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Mortality Prediction in Geriatric Hip Fracture Patients in the Emergency Department: A Comparison of HALP, mHALP, and mREMS Scores

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Abstract

Aim: To compare the performance of hemoglobin, albumin, lymphocyte, and platelet (HALP), modified HALP (mHALP), and modified Rapid Emergency Medicine score (mREMS) in predicting 30-day mortality in geriatric patients presenting to the emergency department (ED) with hip fractures.

Materials and Methods: This prospective, observational cohort study included 63 geriatric patients with hip fractures who presented to the ED. Demographic characteristics, vital signs, laboratory parameters, and clinical outcomes were recorded. The predictive performance of HALP, mHALP, and mREMS scores for mortality was evaluated using ROC analysis, and the area under the curve (AUC) were compared using the DeLong test.

Results: The mean age of the patients was 78.59±6.81 years, and 63.5% were female. The 30-day mortality rate was 6.3% (n=4). In patients who died, heart rate and mREMS score were significantly higher, while oxygen saturation was significantly lower. ROC analysis showed that the mREMS score had apparent discriminative performance (AUC: 0.981; 95% confidence interval: 0.942-1.00; p<0.001); however, this estimate should be interpreted cautiously given the low number of mortality events (n=4). For mREMS, at a cut-off value of 7.5, sensitivity was 100% and specificity was 84.7%. HALP (AUC: 0.581; p=0.690) and mHALP (AUC: 0.513; p=0.942) scores showed no significant predictive value for mortality. The DeLong test results showed a statistically significant difference between mREMS and mHALP scores (p=0.009).

Conclusion: The mREMS score showed apparent superiority over HALP and mHALP in predicting 30-day mortality; however, these findings should be considered exploratory and require confirmation in larger studies.

Keywords: Hip fractures, aged, mortality, emergency service, hospital, risk assessment

Introduction

Trauma is a leading cause of death worldwide. For individuals aged 5-29, three of the top five causes of death are trauma-related, and 8% of all deaths are trauma-related (1). In the United States, unintentional injuries, a major cause of trauma, rank as the third leading cause of death after heart disease and malignancies (2). In the United States, traumatic injuries are a major cause of both mortality and morbidity. In 2014, there were 30,838,741 non-fatal injury admissions to emergency departments (EDs) in the US.

Hip fractures represent a significant proportion of unintentional injuries. Motor vehicle accidents and falls are common causes of hip fractures. According to Web-based Injury Statistics Query and Reporting System data developed by the Centers for Disease Control and Prevention, falls are among the leading causes of ED visits and hospitalizations for injuries among older adults (3). With increasing life expectancy, the incidence of hip fractures is expected to rise. Consequently, driven in part by osteoporosis, hip fractures remain a major global public health concern, with more than 10 million cases annually worldwide (4). One study predicts that the number of hip fractures will double by 2050 compared to 2018 (5).

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The Rapid Emergency Medicine score (REMS) is an effective triage score for predicting in-hospital mortality among non-trauma hospital admissions (6). REMS consists of variables such as age, mean arterial pressure (MAP), heart rate, respiratory rate, oxygen saturation, and the glasgow coma scale (GCS). This score was subsequently modified for trauma patients. It is also a simple and accurate predictor of in-hospital mortality among trauma patients. The modified REMS (mREMS) is an adapted version of the REMS score designed to serve as a practical, real-time triage score, in contrast to more complex scores that often require invasive measurements (7).

The hemoglobin, albumin, lymphocyte, and platelet score (HALP), a composite index derived from routine laboratory parameters, was first studied in patients with malignancy and found to be a significant predictor of mortality (8). The HALP score is a useful prognostic biomarker in various malignancies, including myelodysplastic syndromes (9). In another study, it was also found to be a significant predictor of mortality in breast cancer (10). Similarly, the results showed that cancer patients with high HALP scores had a lower long-term risk of death compared to patients with low HALP scores, and this was consistent across all subgroups (11). Similarly, the modified HALP score (mHALP) was a significant predictor of 3-month mortality in patients with acute heart failure. An increased mHALP score was associated with a good prognosis (12).

Two studies in patients with hip fractures examined 90-day and 1-year mortality and showed an inverse relationship between HALP score and risk of death (13,14). In addition, the HALP score was compared with C-reactive protein and the C-reactive protein-albumin ratio, and HALP was found to be a more significant predictor of mortality (14).

In patients with hip fractures, mortality may be influenced by both acute physiological deterioration (measured by mREMS) and the patient's underlying chronic reserve (measured by HALP). This study investigated which marker better predicted short-term mortality. In our literature review, we found no studies comparing HALP, mHALP, and mREMS for predicting mortality in patients presenting with hip fractures. Therefore, we hope to contribute to the literature by prospectively examining the HALP score, the mHALP score, and the mREMS in patients presenting to the ED with hip fractures.

Materials and Methods

Study Design and Setting

This was a single-center prospective observational cohort study conducted in the ED of University of Health Sciences Türkiye, Konya City Hospital, Konya, Türkiye, between June 15, 2025, and December 15, 2025, with follow-up for 30-day mortality. The study population included geriatric patients (aged ≥65 years) who presented to the ED with trauma complaints and were diagnosed with a hip fracture (including femur head, neck, intertrochanteric, or subtrochanteric types) confirmed by clinical and imaging evaluations. The primary outcome measure was 30-day all-cause mortality, rigorously tracked and confirmed using the National Death Registry of the Ministry of Health and, when necessary, supplemented by direct telephone follow-up with patients or their legally authorized representatives. Secondary outcomes, hospital stay length and the comparative predictive performance of the HALP, mHALP, and mREMS scores in estimating these outcomes.

The study protocol was approved by the University of Health Sciences Türkiye, Konya City Hospital Non-Interventional Clinical Research Ethics Committee (decision number: 2025/76, date: 12.05.2025). The research was conducted in strict accordance with the ethical principles outlined in the Declaration of Helsinki. Prior to participation, informed written consent was obtained from all patients included in the study or from their legally authorized representatives.

Participants (Inclusion and Exclusion Criteria)

The study population consisted of geriatric patients (aged ≥65 years) who presented to the ED with traumatic injuries.

Inclusion Criteria: Patients aged ≥65 years and diagnosed with a hip fracture (femur head, neck, intertrochanteric, or subtrochanteric types) confirmed by clinical evaluation and imaging (X-ray or computed tomography).

Exclusion Criteria: Patients brought to the ED in cardiopulmonary arrest, those with a known diagnosis of malignancy, patients with pathological fractures due to tumors or infections, and those discharged at their own request. Additionally, patients with serious metabolic or infectious diseases (e.g., end-stage renal or hepatic failure, sepsis) that could biologically confound HALP and mHALP scores were excluded.

Sample Size and Statistical Power

The sample size was determined by the number of consecutive eligible patients presenting during a predefined six-month study period. This period was selected to ensure feasibility and to capture a representative sample of geriatric hip fracture patients presenting to a high-volume tertiary ED. A total of 63 patients were included in the final analysis.

As this study was designed as an exploratory, hypothesis-generating investigation, no formal a priori sample size calculation was performed. However, considering the primary objective of evaluating discriminative performance using ROC analysis, a minimum number of outcome events is generally recommended to obtain stable area under the curve (AUC) estimates. In this study, the number of mortality events (n=4) was substantially below commonly suggested thresholds, which limits the precision and reliability of the performance estimates.

A post-hoc assessment based on the observed ROC performance of the mREMS score (AUC=0.981) suggested that the observed effect was statistically detectable; however, given the very low number of mortality events (n=4), the assessment does not overcome the limitations in precision, stability, and the risk of optimism bias. Therefore, the findings should be interpreted as exploratory and require confirmation in larger, adequately powered studies.

To further address the limitations related to sample size, confidence intervals (CIs) and bootstrap resampling (1000 iterations) were used to improve the robustness of the estimates. Despite the large observed effect size, the low number of events may still lead to overestimation of model performance, and the results should be interpreted with caution.

Data Collection and Variables

The study was conducted prospectively. Consecutive sampling was used to minimize selection bias. Vital signs of patients presenting to the ED with trauma were obtained according to standard clinical practices and evaluated by the emergency physician. Patients diagnosed with a hip fracture based on imaging were considered eligible for inclusion. No additional laboratory tests or imaging were performed for the purposes of the study; only data obtained during routine clinical evaluation were used. Data were recorded from patients who provided informed consent. Patients who met the exclusion criteria were excluded from the study. In the included patients, age, gender, GCS, systolic blood pressure (SBP), respiratory rate, heart rate, SpO_2, mREMS score, hemoglobin (g/L), albumin (g/L), lymphocyte (10^9/L), platelet (10^9/L), HALP score, mHALP score, fracture type, surgical treatment status, in-hospital outcome, and 30-day mortality data were recorded.

The prognostic performance of three distinct scoring systems was evaluated:

HALP score: This index reflects the immuno-nutritional status and was calculated as:

HALP=[hemoglobin (g/L) × albumin (g/L) × lymphocyte count (10^9/L)] / platelet count (10^9/L)

mHALP score: To assess variations in predictive accuracy based on modified weightings of nutritional and inflammatory components, the mHALP score was calculated as:

mHALP=[hemoglobin (g/L) × albumin (g/L) × lymphocyte count (×10^9/L) × platelet count (×10^9/L)].

All parameters used in the calculation of HALP and mHALP scores were obtained from routine laboratory measurements at the time of ED admission, and standard SI units were consistently applied to ensure reproducibility. For score calculations, laboratory values originally measured in different units (e.g., g/dL) were converted to consistent SI-equivalent units prior to computation.

mREMS score: The mREMS was calculated based on physiological parameters (age, heart rate, respiratory rate, SBP, SpO_2, and GCS) to provide a standardized snapshot of acute physiological distress upon ED presentation.

Following data collection, patients were grouped according to their 30-day mortality status. The predictive performance of HALP, mHALP, and mREMS scores for mortality was assessed by comparing patients who died with those who survived.

Rationale for Comparison

The rationale for comparing these specific scores lies in the multi-faceted nature of geriatric trauma, where outcomes are determined by both the severity of the acute injury and the patient's underlying physiological reserve. While mREMS is a validated tool for assessing acute physiological instability in the ED, it primarily captures the immediate stress response and does not account for the patient's baseline nutritional status or chronic inflammatory state. Conversely, the HALP and mHALP scores serve as objective indicators of the host's biological resilience and immune-nutritional capacity, both of which are critical determinants of recovery in older adults. By comparing these scores, the study aims to determine whether objective laboratory-based indices can supplement or even outperform traditional physiological scores in identifying high-risk geriatric patients who may otherwise appear stable during initial triage.

Statistical Analysis

Statistical analyses were performed using Jamovi (version 2.7.13). As the study was conducted prospectively with real-time data collection, no missing data were observed; therefore, no imputation was required. The normality of continuous variables was assessed using the Shapiro-Wilk test and was supported by graphical methods. Continuous variables were expressed as mean ± standard deviation or median (interquartile range), as appropriate, while categorical variables were presented as frequencies and percentages.

Group comparisons were performed using Student's t-test or the Mann-Whitney U test, depending on the distribution of the data and homogeneity of variances. Categorical variables were analyzed using the chi-square test or Fisher's exact test, when appropriate.

Because of the small sample size and the limited number of mortality events (n=4), effect sizes were calculated to complement p-values. Rank-biserial correlation was used for non-parametric comparisons, and effect size measures were not systematically reported for all parametric and categorical variables.

The predictive performance of HALP, mHALP, and mREMS scores for 30-day mortality was evaluated using ROC curve analysis. Internal validation was performed using bootstrap resampling (1000 iterations) to estimate 95% CIs for the AUC. ROC curves were compared using the DeLong test. Optimal cut-off values were determined using the Youden index, and sensitivity, specificity, and predictive values were calculated with 95% CIs. Given the low number of events, the results of these analyses should be interpreted with caution. A p-value<0.05 was considered statistically significant.

In addition, an exploratory logistic regression analysis was performed to assess the association between mREMS score and 30-day mortality. However, due to the very small number of outcome events (n=4), the model was prone to overfitting and to complete separation. Therefore, adjusted effect estimates could not be reliably obtained, and the regression analysis was interpreted descriptively.

Results

A total of 84 patients were initially assessed for eligibility. Twenty-one patients were excluded for the following reasons: malignancy (n=8), treatment refusal (n=3), and severe metabolic or infectious conditions (n=10). Consequently, 63 patients were included in the final analysis.

The mean age of the 63 patients was 78.59±6.81 years, and 63.5% (n=40) were female. Most patients (93.7%, n=59) had at least one comorbid condition at admission. Regarding fracture types, 52.4% (n=33) were intertrochanteric fractures and 47.6% (n=30) were femoral neck fractures. All patients underwent surgical treatment. Most ED admissions resulted in ward hospitalization (96.8%, n=61), while 3.2% (n=2) required intensive care. The median length of hospital stay was 6 (4-10) days. The 30-day mortality rate was 6.3% (n=4). Given the small number of mortality events, subsequent analyses should be interpreted with caution because of limited statistical robustness. Patient demographics, clinical characteristics, and outcome data are presented in Table 1.

In the mortality group, heart rate (102.00 vs. 80.34 beats/min; p<0.001) and mREMS score (9 vs. 6 points; p<0.001) were significantly higher, while oxygen saturation was significantly lower (p=0.036). The length of hospital stay was also significantly longer in this group (p=0.047). No significant differences were observed between groups with respect to age, SBP, respiratory rate, or laboratory parameters, including albumin, hemoglobin, platelet count, lymphocyte count, and HALP and mHALP scores. A comparison of the groups based on 30-day mortality is shown in Table 2.

The distribution of mREMS scores across mortality groups is shown in Figure 1.

ROC analysis, conducted to evaluate the mREMS score's ability to predict 30-day mortality, yielded an AUC of 0.981 (95% CI: 0.942-1.00), which was statistically significant (p<0.001).However, this very high AUC value should be interpreted with caution, as it

Table 1. Baseline demographic, clinical, laboratory characteristics, and hospital outcomes of the study population

Variables	Total (n=63)
Demographic characteristics	
Age (years), mean ± SD	78.59±6.81
Gender, n (%)	
Woman	40 (63.5%)
Man	23 (36.5%)
Clinical features	
Comorbid diseases, n (%)	
Yes	59 (93.7%)
No	4 (6.3%)
Fracture type, n (%)	
Intertrochanteric	33 (52.4%)
Femoral neck	30 (47.6%)
Vital signs	
Systolic blood pressure (mmHg), median (IQR)	130 (119-140)
Heart rate (beats/min), mean ± SD	81.71±12.27
Respiratory rate (/min), median (IQR)	14 (13-15)
Oxygen saturation (%), mean ± SD	94.54±3.01
Laboratory parameters	
Hemoglobin (g/L), mean ± SD	121.7±18.4
Albumin (g/L), mean ± SD	36.13±4.46
Platelet (109/L), mean ± SD	228.83±80.79
Lymphocyte (109/L), median (IQR)	1.17 (0.79-1.67)
Emergency department outcomes	
Admission to service, n (%)	61 (96.8%)
Admission to intensive care unit, n (%)	2 (3.2%)
In-hospital endings	
Hospital stay length (days), median (IQR)	6 (4-10)

SD: Standard deviation, IQR: Interquartile range

Table 2. Comparison of patients based on 30-day mortality status			
Variables	**Survivors (n=59)**	**Deaths (n=4)**	**p-value**
Age (years)*	78.6±6.7	77±4.08	0.634
Vital signs			
Heart rate (beats/min)*	80.34±9.15	102.00±30.16	<0.001
Oxygen saturation (%)*	94.75±2.83	91.50±4.36	0.036
Systolic blood pressure (mmHg)^	130 (120-140)	125 (110-135)	0.470
Respiratory rate (/min)^	14 (13-15)	15 (14-18)	0.178
Laboratory values			
Albumin (g/L)*	36.2±4.4	37.5±4.2	0.529
Hemoglobin (g/L)*	122±18	119±21	0.810
Platelet (109/L)*	229.1±80.5	215.5±95.2	0.513
Lymphocyte (109/L)^	1.18 (0.80-1.68)	1.05 (0.65-1.45)	0.390
Scores			
HALP score^	24.4 (14.6-40.5)	15.5 (13.1-765)	0.602
mHALP score (103/L)^	1206 (698-1733)	869 (763-6656)	0.944
mREMS score^	6 (6-6)	9 (8.75-9)	<0.001
Hospital stay (days)^	6 (4-9.5)	13 (10.25-17.75)	0.047
Values marked with *are presented as mean ± standard deviation, whereas values marked with ^are presented as median (interquartile range)			

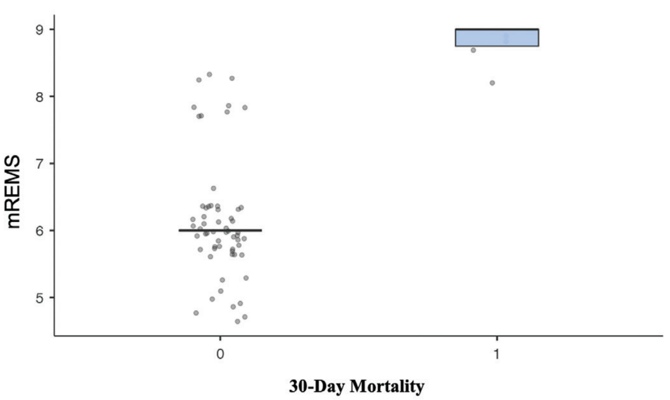

Figure 1. Distribution of mREMS scores according to 30-day mortality status (Box Plot)

mREMS: Modified Rapid Emergency Medicine score

is likely influenced by the extremely small number of outcome events and may reflect overestimation of model performance (optimism bias).

Using the Youden index, the optimal cut-off value for mREMS was determined to be 7.5. Based on this cut-off value, the following classification was made:

Four of 13 patients (30.8%) with an mREMS score of 7.5 or higher died.

No deaths occurred among the 50 patients (0%) with an mREMS score below 7.5.

Based on these findings, the sensitivity of the test at a cut-off value of 7.5 was 100%, and its specificity was 84.7%. The negative predictive value (NPV) was 100% in this study sample. Nevertheless, the observed perfect sensitivity and NPV should be interpreted cautiously, as these estimates are highly unstable and prone to inflation in small samples with very few events.

Univariate logistic regression analysis using the mREMS score failed to produce stable estimates because of complete separation: no mortality events were observed among patients with lower mREMS values. This resulted in inflated coefficients and standard errors, precluding meaningful interpretation of odds ratios. This further highlights the limitations imposed by the low event rate on model-based inference.

In contrast, when the predictive power of HALP and mHALP scores for mortality was examined in the same patient group, no statistically significant discriminatory ability was observed. The AUC for the HALP score was 0.581 (95% CI: 0.185-0.976, p=0.690) and the AUC for the mHALP score was 0.513 (95% CI: 0.171-0.854, p=0.942). Given their limited and non-significant discriminative performance, further diagnostic classification analyses were not pursued for the HALP and mHALP scores (Figure 2).

Pairwise comparisons of ROC curves were performed using the DeLong test. The mREMS score demonstrated significantly greater discriminative performance than the mHALP score (AUC difference=0.4682; 95% CI: 0.1188-0.818; p=0.009).

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The AUC difference between mREMS and HALP scores was 0.4004, but it did not reach statistical significance (95% CI:-0.0149-0.816; p=0.059).

No significant difference was observed between HALP and mHALP scores for AUC (AUC difference=0.0678; 95% CI:-0.1052-0.241; p=0.442).

Discussion

This study compared the performance of HALP, mHALP, and mREMS scores in predicting 30-day mortality in geriatric patients presenting to the ED with hip fractures. The findings indicate that the mREMS score shows higher apparent discriminative performance in predicting mortality, whereas HALP and mHALP scores do not significantly contribute to discriminating short-term mortality. These findings suggest that scoring systems incorporating acute physiological parameters may be more suitable for predicting short-term outcomes in this patient population.

The strong performance of the mREMS score in our study can be explained by its components, which reflect acute physiological deterioration. The mREMS score was initially developed to predict mortality in non-surgical patients presenting to the ED, and combining vital signs and age has been shown to improve

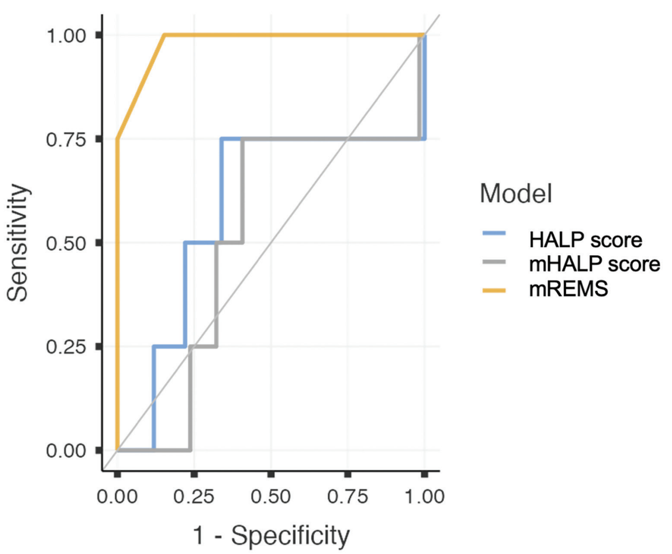

Figure 2. ROC curve analysis for predicting 30-day mortality. The predictive performance of the scoring systems is illustrated. mREMS demonstrated strong discriminative ability, with an AUC of 0.981 (95% CI: 0.942-1.000, p<0.001). HALP and mHALP scores showed lower, non-significant predictive performance, with AUCs of 0.581 (95% CI: 0.185-0.976, p=0.690) and 0.513 (95% CI: 0.171-0.854, p=0.942), respectively

mREMS: Modified Rapid Emergency Medicine score, AUC: Area under the curve, CI: Confidence interval, mHALP: modified hemoglobin, albumin, lymphocyte, and platelet score

its prognostic power (6). Later, the mREMS score, adapted and improved for the trauma population, has been reported to perform better than most existing trauma scores in predicting mortality (7). Since a significant portion of hip fracture patients falls within a clinical spectrum where acute trauma physiology and frailty syndrome intersect, a score measuring the deterioration of acute physiological reserve is expected to better predict short-term mortality. The strong association of acute physiological parameters, such as increased heart rate, decreased oxygen saturation, and high mREMS scores, with death in patients in our study also supports this approach.

In contrast, the finding that HALP and mHALP scores were not significant predictors of short-term mortality is valuable. The HALP score was developed as a composite index that evaluates the patient's inflammatory, immunological, and nutritional status by combining HALP levels (8). In the literature, the HALP score is most often associated with long-term prognosis in patients with malignancy and can serve as an independent prognostic marker (9-11). The common feature of these studies is that the HALP score reflects chronic inflammation, nutritional status, and immune reserve rather than acute physiological instability. Therefore, the limited performance of the HALP score in ED populations, where acute physiological changes are prominent in determining short-term mortality, is biologically plausible.

Similar results have been reported in ED-based studies. A study in patients with acute heart failure showed that the mHALP score had moderate prognostic value. In contrast, the classical HALP score is insufficient to predict early and short-term mortality (12). This finding supports the idea that biochemical composite scores, which do not directly measure physiological deterioration in acute clinical conditions, may be limited in this regard. In our study, the lack of significant differences in HALP and mHALP scores across mortality groups suggests that mortality risk is determined primarily by the acute clinical condition.

Studies evaluating HALP scores in hip fracture populations have focused primarily on medium- and long-term mortality. In large-sample cohort studies, HALP scores have been reported to be independently associated with 90-day and long-term mortality and to improve predictive performance when added to risk models (13). Similarly, in elderly proximal femur fracture patients, HALP scores have been reported to be effective in predicting 30-day and 1-year mortality and to show stronger discrimination compared to other inflammatory markers (14). Several factors may account for the differences between our study and these studies. First, the relatively small sample size and a low number of mortality events may have limited the statistical power, particularly for detecting weaker associations, such as those related to HALP-based indices. Second, since HALP scores are markers of chronic reserve, their effect may be limited to a short time interval, such as 30 days.

In addition to these findings, recent studies have reported mixed results regarding the predictive value of HALP in hip fracture populations. In a cohort of elderly patients undergoing hemiarthroplasty for femoral neck fractures, the HALP score was identified as an independent predictor of six-month mortality, with moderate discriminative performance (AUC≈0.80) (15). These findings support the role of HALP as a marker of overall physiological reserve and mid-term outcomes.

However, not all studies have demonstrated a consistent association between HALP and short-term mortality. In a more recent ED-based cohort, although HALP scores were numerically lower in non-survivors, no statistically significant association was found with either 30-day or 1-year mortality (16). Instead, factors such as age, hypoalbuminemia, and indicators of acute clinical severity, including requirement for intensive care and prolonged hospitalization, were more strongly associated with mortality.

Taken together, these findings suggest that while HALP may have prognostic value in certain contexts, particularly for longer-term outcomes, its role in predicting early mortality in the emergency setting remains uncertain. This variability across studies further supports the notion that acute physiological parameters may be more relevant for short-term risk assessment in this patient population.

The very high AUC observed for the mREMS score in this study should be interpreted with caution. In small-sample studies, model performance may be overestimated due to optimism bias or overfitting. Although internal validation using bootstrap resampling was performed, external validation in larger, independent cohorts is required to confirm the robustness and generalizability of these findings. However, the high sensitivity and NPV of the mREMS score, at a cut-off of 7.5, suggest that it may be useful for identifying low-risk patients in early clinical settings.

In addition, adjustment for potential confounding factors could not be performed reliably. Although an exploratory logistic regression analysis was attempted, the extremely low number of mortality events (n=4) resulted in complete separation and unstable parameter estimates. Therefore, the independent effects of variables such as comorbidities, frailty, and baseline clinical status could not be evaluated; residual confounding cannot be excluded. Importantly, the absence of a multivariable analytical approach limits the ability to determine whether the observed associations, particularly for the mREMS score, are independent of these clinically relevant factors. As such, the apparent predictive performance of the mREMS score may be partially influenced by unmeasured or uncontrolled confounders.

Another key finding of this study is that scores assessing acute physiological status may be more predictive of short-term mortality than chronic biochemical indices. In geriatric patients with hip fractures, mortality is influenced not only by underlying comorbidities but also by the physiological response to acute trauma. Therefore, the use of easily applicable scores, such as mREMS, in triage and early risk assessment processes can support clinical decision-making. From a clinical perspective, incorporating such tools into ED workflows may facilitate more accurate risk stratification and optimize resource allocation, particularly in high-risk geriatric populations.

Study Limitations

This study has several strengths, including the head-to-head evaluation of acute physiological (mREMS) and immuno-nutritional (HALP, mHALP) indices in a specific geriatric hip fracture cohort. To our knowledge, direct comparisons of these three scores in predicting short-term mortality are limited, making this study a potentially valuable contribution to the literature.

However, several limitations must be acknowledged. First, the single-center design and relatively small sample size (n=63) limit the generalizability of our findings. The low number of mortality events (n=4) significantly constrains the statistical power of the analyses. This may have influenced the stability of the performance estimates, including the high AUC value observed for the mREMS score. In small-sample settings, such findings may be affected by optimism bias or model overfitting.

Additionally, the limited number of events may have reduced the ability to detect statistically significant associations for HALP and mHALP scores, despite their potential clinical relevance. Furthermore, the study primarily relied on univariate analyses and ROC-based discrimination methods, without adjusting for potential confounding variables. Important clinical factors such as comorbidities, frailty status, and baseline functional or physiological conditions could not be incorporated into a multivariable model due to the limited number of outcome events. As a result, the independent predictive value of the evaluated scores could not be determined, and residual confounding may have influenced the observed associations. Therefore, the findings of this study should be interpreted with caution and considered exploratory.

Finally, the lack of external validation is another important limitation. Multicenter prospective studies with larger sample sizes and independent validation cohorts are needed to confirm the robustness and clinical applicability of these scoring systems in geriatric trauma populations.

Conclusion

This study suggests that the mREMS score appears to demonstrate discriminative performance in predicting short-term mortality and may outperform the HALP and mHALP scores in this patient population. However, these findings should be interpreted with caution due to the extremely limited number of mortality events, which may have led to overestimation of the AUC and sensitivity.

In contrast, HALP and mHALP scores did not show significant predictive value for 30-day mortality. The high sensitivity and NPV of the mREMS score indicate potential clinical utility, particularly for identifying low-risk patients; however, these results should be considered exploratory.

Further validation in larger, adequately powered studies is required.

Ethics

Ethics Committee Approval: The study protocol was approved by the University of Health Sciences Türkiye, Konya City Hospital Non-Interventional Clinical Research Ethics Committee (decision number: 2025/76, date: 12.05.2025). The research was conducted in strict accordance with the ethical principles outlined in the Declaration of Helsinki.

Informed Consent: Written informed written consent was obtained from all patients included in the study or from their legally authorized representatives.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.D., Concept: A.D., Design: A.D., Data Collection or Processing: A.D., Analysis or Interpretation: A.D., A.Ü., Literature Search: A.D., A.Ü., Writing: A.D., A.Ü.

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