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Evaluation of the Relationship between Base Excess Value and Mortality in Multiple Trauma Patients Admitting to the Emergency Medical Clinic

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Abstract: ***Background:*** Early identification of severe injury and patients at risk of death remains a core challenge in the emergency management of multiple trauma. Base excess (BE), obtained rapidly from venous blood gas analysis, reflects metabolic derangement and may support early risk stratification. To evaluate the association between admission venous BE and mortality/clinical disposition in adult multiple-trauma patients, and to assess the discriminative performance of absolute BE for predicting trauma severity using the New Trauma Severity Score (NTSS). ***Methods:*** This prospective observational study included 307 adult (≥16 years) multiple-trauma patients presenting to the emergency department between 1 June 2012 and 1 February 2013. Venous blood gas samples were obtained within the first hour of arrival, and BE was measured using a blood gas analyzer. BE values were compared across comorbidity strata and disposition/outcome groups (death, ICU admission, ward admission, discharge). The ability of |BE| to discriminate NTSS ≤15 vs NTSS>15 was evaluated using ROC analysis and agreement metrics at predefined cut-offs. ***Results:*** Admission BE did not differ significantly according to the presence of comorbidity, including coronary artery disease, diabetes mellitus, hypertension, congestive heart failure, or chronic kidney disease (all $p>0.05$). In contrast, BE differed significantly across disposition/outcome categories, demonstrating a stepwise increase with clinical severity: death 16.35±0.92, ICU 9.57±4.79, ward 4.48±2.07, and discharge 1.70±1.23 (overall $p<0.001$). |BE| showed excellent discrimination for YTCS >15 (AUC 0.959). At |BE|>2, discrimination was moderate (AUC 0.810) with high sensitivity (98.8%) and negative predictive value (99.3%), whereas |BE|>4 improved overall classification balance (AUC 0.887; sensitivity 84.5%, specificity 92.9%, PPV 82.6%, NPV 93.8%). ***Conclusions:*** Early venous BE, particularly |BE|, is strongly associated with adverse disposition and mortality in multiple-trauma patients and demonstrates high performance for identifying patients with YTCS >15. BE may serve as a rapid, practical adjunct for early emergency department triage and severity assessment.

Keywords: Multiple Trauma, Base Excess, Venous Blood Gas, Mortality, Trauma Severity, Emergency Department, ROC Analysis, Injury Severity Scoring.

Research Paper

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1. INTRODUCTION

Trauma constitutes a major cause of premature mortality and disability globally. Patients with multiple trauma are at particularly high risk in emergency care [1] . Early deaths following severe injury often occur within the first hours and are frequently due to preventable mechanisms, most notably uncontrolled hemorrhage [2]. Rapid physiological risk stratification at emergency department (ED) arrival is thus clinically critical [3].

The initial clinical presentation may appear deceptively reassuring. Compensatory organic responses, pre-existing comorbidities, medications, and age-related changes can mask typical vital sign abnormalities [4]. This permits occult hypoperfusion to continue despite normal systolic blood pressure and heart rate. As a result, current trauma guidelines stress the early use of metabolic markers, especially lactate and base deficit/excess, to detect poor tissue perfusion and guide care decisions [5, 6].

Base excess (BE), often reported as 'standard base excess' by blood gas analyzers, quantitatively describes the metabolic component of acid–base status under standardized conditions [7]. BE is calculated as the amount of strong acid required to titrate fully oxygenated blood to a normal pH at standard temperature and carbon dioxide tension. Negative BE values indicate a base deficit, which typically reflects metabolic acidosis from tissue hypoperfusion and oxygen debt. BE can be rapidly obtained from small arterial or venous blood samples, depending on local workflow. This makes it suitable for time-critical ED triage in severely injured patients [8, 9].

In multiple trauma, BE abnormalities result from interconnected pathophysiological mechanisms, including hemorrhage-induced reductions in oxygen delivery, microcirculatory failure, anaerobic metabolism, and shock-related inflammatory and coagulation disturbances [10,11]. These processes frequently develop early, sometimes before overt hypotension. As a result, BE has been studied as a marker for shock severity, transfusion requirements, complications, and mortality [12]. European guidelines on major bleeding and coagulopathy after trauma state that BE is a component of many shock evaluation models. It may provide a rough estimate of blood loss and transfusion needs, although limitations are recognized [6].

Recent clinical studies continue to support the prognostic significance of BE and base deficit (BD) in acute trauma care [13]. In a prospective cohort of severely injured patients, ED base deficit was found to independently predict mortality [14]. This illustrates the link between early metabolic debt and outcomes. Research on emergency care populations shows that BE, alone or in combination with other bedside scores, adds value to short-term mortality risk stratification [15]. These findings uphold the potential of BE as an early warning indicator when time and resources are limited.

In multiple trauma, blood gas parameters have been directly compared as early prognostic tools. A large emergency department analysis showed the clinical utility of blood gas assessment in polytrauma and evaluated BE, lactate, and pH for predicting early mortality within 72 hours [16]. This demonstrates ongoing efforts to identify the metabolic marker that best identifies early, actionable risk. Trauma literature consistently links BE abnormalities with increased blood and product use and adverse outcomes. This supports the model that worsening metabolic acidosis indicates the severity and duration of shock [17].

Despite the biological plausibility and growing evidence, significant uncertainties endure. The performance of BE varies across trauma systems, injury mechanisms, prehospital timelines, sampling methods (arterial versus venous), and patient populations. Differences include traumatic brain injury rates and comorbidity burden. Definitions of occult hypoperfusion also differ, though recent syntheses increasingly support using BE thresholds, such as below −3 mmol/L, in patients with normal vital signs [5]. These gaps are important because emergency clinicians need markers that are rapid, interpretable, and practical—not just statistically tied to mortality.

This study intends to evaluate the association between base excess at ED presentation and mortality in patients with multiple trauma. The results aim to clarify the prognostic role of BE in emergency care workflows and to inform early risk stratification for this high-risk group.

2. MATERIAL AND METHODS

2.1 Study Design and Setting

This prospective, single-center observational study was done in the Emergency Department of Dr. Lütfi Kırdar Kartal Training and Research Hospital, Istanbul, Türkiye, from 1 June 2012 to 1 February 2013. Study design and reporting followed the STROBE guidelines for observational research.

2.2 Study Population

Consecutive ED trauma resuscitation area patients with multiple trauma were screened. Inclusion: patients 16 or older. Exclusion: under 16, or prior evaluation/intervention at another hospital, to reduce heterogeneity from pre-enrollment resuscitation. 307 eligible patients were enrolled. All variables were recorded prospectively on a standardized form by ED specialists and residents.

2.3 Data Collection and Study Variables

Demographic and clinical data at ED arrival included age, sex, injury mechanism, and Glasgow Coma Scale (GCS) score. Initial physiologic variables: systolic blood pressure, heart rate, respiratory rate, and SpO_2. Comorbidities (hypertension, diabetes, coronary disease, and chronic kidney disease) were noted from history and records.

2.4 Trauma Severity Scoring

Physiologic injury severity was measured by the Revised Trauma Score (RTS), calculated from coded GCS, systolic blood pressure, and respiratory rate per standard methods.

Anatomical injury severity was assessed using the Abbreviated Injury Scale (AIS) and recorded as the New Trauma Severity Score (NTSS). Injuries were coded according to the AIS and combined for each

patient to aid risk categorization and outcome comparisons.

2.5 Venous Blood Gas Sampling and Base Excess Measurement

Venous blood gas samples were taken within the first hour of ED arrival. Base excess (BE) in mmol/L was measured in the emergency laboratory using a SIEMENS Rapidlab analyzer (Germany). The primary exposure was the initial BE value.

2.6 Outcomes

The primary outcome was all-cause mortality during the hospital stay, defined as death in the ED or later in the hospital. Secondary analyses explored associations of BE with trauma severity scores (RTS and NTSS) as measures of injury burden.

2.7 Statistical Analysis

Descriptive statistics: mean ± standard deviation for normally distributed continuous variables; median (IQR) for non-normal data; frequency (percent) for categorical variables. Distribution was checked with the Kolmogorov–Smirnov test.

Group comparisons (e.g., survivors vs non-survivors) used a one-way ANOVA for normal continuous data; Kruskal–Wallis or Mann–Whitney U for non-normal continuous data. Categorical variables used chi-square or Fisher's exact test as needed.

BE's ability to predict mortality was assessed using ROC curve analysis with AUC as well as confidence intervals. Cohen's kappa measured agreement between BE thresholds and clinical risk when relevant. All tests were two-sided, $p < 0.05$. Analyses were carried out using SPSS 21.0 (IBM Corp., Armonk, NY, USA).

2.8 Ethics

The study followed the principles of the Declaration of Helsinki. Ethics committee approval and consent methods should be included, along with the institutional approval number and the applicable consent approach (e.g., written consent or an emergency research waiver).

3. RESULTS

3.1 Relationship between Base Excess and Comorbidity Status

Base excess (BE) values did not show significant differences between patients with and without comorbid disease (all $p > 0.05$; Table 1). Likewise, BE was not significantly associated with coronary artery disease (CAD), diabetes mellitus (DM), congestive heart failure (CHF), hypertension (HTN), or chronic kidney disease (CKD) (all $p > 0.05$; Table 1).

Table 1: Comorbid systemic diseases by NTSS group

Comorbidity	BE with comorbidity (mean ± SD)	BE without comorbidity (mean ± SD)	*p*
CAD	3.90 ± 4.25	3.40 ± 3.44	0.986
DM	3.19 ± 2.45	3.43 ± 3.54	0.689
HTN	3.37 ± 2.71	3.42 ± 3.62	0.486
CHF	1.57 ± 1.48	3.43 ± 3.45	0.273
CKD	4.10 ± 2.49	3.40 ± 3.46	0.310

Values are presented as n (%). p values correspond to overall comparisons among NTSS groups using the chi-square test; Fisher's exact test should be used where expected cell counts are insufficient. Cells with no events across all groups are not testable and are shown as "—". CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HTN, hypertension.

3.2 Clinical Disposition and Mortality Outcomes

BE values varied by clinical disposition and outcome. Patients who died had higher BE values than those admitted to the ICU, hospitalized in a ward, or discharged ($p < 0.05$). ICU-admitted patients had higher BE values than ward-admitted and discharged patients ($p < 0.05$). Ward-admitted patients had higher BE values than discharged patients ($p < 0.05$). These results show BE increases stepwise with clinical severity (Table 2).

Table 2: Base excess by clinical disposition/outcome

Variable	Death	ICU admission	Ward admission	Discharged	*p*
Base excess (mean ± SD)	16.35 ± 0.92	9.57 ± 4.79	4.48 ± 2.07	1.70 ± 1.23	<0.001

Values are presented as mean ± standard deviation (SD). Overall group comparison was performed using the Kruskal–Wallis test. Reported p-value reflects the overall comparison across all four outcome/disposition categories. $p < 0.001$.

3.3 Associations between Base Excess and Trauma Severity Strata

Patients were stratified by the NTSS into three groups: ≤15 (Group A), 15<NTSS≤30 (Group B), and >30 (Group C). Age and sex distributions were similar across NTSS groups ($p > 0.05$). Systolic blood pressure, diastolic blood pressure, heart rate, and oxygen saturation did not show significant differences between groups (all $p > 0.05$). However, the respiratory rate in Group A was significantly lower than in Groups B and C ($p < 0.05$), while no significant difference was observed between Groups B and C ($p > 0.05$). The GCS decreased progressively with increasing NTSS: Group A had a higher GCS than Groups B and C ($p < 0.05$), and Group B had a higher GCS than Group C ($p < 0.05$) (Table 3).

Table 3: Physiologic parameters by New Trauma Severity Score (NTSS) group

Parameter	NTSS ≤ 15 (mean ± SD)	15 < NTSS ≤ 30 (mean ± SD)	NTSS > 30 (mean ± SD)	*p*
Systolic blood pressure (mmHg)	141.3 ± 26.2	134.7 ± 26.2	125.0 ± 40.4	0.064
Diastolic blood pressure (mmHg)	81.5 ± 15.6	79.2 ± 16.5	73.2 ± 22.8	0.132
Respiratory rate (breaths/min)	18.3 ± 5.8	19.3 ± 2.9	20.5 ± 5.9	0.002
Heart rate (beats/min)	89.9 ± 15.9	94.0 ± 15.2	96.8 ± 23.6	0.051
SpO_2 (%)	96.8 ± 3.8	96.0 ± 3.3	92.5 ± 9.9	0.074
GSC	14.7 ± 1.4	14.2 ± 2.0	9.8 ± 4.6	<0.001

Values are presented as mean ± SD. p values correspond to overall comparisons among the three NTSS groups (ANOVA for approximately normally distributed variables; Kruskal–Wallis for non-normally distributed variables). Where applicable, post-hoc comparisons should be reported in the main text. GCS, Glasgow Coma Scale; SD, standard deviation; SpO_2, peripheral oxygen saturation.

BE values changed with trauma severity. Group A had lower BE values than Groups B and C ($p < 0.05$). Group B had lower BE values than Group C ($p < 0.05$). This shows BE increases consistently with injury severity (Table 4).

Table 4: Base excess by New Trauma Severity Score group

Variable	NTSS ≤ 15 (mean ± SD)	15 < NTSS ≤ 30 (mean ± SD)	NTSS > 30 (mean ± SD)	*p*
Base excess (mean ± SD)	1.9 ± 1.4	5.1 ± 1.7	9.9 ± 4.5	<0.001

Values are presented as mean ± SD. Overall group comparison was performed using the Kruskal–Wallis test. **$p < 0.001$** indicates a statistically significant difference across NTSS categories.

3.4 Discriminative Performance of Base Excess for NTSS Threshold (≤15 vs >15)

Base excess significantly discriminated between patients with NTSS ≤15 and those with NTSS >15, exhibiting excellent overall performance when evaluated as an absolute value (|BE|) (Figure 1). Threshold-based analyses showed that an absolute BE >4 provided stronger discrimination than an absolute BE >2 (AUC 0.887 vs 0.810; Table 2). Agreement analyses indicated that |BE| >4 achieved a more favorable balance between sensitivity and specificity than |BE| >2, while |BE| >2 yielded very high sensitivity and negative predictive value, consistent with a rule-out profile (Table 5).

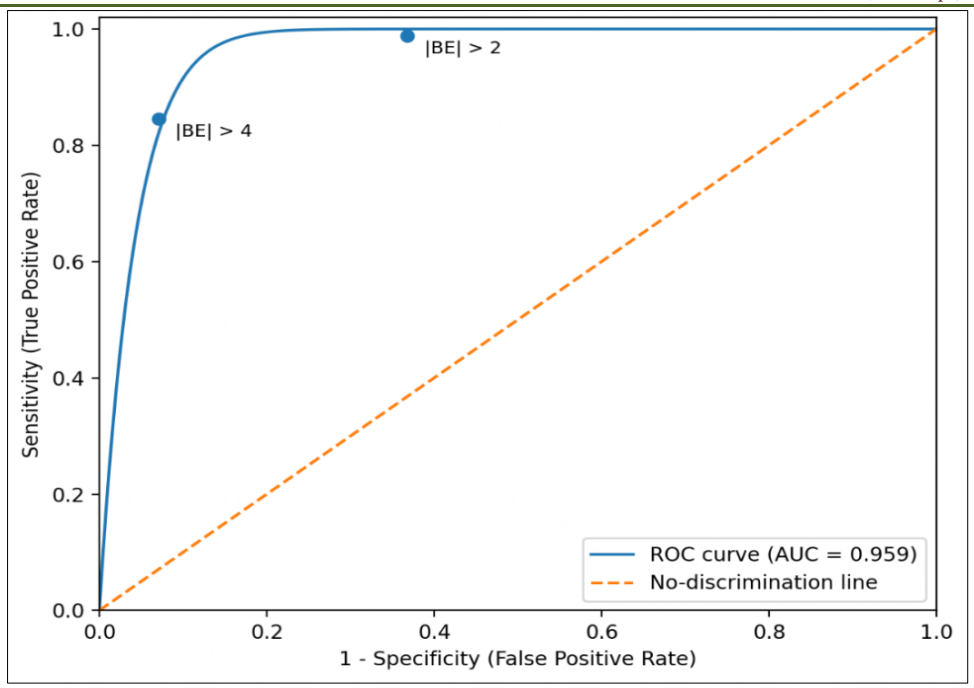

Figure 1: ROC curve of absolute base excess (|BE|) for predicting NTSS >15

Receiver operating characteristic (ROC) curve illustrating the discriminative ability of absolute base excess (|BE|) measured within the first hour of ED presentation to classify patients with NTSS >15 versus ≤15. Threshold markers at |BE| >2 and |BE| >4 highlight the trade-off between sensitivity and specificity; |BE| >2 demonstrates a high-sensitivity (rule-out) profile, whereas |BE| >4 provides improved overall classification balance with higher specificity.

Table 5: Diagnostic performance of absolute base excess (|BE|) for discriminating NTSS ≤15 vs >15

|BE| threshold	AUC (95% CI)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	p
>2	0.810 (0.762–0.858)	98.8	63.2	51.6	99.3	<0.05
>4	0.887 (0.7838–0.937)	84.5	92.9	82.6	93.8	<0.05

AUC, area under the ROC curve; CI, confidence interval; PPV, positive predictive value; NPV, negative predictive value

4. DISCUSSION

In this prospective cohort of adults with multiple trauma who present to the emergency department, early venous base excess (BE)—a blood test indicating the balance of acids and bases in the body—defined as the absolute deviation from normal (|BE|), clearly and meaningfully associates with disease severity and outcomes. |BE| rises progressively across disposition categories: patients who die exhibit the highest levels, followed by those admitted to the ICU, then to the ward, and finally those discharged. This pattern makes biological sense, since worsening metabolic derangement on arrival, which mirrors greater oxygen debt and severe shock physiology, links to adverse trauma outcomes [13-18].

4.1 Relationship to Existing Evidence

Extensive trauma literature supports using base deficit (BD) and base excess (BE)—blood tests of metabolic status—as early markers of hemorrhagic shock severity and predictors of poor outcomes. TraumaRegister DGU® analyses established a shock classification using base deficit, showing that worsening metabolic acidosis (excess acid in the bloodstream) on admission is linked to increases in transfusion needs, complications, and mortality [18]. Recent studies additionally emphasize that acid–base disturbances identified by BE or BD at presentation are clinically informative. These supplements affect traditional vital signs (such as heart rate and blood pressure), which may remain insensitive in the early stages, even as ongoing hypoperfusion (inadequate tissue blood flow) persists [5-13].

These data are consistent with recent comparisons of blood-gas-derived markers in multiple trauma. Large emergency department-based analyses have shown that admission BE (base excess, an indicator of the balance between acids and bases in blood), lactate (a substance produced when oxygen levels are low), and pH (a measure of acidity) are each independently

associated with early mortality [16]. This reinforces the concept that early metabolic metrics have prognostic value even when macro-hemodynamic parameters (e.g., blood pressure and heart rate) appear normal. Additionally, recent studies indicate that lactate and base deficit (a negative base excess, indicating the amount needed to return blood to a normal pH) provide complementary information: base deficit may be especially effective for identifying traumatic coagulopathy (blood's inability to clot, increasing bleeding risk), while lactate may better predict mortality in certain cohorts. This evidence supports a multimarker approach rather than dependence on a single metric [19].

4.2 Why Vital Signs May "Miss" Severity While |BE| Detects It

Within the NTSS strata, most initial vital signs—including systolic and diastolic blood pressure, heart rate, and SpO_2 (oxygen saturation in the blood)—did not differ significantly, whereas GCS and respiratory rate did. However, |BE| increased consistently with greater injury severity. This observation corresponds to the phenomenon of occult hypoperfusion (inadequate tissue perfusion without obvious vital sign changes), where tissue oxygenation is inadequate despite apparently normal vital signs. A recent systematic review proposed a practical definition that includes lactate elevation (increased lactic acid) or BE < −3 mmol/L in the presence of normal systolic pressure and pulse, acknowledging that macroperfusion (overall circulatory adequacy) may appear preserved while metabolic debt accumulates [5]. In this context, the data support the clinical utility of early BE-based assessment as a rapid triage adjunct when initial bedside hemodynamic measurements (circulatory adequacy) are not clearly discriminatory.

4.3 Interpreting the NTSS Cut-Off and Discrimination Metrics

The analysis showed excellent discrimination between NTSS ≤15 and >15 using |BE| (AUC 0.959, where AUC means area under the receiver operating characteristic curve—a measure of a test's ability to distinguish groups), with a clinically meaningful threshold trade-off: |BE| >2 yielded very high sensitivity and negative predictive value, favoring a rule-out strategy, while |BE| >4 improved specificity and positive predictive value, favoring a rule-in approach. This approach is consistent with the operationalization of anatomic severity thresholds in trauma systems, where severe injury is often defined by a threshold of 15 for ISS-family scores (Injury Severity Score), and registry studies commonly classify NTSS >15 as severe injury [20]. In practice, a lower |BE| threshold may be preferable in the emergency department to minimize missed severe injuries, while a higher threshold may better identify patients requiring aggressive resuscitation, early hemorrhage control, and high-acuity monitoring.

4.4 Venous Sampling and Functional Feasibility

A key strength of this study is the use of venous blood gas (VBG) sampling within the first hour of arrival. Previous trauma research shows venous base excess closely approximates arterial base excess for early shock detection and survival prediction. This supports its practicability in urgent workflows, where arterial sampling may be delayed or impractical [21]. Broader critical care evidence also indicates high agreement between venous and arterial measurements for acid–base parameters, including base excess. This further reinforces the operational value of VBG-based triage, using venous blood results to triage patient care [22].

4.5 Comorbidities and Base Excess

The analysis finds no significant differences in BE by comorbidity status (CAD, DM, CHF, HTN, CKD). This outcome may reflect the predominance of acute trauma physiology above baseline metabolic variation at presentation, especially in a cohort with relatively infrequent comorbidities. However, other studies, particularly those focused on geriatric trauma populations, report associations between base deficit and mortality, indicating that age, frailty, preinjury physiology, and case mix can influence the prognostic performance of metabolic markers [23, 24].

4.6 Clinical Implications

These data support the use of early |BE| as a rapid, emergency department–available marker that supplements clinical judgment and trauma scoring. Contemporary European guidelines on major bleeding after trauma recommend structured early assessment and acknowledge metabolic markers' value, such as lactate and base deficit, for estimating hypoperfusion and bleeding severity, especially when vital signs may mislead [13]. In resource-limited or high-throughput settings, |BE| thresholds may be used to facilitate early risk stratification, emphasize rapid imaging, assess transfusion readiness, and provide ICU-level monitoring for the highest-risk patients.

4.7 Limitations and Future Directions

Several limitations warrant caution. First, this was a single-center cohort; generalizability may be influenced by local trauma epidemiology (the types and patterns of injuries in a given region), prehospital timelines (the duration and care before hospital arrival), and resuscitation practices (methods for stabilizing trauma patients). Second, BE is influenced not only by hemorrhage and hypoperfusion but also by ventilation status (how well the lungs are working), renal handling (kidney function in preserving balance), and iatrogenic factors (changes caused by medical treatment); therefore, confounding remains possible absent comprehensive

adjustment for prehospital fluids, ventilation, and injury patterns (e.g., isolated severe TBI [traumatic brain injury]). Third, we analyzed admission values rather than serial clearances; yet, time-to-normalization of metabolic derangements is often informative for trajectory as well as outcomes. Future multicenter studies should validate optimal |BE| thresholds against hard endpoints (mortality, massive transfusion, organ failure), and evaluate whether combining |BE| with lactate and coagulation markers (e.g., INR [international normalized ratio], fibrinogen—a protein involved in clotting) improves early decision-making—an approach increasingly explored in contemporary trauma risk models.

4.8 CONCLUSION

Early venous |BE| shows a strong association with trauma severity and outcomes in patients with multiple trauma, rising across disposition categories and providing high discrimination for severity thresholds. These results encourage the incorporation of admission |BE| into early emergency department triage and resuscitation pathways, with customized threshold selection for specific rule-out or rule-in priorities.

Ethical Statement:

Ethical approvals were obtained from the ethics committee of the healthcare institution where the study was conducted. Compliance with the ethical principles of the Declaration of Helsinki was essential at every stage. No participants were forced to participate in the study.

Data Availability Statement:

The datasets generated and analyzed during the current study are not publicly available due to patient privacy restrictions but are available from the corresponding author on reasonable request.

Author Contribution:

Conceptualization: SS, Data curation: OG, Formal analysis: SS, Funding acquisition: None, Investigation: SS, OG, GS Methodology: OG, Project administration: SS, OG, BO, Resources: GS, BO Software: GUMUS S, Supervision: SS, Validation & Visualization: BO, Critical revision with the introduction of valuable intellectual content: SS.

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Declaration of Competing Interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. All authors have approved the manuscript and submission.

During the preparation of this work the author used AI technologies in order to improve readability and correct spelling errors. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Patient Permission/Consent Declarations*:* The research was conducted using medical records. There are no human or animal elements.

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