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Article

Prognostic Effectiveness of Blood Gas Lactate Values and Peripheral Perfusion Indices in Patients Diagnosed with Acute Coronary Syndrome in The Emergency Department

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Abstract: This study aimed to investigate the potential correlations and differences between patients with Acute Coronary Syndrome (ACS) and controls. Emphasis was placed on examining the relationship between arterial blood gas PH value and arterial blood gas lactate value as well as assessing the utility of the Peripheral Perfusion Index (PI) in ACS management. Materials and Methods: A prospective observational study was conducted between January 1, 2023, and July 1, 2023, involving 60 ACS patients and 30 control subjects in an emergency department. The diagnosis of ACS was confirmed by experienced emergency physicians, and various parameters, such as peripheral perfusion index, blood gas values, and cardiac biomarker values, were collected. The statistical analyses included Pearson's chi-square test, Mann-Whitney U test, Student's t-test, and others, using SPSS version 18.0. There were significant differences in the mean age, perfusion index, and lactate levels between the patient and control groups. A robust negative correlation was found between age and PI, and a moderate negative correlation was observed between pH and lactate levels ($r = -0.301$, $p=0.004$). The perfusion index in the patient group was significantly lower, indicating its potential diagnostic utility. The findings demonstrate the importance of arterial blood gas pH and lactate values in understanding ACS patient profiles, emphasizing the potential of PI as a noninvasive diagnostic method. The negative correlation between pH and lactate levels may offer valuable insights into risk stratification and treatment strategies for patients with ACS.

Keywords: acute coronary syndrome; peripheral perfusion index; arterial blood gas; lactate; diagnostic metrics; noninvasive techniques

1. Introduction

The ubiquity of cardiovascular ailments, particularly Acute Coronary Syndrome (ACS), in contemporary healthcare landscapes is a stark reality. With alarming mortality rates and propensity for rapid deterioration, ACS has emerged as a focal concern in emergency medical care, necessitating innovative and precise diagnostic measures [1]. Consequently, the demand for accessible and efficacious evaluation methods in the emergency department (ED) has never been high. In recent years, the Perfusion Index (PI), a non-invasive parameter, has attracted the attention of medical researchers and practitioners [2]. The PI, derived from infrared signals through a finger probe, computes the ratio of pulsatile to non-pulsatile components of peripheral blood flow. It serves as a nuanced monitor of a patient's cardiac output and overall hemodynamics, transcending the boundaries of traditional vital sign measurements [1]. Acute Coronary syndrome, with its capricious clinical trajectory and potential to abruptly escalate into life-threatening scenarios, necessitates an urgent, precise, and comprehensive diagnostic strategy. As a formidable global health adversary, ACS demands not merely a timely but also an astutely accurate intervention to thwart its potentially devastating consequences. While conventional diagnostic approaches, such as electrocardiograms (ECGs) and cardiac biomarker analysis, have remained pivotal, their utility can be substantially amplified when synchronized with innovative tools like the Peripheral Perfusion Index (PI).

The merit of PI emerges vividly in its capacity to instantaneously unravel the complexities of hemodynamic parameters, shedding light on physiological realms that are ordinarily less palpable through traditional monitoring [3-6]. With its potential to deftly differentiate diagnostic conundrums, adeptly assess risk, and proficiently navigate the intricate management maze of ACS, PI promises not only an enhanced diagnostic acumen but also a more nuanced patient-centric care strategy in the emergency department [4].

Technological advancements in the realm of cardiovascular diagnostics, such as PI, digital pulse amplitude tonometry, and flow-mediated brachial artery dilation, underscore a vibrant evolution in emergency care, where precise, timely, and patient-friendly diagnostic tools are progressively altering the medical landscape. While the innovative potential of these methodologies has been demonstrated through improved patient assessments and outcomes, their widescale implementation is often tempered by challenges encompassing financial investments and the requisition of specialized training [7, 8].

Conversely, PI, with its inherently non-invasive methodology and the ability to indirectly assess microvascular peripheral perfusion, emerges as a notably accessible and versatile diagnostic adjunct. The preliminary indications of PI's efficacy in evaluating cardiac function, particularly in critical, high-stakes contexts such as ACS, is emblematic of a broader movement towards incorporating noninvasive diagnostic strategies into the emergency care matrix [3, 4, 6].

As ACS continues to assert its presence in emergency care, the integration of PI may pave the way for a more nuanced and agile response, aligning with the broader mission of enhancing the accuracy, timeliness, and efficiency of emergency care for cardiovascular patients.

Leveraging insights from foundational research that explored the relationship between the PI and coronary artery diseases, the present study aims to meticulously examine the comparative efficacy of peripheral perfusion indices and blood gas lactate values in patients diagnosed with ACS in the ED. Karaman et al. [2] probed into the role of the Peripheral Perfusion Index in differentiating diagnoses between cardiac and pulmonary-origin dyspnea within the emergency service domain. Conversely, Chequer et al. [9] embarked on an investigative journey into the noninvasive assessment of ST-segment alterations during exercise testing in coronary artery disease through the lens of PI, while Menezes et al. [1] directed their investigative focus towards the exploration of endothelial functions in atherosclerosis employing PI as a critical tool in their research methodology [19].

ACS, characterized by its unpredictable trajectory and potential severity, commands a swift and accurate diagnosis. The urgency for timely intervention cannot be overstated in the face of the global menace that the ACS poses. Conventional diagnostic pathways, while indispensable, are complemented by novel tools, such as PI. This alignment with noninvasive technologies such as PI can potentially sharpen diagnostic precision and expedite crucial treatments. The virtue of PI lies in its ability to provide instantaneous insights into hemodynamic parameters. Its role in differentiating diagnoses, assessing risks, and navigating the complex landscape of ACS management is promising. The integration of PI within the ED, akin to emerging technologies in other circulatory disease contexts, symbolizes an exciting frontier in patient care.

Newer methodologies such as PI, akin to digital pulse amplitude tonometry, and flow-mediated brachial artery dilation in the assessment of peripheral arteries highlight the evolving arsenal in emergency care diagnostics. While these techniques have shown valuable results in patient assessment, their implementation often faces barriers, such as high costs and the need for specialized training. In contrast, PI's non-invasive nature and indirect measurement of microvascular peripheral perfusion make it a potentially versatile and accessible tool. Although preliminary, the use of PI to evaluate cardiac function in critical scenarios, such as ACS, aligns with the trend of maximizing noninvasive evaluations.

As ACS continues to assert its presence in emergency care, the integration of PI may pave the way for a more nuanced and agile response, aligning with the broader mission of enhancing the accuracy, timeliness, and efficiency of emergency care for cardiovascular patients. Building on prior foundational studies, such as those by Karaman [2], Gürmen [3], and others [1, 4], this research aimed to delve into the comparative efficacy of peripheral perfusion indices and blood gas lactate values in

patients diagnosed with ACS in the ED. By synergizing novel and traditional diagnostic methods, we aimed to elucidate the potential of PI in enhancing patient management protocols in ACS scenarios.

As emergency medicine continues to evolve in response to new diagnostic techniques and the ever-increasing demands of acute care, the integration of noninvasive tools such as PI may offer a transformative approach to patient care. This study seeks to shed light on the potential of PI, hoping to contribute meaningfully to the broader discourse on optimizing ACS management in emergency settings.

2. Materials and Methods

2.1. Study Design and Population

Our team embarked on a meticulous, prospective observational study unfolding from January 1 to July 1, 2023, set within the bustling environment of our emergency department. The focal point of this investigation was a distinctive population: patients greeted with the ominous diagnosis of Acute Coronary Syndrome (ACS) upon their unforeseen arrival at the department. Our investigation peered into the intricate nuances of ACS, aiming to shed light on the myriad facets of its occurrence, diagnosis, and subsequent management, thereby contributing to the ever-expanding reservoir of clinical knowledge pertaining to cardiac emergencies.

2.2. Inclusion Criteria

In a bid to uphold the integrity and specificity of our study, a well-defined eligibility criterion was established. Only individuals diagnosed with ACS during the specified study window were brought under the investigative lens. Conversely, exclusion criteria were judiciously identified to mitigate confounding variables, these encompassed patients below the tender age of 18, those who faced the calamity of cardiopulmonary arrest, and individuals with a history mired by prolonged cardiopulmonary resuscitation (CPR) during their presentation, thereby ensuring a homogenous and relevant study population.

2.3. Procedure

Upon the precarious entry of patients into the emergency department, an emergency service assistant physician, seasoned with three years of unbridled exposure and experience in emergency service, meticulously validated the ACS diagnosis. Subsequent to this critical verification, an exploration into the Peripheral Perfusion Index (PI) was embarked upon, utilizing a specific device dedicated to such measurements. Ensuring a systematic and error-free documentation, data for each patient were scrupulously logged using a pre-structured case form, designed to harness vital clinical information efficiently and accurately.

2.4. Data Collection

The data, an amalgamation of quantifiable clinical snapshots, was conscientiously recorded by the emergency service assistant. This encompassed a rich tapestry of patient demographics, traversing age, sex, along with indispensable clinical metrics like blood gas parameters and pivotal cardiac biomarker readings. This data, not merely numbers and values but a story of each patient's physiological state, was assimilated with the utmost precision to enable a holistic understanding of their clinical picture.

2.5. Consultation and Diagnosis Confirmation

Ensuring robustness in diagnostic validity, all patients shrouded with the suspicion of ACS underwent a thorough consultation with the esteemed cardiology department. The seasoned experts within the cardiology department lent their profound insights and recommendations, serving as a bedrock for diagnostic crystallization. This collaborative multidisciplinary approach enhanced the

accuracy and reliability of the finalized diagnoses, intertwining clinical acumen with holistic patient care.

2.6. Statistical Analysis

The Kolmogorov–Smirnov test was employed to determine the normality of the data distribution. Pearson's chi-squared test was used to discern relationships between categorical variables, while the Mann-Whitney U test was used to assess relationships between numerical variables. Continuous variables are presented as mean ± standard deviation (SD). Statistical significance was set at $P < 0.05$. The ANOVA test further bolsters the analytical approach. All statistical computations were conducted using the Statistical Program for the Social Sciences (SPSS), version 18.0.

2.7. Ethical Considerations

This study was conducted in accordance with ethical guidelines and was approved by the non-interventional clinical research ethics committee at the Tekirdag Namik Kemal University on 27.12.2022, with Approval Number 2022.225.12.03. Informed consent was obtained from all participants, and confidentiality was maintained throughout the research process.

3. Results

The study cohort consisted of 90 individuals subdivided into two groups: patients diagnosed with the condition under investigation ($n=60$, 66.7%) and control subjects ($n=30$, 33.3%). The sex distribution was equally balanced across both groups, with 45 males (50%) and 45 females (50%). Among the patients, prevalent comorbidities were identified, including diabetes mellitus (DM) in 29 (32.2%), hypertension (HT) in 45 (50%), chronic heart failure (CHF) in 10 (11.1%), chronic kidney disease (CKD) in 6 (6.7%), coronary artery disease (CAD) in 40 (44.4%), and chronic obstructive pulmonary disease (COPD) in 7 (7.8%). Table 1 presents the general characteristics of the study cohort in detail.

A cohort of 90 individuals was further delineated into specific diagnostic categories within the emergency department. The control group comprised of 30 participants (33.3%). Among the patients, 15 were diagnosed with Unstable Angina Pectoris (USAP), constituting 16.7% of the cases, 31 with Non-ST Elevation Myocardial Infarction (NON-ST MI), representing 34.4%, and 14 with ST-Elevation Myocardial Infarction (ST MI), comprising 15.6%. Following the emergency department evaluation, the disposition of patients varied. Thirty control cases (33.3%) were recorded, along with 16 transfers to the coronary angiography unit (17.8%), 43 admissions to the coronary intensive care unit (47.8%), and one death (EX), representing 1.1% of the cases.

Upon conducting a detailed comparative evaluation of the patient and control cohorts, salient variations in specific clinical parameters were evident. The patient group exhibited an older mean age of 63.03 compared with 39.57 in the control group ($p<0.001$), indicating a significant age difference. Additionally, the perfusion index in the patient group was notably lower, with a mean value of 1.55, compared to 3.39 in the control group ($p<0.001$). However, pH levels did not differ significantly between the two groups. Lactate levels were significantly higher in the patient group (mean of 2.02, compared than 0.41 in the control group ($p<0.001$). These findings highlight the distinctive profiles of the two groups, with significant differences in age, perfusion index, and lactate levels (Figure 1). These differences are listed in Table 2.

Table 1. Demographic and clinical characteristics of acute coronary syndrome patients and controls.

Variable	Subcategory	Count (n)	Percentage (%)
Cohort	Patient	60	66.7
	Control	30	33.3
Gender	Male	45	50
	Female	45	50

Variable	Subcategory	Count (n)	Percentage (%)
Diabetes Mellitus (DM)	Yes	29	32.2
	No	61	67.8
Hypertension (HT)	Yes	45	50
	No	45	50
Congestive Heart Failure (CHF)	Yes	10	11.1
	No	80	88.9
Chronic Kidney Disease (CKD)	Yes	6	6.7
	No	84	93.3
Coronary Artery Disease (CAD)	Yes	40	44.4
	No	50	55.6
Chronic Obstructive Pulmonary Disease	Yes	7	7.8
	No	83	92.2
Reason for Emergency Department Visit	Control	30	33.3
	Unstable Angina (USAP)	15	16.7
	Non-ST Elevation Mvocardial	31	34.4
	ST-Elevation Mvocardial Infarction	14	15.6
	Discharged with Control	30	33.3
Outcome	Referred to Angiography Unit	16	17.8
	Admitted to Coronary Care Unit	43	47.8
	Expired (EX)	1	1.1
Total	-	90	100

Table 2. Comparative analysis of Age, Perfusion Index, pH, and Lactate levels between patient and control groups.

Observed Parameters	Group	N	Mean	Standard Deviation	Median	P-value
Age	Patient	60	63.03	10.84	63.00	0.001*
	Control	30	39.57	10.79	39.00	
Perfusion Index	Patient	60	1.55	0.86	1.400	0.001**
	Control	30	3.39	0.83	3.300	
pH	Patient	60	7.38	0.07	7.390	0.177*
	Control	30	7.40	0.03	7.390	
Lactate	Patient	60	2.02	2.07	1.500	0.001**
	Control	30	0.41	0.20	0.355	

*Student T Test, Mann Whitney U Test.

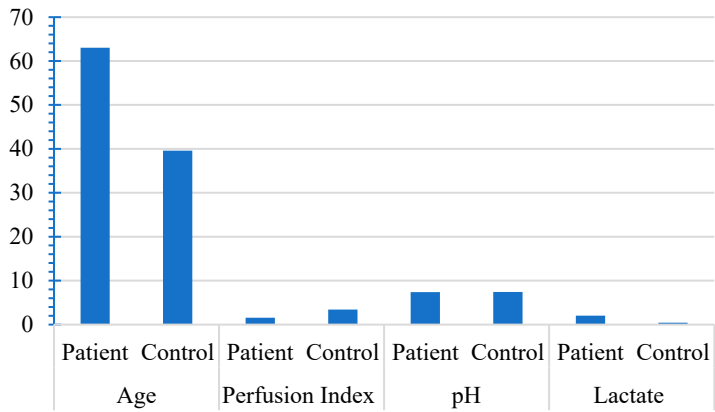


Figure 1. The means of perfusion index, pH, and lactate between patient and control groups.

The dataset was meticulously analyzed to explore the relationships between various continuous variables, with particular attention given to the correlation between arterial blood gas pH and lactate

values. Nuanced and multifaceted interconnections were discerned among the assessed variables. A prominent negative correlation emerged between age and PI ($r = -0.677$, $p < 0.001$), along with a substantial positive correlation between age and lactate levels ($r = 0.426$, $p < 0.001$).

The core investigation of the analysis, focusing on the relationship between arterial blood gas pH and lactate values, revealed a significant negative correlation ($r = -0.301$, $p = 0.004$). This association implies that decreased pH values tend to coincide with increased lactate levels in the study population. The intricacies of these correlations are detailed and synthesized in Table 3, providing valuable insights into the underlying dynamics of the examined parameters.

Table 3. Interrelationships among Age, Perfusion Index, arterial blood gas pH, and Lactate levels in the study population.

Observed Parameters		Age	Perfusion Index	pH
Perfusion Index	r	-0.677		
	p	0.000		
pH	r	-0.199	0.174	
	p	0.060	0.101	
Lactate	r	0.426	-0.461	-0.301
	p	0.000	0.000	0.004

4. Discussion

In the present study of 90 participants, we investigated how well the peripheral perfusion index and blood gas lactate values could diagnose acute coronary syndrome. Neither PPI nor lactate values were very reliable in predicting who would be hospitalized or exactly determining the type of ACS. This is different from what some other studies suggested. As far as we know, ours is the first study to closely link PPI and lactate values to ACS diagnosis. Our participants, generally older with specific PPI and lactate trends, reflected what is commonly seen in ACS patients. Yet, our results highlight the need to better understand the use of PPI and lactate in diagnosing ACS and perhaps to explore other methods or indicators.

This investigation of a cohort of 90 individuals, focusing on the diagnosis and differentiation of ACS using PPI and blood gas lactate values, has revealed significant insights into the complex clinical scenario. The patient pool reflected a diverse spectrum of prevalent comorbidities and ACS presentations commonly encountered in emergency departments.

The cohort included patients of both sexes with various common comorbidities, such as diabetes, hypertension, and heart disease. It is divided into specific diagnostic categories, such as Unstable Angina and different types of Myocardial Infarction. This diversity reflects the complexity of real-world patients in the ED, supporting the validity of this study and enabling a more nuanced analysis of the ACS spectrum.

The central finding of our study was that neither PPI nor blood gas lactate values were effective in predicting hospitalization and discriminating the ACS form. Contrary to expectations, PPI failed to serve as an effective marker of peripheral perfusion, hospitalization, or mortality in this study. Despite the demonstrated use of PPI as an objective indicator of peripheral circulatory disorders, our findings, consistent with previous reports [9-11], showed that PI was an insignificant parameter for deciding hospitalization or diagnosing outcomes of ACS in the ED. PPI has become recognized as a straightforward and noninvasive method for indicating compromised peripheral perfusion in critically ill patients [11, 12]. Initially, Lima et al. [13] established that in intensive care settings, a PPI value of 1.4 or lower served as a strong sign of reduced perfusion [13]. Pirneskoski et al. [12] suggested that measuring the pulse photoplethysmography wave amplitude might function as an assessment tool in the ED [14]. This could imply that PPI might act as a determinant of hospitalization and fatality rates in ED patients. Our findings align more closely with Oskay et al. [15]'s report that PPI use was insignificant in predicting ED outcomes [15].

In our research, the study most closely aligned with ours was conducted by Compagnoni et al. [4]. In contrast to our approach, they evaluated the diagnostic value of Perfusion Index (PI) in coronary artery patients who experienced medically-induced arrests. Specifically, Compagnoni et al. [3] explored the diagnostic utility of PI in patients who experienced medical out-of-hospital cardiac arrests, particularly for diagnosing ST-Elevation Myocardial Infarction (STEMI). They discovered a correlation between PI values and the percentage of false-positive Electrocardiograms (ECG). This implies that an ECG may reveal transmural myocardial ischemia without the presence of a significant obstructive coronary artery disease that warrants percutaneous transluminal coronary angioplasty (PTCA), especially in patients with low peripheral perfusion following resuscitation. Intriguingly, patients who experienced efficient perfusion post-resuscitation were often those with a lower rate of false-positive ECGs, thereby yielding more dependable diagnostic ECG results. This pivotal finding from their study invites discussion, both from pathophysiological and practical viewpoints. From a pathophysiological perspective, it's notable that the profound ischemia, induced by the reduced perfusion during the no-flow or low-flow phases of cardiac arrest, is likely to influence post-Return of Spontaneous Circulation (ROSC) ECG findings. Consequently, a decrease in PI values following resuscitation can be anticipated.

The role of lactate levels has emerged as a point of notable interest in our study, despite the findings not substantiating blood gas lactate values as effective in diagnosing ACS. Contrarily, existing literature underscores lactate's role in prognosticating ACS outcomes, inclusive of ST-Elevation Myocardial Infarction (STEMI) and non-ST-segment elevation myocardial infarction [1, 2]. Lazzeri et al. [14] articulate that temporal serial lactate measurements, or lactate clearance, tend to exhibit more clinical reliability than absolute lactate values, even within acute cardiac patient populations [1]. This is corroborated across various study designs, temporal lactate measurement intervals, and acute cardiac conditions, such as cardiogenic shock and cardiac arrest. A pervasive theme in existing studies denotes that elevated lactate levels upon admission and superior lactate clearance are congruent with non-survival and improved outcomes, respectively.

Furthermore, the presence of hyperlactatemia upon admission has been correlated with suboptimal outcomes in STEMI patients and has demonstrated a surge in 30-day mortality rates in ACS patients according to a large retrospective cohort study by Liang et al. [17]. Lactate not only emerged as an independent predictor of mortality and complications but also, the zenith of blood lactate within the initial 24 hours has been identified as a predictor of mortality in ACS patients undergoing extracorporeal membrane oxygenation [3, 4].

Interestingly, lactate levels have drawn significant attention in our study. While our results did not find blood gas lactate values effective in diagnosing ACS, the literature supports the role of lactate in the prognosis of ACS, including STEMI and non-ST-segment elevation myocardial infarction [10, 11]. For example, hyperlactatemia at arrival has been associated with worse outcomes in patients with STEMI, increased 30-day mortality, and intra-aortic balloon pump use [11]. In some studies, lactate served as an independent predictor of mortality and complications, such as acute pulmonary edema and arrhythmias [12, 13].

The patient group in our study, characterized by a higher mean age, lower PPI, and increased lactate levels, mirrors the general trends often noted in patients with ACS. These significant correlations, along with the negative correlation observed between arterial blood gas pH and lactate values, accentuate the multifaceted metabolic and physiological interactions intrinsic to ACS [2, 20]. They may even hint at underlying compensatory mechanisms at play, as indicated by the absence of significant differences in pH levels.

Additionally, the correlations between age and PPI could be indicative of age-related changes in the peripheral circulation, adding another layer to the complex network of interactions within ACS. The intricate interrelationships among these parameters not only affirm the consistency and generalizability of our study but also elucidate the complexity of the physiological and metabolic aspects of ACS. This compelling evidence calls for further research to unravel these complex interactions and their potential implications in clinical practice.

4.1. Clinical Implications

These results, being the first of their kind in patients with ACS, contribute significantly to our understanding of the role of PPI and blood gas lactate values in this context. The fact that these measures were not effective in diagnosing ACS may guide clinicians in seeking alternative markers or methodologies.

4.2. Limitations

This study should be interpreted in light of its limitations, including the sample size, which may affect the power to detect subtle differences. Furthermore, given that both PI and Blood Gas Lactate Values can be affected by sympathetic activity [9,10], a thorough examination of other relevant parameters could enhance interpretation.

5. Conclusions

While our study found that PPI and blood gas lactate values were ineffective in diagnosing ACS in the ED, it adds to the growing body of evidence surrounding the complex relationships between these parameters, age, and various comorbidities. The relevance of lactate as an independent prognostic marker in ACS emphasizes the need for further research to explore its role in diagnostic settings. Our findings also prompt the reconsideration of PPI as an assessment tool in the ED, encouraging more extensive studies to confirm or challenge its applicability in different patient populations and clinical contexts.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Non-interventional Clinical Research Ethics Committee of the Tekirdağ Namık Kemal University (protocol code: 2022.225.12.03, date of approval: 27.12.2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.

Data Availability Statement: Data are available upon request.

Conflicts of Interest: The authors declare no conflict of interest.

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