristics of preterm infants ($N = 90$)**				
Characteristics	**Transilluminator group ($n = 30$)**	**Infrared group ($n = 30$)**	**Control group ($n = 30$)**	**Statistical test; P value**
Gestational age, mean ± SD, wk	33.93 ± 1.53	34.27 ± 1.57	34.33 ± 1.42	$F = 0.604$; $P = .549$
[Min-Max]	[32-37]	[32-37]	[32-36]	
Gender, *n* (%)				
Female	15 (50)	15 (50)	14 (46-6)	$\chi^2 = 0.089$; $P = .957$
Male	15 (50)	15 (50)	16 (53-4)	
Weight, mean ± SD, g	2152 ± 509	2425 ± 578	2419 ± 646	$F = 2.155$; $P = .122$
[Min-Max]	[1420-3075]	[1480-3270]	[1450-3240]	
Length, mean ± SD, cm	44.37 ± 2.44	44.93 ± 2.47	45.00 ± 2.50	$F = 0.593$; $P = .555$
[Min-Max]	[40-50]	[40-48]	[40-48]	

the demographic variables (gestational weeks, gender, weight, or length) (see Table 1).

Infrared, transilluminator, and control groups' physiological parameters

There was no significant difference in body temperature or pulse rate among the 3 groups in the pre- and postintervention periods (see Table 2). Respiratory rates were significantly lower for the infrared group (51.93 ± 5.12) than for the transilluminator (58.03 ± 10.56) and control groups (55.27 ± 8.50) in the postintervention period ($P = .022$) (see Table 2).

Infrared, transilluminator, and control groups' cannulation success

Time to successful cannulation (seconds) was significantly lower for the infrared group (8.70 ± 2.56) than for the transilluminator (45.27 ± 30.83) and control groups (17.30 ± 8.40) ($P = .000$) (see Table 2).

Infrared, transilluminator, and control groups' first-attempt success

Success of the first attempt was significantly higher in the infrared (80%) and control groups (86.7%) than in the transilluminator group (60.0%) ($P = .04$) (see Table 2). But there was no difference in the success rate of the first attempt between the control group and the infrared group ($P > .05$).

Infrared, transilluminator, and control groups' dwell time and pain scores

Dwell time of the PIVC in place was significantly higher in the infrared group (1.57 ± 0.50) than in the transilluminator (1.27 ± 0.45) and control (1.27 ± 0.45) groups ($P = .02$) (see Table 3). NIPS scores were significantly higher in the transilluminator group (0.60 ± 0.85) than in the infrared (0.33 ± 0.18) and control groups (0.33 ± 0.18) while seeking an appropriate vein. During cannulation of the vein, there was no difference in NIPS scores among the groups (see Table 3).

Table 2. **Comparison of the physical parameters and cannulation success of preterm infants ($N = 90$)**				
Variables	**Transilluminator group ($n = 30$)**	**Infrared group ($n = 30$)**	**Control group ($n = 30$)**	**Statistical test; P value**
Body temperature, °C				
Preintervention	36.37 ± 0.17	36.46 ± 0.11	36.14 ± 1.78	$F = 0.773$; $P = .465$
Postintervention	36.39 ± 0.17	36.46 ± 0.11	36.44 ± 0.14	$F = 1.605$; $P = .207$
Pulse rate				
Preintervention	142.20 ± 12.75	136.70 ± 14.34	138.93 ± 17.90	$F = 0.999$; $P = .372$
Postintervention	148.00 ± 13.33	139.43 ± 13.57	143.63 ± 16.41	$F = 2.615$; $P = .079$
Respiratory rate				
Preintervention	53.73 ± 8.45	50.13 ± 5.08	50.37 ± 5.80	$F = 2.789$; $P = .067$
Postintervention	58.03 ± 10.56	51.93 ± 5.12	55.27 ± 8.50	$F = 3.991$; $P = .022$
Time to successful cannulation mean ± SD, s	45.27 ± 30.83	8.70 ± 2.56	17.30 ± 8.40	$F = 32.01$; $P = .000$
Success of the first attempt, *n* (%)				
Yes	18 (60)	24 (80)	26 (86.7)	$\chi^2 = 6.26$; $P = .04$
No	12 (40)	6 (20)	4 (13.3)	

Table 3. **Comparison of dwell time and pain scores of preterm infants ($N = 90$)**

Variables	Transilluminator group ($n = 30$)	Infrared group ($n = 30$)	Control group ($n = 30$)	Statistical test; P value
Dwell time of PIVC, mean ± SD, d [Min-Max]	1.27 ± 0.45 (1-2)	1.57 ± 0.50 (1-2)	1.27 ± 0.45 (1-2)	$F = 4.10$; $P = .02$
NIPS scores, mean ± SD				
Preintervention	0.17 ± 0.38	0.23 ± 0.43	0.20 ± 0.41	$F = 0.202$; $P = .817$
During seeking appropriate vein	0.60 ± 0.85	0.33 ± 0.18	0.33 ± 0.18	$F = 12.076$; $P = .000$
During cannulating the vein	1.66 ± 0.84	1.33 ± 0.96	1.26 ± 0.64	$F = 2.025$; $P = .138$

Abbreviations: NIPS, Neonatal Infant Pain Scale; PIVC, peripheral intravenous catheter.

DISCUSSION

PIVC placement is a very important, difficult, and painful procedure implemented frequently in NICU interventions. Often, a nurse is not able to find a vein, especially in preterm infants. To overcome this problem, many types of vein visualization devices have been developed.[4] Our study was conducted to determine effects and compare the infrared and transilluminator vein visualization technologies and the routine method on cannulation and success of the first attempt, dwell time of the PIVC, and pain scores in preterm infants aged between 32 and 37 gestational weeks.

Successful cannulation is an important point in preterm infants' PIVC intervention. In our study, time to successful cannulation (seconds) was significantly lower in the infrared group than in the transilluminator and control groups. Similarly, Sun and colleagues[6] and Hosokawa and colleagues[7] suggested a shorter time in the infrared group than in the control group in pediatric patients.[6,7] In addition, success at the first attempt is an important variable in demonstrating the efficacy of vein visualization devices since they impact the pain level of the patients and lead to demoralization among the nurses. The study shows that the success rate in the first attempt is statistically higher in the infrared and control groups than in the transilluminator group. The transilluminator device is placed under the vascular access area during the PIVC procedure. We have observed that this device does not significantly increase vein visibility during PIVC placement. The results of the transilluminator device, which have been even lower than those in the control group, may have been caused by the fact that the device did not significantly increase the vein visibility. It can be concluded that the use of the transilluminator device is not effective for preterm infants and does not facilitate the implementation.

Many studies have reported an increase in successful first attempts using vein visualization devices at PIVC placement.[4,8,20] On literature review, we encountered 2 studies that were conducted using the AccuVein AV400. Demir and Inal,[9] and Delvo-Favre and colleagues[10] determined that infrared vein visualization technology was effective during first-attempt PIVC placement.[9,10] Kaddoum et al[11] reported that although the device (AccuVein AV300) increased the visibility of veins in a randomized controlled study with 146 patients aged 0 to 17 years, it was not more effective than the standard method. Another study conducted by Aulagnier et al[7] using AccuVein AV300 concluded that use of the AccuVein AV300 did not affect PIVC placement attempts in adult patients in the emergency department. The high success rate without using the device in these studies may be because the veins of the adults and children aged 0 to 17 years are larger and more visible than those of the preterm infants and the device used in the study was an earlier version of the device used in our study.

It can be said that the naked eye and infrared technology could help both in carrying out the procedure in less time for the infants and in the effective use of the nurses' time.

In our study, dwell time of the PIVC was longer in the infrared group than in the transilluminator and control groups. In addition, procedural pain levels were lower in the infrared and control groups than in the transilluminator group while seeking an appropriate vein. Also, pain scores were equal in the infrared and control groups. These results were similar to those of Demir and Inal.[9] These similarities in success rates and pain between the infrared and control groups for the first attempt may be due to the fact that the research nurse had experience of 10 years or more in NICU nursing.

LIMITATIONS OF THE STUDY

Our study has some limitations; the study was conducted on infants 32 to 37 weeks' gestational age. Hence, the findings may not be generalizable to all pediatric patients. Blinding was not feasible, and a bias against infrared (AccuVein AV400) and transilluminator (Wee-Sight Transilluminator) from nurses, because they needed to change their routine, cannot be ruled out.

CONCLUSION

The use of an infrared device (AccuVein AV400) demonstrates efficacy in time to successful cannulation, success of the first attempt, dwell time of the PIVC, and technique-related pain compared with the transilluminator device (Wee-Sight Transilluminator) for preterm infants. In this regard, the infrared vein visualization device provides efficacy and reliability. Neonatal nurses can safely use an infrared vein visualization device in preterm infants during the PIVC placement procedure. It is suggested to disseminate the use of effective and evidence-based vein visualization technologies in preterm infants and also to increase the motivations of nurses to use these technologies.

References

1. Danski MT, Mingorance P, Johann DA, Vayego SA, Lind J. Incidence of local complications and risk factors associated with peripheral intravenous catheter in neonates. *Rev Esc Enferm US*. 2016;50(1):22–28.
2. Bashir RA, Swarnam K, Vayalthrikkovil S, Yee W, Soraisham AS. Association between peripherally inserted central venous catheter insertion site and complication rates in preterm infants. *Am J Perinatol*. 2016;33(10):945–950.
3. Szmuk P, Steiner J, Pop RB, Farrow-Gillespie A, Mascha EJ, Sessler DI. The VeinViewer vascular imaging system worsens first-attempt cannulation rate for experienced nurses in infants and children with anticipated difficult intravenous access. *Anesth Analg*. 2013;116(5):1087–1092.
4. Cuper NJ, de Graaff JC, Verdaasdonk RM, Kalkman CJ. Near-infrared imaging in intravenous cannulation in children: a cluster randomized clinical trial. *Pediatrics*. 2013;131(1):e191–e197.
5. Kennedy RM, Luhmann J, Zempsky WT. Clinical implications of unmanaged needle-insertion pain and distress in children. *Pediatrics*. 2008;122(3):S130–S133.
6. Sun CY, Lee KC, Lin IH, et al. Near-infrared light device can improve intravenous cannulation in critically ill children. *Pediatr Neonatol*. 2013;54(3):194–197.
7. Aulagnier J, Hoc C, Mathieu E, Dreyfus JF, Fischler M, Guen M. Efficacy of AccuVein to facilitate peripheral intravenous placement in adults presenting to an emergency department: a randomized clinical trial. *Acad Emerg Med*. 2014;21(8):858–863.
8. Hosokawa K, Kato H, Kishi C, Kato Y, Shime N. Transillumination by light-emitting diode facilitates peripheral venous cannulations in infants and small children. *Acta Anaesthesiol Scand*. 2010;54(8):957–961.
9. Demir D, Inal S. Does the use of a vein visualization device for peripheral venous catheter placement increase success rate in pediatric patients? *Pediatr Emerg Care*. 2017. doi:10.1097/PEC.0000000000001007.
10. Delvo-Favre ED, Daneti G, Guin P. Implementation of near-infrared technology (AccuVein AV-400) to facilitate successful PIV cannulation. Poster presentation at: The 2014 Infusion Nurses Society Conference; 2014. http://download.lww.com/wolterskluwer_vitalstream_com/PermaLink/JIN/A/JIN_2014_06_10_DELVO_00029_SDC20.pdf. Accessed June 31, 2016.
11. Kaddoum RN, Anghelescu DL, Parish ME, et al. A randomized controlled trial comparing the AccuVein AV300 device to standard insertion technique for intravenous cannulation of anesthetized children. *Pediatr Anesth*. 2012;22(9):884–889.
12. Urbaniak GC, Plous S. Research randomizer (version 3.0). http://randomizer.org. Published 2007. Accessed June 5, 2016.
13. Canbulat Şahiner N, Açıkgöz A, Demirgöz Bal M. *Çocuk Hemşireliği Klinik Uygulama Becerileri Kitabı* [Clinical Skills Manual for Principles of Pediatric Nursing]. 5th ed. Ankara, Turkey: Nobel Tıp Kitabevi; 2014:89–92.
14. Ortega R, Sekhar P, Song M, Hansen CJ, Peterson L. Peripheral intravenous cannulation. *N Engl J Med*. 2008;359(21):26–29.
15. Savaşer S, Yıldız S, Gözen D, Balcı S, Mutlu B, Çağlar S. İlaç Uygulamaları [Drug administration]. In: Savaşer S, Yıldız S, eds. *Çocuk Sağlığı ve Hastalıkları Öğrenim Rehberi [Pediatric Health and Diseases Learning Guide]*. Istanbul, Turkey: İstanbul Medikal Yayıncılık Ltd Şti; 2009:107–111.
16. AccuVein. AV400 Vein Viewing System. AccuVein Web site. http://www.accuvein.com/products/catalog/av400-vein-viewving-system. Published 2016. Accessed June 5, 2016.
17. Koninklijke Philips N.V. Wee-Sight Transilluminator vein finder. https://www.usa.philips.com/healthcare/product/weesight-transilluminator-vein-finder. Published 2016. Accessed May 7, 2016.
18. Lawrence J, Alcock D, McGrath P, Kay J, MacMurray SB, Dulberg C. The development of a tool to assess neonatal pain. *Neonatal Netw*. 1993;12(6):59–66.
19. Akdovan T. *Assessment of Pain in Healthy Neonates, Investigation of the Effects of Pacifying and Holding in the Arms* [master's thesis]. Istanbul, Turkey: Health Science Institute, Marmara University; 1999.
20. Strehle EM. Making the invisible visible: near infrared spectroscopy and phlebotomy in children. *Telemed E Health*. 2010;16(8):889–893.

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