Anatolian Journal of Emergency Medicine 2025;8(4):182-187

ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ

Comparison of Shock Indexes, Lactate Level, and Base Deficit in Predicting Mortality in Community-Acquired Pneumonia: A Retrospective Analysis

Toplum Kökenli Pnömonide Mortalite ve Hospitalizasyonun Öngörülmesinde Şok Indeksleri, Laktat Düzeyi ve Baz Fazlalığının Karşılaştırılması: Retrospektif Analiz

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ABSTRACT

Aim: Community-acquired pneumonia (CAP) can lead to higher rates of morbidity and mortality. Shock index (SI) parameter can be easily calculated in patients who present to the emergency department, and has been used to predict mortality in numerous diseases. This study aimed to compare shock indices with each other and with lactate level and base deficit for predicting mortality in CAP.

Material and Methods: This was a retrospective cohort study. Patients' vital signs at the time of presentation to the emergency department were collected and the shock indices were calculated. The predictive performance of SI, adjusted shock index (ASI), modified shock index (MSI), blood lactate level, and base deficit in predicting mortality and hospitalization in patients with CAP was compared.

Results: Among the 195 included patients (mean age 67.2 years, 55.9% male), the 30-day mortality rate was 9.8%. Lactate, SI, ASI, and MSI were significantly higher in nonsurvivors ($p < 0.05$), whereas base deficit showed no association ($p = 0.635$). The AUC (95% CI) values for predicting 30-day mortality were as follows: lactate = 0.656 (0.492–0.820), SI = 0.697 (0.540–0.854), ASI = 0.720 (0.581–0.858), and MSI = 0.694 (0.535–0.853). Among these, ASI had the highest sensitivity (70.6%) and acceptable specificity (70.1%).

Conclusion: SI, ASI, MSI, and lactate levels may assist physicians in estimating short-term outcomes in CAP, but should not be used as standalone tools for clinical decision-making. Further multicenter prospective studies are warranted to confirm their predictive performance.

Keywords: Age-adjusted shock index, base deficit, community-acquired pneumonia, lactate, pleural effusion, shock index

ÖZ

Amaç: Toplum kökenli pnömoni (TKP), yüksek morbidite ve mortalite oranlarına yol açabilmektedir. Şok indeksi (Şİ) parametresi acil servise başvuran hastalarda kolayca hesaplanabilir ve şok indeksi birçok hastalıkta mortaliteyi öngörmek için kullanılmıştır. Bu çalışmanın amacı, şok indekslerini birbirleriyle ve mortaliteyi öngörmede laktat düzeyi ile baz fazlası/eksikliği (base deficit) parametreleriyle karşılaştırmaktır.

Gereç ve Yöntemler: Bu retrospektif kohort çalışmadır. Hastaların acil servise başvurduklarındaki vital bulguları toplanarak şok indeksleri hesaplandı. TKP hastalarında mortalite ve hastaneye yatışı öngörmede Şİ, düzeltilmiş şok indeksi (AŞİ), modifiye şok indeksi (MŞİ), kan laktat düzeyi ve baz fazlası/eksikliğinin etkinliği karşılaştırıldı.

Bulgular: 30 günlük mortalite analizinde, kan laktat düzeyi ($p = 0,036$), Şİ ($p = 0,008$), AŞİ ($p = 0,003$) ve MŞİ ($p = 0,009$) anlamlı derecede yüksek bulundu, ancak baz fazlası/eksikliği ile anlamlı bir ilişki gözlenmedi ($p = 0,635$). AŞİ 30 günlük mortalite için en anlamlı parametre olmasına rağmen %70,59 duyarlılık oranına sahipti ($p = 0,003$). Hastaneye yatırılan hastalarda kan laktat düzeyi ($p = 0,001$), Şİ ($p = 0,003$), AŞİ ($p < 0,001$) ve MŞİ ($p = 0,002$) anlamlı derecede yüksek bulundu, ancak baz fazlası/eksikliği ile anlamlı ilişki saptanmadı ($p = 0,115$).

Sonuç: Şİ, AŞİ, MŞİ ve kan laktat düzeyi TKP'de mortaliteyi ve hastaneye yatışı öngörmede kullanılabilir. Bu parametreler arasında en yüksek duyarlılık oranına AŞİ'nin sahip olduğu görüldü. Baz fazlası/eksikliği ise TKP'de mortaliteyi ve hastaneye yatışı öngörmede anlamlı bulunmadı.

Anahtar Kelimeler: Yaşa bağlı şok indeksi, baz defisiti, toplum kökenli pnömoni, laktat, plevral efüzyon, şok indeks

Received: 7 September 2025 Accepted: 30 November 2025

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Atıf için/Cited as: Ağaçkıran İ, Ağaçkıran M. Comparison of Shock Indexes, Lactate Level, and Base Deficit in Predicting Mortality in Community-Acquired Pneumonia: A Retrospective Analysis. Anatolian J Emerg Med 2025;8(4): 182-187. https://doi.org/10.54996/anatolianjem.1779658.

Introduction

Community-acquired pneumonia (CAP) is a prevalent lung infection with high morbidity and mortality, resulting in approximately 4 million deaths globally each year (1). One of the most crucial steps in the treatment of CAP is to determine the severity of pneumonia following the emergency department diagnosis, which helps physicians details to make decisions associated with hospitalization of patients and predicting the mortality risk in patients (2).

The shock index (SI) is a bedside parameter that can be easily determined by dividing the heart rate by systolic blood pressure (3). SI is widely used for predicting mortality in acute fatal diagnoses, including myocardial infarction, pulmonary thromboembolism, hypovolemia, and sepsis (4–6). Elevated levels of SI can be used to determine changes required in management of patients with vital signs without obvious abnormalities or in regard to intensive care unit admission (7). Additional parameters, such as age-adjusted shock index (ASI) and modified shock index (MSI), have also emerged over time. ASI is calculated as age multiplied by shock index, whereas MSI as heart rate divided by mean arterial pressure. The ASI was first used to predict mortality in traumatized elderly patients (8). It was reported that MSI was superior to other shock indices in predicting in-hospital mortality in patients with myocardial infarction and decompensated heart failure (9,10). Previous studies have shown that early triage tools and severity scores can predict short-term outcomes in pneumonia (11). Their findings support the use of easily obtainable parameters for early prognostic assessment in pneumonia.

Increased blood lactate level indicates tissue hypoperfusion in sepsis and is thought to be effective in predicting mortality (12). A lactate value of >2 mmol/L was found to be significant in predicting mortality during hospitalization in patients with CAP by Song et al (13). In addition to static lactate levels, lactate clearance, one of the dynamic indicators, has been shown to more accurately predict mortality in emergency department patients (14). Base deficit is important in demonstrating metabolic acidosis in circulatory shock and may be the first finding. Therefore, many researchers have accepted base deficit as an indicator of hypovolemia and oxygen debt (15).

This study aimed to evaluate the predictive capacity of shock indices, lactate, base deficit for mortality and hospitalization in CAP in patients who presented to the emergency department of our hospital.

Material and Methods

Study Design

This was a retrospective cohort study. The required approval for the commencement of this study was obtained from the Hitit University Faculty of Medicine Research Ethics Committee (Decision date: 10 July 2024 and decision No.: 2024-40). The study was conducted in accordance with the principles of the Declaration of Helsinki (World Medical Association Declaration of Helsinki–Ethical Principles for Medical Research Involving Human Subjects).

All adult patients (≥18 years old) who presented to the emergency department between April 1, 2019, and March 31, 2020 and were diagnosed with community-acquired pneumonia (CAP) were considered for inclusion. Cases were identified through both ICD-10 discharge codes (J18.0–J18.9) and manual screening of emergency department electronic medical records using the keywords pneumonia, infiltrate, and respiratory infection in the clinical notes or initial diagnoses.

Screening and Case Validation

Each potential case was reviewed manually by two emergency physicians to confirm that it met the predefined diagnostic criteria for CAP. The diagnostic definition required the presence of a new infiltrate on chest X-ray plus at least one clinical sign or symptom of infection (fever >37.8°C, productive cough, dyspnea, or purulent sputum) and abnormal chest auscultation findings (crackles, bronchial breath sounds, or evidence of pleural effusion).

If discrepancies arose between the physician-assigned diagnosis and the study definition:

-Patients labeled as “pneumonia” by the treating clinician but not meeting the study definition were excluded from analysis.

-Patients not labeled as “pneumonia” but meeting all study criteria were included if confirmed by both reviewers after consensus.

Disagreements between reviewers were resolved through discussion with a senior emergency medicine specialist. Patients whose data could not be accessed accurately were excluded from the study.

Data Collection

Data regarding demographics, comorbidities, vital signs, laboratory results, hospitalization and discharge decisions, and CURB-65 scores in patients with CAP were collected. Mortality outcomes of the patients were followed through hospital automation system, and the national patient information system.

Calculation of Shock Indices

SI was calculated as heart rate divided by systolic blood pressure, ASI as age multiplied by SI, and MSI as heart rate divided by mean arterial pressure using vital signs measured at presentation to the hospital.

Statistical Analysis

The Statistical Package for the Social Sciences by IBM (version 23) was used to analyze the study data. Normal distribution hypothesis was tested using Kolmogorov–Smirnov and Shapiro–Wilk tests. Mann–Whitney U test was used to compare non-normally distributed data according to paired groups, and independent two-sample t-test was used for normally distributed data. Factors affecting 30-day mortality were analyzed by means of logistic regression analysis. Analysis results were presented as frequency (percentage) for categorical data and median (minimum–maximum) as well as mean ± standard deviation were used for quantitative data. A p value of <0.05 was considered statistically significant. Receiver operating characteristic (ROC) analysis was performed to assess the discriminatory power of each score and to determine the optimal cutoff values with corresponding sensitivity and specificity. The area under the ROC curve (AUC) and its 95% confidence interval (CI) were calculated. Interpretation of AUC values followed established guidance: an AUC of 0.5 indicates no discrimination, 0.7–0.8 acceptable, 0.8–0.9 excellent, and >0.9 outstanding performance. However, values below 0.7 indicate limited clinical usefulness (16).

Results

The study included 195 patients. The mean age of the patients was 67.2 years, 55.9% were men, and 57.9% used ambulance services to reach the hospital. Moreover, 79.5% of the patients had comorbidities, and the most prevalent comorbidity (50.7%) was hypertension (HT). Furthermore, 41% of patients required supplemental O2 therapy, 7.2% had home devices for long-term oxygen therapy, and 3.1% had home devices for noninvasive mechanical ventilation therapy. Upon a review of patient outcomes, it was observed that 63.4% were discharged from the emergency department with the necessary treatment; moreover, 19.6% of the patients were transferred to the ward, 8.7% to the intensive care unit, and 4.1% to other hospitals due to lack of space in our hospital's intensive care unit. Mortality was seen in 2.3% of the patients in the first 24 hours, 9.8% in the first 30 days, and 15.5% in the first 90 days. Additional patient demographics and clinical characteristics can be found in Table 1.

	n = 195
Age, median(IQR25-75)	71(60–79)
Mode of presentation	
Ambulatory	82 (42.1)
Ambulance Service	113 (57.9)
Sex	
Female	86 (44.1)
Male	109 (55.9)
Comorbid diseases*	
Chronic obstructive pulmonary disease	64 (42.7)
Asthma	16 (10.7)
Congestive heart failure	43 (28.7)
Hypertension	76 (50.7)
Diabetes mellitus	48 (32)
Coronary artery disease	43 (28.7)
Malignancy	13 (8.7)
Chronic kidney disease	20 (13.3)
Cerebrovascular disease	4 (2.7)
Supportive oxygen demand	80 (41)
Prolonged oxygen therapy	15 (7.7)
Permanent noninvasive mechanical ventilation device	6 (3.1)
Altered mental status	13 (6.7)
Altered mental status with new onset	11 (5.6)
Intensive care unit indication	25 (12.8)
NIMV	16 (8.2)
IMV	6 (3.1)
Others	3 (1.6)
Endpoint	
Discharged	123 (63.4)
Transferred to the ward	38 (19.6)
Intensive care unit	17 (8.7)
Dispatch	8 (4.1)
Treatment Refusal	8 (4.1)
Mortality	
0–1 day	4 (2.3)
0–30 days	17 (9.8)
0–90 days	27 (15.5)
Curb-65	
0	32 (16.4)
1	60 (30.8)
2	80 (41)
3	15 (7.7)
4	8 (4.1)

Table 1. Descriptive statistics for demographics.
Mean ± standard deviation, n (%). *There are patients with more than one disease in their medical history. IQR: interquartile range, NIMV: noninvasive mechanical ventilation IMV: invasive mechanical ventilation

The mean SI, ASI, and MSI were 0.68, 45.3, and 0.95, respectively. The mean systolic and diastolic blood pressure were 141 and 82 mmHg, respectively. The mean pulse rate was 93 beats/min, and the mean respiratory rate was 22. The mean blood gas pH, partial carbon dioxide, and bicarbonate levels were 7.39, 43.71, and 24.44, respectively. The mean lactate and base deficit levels were 2.37 and 1.2, respectively. The average length of stay in the emergency department was 3.48 hours. Additional patient descriptive statistics of clinical characteristics can be found in Table 2.

The lactate, SI, ASI and MSI values were significantly higher in patients with hospital admission ($p = 0.001$, 0.003, <0.001, 0.002). There was no statistically significant difference between base deficit values according to outcome status of the patients ($p = 0.115$) (Table 3). Patients with 30-day mortality had significantly higher lactate, SI, ASI, MSI values ($p = 0.036$, 0.008, 0.002, 0.009). There was no statistically significant difference between base deficit values by 30-day mortality status ($p = 0.635$) (Table 4).

In patients with 30-day mortality, the cutoff point for SI value was ≥0.83, the AUC (95% CI) value was 0.697 (0.54–0.854),

	n = 195
Systolic blood pressure, mm-Hg	141 ±25.29
Diastolic blood pressure, mm-Hg	82 ±15.94
Pulse rate, /minute	93 ±21.24
Respiratory rate, /minute	22 ±5.28
Oxygen saturation (%)	90 ±9.39
Body temperature (C)	37.05 ± 0.7
WBC (×10³/µL)	10547.95 ± 4941.63
Blood urea nitrogen (mg/dL)	24.97 ± 14.72
Creatinine (mg/dL)	1.18 ± 0.96
pH	7.39 ± 0.07
$PaCO_2$ (mmHg)	43.71 ± 11.39
Bicarbonate level (mmol/L)	24.44 ± 3.57
Lactate (mmol/L)	2.37 ± 1.37
Base deficit (mmol/L)	1.2 ± 4.1
Hemoglobin level (g/dL)	12.84 ± 2.08
Length of stay in the emergency department, hours	3.48 ± 1.64
SI	0.68 ± 0.21
ASI	45.3 ± 17.16
MSI	0.95 ± 0.28

Table 2. Descriptive statistics of clinical characteristics.
Mean ± standard deviation, WBC: white blood cell count, PaCO2: partial carbon dioxide level in blood gas, SI: shock index, ASI: age shock index, MSI: modified shock index

	Endpoint		Test ist.	p
	Discharged	Hospitalization		
Lactate level (mmol/L)	1.97 (0.89–4.2)	2.43 (1.03–11.66)	−3.193	**0.**$^{\mathbf{001m}}$
Base deficit (mmol/L)	0.9 (−7.1–7.5)	2.05 (−12.7–18.5)	−1.577	0.^{115m}
SI	0.63 (0.28–1.2)	0.72 (0.42–1.46)	−2.954	**0.**$^{\mathbf{003m}}$
ASI	40.56 (10.94–91.3)	51.34 (19.25–117.98)	−4.804	**<0.**$^{\mathbf{001m}}$
MSI	0.9 ± 0.23	1.05 ± 0.33	−3.255	**0.**$^{\mathbf{002t}}$

Table 3. Lactate, base deficit, and shock values by the outcome of the patients.
m: Mann–Whitney U test, t: independent two sample t test, Median (minimum–maximum), Mean ± standard deviation, SI: shock index, ASI: age shock index, MSI: modified shock index

	Mortality 30		Test ist.	p^m
	No	Yes		
Lactate level (mmol/L)	2.02 (0.89–11.66)	2.82 (1.08–9)	−2.099	**0.036**
Base deficit (mmol/L)	1.2 (−12.7–11.3)	0.9 (−8.6–18.5)	−0.475	0.635
SI	0.63 (0.28–1.31)	0.88 (0.38–1.46)	−2.664	**0.008**
ASI	41.51 (10.94–115.14)	56.46 (27.56–117.98)	−2.973	**0.003**
MSI	0.89 (0.43–1.67)	1.25 (0.57–1.8)	−2.628	**0.009**

Table 4. Lactate, base deficit, and shock values by the 30-day mortality status of patients.
m: Mann–Whitney U test, Median (minimum–maximum), SI: shock index, ASI: age shock index, MSI: modified shock index

the sensitivity value was 58.82%, and the specificity value was 83.44%. The SI value with a specificity of 83.44% correctly predicted patients with 30-day mortality and correctly predicted patients without 30-day mortality in the real-life situation with a rate of 58.82%. In patients with 30-day mortality, the cutoff point for ASI value was ≥49.29, the AUC (95% CI) value was 0.720 (0.581–0.858), the sensitivity value was 70.59%, and the specificity value was 70.06%. For the ASI value, it was observed that it was able to correctly identify patients who developed 30-day mortality with a rate of 70.06% and correctly identify patients who did not develop 30-day mortality in the real situation with a rate of 70.59%. In patients with 30-day mortality, the cutoff point for the MSI value was ≥1.22, the AUC (95% CI) value was 0.694 (0.535–0.853), the sensitivity was 58.82%, and the specificity was 88.54%. The MSI value correctly predicted patients with 30-day mortality with a rate of 88.54% and correctly predicted patients without 30-day mortality in the real-life situation with a rate of 58.82% (Table 5). The ROC curves are illustrated in Figure 1.

	AUC (95% CI)	p	Cutoff	Sensitivity	Specificity
Lactate (mmol/L)	0.656 (0.492 - 0.820)	**0.036**	2.47	64.71%	73.91%
SI	0.697 (0.540 - 0.854)	**0.008**	0.83	58.82%	83.44%
ASI	0.720 (0.581 - 0.858)	**0.003**	49.29	70.59%	70.06%
MSI	0.694 (0.535 - 0.853)	**0.009**	1.22	58.82%	88.54%

Table 5. ROC analysis results for shock index values in patients with 30-day mortality.
AUC: area under curve, CI: confidence interval SI: shock index ASI: age shock index MSI: modified shock index

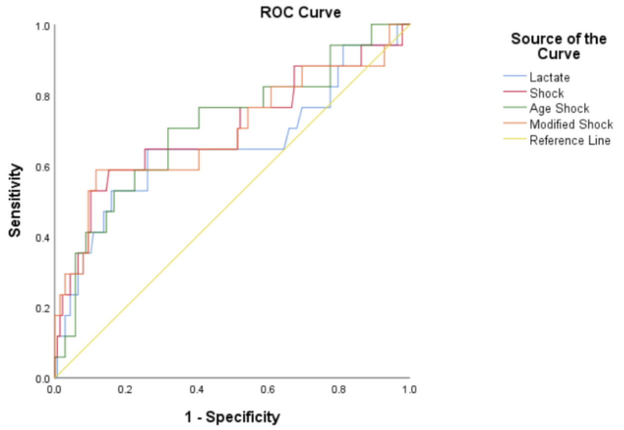

Figure 1. ROC Curve for Shock, Age Shock, and Modified Shock Index Values.

Discussion

As CAP is associated with higher mortality rates, the use of rapid scores to predict mortality in the emergency department may be valuable in improving patient outcomes. This study compared the performance of SI, ASI, and MSI in predicting 30-day mortality with blood lactate levels and base deficit in patients with CAP. In the ROC analysis, the discriminatory ability of the indices was modest, with AUC values below 0.75 for all measures. Portions of the MSI curve falling below the diagonal indicate inconsistent discrimination and limited clinical usability. According to established interpretive thresholds, AUC values below 0.7 suggest poor-to-fair accuracy, implying that these indices should not be used as stand-alone prognostic tools. Nonetheless, they may assist clinicians in rapid risk stratification when combined with clinical judgment and established severity scores such as CURB-65.

SI, ASI, and MSI can be obtained noninvasively and are early markers may serve as early markers to assess hemodynamic stability and tissue perfusion (17). These indices have been used used to predict prognosis not only in patients with shock but also in critically ill patients without shock. Reported ASI cutoffs include 51.74 in coronavirus disease 2019 (COVID-19) patients by Oh and Lee, 45.12 among patients with gastrointestinal bleeding by Kocaoğlu and Çetinkaya, and 44.6 in a study conducted in the emergency department by Torabi et al. (8,18,19). In the present study, it was determined to be 49.29. Based on the literature, there is no clear consensus on SI. It was reported that mortality rate increased when SI was greater than 0.9 (20). Mostly studied in patients with COVID-19, the cutoff SI values were reported as 0.72 by Kurt and Bahadırlı, 0.86 by Rensen et al., 0.92 by Doğanay et al., and 0.87 by Avci and Doğanay (21–24). In the present study, the SI cutoff was 0.83, consistent with the previous studies. Previous studies suggest that an MSI level of <0.7 or >1.3 is associated with increased mortality (25). In the present study, the cutoff value for MSI was calculated as 1.22. When comparing these three indices, ASI performed best in predicting the 30-day mortality.

Increased blood lactate level is considered a marker of hypoperfusion. A number of previous studies suggested that a blood lactate level of >4 mmol/L was associated with mortality (26,27). In the present study, increased blood lactate level was significantly associated with mortality. In 2025, Senguldur et al. demonstrated that early lactate clearance predicted both return of spontaneous circulation and 48-hour mortality. These findings support the prognostic importance of lactate dynamics in emergency department patients (14). Mortality increased when the lactate value is above 2.47. Base deficit (BD) has recently been used as a parameter to predict mortality, especially in patients with fluid loss, and is an indicator of hypoperfusion (28). It was suggested that a BD level of ≥6 was associated with mortality (29). In the present study, BD was not associated with mortality. In a previous study on polytrauma patients, a negative correlation was shown between lactate levels and base deficit (28). Martin et al. showed that blood lactate levels increase mortality more than base deficit (30). In our study, no correlation was found between lactate level and base deficit. This may be because of this correlation in our study may be due to the fact that most most patients had relatively stable vital signs. This correlation may become more pronounced with increased hypovolemia.

In clinical practice, integrating such indices with clinical findings, radiological assessment, and biochemical markers may enhance early decision-making, especially in resource-limited settings. Yet, the results emphasize that clinical judgment remains indispensable, and prognostic scoring tools should complement, not replace, physician assessment. Future studies should investigate whether combining these parameters into multivariable predictive models may improve accuracy and clinical usability in emergency department triage. To our knowledge, this is the first study in the literature in which ASI and BD were used together in CAP.

Limitations

Our study had several limitations. The most important one was that it was a small, single-center retrospective study. Variation in ED management was another limitation. Although patients were treated according to institutional standards, however, implementation may have varied among clinicians. Post-treatment changes in measured parameters may have influenced the results. Larger, multicenter prospective studies are needed.

Conclusion

The levels of SI, ASI, MSI, and lactate demonstrated a noteworthy correlation with short-term mortality and hospitalization in patients diagnosed with community-acquired pneumonia. However, the discriminative performance of these measures was limited. Therefore, it is important to consider these parameters as supportive tools rather than definitive standalone tools for clinical decision-making in the emergency departments. Conducting multicenter studies is imperative to validate these findings and improve generalizability and clinical utility.

Conflict of Interest: The authors declare that there is no conflict of interest.

Financial Support: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Authors' Contribution: İA: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Writing – original draft (lead). **MA:** Data curation; Formal analysis; Investigation; Methodology; Software; Visualization;Writing – original draft (supporting); Writing – review & editing.

Ethical Approval: This study was approved by the Hitit University Faculty of Medicine Research Ethics Committee on July 11, 2024 (No. 2024-40). As this was a retrospective analysis, informed consent was not required and was waived by the Ethics Committee in their approval statement in the 'Ethics approval and consent to participate' section.

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