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# Analysis of Adult Trauma Patients Carried by Helicopter Ambulance According to GAP Score

## Helikopter Ambulansıyla Taşınan Yetişkin Travma Hastalarının GAP Skoruna Göre Analizi

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## Abstract

**Objective:** The aim of the scoring systems used in prehospital triage of trauma patients is to determine the patients with treatment priority. The Glasgow coma scale/age/systolic blood pressure (GAP) score is a physiological scoring system used for this purpose. In this study, the usability of the GAP score in determining the patients with treatment priority in trauma patients transported by helicopter ambulance was examined.

**Methods:** This study was conducted retrospectively with 151 trauma patients transported from the scene by helicopter ambulance between 01.10.2021-01.10.2023. The patients' age, gender, type of trauma and injury, blood pressure, Glasgow coma scale, injury site, and time of death of dead patients were recorded. The patients' GAP scores were calculated and their severity was examined. The usability of the GAP score in helicopter ambulance assignments was evaluated.

**Results:** One hundred and fifty one patients were included in the study. The mean age of the patients was 51.8. 68.9% of the patients were male. 5.2% (n=8) of the patients died within 30 days. It was determined that the GAP score was determinative in mortality prediction with %98 sensitivity and 83.9% specificity when the cut-off value was 2 and below (p<0.001).

**Conclusion:** The GAP score, based on physiological parameters and quickly calculable, can be utilized in helicopter ambulance services. By using the GAP score, unnecessary helicopter ambulance transfers can be prevented. Additionally, it can minimize time lost in identifying severely injured trauma patients, thereby preventing treatment delays.

**Keywords:** Glasgow coma scale/age/pressure score, helicopter ambulance, trauma, transfer

## Öz

**Amaç:** Travma hastalarının hastane öncesi triyajında kullanılan puanlama sistemlerinin amacı, tedavi önceliği olan hastaları belirlemektir. Glasgow koma skalası/yaş/basınç (GAP) skoru bu amaçla kullanılan fizyolojik bir puanlama sistemidir. Bu çalışmada, helikopter ambulansla taşınan travma hastalarında tedavi önceliği olan hastaları belirlemede GAP skorunun kullanılabilirliği incelenmiştir.

**Yöntem:** Bu çalışma, 01.10.2021-01.10.2023 tarihleri arasında helikopter ambulansla olay yerinden taşınan 151 travma hastası ile retrospektif olarak yürütülmüştür. Hastaların yaşı, cinsiyeti, travma ve yaralanma türü, kan basıncı, Glasgow koma skalası, yaralanma yeri ve ölen hastaların ölüm zamanı kaydedilmiştir. Hastaların GAP skorları hesaplanmış ve şiddetleri incelenmiştir. GAP skorunun helikopter ambulans görevlendirmelerinde kullanılabilirliği değerlendirilmiştir.

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## Öz

**Bulgular:** Çalışmaya 151 hasta dahil edilmiştir. Hastaların ortalama yaşı 51,8'dir. Hastaların %68,9'u erkektir. Hastaların %5,2'si (n=8) 30 gün içinde öldü. Kesme değeri 2 ve altında olduğunda GAP skorunun %98 duyarlılık ve %83,9 özgüllükle mortalite tahmininde belirleyici olduğu belirlendi (p<0,001).

**Sonuç:** Fizyolojik parametrelere dayalı ve hızlı bir şekilde hesaplanabilen GAP skoru, helikopter ambulans hizmetlerinde kullanılabilir. GAP skoru kullanılarak gereksiz helikopter ambulans nakilleri önlenebilir. Ayrıca, ağır yaralı travma hastalarının belirlenmesinde kaybedilen zamanı en aza indirebilir ve böylece tedavi gecikmelerinin önüne geçilebilir.


**Anahtar Kelimeler:** Glasgow koma skalası/yaş/basınç skoru, helikopter ambulans, travma, transfer

## Introduction

Trauma ranks as the third leading cause of death across all age groups, following cardiovascular diseases and cancer, and is the leading cause of death among individuals aged 1-44 years[1]. Trauma predominantly affects young individuals and results in significant loss of workforce productivity[2]. Advances in healthcare suggest that trauma will remain one of the most prevalent causes of morbidity in the coming years[3].

Severe traumatic injuries primarily result from traffic accidents, firearm injuries, penetrating and sharp object injuries, falls, and assaults. According to the World Health Organization (WHO), the global annual death toll from road traffic accidents reached approximately 1.35 million in 2016, marking a record high[4]. This represents a significant increase compared to the estimated 1.15 million annual deaths reported by WHO in 2000[4].

Studies have shown that delays in hospital admission or definitive treatment for patients with severe traumatic injuries exacerbate potentially preventable outcomes[5]. Notably, 55.1% of preventable or potentially preventable deaths in prehospital settings have been attributed to hemorrhage[6]. In acute care settings, the majority of preventable deaths are associated with hemorrhage (28.4%), multiple organ dysfunction syndrome or sepsis (23.6%), and traumatic brain injury (21.2%), collectively accounting for 73.2% of preventable deaths[6].

To assess mortality risk in trauma patients, various trauma scoring systems have been developed[7]. These systems are typically based on anatomical and physiological parameters or a combination of both. Physiological scoring systems offer the advantage of being quick and easy to calculate.

The Glasgow coma score (GCS), one of the most commonly used physiological scoring systems, evaluates the patient's ocular, verbal and motor responses[8]. Advanced age increases the risk of mortality in patients with similar trauma severity, whereas systolic blood pressure serves as an early indicator of shock. Due to the rapid variability of these three parameters, the GCS/age/systolic blood pressure (GAP) score has been reported as an effective tool for early prognosis[9,10]. The GAP score, derived from the initials of GAP, was introduced by Kondo et al.[8] in a multicenter study conducted in 114 centers in Japan.

Time lost during the transportation of trauma patients remains a critical issue. To minimize delays, helicopter ambulances are utilized in addition to ground ambulances[11]. The high costs of helicopter ambulance services impose a substantial economic burden on healthcare systems; therefore, their utilization must be carefully planned[12].

This study aims to investigate the relationship between the GAP score and patient prognosis among adult trauma patients transported via helicopter ambulance. Additionally, it seeks to evaluate the utility of the GAP score in minimizing time lost during the hospital transfer of critically injured trauma patients, thereby optimizing the use of helicopter ambulance services.

## Materials and Methods

This retrospective study focused on adult trauma patients transported from the scene of injury by helicopter ambulance between October 1, 2021, and October 1, 2023. Patients with missing data and those under 18 years of age were excluded.

Ethical approval for the study was obtained from Health Sciences University Türkiye, Etlik City Hospital Clinical Research Ethics Committee (approval number: AEŞH-EK1-2023-649, date: 01.11.2023). The study adhered to the ethical principles outlined in the Helsinki Declaration.

Patients included in the study were identified using the Ministry of Health's Emergency Health Automation System. The recorded data included patients' age, sex, type of trauma, trauma mechanisms, affected body regions, GAP, whether the patient had multiple traumas, and the location

and timing of death for deceased patients. The GAP scores were calculated, and mortality within 30 days was assessed. Information regarding interventions and 30-day mortality status was obtained via the Ministry of Health's e-Nabız system.

All adult trauma patients transported by helicopter ambulance from the scene to the hospital were included. In cases where the helicopter could not land directly at the scene, patients were first transported by ground ambulance to a suitable landing site. No exclusion criteria were set based on flight time or distance. GAP scores were calculated and categorized, and their predictive accuracy for patient prognosis was analyzed. Additionally, the study evaluated whether the GAP score could guide helicopter ambulance services to improve cost-efficiency and reduce delays in treating critically injured trauma patients.

The GAP score is determined by scoring GAP (Table 1). Based on this scoring system, patients are categorized into three groups: low risk of mortality (19-24 points), medium risk (11-18 points), and high risk (3-10 points).

### Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 27 (IBM Inc., Chicago, IL, USA). Non-parametric tests were applied to variables that did not follow a normal distribution. Descriptive statistics were presented as the mean and standard deviation for normally distributed numerical data, median and minimum-maximum values for non-normally distributed numerical data, and numbers and percentages for categorical data.

For non-normally distributed numerical variables, the Mann-Whitney U test was used for two-group comparisons, and the Kruskal-Wallis test was used for three-group comparisons. Categorical data were analyzed using the Pearson chi-square test or Fisher's exact test for two-group comparisons.

To evaluate the suitability of the GAP score in predicting mortality among trauma patients transported by helicopter ambulance, a receiver operating characteristic (ROC) analysis was performed, and the area under the curve (AUC) was calculated. Statistical significance was defined as a p-value of <0.05.

## Results

A total of 151 patients were included in the study. The mean age of the patients was 51.8±18.4 years. Of the patients, 68.9% were male. The patients' injuries were classified into 84.2% (n=127) blunt and 15.8% (n=24) penetrating categories. Falling was the most common reason for admission, accounting for 43% (n=65) of the cases. Other trauma causes included traffic accidents outside vehicles (motorcycle, bicycle, pedestrian, etc.) at 23.2%, in-vehicle traffic accidents at 14.6%, gunshot wounds at 4.6%, stab wounds at 11.3%, and assault at 3.3%.

The most frequently injured region was the extremities in 71.5% (n=108) of the patients. Head-neck injuries were the second most frequent at 38.4%, and thoracic injuries ranked third at 22.5%. Multiple trauma was present in 35.1% (n=53) of the patients. Eight patients (5.2%) died within 30 days of follow-up. Of these, 5 patients (3.3%) died in the emergency department. Upon examining the vital signs of the patients included in the study, the average systolic blood pressure was 118±19 mmHg, and the average diastolic blood pressure was 74±12 mmHg. The mean GCS score of the patients was 14 (min: 3-max: 15) (Table 2).

The GAP scores of the patients included in the study were evaluated. Four patients were in Group 1, 27 patients in Group 2, and 120 patients in Group 3. All patients in Group 1 and four patients in Group 2 died within 30 days of follow-up (p<0.001) (Table 3).

When mortality rates were compared based on trauma mechanisms, gunshot wounds ranked first with a mortality rate of 14.3%. Stab wounds ranked second with a mortality rate of 5.9%.

When mortality was evaluated according to the injury region, abdominal injuries were the leading cause with a mortality rate of 31.6% (p<0.001). Pelvic injuries were the second most common cause of mortality, with a rate of 28.6% (p=0.005) (Table 3).

When the relationship between trauma and mortality was further examined, six of the patients who died had multiple trauma. Mortality was significantly higher in patients with

**Table 1. GAP Score**

| Glasgow coma scale | 3-15 | 3-15 points |
|---|---|---|
| Age | <60 years | 3 points |
| | >60 years | 0 points |
| Systolic blood pressure | >120 mmHg | 6 points |
| | 60-120 mmHg | 4 points |
| | <60 mmHg | 0 points |

GAP: Glasgow coma scale/age/systolic blood pressure

multiple trauma (p<0.001). The ROC curve for the GAP score in predicting mortality, along with its sensitivity and specificity findings, is shown below (Figure 1), as well as being presented in Table 4.

## Discussion

The findings of our study reveal the relationships between trauma mechanisms, injury regions, and mortality outcomes. In the cohort analysis, the predominance of blunt trauma reflects the impact of falls and traffic accidents. However, penetrating injuries, particularly firearm-related injuries, were associated with significantly higher mortality rates. This underscores the critical need for tailored management strategies and rapid response protocols for high-risk injuries. Abdominal and pelvic injuries emerged as the most significant predictors of mortality, with rates of 31.6% and 28.6%, respectively. This finding highlights the vulnerability of these regions due to the presence of vital organs and major blood vessels. Early diagnosis and timely surgical interventions for abdominal and pelvic trauma are crucial in improving survival rates. Mortality rates were found to be significantly higher in patients with multiple traumas. The complexity of managing injuries involving multiple anatomical regions emphasizes the importance of establishing a comprehensive trauma system and utilizing advanced resuscitation techniques. The GAP score demonstrated exceptional accuracy in predicting mortality. Integrating this score into emergency care protocols could enable clinicians to allocate resources more effectively and prioritize interventions. We believe that such integration would provide a substantial contribution, particularly in the early identification of high-risk patients and the delivery of optimal care. Trauma continues to be one of the leading causes of premature death and disability worldwide[13], largely due to its potential to result in severe and fatal conditions. In our study, the evaluation of patients' mortality status revealed that abdominal and pelvic injuries emerged as the most significant predictors of mortality, with rates of 31.6% and 28.6%, respectively.

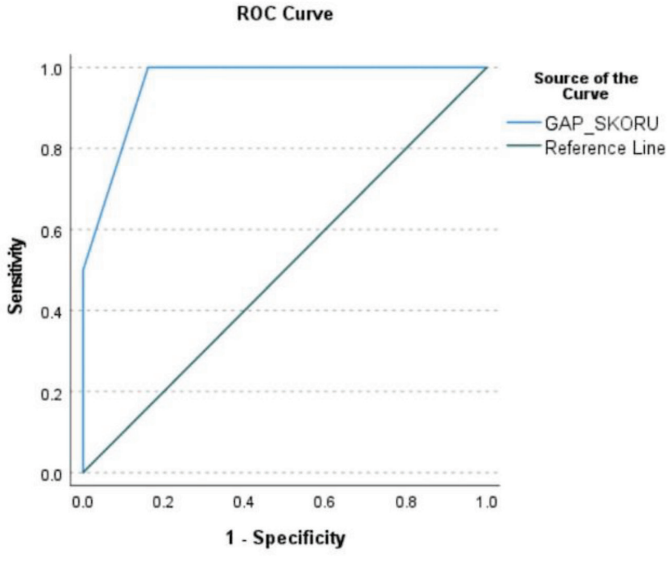


**Figure 1.** ROC analysis graph of GAP score according to mortality status

*GAP: Glasgow coma scale/age/systolic blood pressure, ROC: Receiver operating characteristic*

One-third of trauma-related deaths occur immediately after the injury[14]. To address this critical time frame, helicopter ambulances are utilized for the rapid transportation of patients[15]. However, the use of helicopter ambulances incurs significant costs[16,17]. Proper planning for the allocation of patients and ambulances is essential to ensure the efficient use of resources. Studies have shown that the majority of trauma patients transported from the scene by helicopter ambulances are stable and do not require urgent care[18]. These findings highlight the need for a scoring system capable of accurately predicting patient prognosis in the field to optimize the cost-effective utilization of helicopter ambulances.

In our study, the role of the GAP score in predicting mortality was demonstrated. Incorporating the GAP score into practice for helicopter ambulance transportation could serve as a guide for future multicenter studies involving a larger patient population to further validate its utility and effectiveness.

Studies examining the relationship between gender and trauma have shown that adults, particularly males, are more frequently exposed to trauma[19]. This may be attributed to the higher likelihood of males engaging in high-risk activities, making them more susceptible to accidents resulting in trauma. Similarly, in our study, the majority of trauma patients transported by helicopter ambulance were male. This finding aligns with the existing literature suggesting that males are more prone to trauma. Previous studies have reported that the average age of trauma patients is generally below 40 years[20]. However, in our study, the mean age of trauma patients was found to be 51.8 years. This discrepancy may be explained by the exclusion of patients under the age of 18 in our study. This observation likely reflects differences

**Table 2. Demographic characteristics of the patients**

| | | All patients (n=151) Mean ± SD |
|---|---|---|
| **Age** | | 51.8±18.4 |
| **Gender** | Male | 68.9% (104) |
| | Female | 31.1% (47) |
| **Vitals** | Systolic blood pressure | 118±19 mmHg* |
| | Diastolic blood pressure | 74±12 mmHg |
| **Glaskow coma scale** | | 14 (min: 3-max: 15) |
| **Mortality** | | 8 (5.2%) |
| **Type of trauma** | Blunt | 84.2% (127) |
| | Penetrating | 15.8% (24) |
| **Trauma mechanism** | Fall | 43% (65) |
| | Non-vehicle traffic accidents | 23.2% (35) |
| | In-vehicle traffic accidents | 14.6% (22) |
| | Gunshot wounds | 4.6% (7) |
| | Stab wounds | 11.3% (17) |
| | Assault | 3.3% (5) |
| **Multitrauma** | | 35.1% (53) |
| **Injury site** | Head-neck | 38.4% (58) |
| | Thoracic | 22.5% (34) |
| | Abdominal | 12.6% (19) |
| | Pelvis | 4.6% (7) |
| | Ekstremities | 71.5% (108) |

*mmHg (milimeter of mercury), SD: standard deviation

**Table 3. Comparison of surviving and dead patients**

| | | Surviving patients 94.7% (n=143) | Dead patients 5.3% (n=8) | p-value |
|---|---|---|---|---|
| **Trauma mechanism** | Gunshot wounds | 85.7% (n=6) | 14.3% (n=1) | 0.279 |
| | Non-vehicle traffic accidents | 94.1% (n=16) | 5.9% (n=1) | 0.909 |
| **Injury site** | Abdominal | 68.4% (n=13) | 31.6% (n=6) | **<0.001** |
| | Pelvis | 71.4% (n=5) | 28.6% (n=2) | **0.005** |
| **Multitrauma** | | 88.7% (n=47) | 11.3% (n=6) | **0.015** |
| **Vitals** | Systolic blood pressure (mmHg)** | 120±16 | 74±22 | **<0.001** |
| | Diastolic blood pressure (mmHg) | 76±9 | 44±19 | |
| **GCS** | | 14.5±0.5 | 6.2±2.6 | **0.001** |
| **Type of trauma** | Blunt | 95.3% (n=121) | 4.7% (n=6) | 0.471 |
| | Penetrating | 91.7% (n=22) | 8.3% (n=2) | |
| **GAP score** | 1 | 0 | 100% (n=4) | **<0.001** |
| | 2 | 85.2% (n=23) | 14.8% (n=4) | |
| | 3 | 100% (n=120) | 0 | |

*The p-values were analyzed using the Mann-Whitney U test for two-group comparisons and the Kruskal Wallis-H test for three-group comparisons, **mmHg (milimeter of mercury), GCS: Glasgow coma scale, GAP: Glasgow coma scale/age/systolic blood pressure

**Table 4. ROC analysis results for GAP score in mortality prediction**

| | AUC | %95 CI | Sensitivity | Spesificity | Cut-off | PPV | NPV | LR+ | LR- | p-value |
|---|---|---|---|---|---|---|---|---|---|---|
| GAP score | 0.960 | 91.9-99.8 | 98 | 83.9 | 2 | 25.8 | 98.5 | 6.22 | 0.02 | <0.001 |

PPV: Positive predictive value, NPV: Negative predictive value, LR+: Positive likelihood ratio, LR-: Negative likelihood ratio, CI: Confidence interval, AUC: Area under the curve, GAP: Glasgow coma scale/age/systolic blood pressure, ROC: Receiver operating characteristic

in the age range of the patient population analyzed and the specific limitations inherent to the study design.

Blunt trauma constitutes a significant portion of trauma cases worldwide, making it a critical public health concern. Typically resulting from high-energy mechanisms such as motor vehicle collisions, falls, and other accidents, blunt trauma often leads to internal organ damage and life-threatening complications. A study by Lee et al.[21] identified blunt trauma as the most common mechanism of injury, emphasizing its predominant role in trauma cases. Consistent with these findings, our study revealed that blunt trauma was the leading cause of injury, accounting for 84.2% of all cases. This highlights the global prevalence of blunt trauma, often linked to high-energy mechanisms such as motor vehicle collisions and falls, which underscores the need for targeted prevention strategies and optimized treatment protocols.

Multiple trauma continues to represent a significant public health challenge, being responsible for approximately 10% of global mortality and contributing to long-term morbidity in over 50 million individuals annually[22]. The considerable burden associated with multiple trauma extends beyond immediate fatalities to include profound physical and psychological disabilities, often imposing lifelong consequences on survivors and healthcare systems. A study by Zhang et al.[23] highlighted that preventable deaths in multiple trauma cases frequently result from delays in diagnosis and/or treatment, underscoring the critical importance of rapid assessment and intervention. In our study, 35.1% of patients presented with multiple trauma, and among the deceased patients, six had sustained multiple injuries. These findings emphasize the severity and complexity of multiple trauma cases and highlight the necessity of prompt, advanced medical care. In such situations, air transportation may play a pivotal role by minimizing delays in transferring patients to specialized trauma centers. The ability of air medical services to rapidly transport critically injured patients to facilities equipped with advanced diagnostic and therapeutic capabilities can be life-saving and should be considered an essential component of trauma care systems.

The GAP score is a practical scoring system used to assess the prognosis of trauma patients and predict mortality risk. This system combines three parameters-GAP-into a simple, rapid, and effective evaluation tool. In addition to facilitating the classification of trauma patients, the GAP score also serves as a guide in clinical decision-making processes. Studies on the GAP score have demonstrated its utility as an effective tool for predicting the prognosis of trauma patients[24]. In our study, the evaluation of GAP scores in relation to mortality revealed that lower GAP scores were significantly associated with higher mortality rates. Specifically, the AUC value for the GAP score in predicting mortality was 0.96, with a sensitivity of 98% and a specificity of 83.9%. These findings align with those reported in previous studies. For instance, Zeindler et al.[25] identified an AUC value of 0.93 in their analysis; while Mohammed et al.[26] reported an AUC value of 0.89, with a sensitivity of 81% and a specificity of 78%, closely mirroring our results. Similarly, other studies have documented high sensitivity and specificity for the GAP score in trauma patients[7,27]. In a study involving 2007 trauma patients, the specificity was found to be 80.1%, consistent with our findings[28]. Based on the results of our study, the GAP score can be considered a reliable and practical parameter for identifying high-risk patients who may benefit from transportation via helicopter ambulance. The score is straightforward to apply, even in resource-limited field settings, enabling healthcare personnel to effectively triage and manage trauma patients.

The strengths of the study lie in its ability to highlight the general conditions of trauma patients transported by helicopter ambulance and its contribution to cost-effectiveness by identifying patients who genuinely require air transport. However, the study also has notable limitations. Patients who could not be transported by helicopter ambulance due to meteorological conditions were excluded, potentially affecting the completeness of the analysis. In addition, some patients in relatively stable general condition, who were transported by air ambulance due to geographical constraints rather than medical necessity, were included, which may have influenced the overall findings.

### Study Limitations

Furthermore, this study has inherent limitations. As the data were collected only between 2021 and 2023, the findings may not be generalizable to a broader time frame. The inclusion of only patients aged 18 years and older excluded the pediatric population, who may exhibit different trauma mechanisms and outcomes. Data were obtained from a specific region or center, limiting the generalizability of the results to other regions or healthcare systems. Meteorological conditions may have prevented the operation of helicopter ambulances in some cases, affecting the representativeness of the analyzed cases. Additionally, the preference for using helicopter ambulances for more critical cases could introduce selection bias, restricting the applicability of the GAP score to the general population. These limitations should be carefully considered when interpreting the findings of this study.

## Conclusion

Based on the results of our study, the GAP score can be considered a reliable parameter for the transport of high-risk patients by helicopter ambulance. Healthcare personnel can easily apply this score in the field, where resources are limited, to manage trauma patients effectively.

### Ethics

**Ethics Committee Approval:** Ethical approval for the study was obtained from Health Sciences University Türkiye, Etlik City Hospital Clinical Research Ethics Committee (approval number: AEŞH-EK1-2023-649, date: 01.11.2023).

**Informed Consent:** Retrospective study.

### Footnotes

### Authorship Contributions

Concept: E.A., E.U., Design: E.A., E.U., Data Collection or Processing: E.A., Analysis or Interpretation: E.A., Literature Search: E.U., Writing: E.A., E.U.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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