

Original Paper


The Effect of Modulating Environmental Stimuli on Pain Experience in Premature Infants During Peripherally Inserted Central Catheter-port Implantation



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ABSTRACT

Introduction: Premature infants in neonatal intensive care units are exposed to painful experiences due to various procedures, and effectively and safely pain relief is the responsibility of nurses. Due to their harmful effects on the neural development of premature infants, reducing environmental stimuli such as light and sound is one of the essential pillars of caring for these infants.

Objective: This study aimed to determine the effectiveness of modulation of environmental stimuli on pain caused by peripherally inserted central catheter (PICC) placement in preterm infants.

Materials and Methods: This controlled trial study was conducted on 60 infants receiving PICC-port implantation. The infants who met the inclusion criteria were selected by random sampling. Then, they were randomly placed in an intervention or control group (30 in each group). The sound and light were reduced in the intervention group using earmuffs and eye shields. When implanting a central venous catheter, the pain amount was measured using the premature infant pain profile (PIPP) instrument. The control group measured neonatal pain without light and sound reduction. The data were recorded for statistical tests using the independent t-test, chi-squared test, and Fisher exact test.

Results: Most of the studied neonates were female (56.6%) and analysis of covariance. The total number of newborns who were candidates to receive a PICC-port was 80, of whom 60 were included in the study. The neonates have no surgery and congenital anomalies. Both genders were included in this study; 24.6% of them suffer from respiratory distress syndrome and prematurity simultaneously. The Mean±SD scores of pain were 9.37±3.15 in the intervention group and 12.63±2.19 in the control group. The independent t-test showed no significant difference between the two groups regarding demographic characteristics before the intervention. The mean score of PIPP after the intervention was significantly less in the intervention group than in the control group (P=0.001). According to the results of the analysis of covariance, adjusting the environmental stimuli of light and sound was effective on the pain level of the neonate during PICC implantation with an effect size of 0.917.

Conclusion: Environment modifications are effective, inexpensive, accessible, and safe methods during PICC placement for premature infants in the neonatal intensive care unit and should be used to promote neonatal outcomes in terms of the neural development of the infant.

Keywords:

NICU, Nurses, Pain, Prematurity

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Highlights

- Peripherally inserted central catheter implementation causes moderate to severe pain in neonates.
- Pain management in the neonatal intensive care unit is a serious and essential task for the treatment team.
- Full-term and preterm neonates experience pain and have the right to receive appropriate, sufficient, and healthy pain relievers.
- Management of the environmental, behavioral, and non-pharmacological interventions are the first measures to control and reduce pain.

Plain Language Summary

Peripherally inserted central catheter insertion is a helpful procedure for infants in the neonatal intensive care unit (NICU). It is long-term access of line but a painful procedure like routine care, suction, and blood sampling. Pain experienced in premature neonates has harmful effects on their mental and physical health. Pain management in the NICU is an essential duty for personnel. An example of non-pharmacological pain management is reducing environmental stimuli (light and sound). Environmental stimuli like light and sound (assessed in this study) are inevitable in NICU and affect pain experience in neonates. By reducing these stimuli in this study, we noticed decreased pain experienced during catheter insertion in neonates.

Introduction

Premature birth is the leading cause of hospitalization in neonatal intensive care units (NICUs) [1]. Premature infants experience several painful diagnostic or therapeutic procedures in the NICU, such as intravenous catheterization, venipuncture for blood sampling, gastric nasal tube insertion, endotracheal tube insertion, and peripherally inserted central catheters (PICCs). PICCs are being placed routinely to provide nutrition and medications in NICUs, especially for preterm infants [2-4]. Preterm infants are exposed to frequent painful procedures and agitating stimuli during the many weeks of their stay in the NICU [5]. Noise, pain, and the neonatal intensive care environment can also affect infant neurodevelopment [6]. However, the white noise and lullabies played to premature babies during the blood collection effectively reduced pain [7]. Preterm infants are uniquely vulnerable to early toxic stress exposure and suboptimal neurodevelopmental outcomes while being in the NICUs [8]. Nociceptive signals cause a cascade of physical and behavioral reactions that, alone or in combination, can be observed and used to assess the presence and intensity of pain [9]. The effects of these stresses show up even in the following years of an infant's life with neurological dysfunctions such as memory, attention, and perception [10, 11]. These infants may need a PICC during a relatively long period

of hospitalization to receive total parental nutrition and avoid recurrent venipuncture [10, 12].

PICCs are inserted for various purposes in the NICU, such as administering fluids, blood products, total parental nutrition, and medications [12-14]. To execute PICC better in newborns, it is imperative to use cluster nursing interventions properly and prevent catheter-related bloodstream infection [2, 14, 15]. All treatment policies and strategies should be based on the fact that the infant should never be exposed to relievable pain [16]. A proper interpretation of pain-related behaviors in a preterm infant is crucial. PICC placement is a painful procedure and, like other painful procedures performed on infants, requires non-pharmacological and pharmacological methods to relieve the pain [3]. These methods are helpful, uncomplicated, and cost-effective. Oral sucrose, pacifiers, skin-to-skin contact, containment, and swaddling are the methods most verified in recent years [17, 18].

Pain in the neonate is often challenging to assess but essential to control. Both inadequate pain control and over-utilization of opioids can have long-term consequences, including poor developmental outcomes [19].

Accordingly, adjusting auditory, visual, tactile, olfactory, and taste stimuli in the neonatal care unit is one of the fundamental principles of preterm infant care.

The relevant guidelines suggest strategies to control stimuli in the NICU and provide an environment consistent with the normal conditions of neural development [20, 21]. Controlling light and noise levels in the NICU environment is an essential developmental care intervention promoting preterm infants' development [22]. Preterm infants are vulnerable humans, requiring much care and attention. They may be exposed to irregular noise, light, and odor in the NICUs for several weeks or months. Controlling ambient light and sound are two vital strategies for providing a context that contributes to an infant's behavioral neurodevelopment. Light and sound are potential sources of harm to the baby. Excessive light can damage the retina, disrupt the circadian rhythm and sleep pattern, and impair the infant's growth. Physiological changes in response to sounds, such as fluctuations in heart rate, blood pressure, respiration rate, and oxygen saturation, are some of the effects of noise on the baby [20, 23, 24]. Environmental stimuli modification may increase the effectiveness of supportive interventions for premature infants. Accordingly, this study aimed to investigate the impact of reducing environmental stimuli on the pain caused by PICC insertion.

Materials and Methods

The present study was a controlled randomized clinical trial in the NICUs of the two hospitals affiliated with the Ahvaz Jundishapur University of Medical Sciences (AJUMS) in Ahvaz City, Iran. The total number of infants who were candidates for PICC-port catheter was 80, of whom 14 infants were excluded from the study due to exclusion and 6 due to cardiopulmonary resuscitation problems and death. Sixty infants were thus included in the study (30 in the intervention group and 30 in the control group) that was shown in Figure 1. Even numbers were put in the control and odd numbers in the intervention groups. The inclusion criteria of candidate neonates for PICC insertion were the birth gestational age between 28 to 37 weeks, lack of serious congenital disease based on medical documents, and the vital signs being in the normal range when performing the procedure. The exclusion criteria were changes in the infant's health status during PICC placement, necessitating supportive care, and failure to insert the catheter.

The study instruments included an infant's demographic and clinical characteristics questionnaire (including sex, type of delivery, intubation, weight, and current diseases) and the premature infant pain profile (PIPP).

The PIPP assessment tool, developed by Ballantyne et al. [25], objectively assesses preterm infants' responses to acute pain experienced during procedures. It has seven pain indicators, including behavioral (facial expressions: Brow bulge, eye squeeze, and nasolabial furrow), physiological (heart rate and oxygen saturation), and contextual (gestational age and behavioral state) [26, 27]. Each indicator is scored from 0 to 3. The total score ranges from 0 to 21. A score above 12 indicates moderate to severe pain experienced in the neonate. In this study, two raters scored the Persian PIPP for 10 infants separately, and the inter-rater reliability coefficient was obtained as 0.89. Also, the PIPP content validity was measured through the qualitative content validity method by 10 experts (1 methodologist, 2 instrument developing experts, 5 nurses experienced in NICU, and 2 pain care research experts).

In the intervention group, before performing the procedure, the researcher placed a researcher-made blindfold on the infant's eyes and an earmuff prepared by a medical equipment center dedicated to covering the infant's ears. The standard earmuffs used in this study was designed for premature infants, especially those hospitalized in NICU, by Nature company in San Carlos, USA. These earmuffs, laid on infants, external ears, diminish the sound intensity to at least 7 dB and the sound pressure level by 50% so that they do not block infants, necessary hearing stimulation for nervous system development. The Y-shape design of Natus company goggles protects babies from phototherapy light. The phototherapy goggles were cut to a small size to cover just the eyes, not the eyebrows. The phototherapy goggles block lights up to 99.9%. These infants also received routine care, such as non-nutritive sucking and containment. Infants in the control group received only routine care, and the researcher measured their pain.

Four times a week, the researcher attended the ward from 7:30 to 19:30, recorded the vital signs of patients who were candidates for PICC procedure, and was present at the bedside. The child's pain level has only been investigated during PICC insertion. PICC insertion is done in each department by an expert nurse. During the preparation for implantation, the baby was connected to monitoring, an ear plug was placed on the ears, and a blindfold was worn only on the eyelids. The baby's eyebrows were exposed to measure the amount of eyebrow bulge. Then, the PICC was implanted, and the baby was monitored by two nurses, one of whom was a researcher, and the other checked the heart rate and arterial blood oxygen saturation on the monitor. The pain during the PICC insertion was measured with the PIPP

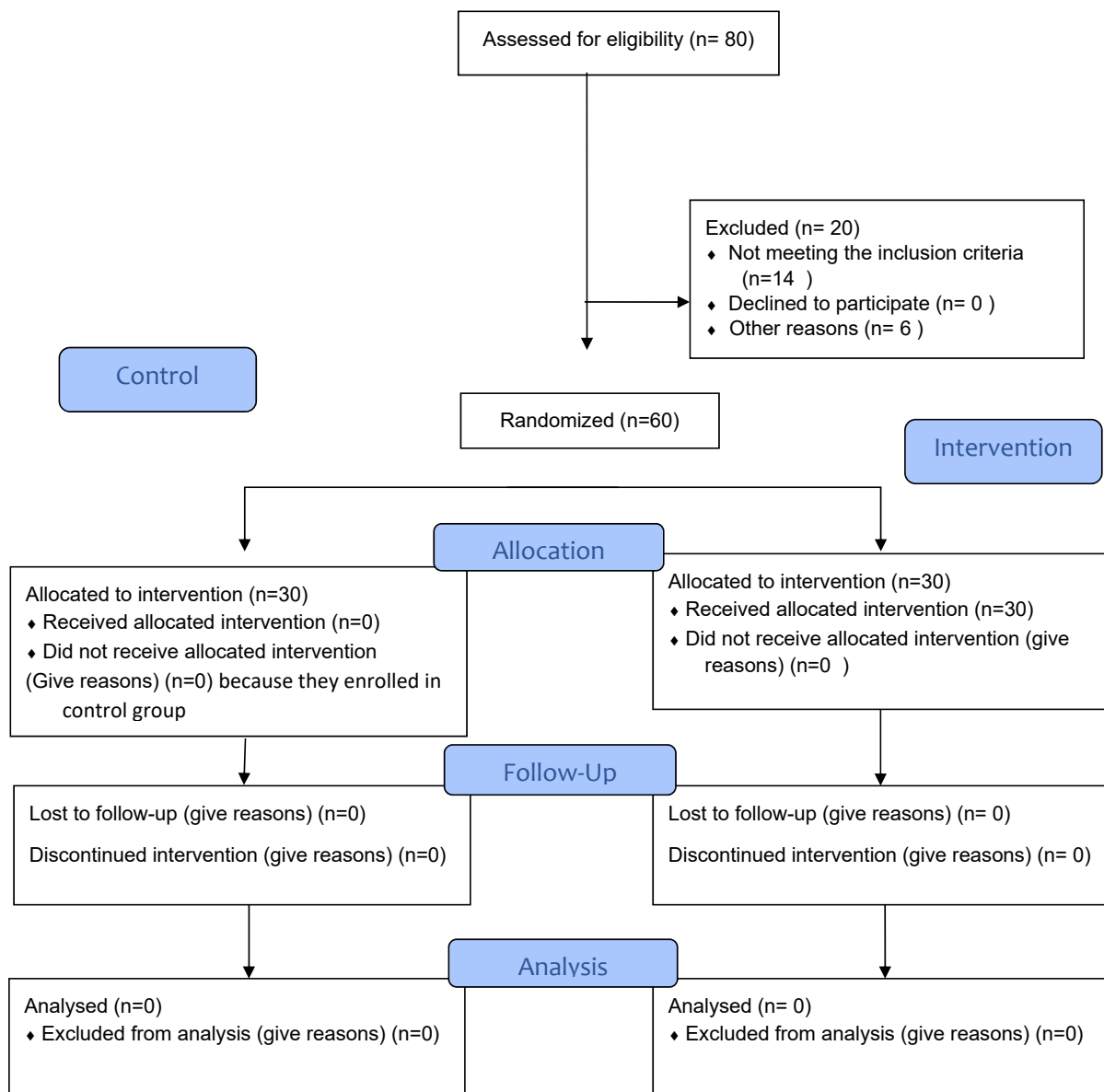


Figure 1. CONSORT flowchart

tool when the baby’s eyelids were covered with a cover, but the facial movements of the raised eyebrows, jumping of the nose edges, frown line, and the line around the lips expressed their pain. The pain level was measured until the end of the PICC insertion, and the results were analyzed after the work was completed. The pain amount during PICC insertion was measured in the control group without using blindfolds and earplugs. The samples were 0 to 28-day-old boys and girls candidates for PICC implantation hospitalized due to prematurity and respiratory distress syndrome. The collected data were analyzed using descriptive statistics (i.e. frequency, mean percentage, and standard deviation) and inferential statistics (independent t-test) in SPSS software, version 16. A $P < 0.05$ was considered significant.

Results

The majority of the studied neonates were female (56.6%), were born through caesarian section, their birth gestational age was between 28 to 31 weeks, their birth weight was between 1501 to 2000 gr, were hospitalized because of prematurity and respiratory distress syndrome, were not intubated, and were the first child of the family (Table 1).

Results of the Kolmogorov-Smirnov test indicated the normal distribution of the PIPP scores; therefore, parametric tests were used in this study. The independent t-test showed no significant difference between the two groups regarding demographic characteristics and the

Table 1. Demographic characteristics of neonates (n=60)

Variables		No. (%)
Sex	Girl	34(56.6)
	Boy	26(43.4)
Type of delivery	Cesarean section	38(63.4)
	Normal vaginal delivery	22(36.6)
Intubation	Yes	35(58.4)
	No	25(41.6)
Neonatal weight (g)	>1000	16(26.6)
	1000-1500	11(18.4)
	1500-2000	30(50)
	>2000	3(5)
Disease diagnosis	R D S	9(15)
	Prematurity	1(1.6)
	Meconium aspiration syndrome	3(5)
	T T N	1(1.6)
	RDS & prematurity	41(68.4)
	RDS & TTN	2(3.4)
	RDS & TTN & prematurity	2(3.4)
	RDS & prematurity & MAS	1(1.6)

Abbreviations: RDS: Respiratory distress syndrome; TTN: Transient tachypnea of newborn; MAS: Meconial aspiration syndrome.

PIPP score. The mean score of PIPP after the intervention was significantly less in the intervention group than in the control group ($P=0.001$). This result is shown in [Table 2](#). According to the results of the analysis of covariance, adjusting the environmental stimuli of light and sound was effective on the pain level of the neonate during PICC implantation with an effect size of 0.917.

Discussion

The mean scores before the intervention were 4.48 in the control group and 4.53 in the intervention, indicating the existence of discomfort in neonates even before the beginning of the procedure. In this respect, the results are consistent with other studies. Harrison and McKechnie studied the amount of discomfort during transport on 140 infants using the PIPP. The mean score of the PIPP in premature infants was about 4 to 5, indicating their mild discomfort. Caregiving relationships

in the postnatal period are critical to an infant’s development. Preterm infants and their parents face unique challenges in this regard, with infants experiencing separation from their parents, uncomfortable procedures, and increased biological vulnerability. Also, parents face difficulties assuming caregiver roles and increased risk for psychological distress [28]. Received neonates can be exposed to light more than recommended in NICU levels, including extremely bright light [29]. Human cerebellar development occurs late in gestation and is hindered by preterm birth. The fetal development of Purkinje cells, the primary output cells of the cerebellar cortex, is crucial for the structure and function of the cerebellum. However, morphological and electrophysiological features in Purkinje cells at different gestational ages and the effects of the NICU environment on cerebellar development are unexplored [30].

Table 2. Neonatal pain mean score before and after the intervention

Variables	Mean±SD		P
	Intervention (n=30)	Control (n=30)	
Pain score before the intervention	4.53±1.20	4.47±1.94	0.874*
Pain score after the intervention	9.37± 3.15	12.63±2.19	0.001*

*The independent t-test.

Preterm infants are sensitive to sound peaks and light level variations, with a slightly higher sensitivity to sound peaks. The mechanisms leading to pain behaviors induced by noise and light changes should be evaluated further in the context of preterm infant brain development.

Environmental lighting can affect weight gain and the length of stay in NICUs [31].

Individualized developmental care is an approach to nursing for hospitalized infants. It includes reading the infant’s cues, engaging the parents, and providing a supportive environment [6]. Developmental care practices that mitigate the infant stress experience are promising as modifiable factors that may change the trajectory of neurodevelopmental outcomes in congenital heart disease [32].

In this study, using eye shields and earmuffs during painful procedures significantly reduced pain scores in the intervention group. The results are consistent with some similar studies. According to Mehrnoush et al., conditions caused by neonatal diseases such as respiratory distress and irritability due to central nervous system damage, and neonatal connections such as intravenous catheters, nasogastric tube, nasal continuous positive airway pressure, and routine procedures such as airway suction, and measurement of vital signs, even change position can put the baby in an unpleasant and distressing physical condition [33]. Alemdar et al. showed a significant difference between the mean scores of the neonatal infant pain scale in the intervention and the control groups after intravenous catheter implantation, mainly related to covering the eyes in the intervention groups. They did not find a significant difference between the two groups’ means of neonatal infant pain scale during the procedure [34]. In their other clinical trial, they aimed to investigate the impact of a recorded mother’s voice, breast milk odor, and incubator cover on the pain during peripheral cannulation between the PIPP scores during and after the painful procedure of the two groups [35].

A study that assessed the effect of eye shield versus massage on preterm infants’ pain response during venipuncture showed that in both intervention groups, the PIPP scores were significantly lower compared with the control group [36].

In a randomized clinical trial by Ajam Hassani et al., the researchers used eye shields and earmuffs for the neonates in the intervention group 4 and 2 hours before the oral gastric tube insertion, respectively. The PIPP scores of the intervention group were significantly lower than the control group during and after the procedure [37].

Premature infants are frequently exposed to painful experiences in the NICU due to their relatively lengthy stay and the need for multiple diagnostic and dermatological procedures. In recent decades, much attention has been paid to research on the effectiveness and safety of various pharmacological or non-pharmacological methods on pain caused by procedures performed in neonatal intensive care units [26, 38]. According to the results, modification of light and sound stimuli reduced preterm infants’ pain during PICC implantation.

Comparing the results of this study with similar studies, it is clear that there are still very contradictory results about the effectiveness of reducing environmental stimuli in reducing neonatal pain. The limitation of the present study was its lack of blindness, which affects the generalizability of the results. Educational classes may be helpful and operational. Holding a training class for medical staff, especially nurses, to manage sound and light in the ward and standardize environmental factors such as light and sound in the NICU.

Based on the study, environment modifications are effective, inexpensive, accessible, and safe methods during PICC placement for premature infants in the NICU. Clinical nurses should use this approach to promote neonatal outcomes due to the destructive effect of sound and light on the neural development of the infant and the occurrence of distress symptoms in infants following procedural pain. One of the limitations that pro-

longed the length of time in this study was that central catheters were not implanted for all infants admitted to the NICU, or some met all the inclusion criteria. However, they were converted in the middle of the way, or sometimes the PICC was inserted when the researcher was not present in the ward, so a long time was spent conducting the study.

Ethical Considerations

Compliance with ethical guidelines

This study was registered at the Iranian Center for Clinical Trials (IRCT) (Code: IRCT640768640768). Also it was approved by the Joint Ethics Committee of **Shahid Beheshti University of Medical Sciences (SBMU)** (Code: IR.SBMU.PHARMACY.REC.1398.062). The researchers conducted the intervention according to the institutional regulations. Informed consent was obtained from the neonates' parents after explaining the research objectives and assuring them of the safety of the intervention.

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Authors' contributions

Conducting research and preparing the first version of the article: Nargess Ranjbari; Designing and supervising the research, participating in writing and editing the article: Anahita Masoumpour; Co-supervising and participating in editing the article: Azam Shirinabadi Farahani; Reviewing and revising the manuscript: Maryam Mahdizadehshahri; Performing expert statistics: Malihe Nasiri; Approve the final version of manuscript: All authors.

Conflict of interest

The authors declared no conflict of interest.

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