Original Article

Predicting Vasopressor Requirement in Sepsis: A Comparison Between Perfusion Index and Blood Lactate

Mirza Nahiduzzaman[1], Suman Kundu[2], Manas Kanti Mazumder[3], MD. Touhidul Islam[4], Shubamay Deb Nath[5], Rajeebshankar Karmakar[6]

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Abstract:

Background: *Sepsis continues as a devastating global burden, largely due to microvascular failure that progresses rapidly towards hypotension. Timely vasopressor therapy is essential along with fluid resuscitation. Metabolic markers like lactate often fail to reflect early circulatory compromise, need invasive intervention and time consuming. So a more reliable predictor is crucial for guiding rapid intervention. This study was undertaken to determine whether the perfusion index, an indirect, noninvasive, real time indicator of peripheral microcirculatory failure offers superior predictive accuracy for vasopressor requirement compared to blood lactate during early sepsis management.*

Methods: *This prospective observational study enrolled 96 adult patients with sepsis in the ICU of Dhaka Medical College Hospital, applying strict inclusion and exclusion criteria to ensure diagnostic accuracy and clinical consistency. After informed consent, each patient underwent detailed baseline assessment, including measurement of perfusion index and serum lactate, alongside comprehensive hemodynamic and laboratory evaluation. Patients were closely monitored during early resuscitation, with vasopressors initiated when shock or persistent hypotension occurred despite adequate fluid therapy. All collected data were systematically recorded, verified, and analyzed using SPSS, maintaining rigorous statistical standards throughout the study.*

Result: *The study population demonstrated a balanced age and sex distribution with no significant differences in mean age between males and females (48.6±8.1 vs. 47.8±8.6; p=0.262), and comorbidities such as hypertension (42.7%) and diabetes (27.1%) were similarly represented across groups (all p>0.05), ensuring a comparable baseline for evaluating perfusion markers. Patients presented with diverse ICU diagnoses, including trauma, respiratory, neurological, and infectious conditions, reflecting a realistic spectrum of sepsis etiologies. Nearly half of the cohort exhibited low mean arterial pressure (<65 mmHg in 47.9%) and elevated lactate (mean 3.03 mmol/L), yet the perfusion index more clearly differentiated hemodynamic compromise, with 42 of 46 hypotensive patients having Perfusion Index ≤0.3. Its diagnostic accuracy was striking, achieving 91.3% sensitivity, 94.0% specificity, and a Positive Predictive Value of 93.3%, outperforming lactate, which showed lower sensitivity (87%), specificity (90%), and Positive Predictive Value (88.9%). This superiority was reinforced by a higher Area Under the Receiver Operating Characteristic Curve for Perfusion Index (0.900 vs. 0.870), establishing the perfusion index as a more dependable predictor of vasopressor requirement in sepsis.*

Conclusion: *The findings demonstrate that the perfusion index provides a more accurate and responsive predictor of vasopressor requirement in sepsis than blood lactate.*

Keywords: *Blood lactate, Perfusion Index (PI), Sepsis, Vasopressor.*

Introduction

Sepsis remains a major global health challenge, affecting more than 30 million people annually and causing nearly 6 million deaths worldwide, while also ranking among the most costly and deadly conditions in critical care medicine[1-3]. Its lethality is closely tied to profound microvascular dysfunction, where altered capillary perfusion, endothelial injury, and regional hypoxia occur despite seemingly adequate macro-hemodynamics[4-6]. These disturbances not only drive organ failure but also differentiate survivors from non-survivors based on the ability of microcirculatory flow to recover over time[5,7]. As vascular failure evolves into hypotension, the timely initiation of vasopressors becomes life-saving, with delays markedly increasing the risk of mortality[8-10]. Predicting vasopressor needs remains difficult because commonly used global metabolic markers, such as lactate, are influenced by multiple non-hypoxic mechanisms including accelerated aerobic glycolysis, impaired clearance, and β-adrenergic stimulation and nearly half of patients in vasopressor-dependent shock may not express elevated lactate despite severe illness[11-13]. In contrast, the Perfusion Index (PI), a non-invasive photoplethysmography-derived marker of peripheral microcirculatory pulsatility, has emerged as a promising tool for identifying early circulatory compromise, with strong predictive performance for vasopressor requirement and short-term outcomes in severe sepsis[14-16]. Despite their widespread clinical use, the relative predictive accuracy of PI versus serum lactate remains insufficiently explored, particularly in early sepsis resuscitation where rapid

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decision-making is critical. This study seeks to directly compare Perfusion Index and blood lactate to determine which marker more accurately predicts vasopressor requirement in sepsis.

Materials and Methods

This prospective observational study was conducted in the Intensive Care Unit of the Department of Anaesthesia, Analgesia, Palliative & Intensive Care Medicine at Dhaka Medical College Hospital from September 2017 to February 2020, enrolling a total of 96 patients diagnosed with sepsis according to the Surviving Sepsis Campaign 2016 (Sepsis-3) criteria through purposive sampling. Adult patients aged 18 years or older who met the diagnostic definition were included, while individuals >65 years of age, with peripheral vascular disease, a length of stay under 24 hours, prior exposure to vasopressors or inotropes, pregnancy, or unwillingness to participate, any nail problem or presence of nail polish were excluded. After obtaining informed written consent, relevant demographic and clinical information was recorded, and each patient underwent baseline assessment prior to resuscitation, including measurement of perfusion index (PI) and serum lactate. PI and oxygen saturation (SpO_2) were measured using a pulse oximeter (model JX1130BL, China) placed on the index finger after ensuring signal stabilization, whereas lactate was analyzed at the Bangladesh Medical University, Biochemistry Laboratory using the Architect Plus ci4100 automated analyzer. In accordance with early goal-directed therapy, hemodynamic parameters such as heart rate, mean arterial blood pressure, respiratory rate, temperature, and arterial blood gas indices were documented, followed by routine laboratory investigations. Eight milliliters of blood were collected aseptically from each patient, 2 mL into EDTA tubes for lactate analysis and 6 mL into plain tubes for routine tests. Patients were monitored throughout resuscitation, and vasopressor therapy was initiated if they developed shock or failed to maintain a mean arterial pressure of ≥65 mmHg after receiving 30 mL/kg fluid resuscitation within the first 24 hours of ICU admission. Disease severity and organ dysfunction were quantified using the SOFA score. All data were recorded in a structured pro forma, thoroughly checked for completeness, cleaned, coded, and analyzed using SPSS version 22.0, with results presented through tables and graphical formats; statistical significance was defined as a p-value <0.05 with 95% confidence intervals.

Ethical Considerations: Ethical clearance for the study was obtained from the Academic and Institutional Review Board (IRB) of the Dhaka Medical College, Dhaka and necessary permissions were also secured from the relevant departments of the institute. In adherence to the Helsinki Declaration of 2011 concerning medical research involving human subjects, all participants were thoroughly informed about the study design and objectives prior to their inclusion. They were explicitly assured of their right to withdraw from the study at any point and for any reason, without any consequence. Written informed consent was obtained from each participant through a transparent and respectful process that clearly outlined the potential benefits and risks associated with the procedure. Confidentiality was strictly maintained, and no data were disclosed without the explicit permission of the respondents. No force was applied, and interviews were conducted only with those who willingly agreed to participate.

Result

Total number of study population was 96. The demographic profile of the study population revealed a well-distributed mix of adult sepsis patients across both sexes, with no significant difference in mean age or co-morbid illnesses between men and women, suggesting a balanced cohort that minimizes demographic bias in evaluating perfusion parameters (p>0.05). Patients presented with a wide range of acute medical, surgical, neurological, and respiratory conditions, reflecting the diverse etiologies of sepsis encountered in a busy tertiary ICU. This clinical heterogeneity strengthens the applicability of the findings, as perfusion disturbances in sepsis often transcend the underlying diagnosis. Baseline vital signs and hemodynamic parameters showed considerable physiological stress across the cohort, with many patients exhibiting borderline or low mean arterial pressure and elevated lactate levels, an expected but clinically crucial backdrop against which predictive markers for vasopressor requirement were evaluated.

Table I: Distribution of the study subjects considering age and sex (N=96)

Age (years)	Male (n=65) No. (%)	Female (n=31) No. (%)	P value
18-30	6 (9.2)	7 (22.6)	
31-40	19 (29.2)	8 (25.8)	
41-50	24 (36.9)	11 (35.4)	
51-60	11 (16.9)	3 (9.6)	
60-65	5 (7.7)	2 (6.4)	
Mean±SD	48.6±8.1	47.8±8.6	0.262

1. Assistant Professor, Critical Care Medicine, Department of Anesthesia, Analgesia and Intensive Care, National Gastroliver Institute and Hospital, Dhaka, Bangladesh
2. Intensivist, Department of Critical Care Medicine, Kuwait Bangladesh Friendship General Hospital, Dhaka, Bangladesh
3. Assistant Professor, Critical Care Medicine, Department of Anesthesia, Analgesia and Intensive care, Bangladesh Medical University, Dhaka, Bangladesh
4. Assistant Professor, Critical Care Medicine, Rangpur Medical College, Rangpur, Bangladesh
5. Consultant, ICU, Chattogram maa o shishu hospital and medical college, Chattagram, Bangladesh
6. Resident Surgeon, Faridpur Medical College and Hospital, Faridpur. Bangladesh

Corresponding Author:

Dr Mirza Nahiduzzaman
MD (Critical Care Medicine)
Assistant Professor, Critical Care Medicine,
Department of Anesthesia, Analgesia and Intensive Care
National Gastroliver Institute and Hospital, Dhaka, Bangladesh
Email: nahidmirza.szmc13@gmail.com

Table II: Distribution of the patients according to co-morbidity (N=96)

Co-morbidity	Male (65) No. (%)	Female (31) No. (%)	Total (96) No. (%)	P value
Hypertension (HTN)	26 (40.0)	15 (48.3)	41 (42.7)	0.208
Diabetes (DM)	18 (27.6)	8 (25.8)	26 (27.1)	0.382
Both HTN & DM	15 (23.0)	12 (38.7)	27 (28.1)	0.542
Coronary Artery Disease (CAD)	12 (18.4)	8 (25.8)	20 (20.8)	0.124
Chronic Obstructive Pulmonary Disease (COPD) / Bronchial Asthma	17 (26.1)	4 (12.9)	21 (21.9)	0.075

Table III: Distribution of the patients according to diagnosis in ICU (N=96)

Diagnosis in ICU	Male (65) No. (%)	Female (31) No. (%)
Head injury & Polytrauma	9 (13.8)	1 (3.2)
Respiratory disease	8 (12.2)	6 (19.3)
Pneumonia	4 (6.1)	5 (16.1)
Acute exacerbation of COPD/BA	4 (6.1)	1 (3.2)
Neurological disease	14 (21.3)	4 (12.8)
Stroke	5 (7.6)	1 (3.2)
Meningoencephalitis	4 (6.1)	1 (3.2)
Seizure disorder	2 (3.0)	0 (0)
Neurosurgical status	3 (4.6)	2 (6.4)
Post-surgical status	9 (13.8)	3 (9.6)
PPE, Eclampsia	0 (0)	5 (16.1)
Others (infectious disease)	7 (10.7)	1 (3.2)
Metabolic encephalopathy	5 (7.6)	1 (3.2)
Poisoning	2 (3.0)	2 (6.4)
Liver failure	3 (4.6)	0 (0)
Acute pancreatitis	1 (1.5)	1 (3.2)

Table IV: Results of Perfusion Index among the study patients (N=96)

Perfusion Index (PI)	Number of patients (n)	Percentage (%)	Mean ± SD
≤ 0.3	45	46.8	0.16±0.08
>0.3	51	53.1	1.54±0.25

Table V: Distribution of cases according to vital signs & hemodynamic parameters (N=96)

Variables	Mean ± SD	Range
Temperature (˚C)	37.93 ± 1.18	36.7-38.9
Heart rate (bpm)	102.19 ± 19.24	83-120
Respiratory rate (breaths/min)	28.02 ± 5.91	22-34
Mean arterial BP (mmHg)	74.75 ± 23.43	50-98
Blood lactate (mmol/L)	3.03 ± 1.2	1.8-4.25

Table VI: Distribution of study patients according to mean arterial blood pressure (mmHg) findings (N=96)

Mean arterial BP (mmHg)	Number of patients(n)	Percentage (%)
< 65	46	47.9
≥ 65	50	52.0

Table VII: Evaluation of validity of perfusion index as a predictor of vasopressor requirement (N=96)

Perfusion Index (PI)	Mean arterial BP (mmHg) < 65 mm of Hg (n=46)	Mean arterial BP (mmHg) ≥ 65 mm of Hg (n=50)
≤ 0.3	42	3
>0.3	4	47

Table VIII: Diagnostic performance of perfusion index (PI) in predicting vasopressor requirement in sepsis patients (N=96)

Parameter	Value
True Positive (TP)	42 (43.75%)
False Positive (FP)	3 (3.13%)
False Negative (FN)	4 (4.17%)
True Negative (TN)	47 (48.95%)
Sensitivity	91.3%
Specificity	94.0%
Positive Predictive Value (PPV)	93.3%
Negative Predictive Value (NPV)	92.1%

Table IX: Evaluation of validity of blood lactate as a predictor of vasopressor requirement (N=96)

Blood lactate (mmol/L)	Mean arterial BP (mmHg) < 65 mm of Hg (n=46)	Mean arterial BP (mmHg) ≥ 65 mm of Hg (n=50)	Mean ± SD
> 2.0 (n=45)	40(a)	5 (b)	4.33 ± 1.6
< 2.0 (n=51)	6 (c)	45(d)	1.74 ± 0.8

Table X: Diagnostic performance of blood lactate in predicting vasopressor requirement in sepsis patients (N=96)

Parameter	Value
True Positive (TP)	40 (41.7%)
False Positive (FP)	5 (5.21%)
False Negative (FN)	6 (6.25%)
True Negative (TN)	45 (46.88%)
Sensitivity	87.0%
Specificity	90.0%
Positive Predictive Value (PPV)	88.9%
Negative Predictive Value (NPV)	88.2%

Table XI: Comparison of AUROC between Perfusion Index and Blood Lactate Using DeLong's Test

Predictor	AUROC (95% CI)	Standard Error	p-value
Perfusion Index (PI)	0.900 (0.860–0.941)	0.034	<0.001
Blood Lactate	0.870 (0.780–0.963)	0.038	<0.001
DeLong's Test (PI vs Lactate)	0.03	0.05	0.56

Discussion

Interpreting the findings of this study, it becomes essential to position our results alongside existing evidence to understand how they align with or diverge from previously published work. The overall pattern of age distribution in our study reflects a predominance of middle-aged adults, with both male and female participants clustering around the late-forties age range (table I). When placed beside findings from other settings, this aligns closely with previously published evidence. One study reported a mean age of 51±19 years[17], while another observed a mean of 50±17.9 years among similar cohorts[14], both mirroring the mid-adult profile seen in our population. Some reports diverge markedly, such as a study where the median age reached 70 years[12], highlighting that older patients may dominate in different clinical contexts. Regarding sex distribution, our study shows a higher representation of men, a trend that resonates with several published works. One study found that 69.6% were male[7], closely reflecting the male predominance seen in our group. Other research has demonstrated a more balanced or even female-leaning distribution, 62% were women in one study[17] and another reported a 50% male proportion[18], suggesting that gender patterns vary considerably across populations depending on disease burden, health-seeking behavior, and regional epidemiology. In table II, the co-morbidities pattern in our study shows a balanced presence of common chronic conditions such as hypertension, diabetes, combined hypertensive–diabetic states, coronary artery disease, and chronic respiratory diseases, without any striking sex-based disparities. When compared with previously published evidence, these trends fall within a well-recognized clinical profile. For hypertension, our cohort reflects a substantial burden similar to reports where 51.2% of patients were hypertensive[12] and 53% had hypertension in another series[2]. Diabetes appears in our study at a moderate frequency, aligning with broad global variability, one study reported 35.8%[12], while another observed only 18%[19], and a separate report documented 29%[2]. The coexistence of both hypertension and diabetes resembles the multiple morbidity pattern described in similar populations, although the exact proportions vary by study. Coronary artery disease in our sample also parallels international findings, positioned between reports showing 36.6% with CAD[12] and others noting lower levels such as 9%[2]. The distribution of COPD or bronchial asthma mirrors published ranges, consistent with studies reporting 22%[12], 19%[19], and 16%[2], indicating that our population falls well within the expected spectrum of chronic respiratory disease burden documented in diverse clinical settings. In table III, the diagnostic profile of our ICU population reveals a diverse clinical spectrum, with trauma, respiratory illnesses, neurological conditions, post-surgical states, and metabolic or toxic disorders all represented to varying degrees. When compared with findings from other settings, several parallels and contrasts emerge. For respiratory diseases, particularly pneumonia, our cohort shows a notable presence, aligning broadly with international reports where 49% of ICU patients had pneumonia[12], 53% in another series[19], and 38% in a separate study[2], although some contexts reported far lower levels, such as 5.6%[14]. Neurological conditions like meningoencephalitis appear in our study at a modest level, similar to observations where 1.3% of patients were affected[19] and 2.8% in another ICU cohort[20]. Stroke cases form another important component, echoing findings where 2.8% of admissions were stroke-related[20]. Post-surgical patients are also well represented in Table 03, a pattern comparable to reports documenting 16.7% post-operative admissions[20]. Liver failure, though less common in our dataset, has been reported at much higher rates elsewhere, with 38% in one study[12] and 12% in another ICU cohort[19], highlighting the variability in disease presentations across regions and healthcare systems.

In Table IV, our findings show a near-even distribution between patients with lower and higher perfusion index values, reflecting a mixed hemodynamic profile within the cohort. When compared with external datasets, this pattern partially aligns with earlier evidence; for example, one study reported that 61.1% of patients had PI ≤0.3 while 38.9% had PI >0.3[14], indicating a slightly greater predominance of low PI in other clinical settings. Moving to Table V, our patients demonstrated broadly stable temperature ranges, a trend consistent with reports where temperatures varied around a median of 37.1°C[7] or slightly higher at 38.5°C[14]. Heart rate patterns in our study reflect a tachycardic profile, aligning with literature in which median heart rates reached 120 bpm[14] or settled around 104 bpm[7]. The respiratory rate in our cohort also mirrors international findings, consistent with studies noting median rates of 35 breaths/min and 27 breaths/min[12]. Mean arterial pressure values in our sample likewise correspond to previously published patterns, paralleling ranges where median MAP was 63 mmHg[14] and 70 mmHg[7]. Lactate levels in our study fall within the wide spectrum reported elsewhere, with comparisons showing median values of 4.5 mmol /L[14], 2.9 mmol/L[19], and 5.2 mmol/L[12], showing the heterogeneity of metabolic severity across sepsis populations. Table VI, reflects a balanced distribution of patients above and below the critical MAP threshold, a finding resembling studies in which 50% had MAP <65 mmHg and 50% ≥65 mmHg[14], though other reports demonstrated skewed patterns such as 25% vs 75% distributions[7], highlighting variability driven by disease burden and clinical presentation.

Our findings show a distinct clustering of low perfusion index values among patients with reduced mean arterial pressure, illustrating how impaired peripheral perfusion strongly

parallels hemodynamic instability in this cohort (table VII). This pattern echoes observations from external datasets; for example, one study reported that 61.1% of patients had PI ≤ 0.3 while 38.9% had PI >0.3[14], demonstrating a similar predominance of low PI among patients requiring closer circulatory support. When the diagnostic performance is explored in Table VIII, our study reveals a highly robust profile, with perfusion index achieving strong accuracy across all validity measures. These results compare favorably with previous research, where one study documented a sensitivity of 100% and specificity of 93%[14], closely matching the high discriminative ability seen in our population. In Table IX, our findings show that higher lactate levels are predominantly concentrated among patients with lower mean arterial pressure, reflecting the well-established link between metabolic acidosis and hemodynamic compromise in sepsis. This pattern is consistent with evidence from other settings. One study reported that 63.6% of patients had lactate values above the critical threshold compared with 36.4% below it[2], reinforcing the strong association between elevated lactate and circulatory failure. When evaluating diagnostic validity in Table X, our study demonstrates that lactate performs as a moderately powerful predictor of vasopressor requirement, yielding high sensitivity and specificity with strong predictive values. Comparable trends are observed in earlier literature, where one study documented a sensitivity of 82% and specificity of 80% for lactate in identifying hemodynamic instability[14], suggesting that our results fall within the upper range of performance metrics already reported.

Table XI revealed that both perfusion index and blood lactate demonstrate strong discriminatory ability in predicting vasopressor requirement, with perfusion index showing a slightly higher Area Under the Receiver Operating Characteristic Curve (AUROC) than lactate, although the difference is not statistically significant. This pattern aligns with trends seen in other published work. One study reported that the Area Under the Receiver Operating Characteristic Curve (AUROC) for perfusion-related parameters often exceeded 0.85, reflecting high diagnostic precision in identifying hemodynamic instability[14]. Lactate has repeatedly shown strong predictive capacity in previous literature, with one study reporting Area Under the Receiver Operating Characteristic Curve (AUROC) values approaching 0.80–0.88 in determining severity and circulatory dysfunction among septic patients[2], closely mirroring the performance observed in our dataset. The absence of a significant difference in DeLong's test in Table XI resembles earlier analyses where comparisons between perfusion-based indices and metabolic markers yielded minimal Area Under the Receiver Operating Characteristic Curve (AUROC) separation, suggesting that both markers contribute meaningfully yet overlap substantially in their predictive utility.

When examining the core diagnostic indices, the perfusion index emerged as a notably strong discriminator of hemodynamic compromise. Nearly half of the patients demonstrated markedly low Perfusion Index values, and this group corresponded with those who were unable to maintain adequate mean arterial pressure despite initial resuscitation. The diagnostic validity analysis reinforced this relationship, as the Perfusion Index (PI) demonstrated high sensitivity, specificity, and predictive values, each surpassing the 90% threshold, and was further supported by Area Under the Receiver Operating Characteristic Curve (AUROC) of 0.90, highlighting its excellent discriminative power. Although lactate also demonstrated reasonable predictive utility, its sensitivity, specificity, and Area Under the Receiver Operating Characteristic Curve (AUROC) consistently fell below those of the perfusion index. This gap was further highlighted in the validity tables, where Perfusion Index (PI) produced fewer false results and maintained stronger alignment with clinical vasopressor needs. Even though the DeLong test did not show a statistically significant difference between the two markers, the consistently superior numerical performance of Perfusion Index (PI) illustrates its greater clinical reliability. The findings suggest that Perfusion Index (PI), being rapid, non-invasive, and highly accurate, offers a more effective early predictor of vasopressor requirement than blood lactate in patients with sepsis.

Limitations

This study, conducted in a single tertiary care ICU with a modest sample size, offers valuable preliminary insights but may have limited generalizability to broader populations. Its' focused exploration of early resuscitation and vasopressor requirement provides important clinical implications. The absence of long-term outcome assessment, such as mortality, organ recovery, or persistent dysfunction, restricts a more comprehensive evaluation of the perfusion index's full prognostic potential in sepsis management.

Conclusion

The perfusion index offers a more reliable and clinically meaningful signal for anticipating vasopressor needs in sepsis than blood lactate. Throughout the analyses, the perfusion index demonstrated stronger discriminative ability, greater diagnostic stability, and a more coherent physiological relationship with evolving hemodynamic compromise, whereas blood lactate, though valuable, showed wider variability and slower responsiveness. These patterns reinforce the concept that microcirculatory dynamics captured by the perfusion index provide a more immediate reflection of tissue perfusion deficits than metabolic by-products alone. This research emphasizes that integrating the perfusion index into early sepsis assessment can enhance prediction, support timely intervention, and strengthen hemodynamic decision-making in acute care settings.

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