# Prognostic Value Of Initial Computed Tomography Findings In Patients With Traumatic Acute Subdural Hematoma

## Travmatik Akut Subdural Hematomlu Hastalarda Başvuru Bilgisayarli Tomografi Bulgularinin Prognostik Değeri

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**Abstract:** ***Objective***: The prognostic value of initial computed tomography (CT) findings in cases of traumatic acute subdural hematoma (ASDH) is unclear. The aim of this study was to investigate relationships between initial CT findings and outcome in this patient group.

***Methods***: Sixty-five cases of traumatic ASDH were retrospectively analyzed. Of these, 20 were selected based on two main criteria: initial Glasgow Coma Scale score <10, and time from trauma to surgery <4 hours. All 20 patients received the same medication and underwent the same surgical procedures. Initial CT findings of hematoma thickness, midline shift, subarachnoid hemorrhage (SAH), basal cistern obliteration (BCO), intraparenchymal hematoma and contusion (IPH/C) in the same hemisphere, and calculated brain-swelling factor (BSF) were assessed in each case. Neurological (functional) outcome was evaluated with the Glasgow Outcome Scale, and mortality rates related to the different parameters were calculated.

*Results*: The overall rates of mortality and functional recovery were 75% and 25%, respectively. Initial CT findings of greater midline shift, BCO, IPH/C, and BSF were associated with poor outcome.

*Conclusions*: BSF is one of the most important predictors of prognosis in patients with traumatic ASDH. On initial CT in this patient group, hematoma thickness and presence of SAH are not accurate indicators of outcome.

**Key Words**: Acute subdural hematoma, computed tomography, outcome

**Özet:** *Amaç:* Travmatik akut subdural hematomlu hastalarda başvuru bilgisayarlı tomografi bulgularına dayalı prognoz göstergeleri tartışmalıdır. Bu çalışmada, başvuru esnasındaki bilgisayarlı tomografi bulguları ile sonuçlar arasındaki ilişkinin gösterilmesi amaçlandı.

*Yöntem:* Travmatik akut subdural hematomlu 65 hastanın retrospektif analizi yapıldı. Bunlardan 20 hasta iki ana kritere dayanılarak seçildi. Bunlar başvuru Glasgow Koma Skalası skoru 10' nun altında, travma ile operasyon arasında geçen zaman aralığı 4 saaten az olan hastalardı. Seçilen bu 20 hastanın hepsinde aynı medikasyon ve aynı cerrahi girişim prosedürü uygulanmıştı. Başvuru bilgisayarlı tomografisinde hematom kalınlığı, ortahat şifti, subaraknoid kanama, bazal sistern obliterasyonu, aynı hemisferde intraparenkimal hematom ve kontüzyon ve "beyin şişme faktörü" hesaplanması her bir vaka için değerlendirildi. Nörolojik sonuçlar Glasgow Sonuç Skalasına göre değerlendirildi ve farklı parametrelere göre mortalite oranları hesaplandı.

*Bulgular:* Genel mortalite oranı %75 ve fonksiyonel iyileşme oranı %25 idi. Kötü prognoz, başvuru tomografisinde orta hat şiftinin büyüklüğü, basal sistern obliterasyonunun varlığı, aynı hemisferde kontüzyon ya da intraparenkimal hematomun varlığı ve artmış beyin şişme faktörü ile ilişkiliydi.

*Sonuç:* Akut travmatik subdural hematomlu hastalarda kötü prognozun en önemli göstergelerinden biri artmış beyin şişme faktörüdür. Bu hasta grubunda başvuru bilgisayarlı tomografisinde tek başına hematom kalınlığının ölçülmesi ya da subaraknoid kanamanın olması akut subdural hematomlarda tek başına prognozu belirlemez.

**Anahtar Kelimeler:** Akut subdural hematom, bilgisayarlı tomografi, sonuç

## INTRODUCTION

Mortality is high in cases of traumatic acute subdural hematoma (ASDH), with reported rates ranging from 50-90% (2,3,7-9,12,16). Several factors that influence outcome in these cases have been studied extensively, including patient age, initial Glasgow Coma Scale (GCS) score, timing of surgical intervention, and initial computed tomography (CT) findings (3,4,7-9,12,17,18).

In modern emergency service systems, patients are often treated with sedation, intubation, and ventilation at the accident site before a neurosurgical assessment is done. These treatments make it impossible to assess neurological status accurately on arrival at the hospital. In such cases, surgical decisions and prognosis prediction are largely based on initial CT findings (4,17).

In this report, we assessed the relationships between initial CT findings and outcome in 20 patients with traumatic ASDH who underwent surgery. The aim was to determine the prognostic value of these CT findings.

## PATIENTS AND METHODS

Between 1998 and 2001, 65 patients with traumatic ASDH were treated surgically at our institution. We used the following criteria to select a homogeneous patient population for this study: 1) GCS score on initial neurological examination <10 (patients with a GCS score of 3 were excluded); 2) treatment with large craniectomy, hematoma evacuation, and duraplasty; 3) time from trauma to surgery <4 hours; 4) same postoperative medication (phenytoin, antibiotics, fluids restriction, mannitol, and furosemide); and 5) same postoperative management (insufficient respiration treated with intubation and ventilation to maintain $PaO_2$ above 100 mmHg and $PaCO_2$ at 25-30 mmHg). Patients with prolonged hypotension, multiple trauma, complicated head injury (such as open head injury or depressed skull fracture), bilateral ASDH, or contusions on the contralateral side were excluded.

In the 20 cases that met the above criteria, six separate CT findings were retrospectively analyzed: hematoma thickness, extent of midline shift, presence of subarachnoid hemorrhage (SAH), presence of basal cistern obliteration (BCO), presence of intraparenchymal hematoma or contusion (IPH/C) in the same hemisphere, and calculated "brain-swelling factor" (BSF). Hematoma thickness was measured as the largest vertical distance between the cortex and the inner table of the cranium at the lesion site on axial CT. Extent of midline shift was measured as the distance from the point of the septum pellucidum that had shifted most greatly from a reference line that joined the frontal crest and the internal occipital protuberance. BSF was calculated as the difference between midline shift and hematoma thickness, as described by Zumkeller et al. (18), and was expressed in millimeters. The follow-up time ranged from 6 to 27 months. Neurological outcome was evaluated by Glasgow Outcome Scale (GOS), and GOS I and GOS II were accepted as functional recovery (FR+). Mortality rates were calculated in relation to the parameters listed above.

Statistical analysis was performed using Chi-square and Fisher's exact tests. A p value <0.05 was considered to indicate a statistically significant difference.

## RESULTS

Fifteen of the 20 patients with traumatic ASDH died (mortality 75%) and 5 (25%) achieved functional recovery. The relationship between hematoma thickness and outcome is shown in Table 1. The 5 individuals with hematoma thickness >20 mm had the highest mortality rate (100%). Twelve patients' hematomas were between 11 and 20 mm thick, and the rates of mortality and functional recovery in this group were 67% and 33%, respectively. Three patients had hematomas =10 mm thick, and mortality was 67% in this group. There were no significant differences among the mortality rates when patients were categorized according to hematoma thickness (p>0.05 for all).

Table 2 shows the relationship between midline shift and outcome. The mortality rate for the 6 patients with midline shift >20 mm was 100%. Nine patients exhibited midline shift between 11 and 20 mm, and mortality was 89% in this group. The mortality rate for the 5 patients with shift =10 mm was 20%. There were significant differences among the mortality rates and functional recovery rates when patients were categorized according to extent of midline shift (p<0.05). Greater midline shift on initial CT scan was associated with poorer outcome.

SAH was present in 17 (85%) of the cases. Of this group, 14 patients (82%) died and 3 (18%) achieved functional recovery. The rates of mortality

Table I: Relationship between hematoma thickness and outcome. (FR: functional recovery)

| Hematoma Thickness | Exitus | | FR (+) | | Total | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| = 10 mm | 2 | 67 | 1 | 33 | 3 | 15 |
| 11-20 mm | 8 | 67 | 4 | 33 | 12 | 60 |
| > 20 mm | 5 | 100 | - | - | 5 | 25 |
| Total | 15 | 75 | 5 | 25 | 20 | 100 |

Table II: Relationship between midline shift and outcome. (FR: functional recovery)

| Midline Shift | Exitus | | FR (+) | | Total | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| = 10 mm | 1 | 20 | 4 | 80 | 5 | 25 |
| 11-20 mm | 8 | 89 | 1 | 11 | 9 | 45 |
| > 20 mm | 6 | 100 | - | - | 6 | 30 |
| Total | 15 | 75 | 5 | 25 | 20 | 100 |

Table III: Relationship between subarachnoid hemorrhage (SAH) and outcome. (FR: functional recovery)

| | Exitus | | FR (+) | | Total | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| SAH (-) | 1 | 33 | 2 | 67 | 3 | 15 |
| SAH (+) | 14 | 82 | 3 | 18 | 17 | 85 |
| Total | 15 | 75 | 5 | 25 | 20 | 100 |

and functional recovery for the 3 patients who did not have SAH were 33% and 67%, respectively (Table 3). There was a trend towards poorer outcome in the cases with SAH; however, there were no statistically significant differences between the outcomes when the cases were analyzed according to presence of this lesion ($p>0.05$).

Fourteen (70%) of the patients showed BCO. Of these, 13 (93%) died and only one (7%) achieved functional recovery. In the 3 patients who did not show BCO, the mortality rate was 33% and the functional recovery rate was 67% (Table 4). The mortality rates for the groups with and without BCO were significantly different ($p<0.05$), and BCO was associated with poor outcome.

Thirteen (65%) of the cases exhibited IPH/C in the same hemisphere as the ASDH. Of these individuals, 12 (92%) died and only one (8%) achieved functional recovery. In the 7 cases without this CT finding, the rates of mortality and functional recovery were 43% and 57%, respectively (Table 5). The mortality rates for the groups with and without this lesion were statistically different ($p<0.05$), and IPH/C in the same hemisphere was associated with poorer outcome.

Table 6 shows the relationship between BSF and outcome. There were significant differences in outcome when patients were grouped according to BSF values ($p<0.05$). Higher BSF was associated with poorer outcome.

## DISCUSSION

Many investigators have examined relationships between initial CT findings and outcome in patients with traumatic ASDH (3,4,8,9,11,12,17,18). To our knowledge, ours is the first study that has investigated all the commonly used CT parameters (hematoma thickness, midline shift, presence of SAH, BCO, presence of IPH/C, and BSF) in one group of patients. Our aim was to determine the value of these parameters for predicting prognosis in patients with ASDH.

Table IV: Relationship between basal cistern obliteration (BCO) and outcome. (FR: functional recovery)

| | Exitus | | FR (+) | | Total | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| BCO (-) | 2 | 67 | 4 | 33 | 6 | 30 |
| BCO (+) | 13 | 93 | 1 | 7 | 14 | 70 |
| Total | 15 | 75 | 5 | 25 | 20 | 100 |

Table V: Relationship between outcome and intraparenchymal hematoma/contusion (IPH/C) in the same hemisphere. (FR: functional recovery)

| | Exitus | | FR (+) | | Total | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| IPH/C (-) | 3 | 43 | 4 | 57 | 7 | 35 |
| IPH/C (+) | 12 | 92 | 1 | 8 | 13 | 65 |
| Total | 15 | 75 | 5 | 25 | 20 | 100 |

Table 6. Relationship between brain-swelling factor (BSF) and outcome. (FR: functional recovery)

| BSF (mm) | Exitus | | FR (+) | | Total | |
|---|---|---|---|---|---|---|
| | N | % | n | % | n | % |
| (-10) - (-6) | 1 | 20 | 4 | 80 | 5 | 25 |
| (-5) - (-1) | 4 | 80 | 1 | 20 | 5 | 25 |
| 0 | 7 | 100 | - | - | 7 | 35 |
| (+1) - (+5) | 3 | 100 | - | - | 3 | 15 |
| (+6) - (+10) | - | - | - | - | - | - |
| Total | 15 | 75 | 5 | 25 | 20 | 100 |

In a previous study, we found no statistically significant relationship between age and outcome in patients with traumatic ASDH (7). The results identified initial GCS score as a potentially important prognostic indicator, and showed that early surgery reduces mortality in these cases. Based on our previous findings, we did not analyze whether patient age was linked to mortality in the present study. To standardize the study group, we excluded patients who were operated on more than 4 hours post-trauma, and those with initial GCS scores >10. Patients with GCS scores of 3 were also excluded.

Analysis revealed that the mortality rate for cases with hematomas >20 mm thick was 100%, whereas the rate for the patients with hematomas <20 mm thick was 67%. However, there was no statistical correlation between hematoma thickness and outcome. Even cases that involve small traumatic ASDHs may have poor outcomes, since these lesions may be associated with serious brain damage. Brain contusions can produce significant cerebral edema (9).

Numerous authors have studied the effect of midline shift on prognosis for patients with intracranial hematomas (9,11,15). Langfitt and Gennarelli identified midline shift on CT as one of the most important prognostic predictors in traumatic ASDH (11). Similarly, Kotwica and Brzezinski found a significant correlation between midline shift and outcome in this patient group, and suggested that more extensive midline shift is associated with poorer outcome (9). In contrast, Ross et al. found no link between midline shift in the pineal region and outcome in traumatic ASDH (15). However, they did identify extensive septal shifts and effacement of the perimesencephalic cisterns as poor prognostic factors. We found a significant negative correlation between midline shift and outcome in this patient group.

In their study of patients with traumatic ASDH, Domenicucci et al. identified intact subarachnoid space as a favorable prognostic factor (3). They suggested that the integral visceral membrane of the hematoma prevents diffusion of neurotoxic and vasoactive substances into the subarachnoid space. However, our results revealed no statistically significant difference in outcomes between patients with intact subarachnoid space and those who had hemorrhage in the subarachnoid space. We did note a trend towards poorer prognosis in the patients with SAH.

Our investigation identified BCO as a significant prognostic indicator. The mortality and functional recovery rates for patients with this finding on initial CT were 93% and 7%, respectively. Brain swelling may be responsible for this change and the associated poor outcome. Ross et al. noted effacement of the perimesencephalic cisterns as a poor prognostic factor in patients with intracranial hematoma (15). Our findings related to the basal cisterns are line with these results.

Brain contusion in patients with traumatic ASDH leads to decreased cerebral blood flow (14), increased ischemic damage (5,13), and rapid development of brain swelling (1,6). Further, intraparenchymal hematomas may result in increased intracranial pressure and midline shift. These intracranial space-occupying lesions should be considered poor prognostic factors. A report by Massaro et al. on CT findings in patients with traumatic ASDH pointed to concomitant brain damage as the most important factor related to outcome (12). We also found the presence of IPH/C in the same hemisphere to be a significant prognostic indicator. Bleeding into the cerebral parenchyma, irreversible vascular damage, and brain laceration may all trigger ischemic neural damage. Moreover, experimental studies have shown that evacuation of an intraparenchymal hematoma does not significantly reduce the focal progression of ischemia and edema (10). This is one reason why immediate medical treatment is crucial for preventing secondary brain injury in traumatic ASDH.

Zumkeller et al. observed that the difference between midline shift and hematoma thickness was a significant prognostic indicator for patients with traumatic ASDH (18). The authors used this parameter as a measure of brain edema and coined the term "brain-swelling factor." They reported that increased BSF was associated with lower survival rate. In our study, we found a significant relationship between BSF and outcome. Increased BSF was associated with poor prognosis. As Table 6 shows, positive values, zero values, and minus values close to zero are indicators of poor prognosis. Our results are in line with those of Zumkeller el al. (18), and provide further evidence that BSF on initial CT is one of the main predictors of outcome in cases of traumatic ASDH.

In summary, we conclude that initial CT findings of extensive midline shift, BCO, IPH/C in the same hemisphere, and BSF are important predictors of prognosis in cases of traumatic ASDH. In contrast, single assessment of hematoma thickness and presence of SAH are not good predictors of outcome in these patients.

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***Hyperacute measurement of intracranial pressure, cerebral perfusion pressure, jugular venous oxygen saturation, and laser Doppler flowmetry, before and during removal of traumatic acute subdural hematoma.***

*Verweij BH, Muizelaar JP, Vinas FC.*

**Intracranial pressure is higher than previously suspected and CPP is very low in patients with ASDH. Removal of the bone flap yielded a significant reduction in ICP, which was further decreased by opening the dura and evacuating the hematoma. The SjvO2 as well as laser Doppler flow increased in all patients but one immediately after removal of the hematoma.**