Original Article

The Correlation of the Perfusion Index with Pain Scales in Infants Undergoing Surgery

Razieh Sangsari, Maryam Saeedi, Kayvan Mirnia, Mohammad Aziz Anwary, Maryam Veysizadeh, Mehrdad Azad

Department of Pediatrics, Division of Neonatology – School of Medicine, Tehran University of Medical Sciences, Children's Medical Center, Tehran, Iran

Abstract

Background: The Perfusion Index (PI) is considered an important tool for evaluating the condition of infants, but there are few studies on the correlation between PI and pain assessment in infants. Therefore, this study aimed to investigate the correlation between PI and pain scale in infants undergoing surgery. **Materials and Methods:** This prospective, cross-sectional study was conducted in the Neonatal Intensive Care Unit (NICU) of the Children's Medical Center in Tehran, Iran, between April 2020 and April 2023. Using the Crying Requires, Oxygen, Increased vital signs, Expression, and Sleeplessness and right-hand mean PI, using a Masimo pulse oximeter, pain scales were recorded immediately after surgery in the NICU and every 4 h for a total of 24 h by a skilled nurse unaware of the study. The correlation between PI and factors such as age, weight, NICU admission length, and pain scale was analyzed. **Results:** Our study found an inverse correlation between the pain scale and PI ($p < 0.05$; r: −0.385). Additionally, age, gestational age, and PI had a positive correlation with weight ($p < 0.05$; r: 0.233, 0.132, and 0.044, respectively). The age of the infant was also correlated with PI ($p < 0.05$; r: 0.307). Moreover, NICU admission length was inversely related to the PI scale ($p < 0.05$; r: −0.119).m **Conclusions:** The ease of use and objective measurement method of the PI makes it a valuable nursing tool for pain measurement in infants, in addition to other methods. However, further studies are needed to confirm the effectiveness of this correlation.

Keywords: *Index, infant, neonatal intensive care unit, pain, perfusion*

Introduction

Perfusion Index (PI) is a reliable measure of pulse intensity obtained from the photoelectric plethysmography signal of a pulse oximeter. Noninvasive oximeters use PI to assess the ratio of absorbed light by the pulsatile (AC) and nonpulsatile (DC) components of blood flow in peripheral tissue.[1,2] This allows for continuous and noninvasive quantification of perfusion changes and pulse intensity in real time.[1]

PI percentiles are widely used in clinical practice to evaluate the condition of infants as monitoring the PI value provides valuable insights into their clinical status.[3] Several studies have demonstrated that a low PI level is indicative of the severity of neonatal disease.[4-6] The correlation between pain and sympathetic stimulation and hemodynamic changes suggests that PI can be used to evaluate pain levels.[7,8] Studies have reported a correlation between PI and pain intensity, indicating that higher pain intensity is associated with higher PI values. This suggests that PI can be utilized for the evaluation of postoperative pain and the assessment of responses to analgesics.[8,9]

Neonates are especially vulnerable to the effects of unrelieved pain due to their immature nervous systems and limited ability to communicate discomfort. To properly manage and alleviate pain in neonates, accurate assessment is crucial. Since neonates cannot verbally communicate their pain, healthcare providers must rely on observation scales that take into account physiological and behavioral responses to pain.[10] The aim of the current study was to investigate the correlation between PI and pain scales in infants undergoing surgery in the Neonatal Intensive Care Unit (NICU). The present study focused on using a noninvasive and objective assessment tool, in addition to other methods, to more accurately assess pain in infants.

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Address for correspondence:
Dr. Maryam Veysizadeh, Bahrami Children's Hospital, Ghasem Abad Station, Damavand Ave., Tehran, Iran. E-mail: maryam58841@gmail.com

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Materials and Methods

This prospective, cross-sectional study was conducted in the NICU of the Children's Medical Center in Tehran, Iran, between April 2020 and April 2023. The study population comprised all infants of less than 3 months of age who underwent surgery in this NICU. The inclusion criteria for this study were infants who had had surgery and had been admitted to the NICU after surgery. The exclusion criteria were administration of analgesic in the NICU prior to evaluation of PI, and the inability to perform pulse oximetry assessment of PI due to pre-shock conditions or edema.

This prospective cross-sectional study was carried out in the NICU of the Children's Medical Center in Tehran, Iran, between April 2020 and April 2023 to investigate the correlation between PI and pain scales in infants undergoing surgery. PI is not a standard evaluation tool for pain in neonates, so if we want to evaluate it, we need to check the connection to a standard tool such as a pain score questionnaire. In order to minimize the effect of confounders, the analysis was categorized into different groups of confounders, including gestational age, weight, and sex.

A researcher-developed checklist included the variables of weight, gestational age, and age of infants at the time of the study (between the years 2020 and 2023), gender, NICU admission length, and the pain scale that was implemented routinely, and PI which was not performed routinely before our study and was only collected by a certain neonatal fellow. The data were collected from various sources, including history, physical examination, medical records, and nursing report sheets.

The decision regarding the infants' hospitalization in the NICU was made by neonatal fellows, while the indication for surgery was determined by neonatal specialists and surgeons (pediatric specialist, pediatric neurosurgeon, or pediatric urology specialist). Pain assessment in operated neonates was routinely conducted using the Crying Requires, Oxygen, Increased vital signs, Expression, and Sleeplessness (CRIES) scale as a valid and standardized tool based on physiological and behavioral responses to pain [Table 1].[11] The PI of the infants' right hand was measured using a calibrated Masimo pulse oximeter (model: Radical-7, USA). For calibration of the pulse oximeter, we used different FiO_2, and, for accurate measurement, PI was measured 3 times every 5 min to record a mean PI. The pain scales and mean right hand PI were recorded immediately after surgery in the NICU and every 4 h for a total of 24 h by a trained nurse who was on the shift and was unaware of the study.

Table 1: Crying Requires, Oxygen, Increased vital signs, Expression, and Sleeplessness scale

Scale	0	1	2
Crying	None	High-pitched	Inconsolable
Requires O_2	None	FiO^*_2 <30%	FiO_2 ≥30%
Increased vital signs	HR** and BP*** preoperative	<20% than preoperative	≥20% than preoperative
Expression	Normal	Grimace	Grimace and grunt
Sleeplessness	None	Wake frequently	Awake constantly

*FiO_2=Fraction of inspired oxygen, **HR=Heart rate, ***BP=Blood pressure

During the study period, if the the intensity of the pain was high, a score of 5 or higher on the CRIES scale, Fentanyl as an analgesia was administered to the infant based on protocol at a dose of 0.5–1 μg/kg.[11] After administering analgesia, the previous PI values were recorded, and the participant was excluded from the study. The neonates who were prescribed Fentanyl immediately after entering the NICU before the first PI scale due to a high CRIES scale score (≥6) were also excluded from the study.

Standard deviation and mean were used to report measures of central tendency and variability for quantitative variables. Percentage and frequency were used to report distributions of qualitative variables. The normality of the quantitative variables was assessed using the Kolmogorov–Smirnov test and quantile-quantile (Q-Q) plot. As data had normal distribution, Pearson's correlation coefficient was used to evaluate the relationship between the variables. The Chi-square test was used to evaluate the relationship between the two categorical variables. In this study, a *p* value of less than 0.05 was considered statistically significant, and all analyses were performed using SPSS software (version 16; IBM Corp., Armonk, NY, USA).

Ethical considerations

This study was approved by the ethics committee of Tehran University of Medical Sciences and received a code of ethics (IR.TUMS.CHMC.REC.1400.101). In this study, all data involving measurements were collected without any harm to the infants, and there was no change in the treatment process of patients. Data coding was implemented to ensure the confidentiality of patients' information. Written informed consent was obtained from the parents of the infants.

Results

Out of 115 babies who underwent surgery, 24 were excluded from the study due to receiving analgesic medication at the beginning of the assessment and before recording the first PI scale due to high CRIES scale score (≥6). Therefore, the analysis included 91 babies who met the inclusion criteria. Among these babies, 66 (72.52%) were male and 25 (27.48%) were female. Gastrointestinal surgery was the most common surgery (25 cases; 27.4%). The mean (standard deviation [SD]) age was 25.7 (8) days. The mean corrected gestational age was 41.6 (5) weeks. The median weight of the babies at the time of study was

3921 (1688) grams. The mean hospitalization time in the NICU was 12.4 (6) days [Table 2]. On average, the infants had a mean (SD) first pain scale of 3.7 (1.5) scales. The mean of the first PI was determined as 2.01 (1%) [Table 3].

No statistically significant relationship was found between gender and any of the variables investigated in this study ($p > 0.05$). The relationship between weight and other variables was also investigated. Statistically significant relationships were found between weight and age at the time of the study, gestational age, and PI. In fact, a positive correlation was observed between weight and the mentioned variables. Increasing age and increasing gestational age were also significantly associated with more weight at the time of the study ($p < 0.05$; r: 0.233 and 0.132). Additionally, increasing weight was found to be associated with a higher PI ($p < 0.05$; r: 0.044). There was a significant negative correlation between weight and NICU admission length ($p < 0.05$, $r = -0.003$), as well as weight and the pain scale ($p < 0.05$, $r = -0.031$). This means that in neonates with higher weight, the duration of NICU admission and the pain scale decreased.

Similarly, the age of the infant at the time of the study showed an inverse relationship with both NICU admission length ($p < 0.05$, $r = -0.270$) and the pain scale ($p < 0.05$, $r = -0.470$). In other words, as the age of the infant increased, the duration of NICU admission and the pain scale decreased. Additionally, the age of the infant was positively associated with the PI ($p < 0.05$, $r = 0.307$). This means that when the age of the infant at the time of the study increased, the PI also increased.

Gestational age was found to have a significant inverse relationship with the length of NICU admission ($p < 0.05$), but with a correlation coefficient of −0.134. Similarly, gestational age was directly correlated to PI, with a correlation coefficient of 0.138 ($p < 0.05$). However, there was no statistically significant relationship between gestational age and the pain scale, with a p value of 0.083. The length of NICU admission was directly associated with the pain scale, with a correlation coefficient of 0.313 ($p < 0.05$), and significantly and inversely related to the PI scale ($p < 0.05$), but with a correlation coefficient of -0.119.

Above all, the pain scale was found to be inversely associated with the PI scale, with a correlation coefficient of −0.197 ($p < 0.001$), although this correlation is weak. Data related to the correlation between PI and Pain scale of studied neonates are presented in Table 4.

Discussion

The aim of the current study was to investigate the correlation between PI and pain scale in infants as a noninvasive and objective assessment tool, in addition to other methods, in order to more accurately assess pain in infants. Tapar *et al*. found a link between higher pain intensity and higher PI values and a negative correlation between pain and PI, suggesting that PI could be used to evaluate postoperative pain and responses to analgesics.[9] Additionally, Kupeli and Kulhan suggested that PI could reflect the perception of painful stimuli as an independent parameter and provide an objective assessment of pain perception.[12] Chu *et al*. reported the potential use of PI as a supplementary discharge criterion for objectively evaluating pain in the post-anesthesia care unit.[13] Ahmed *et al*. assessed postoperative PI using the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS) and found that PI is negatively correlated with the change in CHEOPS ($p = 0.0001$, $r = -0.53$).[14] This suggests that PI has the potential to be a good objective measure for predicting pain in children.[14] Hasanin *et al*. also found a strong association between the change in PI and the change in Behavioral Pain Scale-Non-Intubated values after the application of a painful stimulus in critically ill patients.[15]

All the above studies were conducted on adults or children, and the study of the correlation of pain with PI in infants is very limited. Neonatal pain exposure has been linked to negative impacts on neurodevelopmental outcomes, especially in preterm infants. It is crucial to prioritize and implement appropriate pain management techniques to mitigate the risk of adverse effects on the neurodevelopment of these vulnerable patients.[16]

There are pain assessment tools for infants in the clinical setting. These tools are used to identify and manage infant pain promptly in order to reduce its complications.[17] The

Table 2: Characteristics of neonates

Total number	Sex		Mean corrected GA* (SD) weeks	Mean age (SD)** days	Median weight (SD) gram	Admission time (SD) days
	Male	Female				
91	66	25	41.6 (5)	25.7 (8)	3921 (1688)	12.4 (6)

*GA=Gestational age, **SD=Standard deviation

Table 3: Perfusion index and pain scale of studied neonates

Scales	*n*	Mean of first scale in NICU* after surgery	SD***	Mean 24 h	Minimum	Maximum	SD
Pain scale	91	3.7	1.5	4.750	3	12	1.57
PI**	91	2.01	1	1.65	0.35	4.6	2.04

*NICU=Neonatal intensive care unit, **PI=Perfusion index, ***SD=Standard deviation

Table 4: Correlation between pain scale and perfusion index of studied neonates

Correlation	Pain scale	PI mean
Pain scale		
Pearson correlation	1	-0.197
Significant (two-tailed)*		<0.001
n	91	91
PI mean		
Pearson correlation	−0.197	1
Significant (two-tailed)*	<0.001	
n	91	91

*Significant. PI=Perfusion index

CRIES scale is one of these tools used to assess pain in infants. By combining scores from each physiological and behavioral response to pain, healthcare providers can better understand the level of pain experienced by infants and tailor pain management strategies accordingly,[11] but these measurements are not accurate tools for pain assessment. Physiologic measures of pain, such as heart rate and blood pressure, are influenced by a variety of contextual factors that may not directly relate to the level of pain. Similarly, behavioral measures of pain, such as facial expressions, can also be subject to bias and interpretation by the observer.[18,19] Therefore, using an objective method for assessing pain, such as a PI, in addition to other assessment methods, is helpful.

In the present study, we found that the pain scale had an inverse association with PI ($p < 0.05$, r: −0.197). This means that as the baby's pain and pain scale increased, the PI decreased. Considering that the topic is new and the sample size was small, the relationship may be reported as weak, but as a pilot, its results can be mentioned and it is necessary to reperform the study with a larger sample size.

The limitations of our study include a small sample size of included patients and a high number of excluded patients due to receiving analgesic treatment from the outset with high pain scores (16 neonates). Additionally, variables such as surgery type, sedation protocols, and comorbidities were not analyzed. To draw more accurate conclusions, future studies should consider a larger sample size, include patients who have received analgesics, and combine pain indices with other physiological markers (e.g., heart rate variability) to enhance pain assessment.

Based on the findings of the current study, it is recommended that further research be conducted with a larger sample size to confirm the correlation between PI and pain scale in infants. Additionally, it would be beneficial to include a diverse group of infants, including those who receive analgesic treatment from the beginning, to provide a more comprehensive understanding of the relationship between pain perception and PI. Moreover, longitudinal studies could provide valuable insights into the long-term effects of pain management strategies on neurodevelopmental outcomes in infants. Future studies need to include larger sample sizes and more detailed considerations, including surgery type, sedation protocols, and comorbidities.

Conclusion

Implementing PI as a supplementary tool for pain assessment in clinical practice could potentially enhance the accuracy of pain evaluation and improve pain management strategies for infants. Further research in this area is crucial to advance our understanding of pain assessment in infants and promote better outcomes for this patient population.

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Conflicts of interest

Nothing to declare.

References

1. Saeedi M, Sangsari R, Mirnia K, Ghanbari M. Normal value of perfusion index in healthy neonates born in Iran. Arch Iran Med 2024;27:606-10.
2. Piasek CZ, Van Bel F, Sola A. Perfusion index in newborn infants: A noninvasive tool for neonatal monitoring. Acta Paediatr 2014;103:468-73.
3. Hariharan D, Balasubramanian L, Kannappan V, Veluswami G. Perfusion index used as a sixth vital sign in preterm infants leads to earlier diagnosis of shock, better outcomes. Pediatrics 2018;141:548.
4. Alderliesten T, Lemmers PM, Baerts W, Groenendaal F, van Bel F. Perfusion index in preterm infants during the first 3 days of life: Reference values and relation with clinical variables. Neonatology 2015;107:258-65.
5. Mandala VK, Mendu SB, Bollaboina SK, Kotha R. Role of perfusion index and pulse variability index in the assessment of neonatal hemodynamics: A systematic review. Cureus 2023;15:e48058.
6. Mathew J, Bada Shekarappa C, Padubidri Nanyam Rao S. Correlation between perfusion index and CRIB scale in sick infants admitted to a tertiary center. J Trop Pediatr 2019;65:84-9.
7. Saleh AN, Mostafa RH, Hamdy AN, Hafez AF. Pulse-oximetry derived perfusion index as a predictor of the efficacy of rescue analgesia after major abdominal surgeries. Open Anesth J 2020;14:101-7.
8. Luo F, Zhu H, Mei L, Shu Q, Cheng X, Chenet X, *et al*. Evaluation of procedural pain for neonates in a neonatal intensive care unit: A single-centre study. BMJ Paediatr Open 2023;7:e002107.
9. Tapar H, Suren M, Karaman S, Dogru S, Karaman T, Sahin A, *et al*. Evaluation of the perfusion index according to the visual analog scale in postoperative patients. Saudi Med J 2018;39:1006-10.
10. Williams MD, Lascelles BD. Early neonatal pain—a review of clinical and experimental implications on painful conditions later

in life. Front Pediatr 2020;8:30.
11. Witt N, Coynor S, Edwards C, Bradshaw H. A guide to pain assessment and management in the neonate. Curr Emerg Hosp Med Rep 2016;4:1-10.
12. Kupeli I, Kulhan NG. Can perfusion index be used as an objective tool for pain assessment in labor analgesia? Pak J Med Sci 2018;34:1262-6.
13. Chu CL, Huang YY, Chen YH, Lai LP, Yeh HM. An observational study: The utility of perfusion index as a discharge criterion for pain assessment in the postanesthesia care unit. PLoS One 2018;13:e0197630.
14. Ahmed A, Lotfy A, Elkholy J, Abdelhamid B, Ollaek M. Perfusion index as an objective measure of postoperative pain in children undergoing adenotonsillectomy: A cohort study. J Clin Monit Comput 2022;36:795-801.
15. Hasanin A, Mohamed SA, El-adawy A. Evaluation of perfusion index as a tool for pain assessment in critically ill patients. J Clin Monit Comput 2017;31:961-5.
16. Giordano V, Deindl P, Gal E, Unterasinger L, Fuiko R, Steinbauer P, *et al*. Pain and neurodevelopmental outcomes of infants born very preterm. Dev Med Child Neurol 2023;65:1043-52.
17. Llerena A, Tran K, Choudhary D, Hausmann J, Goldgof D, Sun Y, Prescott SM. Neonatal pain assessment: Do we have the right tools? Front Pediatr 2023;10:1022751.
18. Pillai Riddell R, Fitzgerald M, Slater R, Stevens B, Johnston C, Campbell-Yeo M. Using only behaviours to assess infant pain: A painful compromise? Pain 2016;157:1579-80.
19. Valitalo PA, van Dijk M, Krekels EH, Gibbins S, Simons SH, Tibboel D, *et al*. Pain and distress caused by endotracheal suctioning in neonates is better quantified by behavioural than physiological items: A comparison based on item response theory modelling. Pain 2016;157:1611-7.