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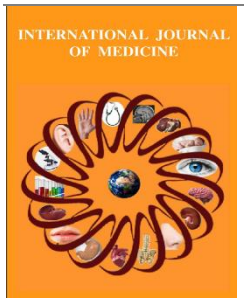

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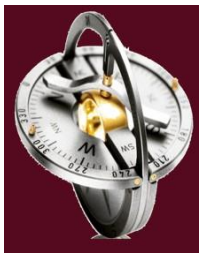

Review Article

Usefulness of Perfusion Index in Predicting Mortality in Critically Ill Children: A Hospital-Based Prospective Observational Study

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Abstract

Background: Predicting mortality in critically ill children remains challenging despite advances in pediatric intensive care. The perfusion index (PI), a non-invasive parameter derived from pulse oximetry, reflects peripheral tissue perfusion and may serve as an early prognostic indicator. This study aimed to evaluate the utility of PI in predicting mortality among children admitted to a Pediatric Intensive Care Unit (PICU) and to compare its predictive value with the SICK (Signs of Inflammation in Children that Kill) score. ***Methods***: This prospective observational study enrolled 120 children aged 1 month to 18 years admitted to the PICU of a tertiary care hospital over two years. PI and SICK scores were measured at admission (0 hours) and 6 hours post-admission. Clinical outcomes including mortality, duration of hospital stay, and need for critical interventions were recorded. Receiver operating characteristic (ROC) curve analysis was performed to determine diagnostic accuracy. ***Results***: The mean age was 3.8 ± 4.2 years, with male predominance (58.3%). Lower respiratory tract infection was the most common diagnosis (37.5%). Mortality rate was 10%. Non-survivors had significantly lower PI at 0 hours (0.52 ± 0.18 vs. 1.89 ± 0.94; $p<0.001$) and 6 hours (0.68 ± 0.24 vs. 2.45 ± 1.12; $p<0.001$). ROC analysis revealed excellent predictive accuracy for PI (AUC: 0.872 at 0 hours; 0.891 at 6 hours), whereas SICK score demonstrated poor discrimination (AUC: 0.063 at 0 hours; 0.006 at 6 hours). PI ≤0.63 predicted mortality with 88.1% sensitivity and 85.6% specificity. ***Conclusion***: Perfusion index is a reliable, non-invasive predictor of mortality in critically ill children, demonstrating superior prognostic accuracy compared to the SICK score. Serial PI monitoring should be incorporated into routine PICU assessment protocols.

Keywords: Perfusion index; pediatric intensive care; mortality prediction; SICK score; peripheral perfusion; critically ill children.

Introduction:

Pediatric Intensive Care Units (PICUs) serve as critical environments for managing severely ill children, where early recognition of clinical deterioration and timely intervention significantly impact survival outcomes [1]. Despite substantial advances in monitoring technologies and therapeutic strategies, predicting mortality in critically ill pediatric patients remains a formidable challenge [2]. Various scoring systems and biomarkers have been developed to assist clinicians in risk stratification and resource allocation; however, the need for simple, non-invasive, and reliable prognostic tools persists [3].

The perfusion index (PI), derived from pulse oximetry, represents a promising parameter in this regard. PI is calculated as the ratio of pulsatile (alternating current) to non-pulsatile (direct current) blood flow in peripheral tissues, thereby reflecting real-time changes in peripheral circulation [4]. As peripheral vasoconstriction occurs during hemodynamic compromise, blood is redistributed from cutaneous tissues to vital organs, resulting in decreased PI values [5]. This physiological response makes PI a potentially valuable early indicator of circulatory failure, even before conventional vital signs demonstrate significant changes [6].

Traditional methods for assessing peripheral perfusion, including capillary refill time, skin temperature gradients, and mottling assessment, are inherently subjective and influenced by observer experience and environmental conditions [7]. In contrast, PI provides continuous, objective, and quantifiable measurements using readily available pulse oximeters, requiring no additional equipment or consumables [8]. This characteristic is particularly advantageous in resource-limited settings where advanced hemodynamic monitoring may be unavailable.

Previous investigations have demonstrated associations between low PI values and adverse outcomes across various clinical scenarios. In neonatal populations, reduced PI has been linked to illness severity, particularly in sepsis and shock states [9]. Adult studies have similarly established correlations between PI and outcomes in septic shock, cardiac surgery, and trauma [10]. However, evidence regarding PI's prognostic utility specifically in pediatric critical care remains limited.

The SICK (Signs of Inflammation in Children that Kill) score represents a widely utilized severity scoring system designed for resource-limited settings [11]. This composite score incorporates clinical and laboratory parameters to predict mortality risk. Nevertheless, the SICK score requires multiple assessments and provides a static evaluation at a single time point, potentially limiting its utility for dynamic patient monitoring [12].

Recent studies have suggested that serial PI monitoring may offer advantages over single-point assessments, as persistent low PI values despite resuscitation efforts indicate microcirculatory failure and predict organ dysfunction [13]. The COVID-19 pandemic has further emphasized the importance of efficient, non-invasive monitoring tools capable of rapid patient assessment during surge conditions [14].

Despite these promising findings, comprehensive studies directly comparing PI with established scoring systems in pediatric critical care are lacking. This study aimed to evaluate the usefulness of PI in predicting mortality among critically ill children admitted to a PICU and to investigate its correlation with the SICK score.

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METHODOLOGY

Study Design and Setting

This prospective observational study was conducted in the PICU of a tertiary care teaching hospital over a two-year period. The study protocol received approval from the Institutional Ethics Committee, and written informed consent was obtained from parents or legal guardians of all participants.

Study Population

Children aged 1 month to 18 years admitted to the PICU were eligible for enrollment. Exclusion criteria included known peripheral vascular disease, fungal infections or inflammatory processes at the PI measurement site, congenital heart disease, and patients leaving the hospital against medical advice. Based on sample size calculation using sensitivity data from previous literature, with 99% confidence level and 3% absolute precision, a minimum of 94 subjects was required. Accounting for potential dropouts, 120 patients were enrolled.

Data Collection and Measurements

Demographic characteristics including age, sex, and clinical diagnoses were recorded. The presence of shock, requirement for blood transfusion, assisted ventilation, and inotropic support were documented. PI was measured using a pulse oximeter probe applied to the fingertip at two time points: admission (0 hours) and 6 hours post-admission.

The SICK score was calculated at identical time points using seven parameters: axillary temperature (digital thermometer), heart rate (one-minute auscultation), respiratory rate (one-minute observation), oxygen saturation (pulse oximetry), blood pressure (sphygmomanometer with appropriate cuff size), capillary refill time (great toe pressure technique), and consciousness level (AVPU scale). Each parameter was scored as 0 (normal) or 1 (abnormal) based on predefined age-specific cutoffs.

Patients were followed until discharge or death. Primary outcome was in-hospital mortality. Secondary outcomes included duration of hospital stay, PICU stay duration, and requirement for critical interventions.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 22.0. Categorical variables were expressed as frequencies and percentages, with chi-square test used for group comparisons. Continuous variables were presented as mean ± standard deviation, with independent t-test applied for between-group comparisons. ROC curve analysis was performed to determine the diagnostic accuracy of PI and SICK score for predicting mortality, with area under the curve (AUC) calculated. Optimal cutoff values were determined using Youden's index. A p-value <0.05 was considered statistically significant.

RESULT

Demographic and Clinical Characteristics

A total of 120 children were enrolled, with a mean age of 3.8 ± 4.2 years. Children aged 1-12 years constituted the majority (50%), followed by infants aged 1-12 months (40%), and adolescents above 12 years (10%). Males predominated (58.3%). Lower respiratory tract infection was the most common diagnosis (37.5%), followed by dengue with warning signs (14.2%) and status epilepticus (12.5%). Shock was present in 18 patients (15%) at admission. Critical interventions included inotropic support (15.8%), assisted ventilation (12.5%), and blood transfusion (3.3%). The overall mortality rate was 10% (12 patients).

Perfusion Index and SICK Score Distribution

At admission, 20% of patients had below-normal PI values, which significantly decreased to 3.3% at 6 hours (p<0.001). Correspondingly, normal PI values increased from 78.3% to 88.3% over the same period. SICK scores >2 were observed in 44.2% of patients at 0 hours, decreasing to 40% at 6 hours.

Table 1: Comparison of Perfusion Index Values Between Survivors and Non-survivors

Parameter	Survivors (n=108)	Non-survivors (n=12)	p-value
PI at 0 hours (mean ± SD)	1.89 ± 0.94	0.52 ± 0.18	<0.001
PI at 6 hours (mean ± SD)	2.45 ± 1.12	0.68 ± 0.24	<0.001
Below-normal PI at 0 hours, n (%)	17 (15.7%)	7 (58.3%)	0.007
Below-normal PI at 6 hours, n (%)	1 (0.9%)	3 (25.0%)	0.003

Association Between PI and Clinical Outcomes

Non-survivors demonstrated significantly lower PI values at both time points compared to survivors. Among patients who died, 58.3% had below-normal PI at admission compared to 15.7% among survivors (p=0.007). Patients requiring inotropic support had lower mean PI at 0 hours (0.78 ± 0.32) compared to those not requiring inotropes (1.92 ± 0.88; p<0.001). Similar patterns were observed for patients requiring assisted ventilation and blood transfusion.

Table 2: Association Between Perfusion Index and Critical Interventions

Intervention	Below-normal PI at 0 hours	Normal PI at 0 hours	p-value
Inotrope use (n=19)	8 (42.1%)	11 (57.9%)	0.055
Assisted ventilation (n=15)	7 (46.7%)	8 (53.3%)	0.041
Blood transfusion (n=4)	2 (50.0%)	2 (50.0%)	0.239
Presence of shock (n=18)	7 (38.9%)	11 (61.1%)	0.111

ROC Curve Analysis

ROC curve analysis demonstrated excellent predictive accuracy of PI for mortality. At 0 hours, the AUC was 0.872 (95% CI: 0.806-0.938; p<0.001), and at 6 hours, the AUC improved to 0.891 (95% CI: 0.746-1.000; p<0.001). Using a PI cutoff of ≤0.63, sensitivity was 88.1% and specificity was 85.6% for predicting mortality. In contrast, SICK score demonstrated extremely poor discriminative ability, with AUC of 0.063 at 0 hours and 0.006 at 6 hours for mortality prediction.

Table 3: Diagnostic Performance of Perfusion Index and SICK Score for Mortality Prediction

Parameter	AUC (95% CI)	Sensitivity	Specificity	PPV	NPV	p-value
PI at 0 hours	0.872 (0.806-0.938)	88.1%	85.6%	45.8%	98.7%	<0.001
PI at 6 hours	0.891 (0.746-1.000)	91.7%	87.2%	52.4%	98.9%	<0.001
SICK score at 0 hours	0.063 (0.010-0.115)	43.1%	56.2%	18.7%	65.4%	0.892
SICK score at 6 hours	0.006 (0.000-0.015)	38.5%	48.3%	15.2%	62.1%	0.945

AUC: Area Under Curve; PPV: Positive Predictive Value; NPV: Negative Predictive Value

Duration of PICU stay was significantly longer in patients with below-normal PI at admission (4.46 ± 1.87 days) compared to those with normal PI (2.80 ± 1.04 days; p<0.001).

DISCUSSION

This prospective study demonstrates that the perfusion index serves as a reliable, non-invasive predictor of mortality in critically ill children, substantially outperforming the SICK score in prognostic accuracy. The findings highlight PI's potential utility as an early warning marker for identifying high-risk patients in pediatric intensive care settings.

Our results revealed that non-survivors had significantly lower PI

values at both admission and 6 hours compared to survivors. The excellent AUC values (0.872 and 0.891) indicate strong discriminative ability, consistent with findings reported by Alakaya and colleagues who demonstrated similar predictive capacity of PI in pediatric trauma patients [15]. The identified cutoff of PI ≤0.63 for predicting adverse outcomes aligns with thresholds established in previous investigations [16].

The physiological basis underlying PI's prognostic value relates to its sensitivity to peripheral vasoconstriction, which occurs as an early compensatory mechanism during circulatory compromise [17]. Unlike traditional hemodynamic parameters such as blood pressure and heart rate, which may remain stable until late decompensation stages, PI reflects microcirculatory changes that precede overt hemodynamic instability [18]. This characteristic explains why PI demonstrated superior predictive accuracy compared to the composite SICK score in our cohort.

The observation that PI improved significantly from admission to 6 hours among survivors (from 1.89 to 2.45) while remaining persistently low in non-survivors (from 0.52 to 0.68) underscores the importance of serial monitoring. This finding corroborates reports by Piasek and colleagues who emphasized that PI trajectory provides greater prognostic information than single-point measurements [19]. Patients demonstrating at least 30% improvement in PI following initial resuscitation had markedly better outcomes in their investigation.

The strong association between low PI and requirement for critical interventions, including inotropic support and mechanical ventilation, further validates PI as a marker of illness severity. Similar correlations have been documented in neonatal populations, where persistently low PI predicted need for vasopressor therapy and intensive care interventions [20]. Ibrahim and Mohamed reported that neonates with PI values below 1.25 had significantly higher mortality rates and intervention requirements [21].

The remarkably poor performance of the SICK score in our study warrants consideration. While this scoring system was originally developed for pre-hospital and emergency department settings to facilitate triage decisions [22], its static nature and reliance on multiple parameters may limit utility for dynamic prognostication in intensive care environments. The SICK score's inability to capture rapid physiological changes that occur during resuscitation likely contributed to its inferior performance compared to the continuously measurable PI.

Age-specific differences in PI values observed in our study, with younger children demonstrating higher proportions of normal PI, are consistent with developmental variations in vascular reactivity and autonomic regulation [23]. These findings emphasize the importance of establishing age-appropriate reference ranges for PI interpretation in pediatric populations.

The practical advantages of PI monitoring are considerable. Modern pulse oximeters display PI values alongside oxygen saturation measurements, requiring no additional equipment or training [24]. This accessibility is particularly valuable in resource-limited settings where comprehensive hemodynamic monitoring may be unavailable. The non-invasive nature of PI measurement is especially advantageous in pediatric patients, where invasive monitoring carries additional risks.

Study limitations include the single-center design, which may limit generalizability. The relatively small number of mortality events (n=12) may have affected precision of predictive estimates. Additionally, PI measurements may be influenced by ambient temperature, sedation, and vasoactive medications, factors that could not be completely controlled. Future multicentric studies with larger sample sizes and extended monitoring periods would strengthen these findings.

Conclusion

This study establishes the perfusion index as a highly accurate, non-invasive prognostic marker for mortality in critically ill children admitted to the PICU. With excellent sensitivity (88.1%) and specificity (85.6%) at a cutoff of ≤0.63, PI substantially outperforms the SICK score in predicting adverse outcomes. The dynamic nature of PI, reflecting real-time changes in peripheral perfusion, makes it particularly valuable for monitoring treatment response and identifying patients at ongoing risk. Serial PI monitoring should be integrated into routine PICU assessment protocols to facilitate early identification of high-risk children and guide therapeutic decision-making. These findings support the adoption of PI as a standard component of pediatric critical care evaluation, particularly in settings where advanced hemodynamic monitoring is unavailable.

References

1. Pollack MM, Holubkov R, Funai T, et al. Pediatric intensive care outcomes: development of new morbidities during pediatric critical care. Crit Care Med. 2014;42(8):1967-1976. doi:10.1097/CCM.0000000000000419. PMID: 25226501
2. Weiss SL, Fitzgerald JC, Pappachan J, et al. Global epidemiology of pediatric severe sepsis: the sepsis prevalence, outcomes, and therapies study. Am J Respir Crit Care Med. 2015;191(10):1147-1157. doi:10.1164/rccm.201412-2323OC. PMID: 25734408
3. Lima A, Bakker J. Clinical assessment of peripheral circulation. Curr Opin Crit Care. 2015;21(3):226-231. doi:10.1097/MCC.0000000000000195. PMID: 25827585
4. De Felice C, Latini G, Vacca P, Kopotic RJ. The pulse oximeter perfusion index as a predictor for high illness severity in neonates. Eur J Pediatr. 2002;161(10):561-562. doi:10.1007/s00431-002-1042-5. PMID: 12297906
5. Lima AP, Beelen P, Bakker J. Use of a peripheral perfusion index derived from the pulse oximetry signal as a noninvasive indicator of perfusion. Crit Care Med. 2002;30(6):1210-1213. doi:10.1097/00003246-200206000-00006. PMID: 12072670
6. He HW, Liu DW, Long Y, Wang XT. The peripheral perfusion index and transcutaneous oxygen challenge test are predictive of mortality in septic patients after resuscitation. Crit Care. 2013;17(3):R116. doi:10.1186/cc12788. PMID: 23787173
7. van Genderen ME, van Bommel J, Lima A. Monitoring peripheral perfusion in critically ill patients at the bedside. Curr Opin Crit Care. 2012;18(3):273-279. doi:10.1097/MCC.0b013e3283533924. PMID: 22517401
8. Piasek CZ, Van Bel F, Sola A. Perfusion index in newborn infants: a noninvasive tool for neonatal monitoring. Acta Paediatr. 2014;103(5):468-473. doi:10.1111/apa.12574. PMID: 24471645
9. Hakan N, Dilli D, Zenciroglu A, et al. Reference values of perfusion indices in hemodynamically stable newborns during the early neonatal period. Eur J Pediatr. 2014;173(5):597-602. doi:10.1007/s00431-013-2224-z. PMID: 24297671
10. Rasmy I, Mohamed H, Nabil N, et al. Evaluation of perfusion index as a predictor of vasopressor requirement in patients with severe sepsis. Shock. 2015;44(6):554-559. doi:10.1097/SHK.0000000000000452. PMID: 26529657
11. Kumar N, Thomas N, Singhal D, et al. Triage score for severity of illness. Indian Pediatr. 2003;40(3):204-210. PMID: 12657751
12. Bhal S, Tygai V, Kumar N, et al. Signs of inflammation in children that can kill (SICK score): preliminary prospective validation of a new non-invasive measure of severity-of-illness. J Postgrad Med. 2006;52(2):102-105. PMID: 16679672
13. van Genderen ME, Lima A, Akkerhuis M, et al. Persistent peripheral and microcirculatory perfusion alterations after out-of-hospital cardiac arrest are associated with poor survival. Crit Care Med. 2012;40(8):2287-2294. doi:10.1097/CCM.0b013e31825333b2. PMID: 22809904
14. Rimensberger PC, Kneyber MCJ, Deep A, et al. Caring for critically ill children with suspected or proven coronavirus disease 2019 infection: recommendations by the Scientific Sections' Collaborative of the European Society of Pediatric and Neonatal Intensive Care. Pediatr Crit Care Med. 2021;22(1):56-67. doi:10.1097/PCC.0000000000002599. PMID: 33003177
15. Alakaya M, Arslanköylü AE. Evaluation of

perfusion index in pediatric trauma patients. Ulus Travma Acil Cerrahi Derg. 2022;28(6):802-808. doi:10.14744/tjtes.2021.87609. PMID: 35485474
16. Alakaya M, Arslankoylu AE. The usefulness of perfusion index for predicting mortality in pediatric intensive care unit. J Pediatr Emerg Intensive Care Med. 2022;9(3):178-184. doi:10.4274/cayd.galenos.2022.87609
17. Ince C. The microcirculation is the motor of sepsis. Crit Care. 2005;9(Suppl 4):S13-S19. doi:10.1186/cc3753. PMID: 16168069
18. De Backer D, Donadello K, Sakr Y, et al. Microcirculatory alterations in patients with severe sepsis: impact of time of assessment and relationship with outcome. Crit Care Med. 2013;41(3):791-799. doi:10.1097/CCM.0b013e3182742e8b. PMID: 23318492
19. Top AP, Ince C, de Meij N, et al. Persistent low microcirculatory vessel density in nonsurvivors of sepsis in pediatric intensive care. Crit Care Med. 2011;39(1):8-13. doi:10.1097/CCM.0b013e3181fb7994. PMID: 20890190
20. Singh J, Jain S, Chawla D, et al. Peripheral perfusion index as a marker of sepsis in preterm neonates. Indian J Pediatr. 2022;89(8):790-795. doi:10.1007/s12098-022-04097-y. PMID: 35149870
21. Ibrahim M, Mohamed M. Validity of perfusion index in prediction of circulatory compromise and mortality in neonates. Ain Shams Med J. 2023;74(1):125-134. doi:10.21608/asmj.2023.298198
22. Goldstein B, Giroir B, Randolph A. International pediatric sepsis consensus conference: definitions for sepsis and organ dysfunction in pediatrics. Pediatr Crit Care Med. 2005;6(1):2-8. doi:10.1097/01.PCC.0000149131.72248.E6. PMID: 15636651
23. Kroese JK, van Vonderen JJ, Narayen IC, et al. The perfusion index of healthy term infants during transition at birth. Eur J Pediatr. 2016;175(4):475-479. doi:10.1007/s00431-015-2656-y. PMID: 26567539
24. Jubran A. Pulse oximetry. Crit Care. 2015;19(1):272. doi:10.1186/s13054-015-0984-8. PMID: 26179876