Early and Delayed CT Findings in Patients with Mild-to-Moderate Head Trauma

Hafif-Orta Kafa Travmalı Hastaların Erken ve Geç BT Bulguları

Sedat DALBAYRAK1, Sevtap GUMUSTAŞ2, Ahmet BAL1, Gur AKANSEL2
1Dr. Lütfi Kürdard Kartal Research and Training Hospital, First Neurosurgery Clinic, Istanbul, Turkey
2Kocaeli University, Faculty of Medicine, Department of Radiology, Kocaeli, Turkey

ABSTRACT
AIM: The aim of this study is to evaluate the changes between the initial and late cranial CT scans in patients with mild-to-moderate head trauma.
MATERIAL and METHODS: Of the two thousand six hundred and forty-four patients hospitalized for head trauma within a two-year period, 112 (4.24%) patients scored 8 or above in the Glasgow coma scale and there were changes between initial and late head CT.
RESULTS: Of these, 103 had worsening CT findings. Neurological status deteriorated in 30% of these cases. Forty-six patients required surgery based on findings seen on the delayed scans. Neurological status was stable in 50% of the cases. All the eight patients who expired had abnormal CT scans initially and had progression in their late scans.
CONCLUSION: In patients with mild-to-moderate head trauma, serial CT scanning may independently modify treatment decisions in a subgroup of patients. Judgment for delayed scans should be made on an individual basis by taking the risk factors into account.
KEYWORDS: Head trauma, Computed tomography, Intracranial hemorrhage, Glasgow coma scale

ÖZ
AMAÇ: Bu çalışmanın amacı, hafif-orta kafa travması olan hastalarda başlangıçta ve sonrasında kranial BT taramalar arasındaki değişikliklerin değerlendirilmesidir.
YÖNTEM ve GEREÇLER: İki yıllık sürede kafa travması nedeniyle yatış yapılan 2,644 hastanın 112’sinde (%4,24) Glasgow koma ölçeğinde puan 8 ve üzeri olduğu ve geç BT taramalarında değişiklik görüldü.
SONUC: Hafif-orta kafa travması olan hastalarda seri BT taramaları bir hafif alt grubunda tedavi kararlarının bağımsız olarak değerlendirilebilir. Geç tarama kararları risk faktörlerini hesaba katarak her hasta için ayrı ayrı verilmelidir.
ANAHTAR SÖZCÜKLER: Kafa travması, Bilgisayarlı tomografi, Intrakranyal kanama, Glasgow coma skoru

INTRODUCTION
The neurosurgery literature is replete with studies and reviews on the use of computerized tomography (CT) scanning in the evaluation of the head trauma patient. Several papers focus on the difficult issue of selecting patients who require CT scans (10,26,38,49). No universal agreement has been reached on the routine use of head CT in cases of less severe head trauma (37,38,49). A number of investigators advocate routine sequential CT scans for follow-up of the head trauma patient (8,15,29,35,43). Relatively little has been published in the radiology literature regarding early and late changes in the head CT scans of trauma patients.

Our aim in this study is to share our observations in a relatively large number of head trauma patients with mild-moderate head injury and their serial CT findings displaying changes.

MATERIAL and METHODS
Two thousand six hundred and forty-four sequential cases admitted to our emergency service and treated with hospitalization with mild or moderate severity head traumas (Table I) within a period of two years were analyzed retrospectively. According to our protocol, CT scan was performed within the first one hour for all the cases according to the protocol of our hospital. Patients that surgery was performed according to the results of the initial CT result were not included in the study. A second CT scan was performed within the first 8 hours following admission for all the 2644 patients included in the study.

Cranial CT scans were performed using a third generation CT scanner within intravenous contrast substance. Sections were...
taken as parallel to the orbitomeatal line, in 5mm thickness for the posterior fossa and 10mm thickness for the brain, and with 1mm intervals for all.

Of the 2644 patients, 2532 (95.76%) were stable according to CT findings, while for the remaining 112 (4.24%) patients, there were changes between the first and second scans (regardless of the initial CT findings or the direction of change).

Clinical and radiological follow-up data of all the cases were recorded. Initial and control CT findings were compared. Increasing or reducing intracranial pathologies were determined. Treatment modes were determined according to the control data. Reflections of the radiological changes in the neurological picture were analyzed.

Follow-up data for the weeks 2 and 6 following the discharge are present for all the patients.

**FINDINGS**

When we evaluated the CT scans of 2644 patients, 5 different causes of head trauma were identified: falls, traffic accidents, physical abuse (non-penetrating injury), penetrating injury and birth trauma (Table II). One hundred and twelve patients who were investigated in detail that changes were found between the initial and control CT scans constituted the 4.24% of the patients admitted to the emergency service within the study period with mild- to moderate head traumas. Of these, 75 (67%) were males and 37 (33%) were females. The range of age was between the neonatal period (first day of life) and 97 years of age, the mean age was 30.88 years.

There was mild trauma in 81 patients according to initial GCS scores (GCS scores between 13 and 15; 72.3%), and moderate-level trauma in 31 patients (GCS scores between 9 and 12; 27.7%). The initial GCS scores of 112 patients are given in Table III. The results of the initial CT scans are given in Table IV. Within 8 hours of admission, a second CT scan of head was obtained in all patients. Table V summarizes the distribution of patients with change from the initial study. Table VI shows the type of change in lesions detected by serial CT scanning for the lesion types seen.

Eight patients (7.1%) where changes were observed in the control CT findings died. All had initial abnormal CT studies with progression on the delayed scans. Seven of these patients (87.5%) were of 65 years or older age.

While the initial CT scans of the 91 patients out of 112 (81.3%) were abnormal, for the 21 (18.7%) normal initial CT scans were obtained. Fourteen patients out of 21 with normal initial CTs (66.7%) had mild traumas and 7 (33.3%) had moderate-level traumas. Surgery was required in four patients out of 14 in the mild trauma group with normal initial CT scores because of the lesions found in the second CT scan (two epidural hematomas and two intracerebral hematomas) (Figure 2A-C). Surgery was required in two patients out of the 7 in the moderate trauma group with normal initial CT scores because of the lesions found in the late scan.

While the CT findings deteriorated in 103 of the patients out of 112 (91%) CT (with newly-appearing lesions or the increase in the size of the known lesion), late CT findings improved only in 9 (8%). Neurological deterioration was seen in 34 patients out of 103 (33%) with deteriorating CT findings. Surgery was required for 22 (64.7%) of these patients (Figure 1A-C).

Forty-six patients out of 112 (41.1%) required surgery according to the late CT findings. In these forty-six patients, the reason for surgery was deterioration in CT findings (Table VII). When compared to the total number of hospitalized patients (2,644), the rate of these 46 patients requiring surgery was 1.7%. The neurological status of the 24 patients with deteriorating CT findings (52.2%) was stable (Table VIII).
While surgery was required in 28 patients out of 81 with mild traumas (34%), the same was required in 18 patients out of 31 with moderate-level traumas (58%). The reason for surgery according to control CT scans performed in 24 patients out of 28 (85.7%) patients with mild traumas, and in 16 patients out of 18 (88.9%) with moderate traumas was deterioration of the abnormality in the CT scan (Figure 3A,B). Surgery was required because of epidural hematoma (EDH) in two patients out of four who had mild traumas and that initial CT scans were normal, and because of intracerebral hematoma (ICH) with delayed appearance in the remaining two. In these patients, neurological deterioration did not accompany the changes in CT findings.

The neurological picture in the four patients out of 18 that surgical treatment was applied according to the control CT scans was stable. Of these eighteen patients, no prominent intracranial pathologies were seen in the initial CT scans. One of these patients was operated because of ICH, and the other was operated for EDH.

Table V: The Distribution of 112 Patients According to the Location and Type of Change on the Second CT Scan Compared to the Initial Scan

<table>
<thead>
<tr>
<th>The change on the second CT scan from the initial</th>
<th>Location of pathology</th>
<th>Type of pathology</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>New lesion on the second scan not present initially</td>
<td>intraaxial extraaxial</td>
<td>ICH EDH SDH</td>
<td>15 5 1 6</td>
</tr>
<tr>
<td>21 patients (18.75%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in size of the lesion present on the initial scan</td>
<td>intraaxial extraaxial</td>
<td>ICH EDH SDH pneumocephalus</td>
<td>47 17 12 6 35</td>
</tr>
<tr>
<td>82 patients (73.21%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease in size or disappearance of the initial lesion</td>
<td>extraaxial</td>
<td>SDH EDH</td>
<td>6 3</td>
</tr>
<tr>
<td>9 patients (8%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ICH: intracerebral hemorrhage, EDH: epidural hemorrhage, SDH: subdural hemorrhage.

Table VI: The Type of Change on Serial Scanning According to Pathology

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Appeared with delay</th>
<th>Increased</th>
<th>Decreased</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICH</td>
<td>15</td>
<td>47</td>
<td>None</td>
</tr>
<tr>
<td>EDH</td>
<td>5</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>SDH</td>
<td>1</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>SAH</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Pneumocephalus</td>
<td>None</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Table VII: The Distribution of 46 Patients Requiring Surgery due to Worsening CT Findings According to Type of Pathology and Severity of Head Trauma

<table>
<thead>
<tr>
<th>Reason for surgery</th>
<th>Appeared with delay</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDH (19 patients: 1 mild, 18 moderate)</td>
<td>3 (2 mild, 1 moderate)</td>
<td>16 (all moderate)</td>
</tr>
<tr>
<td>SDH (12 patients: 4 mild, 8 moderate)</td>
<td>0</td>
<td>12 (4 mild, 8 moderate)</td>
</tr>
<tr>
<td>ICH (13 patients: 4 mild, 9 moderate)</td>
<td>3 (2 mild, 1 moderate)</td>
<td>10 (1 mild, 9 moderate)</td>
</tr>
<tr>
<td>Tension pneumocephalus (2 patients: both moderate)</td>
<td>0</td>
<td>2 (both moderate)</td>
</tr>
</tbody>
</table>


Table VIII: The Distribution of 82 Patients with Worsening CT Findings According to Change in Neurological Status and Necessity of Surgery

<table>
<thead>
<tr>
<th>Neurologically stable</th>
<th>Neurologically deteriorated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underwent surgery</td>
<td>24</td>
</tr>
<tr>
<td>Surgery not required</td>
<td>24</td>
</tr>
</tbody>
</table>
Disappearance of the abnormality in the initial CT scan after the interval was the most frequent in subdural hematomas (SDH) (Figure 4A,B) followed by EDH (Table V).

**DISCUSSION**

The goal of emergency CT scanning in head trauma patients is to depict lesions that need neurosurgical treatment or that can need alternative medical therapy. There is wide agreement on the use of CT in head trauma patients with moderate or severe head injury according to the GCS scores (24). In mild head injury there can also be life-threatening complications that can need further treatment (5). There are some guidelines published regarding the use of CT in patients with mild head trauma (5,6,24,40,45).

In our group of patients hospitalized with mild to moderate trauma and changes in serial CT findings, 27.7% had moderate head injury. Majority (78%) of these patients had
initial CT scan abnormalities. Fifty-eight percent of these patients required surgery due to worsening CT findings or deteriorating neurological status. Two patients (0.06%) were operated due to lesions that were not present on initial CT scans. The majority (72.3%) of our patients had mild head trauma according to the GCS scores. This class constitutes a more heterogeneous group of patients regarding the diagnostic and therapeutic needs as well as the prognosis (9,12,46,48). Due to the increasingly evident inadequacy of GCS scoring system in diagnostic and therapeutic decision making in this group, the definition of mild head injury has been questioned in the neurosurgery literature (46,47). Attempts have been made to further divide this class into high and low risk subgroups by the use of additional clinical data such as loss of consciousness, presence of amnesia, nausea-vomiting, old age, depressed skull fracture, and basal fracture (10,26,37,38,46,48). Hence the term “minor or minimal head injury” describing patients with GCS scores of 13-15, normal neurological examination, and a history of loss of consciousness / amnesia. Efforts have concentrated on separating patients with GCS scores of 13-14 from those with 15 (9,12). Most of these attempts aimed at selecting patients who require CT scanning and / or hospitalization. Although no combination of clinical data could consistently predict CT findings (thereby eliminate the need for CT in a subgroup of patients), debate still continues regarding the benefit of routine CT scanning in patients with minor head injury. The authors who argue against the routine admission CT refer to the fact that only a small percentage of patients with low risk factors will harbor intracranial lesions requiring surgery (37). Objections to this point of view come from those who argue that, especially in the pediatric population, missing this minority who require surgery has severe implications (38,49). The risk factors identified in the literature to be associated with a greater percentage of positive CT findings in head trauma patients are: presence of coagulopathy (34), loss of consciousness (1,14,28), amnesia (1,38), skull fracture (14,26), basilar skull fracture (2,17), old age (2,17,38), white race (12), type of trauma (being a pedestrian or cyclist hit by a vehicle, or being an assault victim) (2,17), severe headache, nausea / vomiting (26), type of SAH, DAI, edema (31), cranial soft tissue injury (2), focal neurological deficit, initial low GCS and decreased GCS after appearance in the emergency department (28) and ethanol intoxication (13). Compagnone et al (7) found that when admission CT showed diffuse injury, the risk of progression to a mass lesion is 23%, and 22% of these patients need an emergency craniotomy. Investigators found that when GCS score was 9 or 10 the predictor of the worst outcome was a low motor GCS score but when GCS score was 11 to 13 the factors that associated with worst outcome were neurological worsening, seizures and medical complications (7). Although it was not our aim to evaluate the risk factors, the old age stood out in addition to the initial GCS score as a risk factor for both injury requiring surgery and poor prognosis in our study.

A growing number of observations on delayed injury after head trauma have been published (8,15,16,18,29,35,36,43,44). In some studies, early progressive head injury was documented in up to 50% of patients without initial warning of clinical symptoms or CT scan findings (22,29,43). Broderick et al (3) revealed doubling in volume of intracranial hematomas within 12 hours in 40% of patients. Changes from the initial CT have been detected up to 2 weeks after trauma. Nearly all of these observations were made on patients with moderate to severe head trauma.

Imhof et al (15) reported worsening of CT findings in 45% of cases up to 2 weeks after trauma regardless of the initial GCS scores on patients with mild-to-moderate head injury. Livingston et al (21) concluded that patients with minimal head trauma could be safely discharged if their initial helical CT of head was negative. In that study, only 5 of the 1,788 patients those with initially negative CT required surgery later. In our study, of the 21 patients whose initial CT scans were normal, 5 required surgery because of the delayed appearance of CT findings. This constitutes 0.2% of the patients hospitalized within the study period. In this group two patients had mild trauma (1 EDH, 1 ICH-HC). This constituted 0.06% of the hospitalized patients.

Several investigators have made an effort to correlate poor prognosis after head trauma with the initial CT findings. Recently Smits et al (41) investigated outcome for minor head trauma patients and found that diffuse axonal injury was associated with higher grades of functional disability on all outcome scales, where intraparenchymal contusions and subdural hematoma were associated with poor outcome according to Glasgow Outcome Scale and Barthel Index. Maas et al (23) studied moderate to severe head trauma and advised a prognostic CT scale for probability of mortality but they did not assess patients with mild trauma. In the pediatric age, the presence of SAH, DAI or edema has been reported to indicate a worse prognosis (31). Presence of SAH, along with a higher grade of initial scan severity using an overall grading system from normal to severe diffuse injury correlated with
worse prognosis in another study (50). Edema, intraventricular hemorrhage and greater midline shift were associated with poorer outcome in another study (11). In our study, most (87.5%) of the expired patients were of age 61 and above.

MRI has been shown to detect traumatic intraaxial CNS lesions more sensitively than CT (19,27). In patients with mild head trauma and normal initial CT scans, MRI detected DAI in 30% (30). With the advent and wider availability of faster scanning techniques, MRI will probably be performed more frequently, especially on patients with less severe trauma who do not require life support equipment. MR spectroscopy and diffusion-weighted MRI are other promising applications with theoretical capability of detecting trauma-induced changes in normal appearing tissue (4,32,39,42). The impact of these novel techniques on treatment decisions remains to be seen.

In our population of patients with mild-to-moderate head trauma and serial CT changes, initial neurological status or changes in neurological status during follow-up were not helpful in predicting the requirement for surgery. Fifty-two percent of patients requiring surgery for evolving CT scan abnormalities remained neurologically stable. Half of the patients with stable neurological status required surgery. Of those with deteriorating neurological status, 33% did not require surgery.

In our study, all studies were reviewed using hardcopy films. Digital reading which permits adjustment of window level and width of images on digital screen could theoretically allow us detect additional patients with more subtle findings on initial or late scans. Such manoeuvres have been documented to allow detection of cerebral infarcts more sensitively (20). The use of a spiral CT scanner could theoretically increase the sensitivity for smaller lesions. However, the surgical treatment decision would be unlikely to be altered.

CONCLUSION

In mild-to-moderate head trauma, late CT scanning of head identifies a subgroup of patients who will benefit from surgical intervention that would otherwise be delayed or missed. Although the number of such patients seem to be relatively low this can be the recommended way especially for patients who have additional risks such as pediatric or old age, coagulopathy and severe neurological symptoms etc.

The decision on the necessity of follow-up CT scans should be made on individual patient basis. Further studies correlating risk factors and prognosis in head trauma may result in more effective use of CT scanning. Radiologists interpreting head CT scans of trauma patients should be aware of the time of trauma as well as factors associated with increased risk of progressive injury and recommend serial studies when they consider necessary.

REFERENCES


