ORIGINAL RESEARCH

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# Determination of Prognostic Factors in Cerebral Contusions

## Serebral Kontüzyonlarda Prognostik Faktörlerin Belirlenmesi

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## Abstract

**Objective:** Cerebral contusion (CC) is vital because it is one of the most common traumatic brain injury (TBI) types and can lead to lifelong physical, cognitive, and psychological disorders. As with all other types of craniocerebral trauma, the correlation of prognosis with specific criteria in CC can provide more effective treatment methods with objective approaches.

**Method:** The results of 105 patients who were hospitalized in the emergency clinic with the diagnosis of CC and whose lesion did not require surgical intervention were evaluated. The demographic variables, Glasgow coma scale (GCS) score, radiographic findings, coexisting traumas and, type, number, and the midline shift of the contusions detected in computerized tomography (CT) were evaluated as a guide in determining the prognosis in one month.

**Results:** Twenty-five patients were female, and 80 were male, and the mean age was 37 years. The traffic accident was the most common cause of head injury. It was seen that while advancing age had a significant effect on mortality, sex factor had no impact on prognosis. Motor posture in GCS score, pupil light reactions, the number of contusions, and presence of accompanying subdural hemorrhage (SDH) on cranial CT were found to be substantial prognostic indicators. The presence of a cranial fracture and the degree of midline shift did not affect prognosis.

**Conclusion:** Advanced age, low GCS score, abnormal motor response, abnormal pupil light reaction, presence of other system traumas, multiple contusions, and accompanying SDH affected the prognosis of the cases adversely.

**Keywords:** Cerebral contusion, head injury, computerized tomography, Glasgow coma scale, intraparenchymal hemorrhage, prognosis, trauma, traumatic brain injury

## Öz

**Amaç:** Kontüzyo serebri, en sık karşılaşılan travmatik beyin yaralanması olması ve ömür boyu süren fiziksel, bilişsel ve psikolojik bozukluklara yol açabilmesi nedeniyle önem taşımaktadır. Diğer tüm kraniyoserebral travma tiplerinde olduğu gibi kontüzyon serebride de prognozun belli kriterlere bağlanması objektif yaklaşımlarla vakit geçirmeden daha efektif tedavi yöntemlerinin belirlenmesini sağlayabilir.

**Yöntem:** Acil poliklinikte kontüzyon serebri saptanılarak yatırılan, lezyonu cerrahi müdahale gerektirmeyen 105 olgu araştırıldı. Demografik değişkenler, Glasgow koma skalası (GKS) skoru, radyografik bulgular, eşlik eden travmalar, kraniyal bilgisayarlı tomografide (BT) saptanılan kontüzyonların tipi, sayısı, ile oluşturduğu orta hat şiftine göre sonuçları bir aylık dönemde prognoz tayininde yol gösterici olarak değerlendirildi.

**Bulgular:** Çalışmadaki olguların 25'i kadın, 80'i erkek olup ortalama yaş 37 idi. Trafik kazalarının kontüzyon serebri oluşumunda ilk sırayı aldığı dikkati çekti. İlerleyen yaşın mortalite üzerinde belirgin etkisi olduğu, cins faktörünün ise prognoza etkisinin olmadığı görüldü. GKS skorunda yer alan motor postür, pupil ışık reaksiyonu, kraniyal BT'deki kontüzyonun sayısı ve eşlik eden subdural hematom (SDH) prognostik açıdan yol gösterici idi. Kranial fraktürün ve orta hat şiftinin prognoza etkisinin olmadığı görüldü.

**Sonuç:** İleri yaş, düşük GKS skoru, anormal motor cevap, anormal pupil ışık reaksiyonu, birlikte diğer sistem travmalarının bulunması, kontüzyonun multipl olması ve beraberinde SDH bulunması olguların prognozunu kötü yönde etkilemekteydi.

**Anahtar kelimeler:** Serebral kontüzyon, kafa travması, bilgisayarlı tomografi, Glasgow koma skalası, intraparankimal kanama, prognoz, travma, travmatik beyin yaralanması

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## Introduction

In economically developing countries, most of the traumatic brain injury (TBI) is caused by motor vehicles and continues to be the fearful dream of today's technology age because it cause not only of disability and loss of life but also of financial losses (1-12).

In patients with trauma, a hemorrhagic contusion is the most common lesion detected on computerized tomography (CT), and in many series, account for approximately 13-35 % of traumas (2,6,12-15).

When the literature is examined, it is seen that many criteria were evaluated for the prognosis of TBI cases. The heterogeneity of TBI is the major obstacle to determining effective treatment and linking prognosis to specific criteria will provide objective approaches and effective treatment methods.

We aimed to evaluate the cases with CC and to determine the possible prognostic factors such as age, sex, brainstem findings (pupil reactions and motor postures), Glasgow coma scale (GCS) score, accompanying traumas, cranial CT findings, and presence of fracture images in the radiographic examination. When the Turkish and English literature were examined, no other study was seen to determine the prognosis of CC using all these criteria together.

## Material and Methods

### Including and Excluding Criteria

In this study, the head trauma cases with CC admitted to our emergency clinic within two years and treated with medical treatment were evaluated retrospectively. The exclusion criteria were as follows: Diffuse periorbital edema, ecchymosis, and lacerations to prevent eye-opening, facial fracture to avoid speech, spinal pathologies to prevent movements of limbs and immobilization due to fractures and alcohol intoxication were excluded from the study because of difficulties in GCS interpretation. Since it would be difficult to assess the consciousness because of the pharmacological sedation or muscle relaxants used for intubation, the patients who were prehospital intubated were not included in the study. Also, the patients with unilateral pupillary response disorder were not included in the survey as this may be due to direct trauma to the eye. In the radiological evaluation, all other fractures were included in the study except patients with open or closed depressed skull fractures. The patients required surgical intervention, and the patients with diffuse axonal injury (DAI) were not included in the study. Total of 105 cases was included in the study.

### Demographic Data

The patients were introduced into 2-decade groups that as 0-20, 21-40, 41-60, 61-80, and ≥81 (Table 1). The effects of the patients' age and gender on one-month prognosis were evaluated.

### Associated Traumas

Other system traumas of the patients were recorded, and their effects on the prognosis were evaluated.

### Neurological Evaluation

The initial state of consciousness was evaluated according to the GCS score. The patients were divided into four groups according to their GCS score: GCS 3-5, GCS 6-8, GCS 9-11, and GCS 12-15. Direct and indirect light responses of both eyes were taken into consideration in the pupillary examination. In the motor system examination, response to a painful stimulus was evaluated separately from GCS. Patients with uni- and bilateral decorticated, uni- and bilateral decerebrated, or bilateral flask posture were compared with those without abnormal posture to determine the prognosis.

### Radiological Findings

The prognosis was determined according to the type, number, and midline shift of the first cranial CT scans taken on the day of hospitalization. In the determination of contusion type, the classification defined by Lobato et al. (16) was used (Appendix 1).

**Appendix 1. Lobato classification**

**Type 1**. Pure extracerebral hematoma

**Type 2**. Extracerebral hematoma + Acute hemispheric swelling

**Type 3**. Single brain contusion +/- Extracerebral hematoma

**Type 4**. Multiple unilateral brain contusion +/- Subdural hematoma

**Type 5**. Multiple bilateral brain contusion

**Type 6**. General brain swelling +/- Small extracerebral hematoma

**Type 7**. Diffuse axonal injury

**Type 8**. Normal CT scans

The amount of shift caused by contusion was determined by measuring the distance between the inner tabulae and septum pellucidum in sections where septum pellucidum was seen.

For output status, the terms of recovery, disability, or dead were used, and these parameters were evaluated as a guide in determining the prognosis in the one month.

### Statistical Analysis

The data were analyzed by SPSS (Statistical Package for Social Sciences) 15 package program, and the results were tested by chi-square test. Number and % were used as descriptive statistics in the evaluation of the data. A p value of less than 0.05 was considered significant, and a p value less than 0.005 was considered highly significant.

## Results

Of the 105 cases in our study group, 24% were female, and 76% were male. Their ages ranged from 1.5 to 86, and the mean age was 37 (Table 1).

### Relationship Between Demographic Data and Prognosis

Age is a statistically significant factor affecting the prognosis. Increasing age caused worse prognosis and higher mortality rate (Figure 1). This relationship was highly significant. The only exception was in the 61-80 age group, but this did not change significance ($\chi^2$=22.010; p<0.005). When the relationship between sex and prognosis was examined, it was observed that 28% of 25 female patients and 15% of 80 male patients died. The relationship between gender and prognosis was not statistically significant ($\chi^2$=3.373; p>0.05) (Figure 2).

### Causes of Trauma

The causes of the trauma of the patients were summarized in Table 2. According to this, the most frequent cause was pedestrian traffic accidents (32.4%) followed by motor vehicle traffic accidents (21.9%) and fall from height (20%).

**Table 1. Age and gender distribution of the patients**

| Year | Total | | Female | | Male | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| 0-20 | 30 | 28.6 | 8 | 32 | 22 | 27.5 |
| 21-40 | 30 | 28.6 | 4 | 16 | 26 | 32.5 |
| 41-60 | 28 | 26.7 | 4 | 16 | 24 | 30 |
| 61-80 | 14 | 13.3 | 8 | 32 | 6 | 7.5 |
| 81- | 3 | 2.8 | 1 | 4 | 2 | 2.5 |
| Total | 105 | 100 | 25 | 100 | 80 | 100 |

n: Number of the patients

### The Effects of Associated Traumas

It was found that long bone fractures were most commonly associated with CC (58%) followed by chest trauma (21%), abdominal trauma (13%) and pelvic trauma (8%), respectively (Table 2). While the mortality rate was 11% in the case of TBI alone, the mortality rate increased to 42% in the presence of other system traumas (Figure 3). The effect of associated injuries on mortality was found to be statistically significant ($\chi^2$=12.313; p<0.005).

### The Effects of Neurological Status on Prognosis

Relationship between GCS and prognosis was found to be statistically significant ($\chi^2$=47.462; p<0.005). It was seen that the healing rate was 0% in score between 3-5 and 62.2 % in those with a score of 12-15. While the mortality rates are 100 % in patients with scores 3-5, the rate is 3% in score 12-15 patients (Table 3).

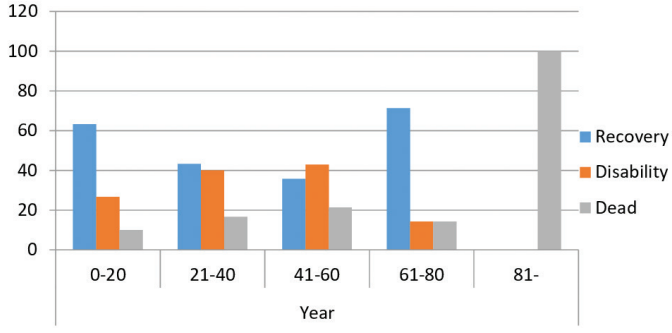


**Figure 1.** The relationship between age and prognosis

**Table 2. Types of trauma and additional injuries**

| Types of trauma | n | % |
|---|---|---|
| Pedestrian traffic accidents | 34 | 32.4 |
| Motor vehicle traffic accidents | 23 | 21.9 |
| Fall from height | 21 | 20 |
| Fall from stairs | 10 | 9.5 |
| Assault | 9 | 8.6 |
| Head hitting against hard objects | 1 | 0.9 |
| Falls on the same level | 7 | 6.7 |
| **Additional Injuries** | **n** | **%** |
| Long bone fractures | 14 | 58.3 |
| Chest trauma | 5 | 20.9 |
| Abdominal trauma | 3 | 12.5 |
| Pelvic trauma | 2 | 8.3 |

n: Number of the patients

The relationships between abnormal motor response and prognosis, and between the bilateral response of pupils to light were also statistically significant ($\chi^2$=18.822; p<0.005, and $\chi^2$=18 822; p<0.005, respectively). The mortality rate was 100% in patients with abnormal posture response to painful stimuli (Table 3). While the recovery was 0% in patients with bilateral abnormal (decreased or lost) pupil reaction, the mortality rate was found to be only 15% in patients with a normal response (Figure 4).

### The Effects of Radiological Findings

Presence of cranial fracture did not affect the one-month prognosis ($\chi^2$=1.171; p>0.05) (Table 4). While the mortality rate was 50% in cases with midline shift in cranial CT, it decreased to 16.8% in cases without shift (Table 4). However, the relationship between the degree of midline shift and the prognosis was not statistically significant ($\chi^2$=2.914; p>0.05).

The relationship between contusion type and prognosis was statistically significant ($\chi^2$=9.808; p<0.05) (Table 4).

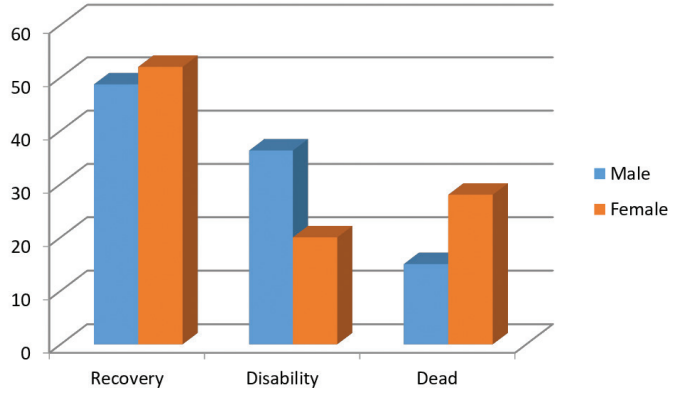


**Figure 2.** The relationship between gender and prognosis

The highest mortality rate was found in type 4 of Lobato classification (multiple unilateral CC +/- Subdural hematoma) (38.5%), which was 4 times higher than the mortality rate in type 3 (Single CC +/- Extra cerebral hematoma) (10%). The relationship between the number of contusions and prognosis was also statistically significant ($\chi^2$=6.111; p<0.05). If the number of contusions detected on cranial CT was more than one, the mortality rate (28.6%) was two times higher than that of single ones (11.1%) (Table 4).

### Length of Hospitalization

The length of hospitalization of the patients ranged from 1 to 23 days, and the mean duration of hospitalization was nine days. The hospitalization period of our deceased patients was between 1-18 (mean 7.5 days), and 53% of the cases who died was lost between 1-10 days (Table 5).

## Discussion

The presence of CC is a factor affecting the outcome of the patients with a head injury. In the literature, mortality in CC was reported as 34% (17), and this rate was found to be 18% in our series. There are some studies evaluating the factors affecting the mortality in these cases. Age is one of these factors. The mean age of the patients with CC was reported to be 27 to 38 in the studies of Lobato et al. and Miller et al. (16,17). In the series of Miller et al. (17) was consisting of non-operated 225 cases, 72% of the cases were between 0 and 40 years of age.

Similarly, Narayan et al. (18) reported that the rate of cases in the 0-40 age group was 72%. The mean age of our patients was 37, and the majority (57%) were composed of male patients aged 0-40 years. At the end of the study, it was seen that age had a significant effect on mortality. While mortality was 10% in the 0-20 age group, it reached 100% in

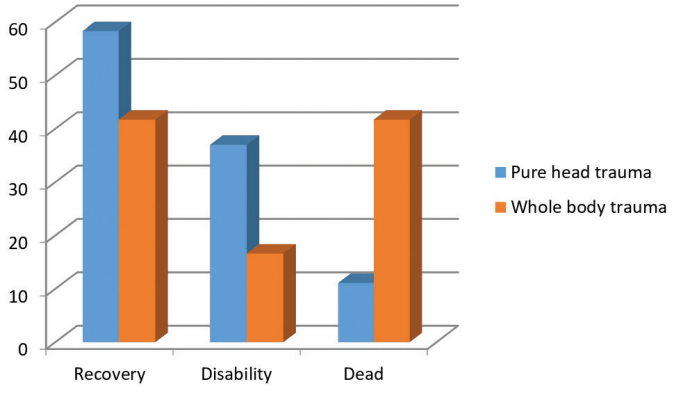


**Figure 3.** The relationship between trauma types and prognosis

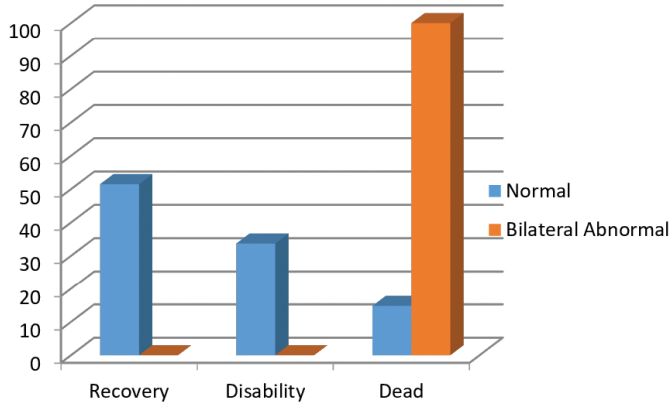


**Figure 4.** The relationship between pupillary responses and prognosis

**Table 3. Initial GCS, motor responses and prognosis relationships**

| | | Total | | Recovery | | Disability | | Dead | |
|---|---|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % | n | % |
| **GCS** | 3 - 5 | 4 | 3.8 | 0 | 0 | 0 | 31.8 | 4 | 100 |
| | 6 - 8 | 15 | 14.3 | 2 | 13.3 | 4 | 26.7 | 9 | 60 |
| | 9 - 11 | 20 | 19 | 9 | 45 | 7 | 35 | 4 | 20 |
| | 12 - 15 | 66 | 62.9 | 41 | 62.2 | 23 | 34.8 | 2 | 3 |
| **Motor response** | Postured | 101 | 96.2 | 52 | 51.5 | 34 | 33.7 | 15 | 14.8 |
| | W/O postured | 4 | 3.8 | 0 | 0 | 0 | 0 | 4 | 100 |

GCS: Glasgow coma scale, n: Number of the patients, W/O: Without

**Table 4. Prognosis according to the radiographic findings**

| | | Total | | Recovery | | Disability | | Dead | |
|---|---|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % | n | % |
| **Skull fracture** | Present | 65 | 61.9 | 32 | 49.3 | 23 | 35.3 | 10 | 15.4 |
| | Absent | 40 | 38.1 | 20 | 50 | 11 | 27.5 | 9 | 22.5 |
| **CC types in CT-scans** | Type 3 | 62 | 59 | 36 | 58 | 20 | 32.3 | 6 | 9.7 |
| | Type 4 | 13 | 12.4 | 3 | 23 | 5 | 38.5 | 5 | 38.5 |
| | Type 5 | 30 | 28.6 | 13 | 43.3 | 9 | 30 | 8 | 26.7 |
| **CC number in CT-scans** | Single | 63 | 60 | 36 | 57.1 | 20 | 31.8 | 7 | 11.1 |
| | Multiple | 42 | 40 | 16 | 38.1 | 14 | 33.3 | 12 | 28.6 |
| **Midline shift in CT-scan** | Present | 4 | 3.8 | 1 | 25 | 1 | 25 | 2 | 50 |
| | Absent | 101 | 96.2 | 51 | 50.5 | 33 | 32.7 | 17 | 16.8 |

CT: Computered tomography, CC: Cerebral contusion, n: Number of the patients

**Table 5. Hospitalization period of the dead cases**

| | n | % |
|---|---|---|
| **0-1 day** | 4 | 21.1 |
| **1- 10 day** | 10 | 52.6 |
| **11 day and ↑** | 5 | 26.3 |
| **Total** | 19 | 100 |

n: Number of the patients

the group over 81 years. In the literature, it is also seen that mortality increases with increasing age (8,17-22).

The gender was also evaluated for its effect on mortality in our study. 24% of our cases were female, and 76% were male. We found no relationship between gender and the prognosis. In the literature also, although the incidence of TBI in men is higher than in women, there is no significant relationship between gender and prognosis (3,17,20).

It was reported that the leading cause of TBI is traffic accidents in underdeveloped countries. Since improved road safety, falls is in the first place in developed countries (4,12,15). When our patients were ranked according to the type of trauma they were exposed to, traffic accidents were at the forefront (54%).

In 23% of our cases, CC was accompanied by other system traumas, and the mortality rate was 11% in pure TBI, but when poly-trauma added mortality was seen raised to 42%. In the literature, the presence of significant extracranial injury has been reported to be one of the important prognostic indicators in TBIs (8,19,23). In our study, the most common systemic traumas were long bone fractures (58%), followed by chest trauma (21%), abdominal trauma (13%), pelvic trauma (8%), respectively. In Miller et al. 's series, 48% of patients had multi-system trauma, and as in our series, extremity injuries were reported to be the most common (17).

Although there are many methods in neurological evaluation, GCS has been reported to be the easiest method of rapid assessment of the patient and predicting the correct outcome early (24,25).

Rimel and Jane (26) divided head trauma into three groups according to GCS, and GCS value 3-8 was accepted as severe, 9-12 as moderate, and 13-15 as mild head trauma. In our study, we found a statistically significant relationship between GCS scores and prognosis (27). As the GCS score increased, the recovery rate increased, and the mortality rate gradually decreased. Similarly, it has been reported in the literature that mortality rates are inversely proportional

to GCS scores. Moreover, in cases with GCS score 9 or higher, mortality or morbidity may occur in the presence of advanced age or other additional complications (2,8,17,18,22,24,28-30). However, it was noteworthy that there were differences between the rates in the literature. The reasons for the differences where they had included the cases requiring operation in their studies, and also, they had formed GCS groups at different levels.

In our study, it was found that motor posture on the coma scale was an additional parameter in prognosis determination, and high rates of mortality were observed in patients with abnormal motor posture. Similarly, it has been reported in the literature that the neurological status is one of the well-established prognostic factors (8,17,18,20,22).

The effect of both pupils' reactions to light on prognosis was also investigated statistically. According to our results, the mortality rate was 100% in patients with a bilateral abnormal pupillary response and 15% in patients with a normal pupillary response. When different series were examined, it was seen that there was a significant relationship between pupillary light response and prognosis (8,17,18).

In our study, the skull fracture rate was 61.9%. However, the effect of the presence of fracture on prognosis was not significant. There was not any data on this issue in the literature.

It was reported in 1977 by Koo and La Roque (6) that neuropathological changes in hemorrhagic contusion can be visualized by CT. Currently, cranial CT is the ideal method for the diagnosis of CC in the first 24 hours after trauma (12,16,31-35). It was reported that the increase in the volume of traumatic cerebral hemorrhage occurs in the first few hours after the trauma in 38 to 59% of the cases. Also, the findings in the first non-contrast cranial CT taken after the injury were related to the quality of life score at 12 months after the accident (14,36-38). In our study, cranial CT was found to be helpful in the determination of short-term prognosis in CC. In particular, the relationship between the type of contusion and the outcome was remarkable. We found that mortality was the lowest in type 3 of Lobato CC classification (10%), and was the highest in type 4 (39%). The higher mortality in Lobato type 4 can be explained by the fact that acute hemispheric swelling in the case of SDH is much more than EDH. It was reported in the literature that the prognosis is negatively affected when acute SDH is added to the traumatic intracerebral hemorrhage (13,21,22,36). It was shown that increases in intracranial pressure in multiple bilateral CCs could be tolerated longer than in multiple unilateral contusions, which may explain the low mortality rate in type 5 compared with type 4 (7) as to be in our study also. These rates found in our study are in line with Lobato et al.'s study (16). Mortality rates in Lobato' s series are twice that of our series. However, when the series was examined, it was observed that most of the cases had advanced shift and accompanying diffuse hemorrhage requiring surgical intervention, which explains the rate differences. We excluded the cases requiring surgical intervention in our series. Another factor guiding the prognosis in cranial CT was the number of contusions. In our series, 60% of cases had single, and 40% had multiple contusions. The mortality rate was 11% in single contusions, and 29% in multiple contusions. There are also studies in the literature showing that multiple contusions are not associated with poor prognosis (30). The results show why the mortality rate in Lobato's type 5 is lower in the literature to be in our study (39).

Contusions located in the deep gray matter, corpus callosum and internal capsule are among the criteria considered to be a poor prognostic marker in cranial CT today. Gennarelli et al. (40) and Adams et al. (39) were described these types of contusions as DAI. In our study, DAI cases were excluded from the study. Because DAI is not clearly and adequately diagnosed by CT, and the diagnosis is usually made by pathological anatomical studies or in patients who are unconscious after two weeks or by magnetic resonance examination (33).

It was emphasized in many studies that the presence of a midline shift was one of the poor prognostic factors on CT image (5,8,16,25,34). However, Raj et al. (41) reported that midline shift was not very important in determining prognosis. In our series, in only four cases, midline shift was detected, and two of these cases died. Since the number of cases was not sufficient, a statistically significant relationship was not determined.

The limitation of our study was that it was a retrospective study, the number of cases was low, and it was performed in a broad range age group. Since the clarification of the prognostic factors in CCs will determine the treatment protocols, prospective studies evaluating the late prognosis with a large number of cases are needed.

## Conclusion

Advanced age, low GCS score, abnormal motor response, abnormal pupil light response, presence of other system traumas, multiple contusions and accompanying SDH had

a negative effect on the in one-month prognosis in the head injury cases with CC.

### Ethics

**Ethics Committee Approval:** Retrospective study.

**Informed Consent:** Retrospective study.

**Peer-review:** Externally peer-reviewed.

### Authorship Contributions

Surgical and Medical Practices: N.S., M.S.D. Concept: N.S., M.S.D. Design: N.S., M.S.D. Data Collection or Processing: N.S., M.S.D. Analysis or Interpretation: N.S., M.S.D. Literature Search: N.S., M.S.D. Writing: N.S., M.S.D.

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

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