Posttraumatic Unilateral Diffuse Cerebral Swelling

Travma Sonrası Tek Taraflı Yaygın Beyin Şişmesi

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Abstract: A series of 41 patients with posttraumatic unilateral diffuse cerebral swelling was studied in order to assess clinical, radiological and operative findings, to determine the incidence and outcome, and to seek features that might identify patients at high risk of unilateral cerebral swelling and a poor outcome. Diffuse and massive expansion of a single cerebral hemisphere, causing marked midline shift on computed tomography was used for diagnosis of these cases. Of 280 severely head injured patients, 14.64 % had a diagnosis of unilateral diffuse cerebral swelling. The most common associated intracranial pathology was subdural hematoma, found in 68.29 % of patients. The mortality rate was 53.65 %, and 34.14 % of patients had functional recovery. This study indicates that the patients at greatest risk of developing posttraumatic unilateral diffuse cerebral swelling are; those with acute subdural hematoma on the initial cranial computed tomography, low post-resuscitation Glasgow Coma Scale score, one or more abnormal pupils, or systemic injuries especially if major chest trauma or hypotension is involved.
Key words: Cerebral swelling, head injury, subdural hematoma

Özet: Travma sonrası tek taraflı yaygın beyin şişmesi olan 41 hasta, klinik, radyolojik ve cerrahi bulguları, sıklık ve sonucu belirlemek, bu durum yönünden yüksek risk taşıyan ve kötü sonlanabilecek hastalar ayırmaya yarayabilecek özellikleri saptamak amacıyla incelendi. Hastaları belirlemede bilgisayarlı tomografi görüntülerindeki bulgulardan (bir hemisferin belirgin orta hat kaymasına neden olan yaygın ve ağır şişmesi) yararlanıldı. Ağır kafa travmalı 280 hastanın % 14.64'ünde tek taraflı yaygın beyin şişmesi vardı. En sık görülen ek kafaiçi patoloji subdural hematomdu (% 68.29). Ölüm oranı % 53.65'tir, hastaların % 34.14ünde işlevsel iyileşme görüldü.Travma sonrası tek taraflı yaygın beyin şişmesi açısından en fazla risk taşıyan hastalar, ilk beyin tomografilerinde akut subdural hematomu olanlar, canlandırma sonrası Glasgow Koma Ölçeği puanı düşük olanlar, pupil anormalliği olanlar ve sistemik yaralanması (özellikle göğüs travması ve hipotansiyon) olanlardır.

Anahtar sözcükler: Beyin şişmesi, kafa travması, subdural hematom

INTRODUCTION

Many clinical factors have been shown to predict the outcome in patients with head injuries. Potential risk factors are the patient's age, the admission Glasgow Coma Scale (GCS) score, pupillary responses, the presence of associated injuries, hypotension, hypoxia and certain intracranial hemorrhages (1, 4, 5, 6, 11, 14, 20, 25, 27, 28, 30). These risk factors are recognized to be significantly related to the prognosis of severe head injury. In addition, some authors have reported that the outcome tends to be worse for patients with posttraumatic unilateral diffuse cerebral swelling (UDCS) associated with uncontrollable intracranial hypertension (5,6,8,12,13,22). Despite the advent of emergency medical service systems, neuroradiological techniques, and aggressive intracranial pressure (ICP) monitoring and treatment, posttraumatic UDCS carries risk of high mortality. Presently, the mortality rate is reported to be between 50 and 90 % (5,6,8,13,22).

The importance of early gross pathological features in patients with severe head injuries is emphasized by showing that they can be predictors of undesirable events, particularly abnormal ICP and death (5,29). Computed tomography (CT) has made the recognition of UDCS possible in head injured patients. This pathological condition is diagnosed by a diffuse and massive expansion of a single cerebral hemisphere, causing marked midline shift (5,13,22). It is customary to explain acute traumatic unilateral cerebral swelling in terms of volume increases within the cerebral parenchyma, caused either by parenchymal hematoma, by contusion associated with increased tissue water (edema) or by cerebral blood volume. However, cerebral hemodynamics associated with acute UDCS, without cerebral hematoma and contusion, are not completely understood.

The aims of this study are to compare the clinical, radiological and operative findings, and to determine the incidence and outcome of posttraumatic unilateral diffuse cerebral swelling, and to seek features that might identify patients at high risk of unilateral diffuse cerebral swelling and a poor outcome.

CLINICAL MATERIAL AND METHODS

From 1990 to 1995, 280 severely head injured patients with Glasgow Coma Scale (GCS) scores of 8 or less were admitted to our department. From these patients, we studied 41 patients diagnosed as having UDCS either alone or in association with acute extra-axial hematoma.

All patients were seen by a neurosurgeon in the emergency room where stabilization and initial neurological evaluation were carried out. The patients with pupillary changes, motor abnormalities, hypotension (systolic blood pressure<90 mmHg), hypoxia (PaO2<70 mmHg), or severe life threatening injuries to any other organ system were recorded. The diagnosis of posttraumatic UDCS was made by CT of the head. The patients that showed midline shift of 4 mm or more associated with diffuse and massive expansion of one hemisphere without parenchymal hemorrhage and contusion on the CT scan, was evaluated for the diagnosis of post-traumatic UDCS. The CT scans were performed on admission and were repeated within 72 hours at the postoperative period. In the case of an urgent operation a CT scan was performed only after the operation because of herniation. The last CT scan was performed before discharge from the hospital, if there was no neurological deterioration previously. Measurement of the midline shift was performed at the level of septum pellucidum. Any patient fitting the clinical criteria for brain death on admission and patients with open head injury such as depressed skull fracture or gunshot wounds were excluded from this study. Patients who had focal mass lesions, such as brain contusion or intra-parenchymal hematoma on the CT scan were also excluded because the midline shift was due to a different mechanism. The 41 patients studied were categorized into three groups based on CT and surgical criteria. Group 1: Patients with UDCS causing only marked midline shift(> 4 mm). Group 2: Patients with persistant marked midline shift after evacuation of an acute extra-axial hematoma. Group 3: Patients with non-surgical acute extra-axial hematoma (acute extra-axial hematoma less than 3 mm in thickness).

Early intubation, ventilation, hemodynamic stabilization, and then fractioned osmotherapy with mannitol (0.25 gm/kg, q 6 hours) and furosemide (1 mg/kg, q 6 hours) were the standard therapy of these patients. The management of some patients was continued by administration of thiopental (1-4 mg/kg/h). All patients received loading doses of diphenylhydantoin, prophylactic antibiotics, and relative fluid restriction (1500 to 2000 ml/day). ICP was continuously recorded epidurally in 13 patients by The Brain-Pressure Monitor, probe-1 (Spiegelberg, Hamburg, Germany). The outcome was assessed according to the Glasgow Outcome Scale (GOS) (9). The results were expressed as the mean ± standard deviation. The t test was employed for statistical comparison of the values.

RESULTS

Of 280 severely head injured patients 41 (14.64 %) had a diagnosis of unilateral diffuse cerebral swelling.Thirty-six patients were men and five were women. Their ages ranged from 8 to 76 years, with a mean of 33.58±16.09. The most frequent cause of head injury was motor vehicle accident, the cause of injury in 31 of the 41 patients. On neurologic evaluation, the average GCS for all patients was 5.31±1.33. Twenty patients had fixed pupillary dilatation, which was unilateral in 15 and bilateral in 5. Thirteen suffered from multiple injuries, including significant chest, abdominal, or orthopedic injuries. A clinical summary of these patients is given in Table I.

Table I. Clinical summary of patients with posttraumatic unilateral diffuse cerebral swelling.

	No	%
Cause of injury		
motor vehicle accidents	31	76
non-motor vehicle accidents	10	24
Skull fractures	23	56
Glasgow Coma Scale score		
3-5	25	61
6-8	16	39
Hypoxia/Hypotension	16	39
Pupillary changes/lateralization	33	80

Radiographic studies revealed a linear fracture in 21 patients, and a minimally depressed skull fracture in 2; 18 patients had no skull fracture. The most common type of fracture was a linear fracture ipsilateral to the hemispheric swelling. On the initial CT scan, unilateral brain swelling appeared as an isolated lesion in only two patients (Group 1). There were 30 patients in Group 2 (hemispheric swelling with extraaxial hematoma requring surgery), and 9 patients in Group 3 (hemispheric swelling with extraaxial hematoma not requiring surgery) (Figures 1 and 2). The patients who were in the non-motor vehicle accident injury category had an 80 % incidence of extra-axial hematoma requiring surgery. The overall incidence for the entire group of mass lesions requiring surgery was 73 %. Table II shows the classification of

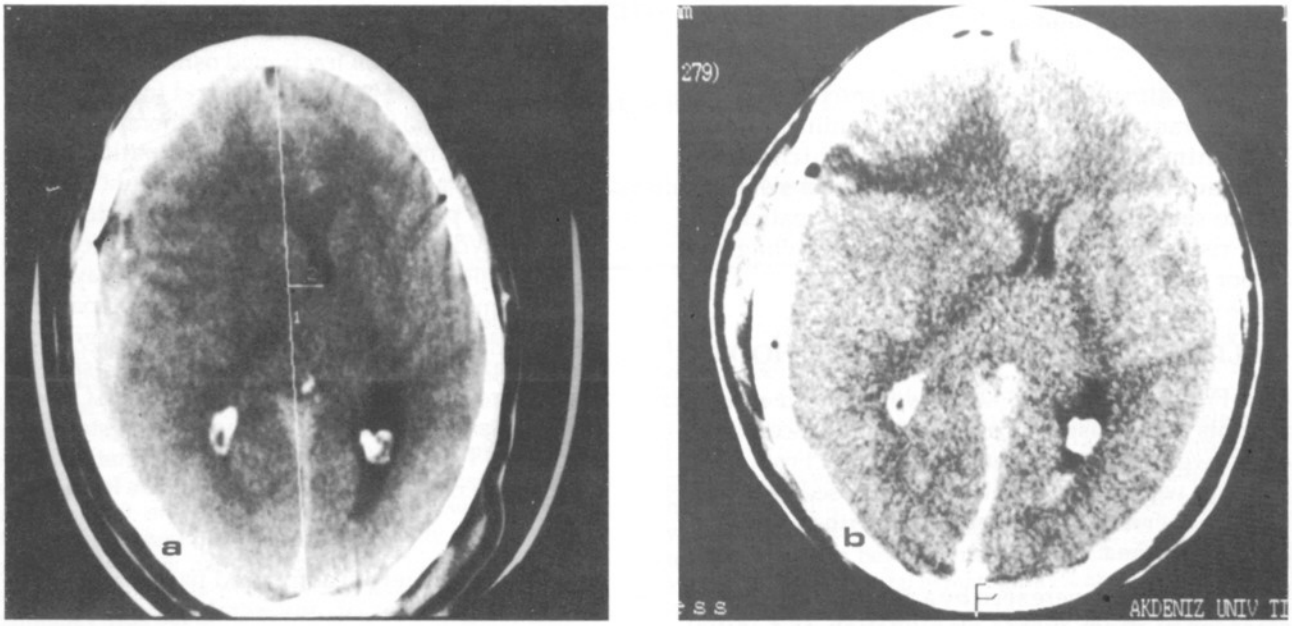
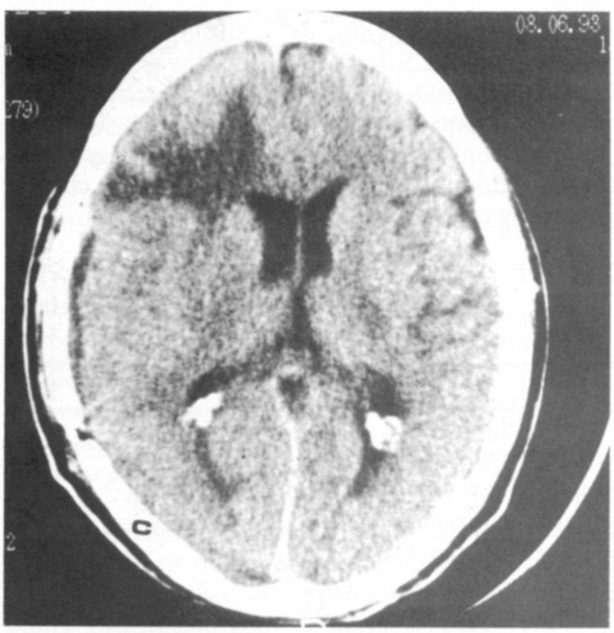


Figure 1:Computed tomography scans of a case with unilateral cerebral swelling after evacuation of acute subdural hematoma. These scans were obtained pre-operatively (a), post-operatively (b) and at the discharge (c, below).



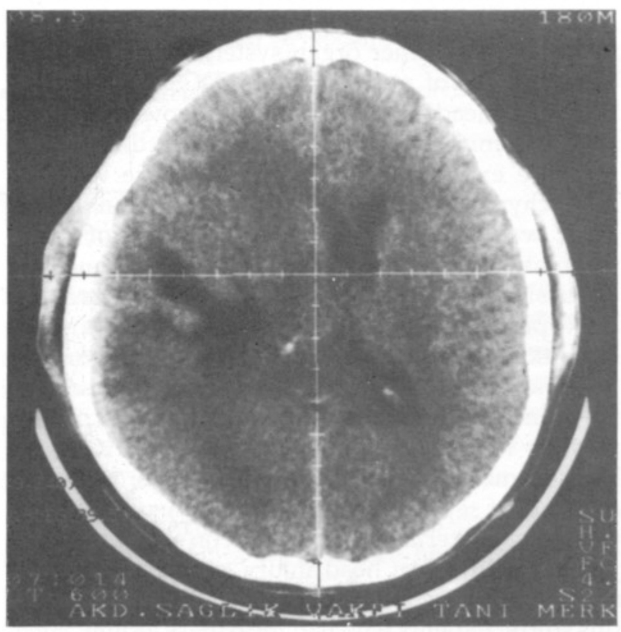


Figure 2: Computed tomography scan of a patient with hemispheric swelling and acute subdural hematoma not requiring surgery.

Table II. Classification of computed tomography and operative findings, and the correlation between radiological/operative features and midline shift in 41 patients with posttraumatic unilateral diffuse cerebral swelling.

	No	Cases %	Midline Initial	shift (mm) Control(*)
Group 1: Isolated UDCS(**)	2	4.87	6.5	6.5
Group 2: UDCS with extra-axial hematoma requiring surgery				
acute subdural hematoma	19	46.34	10.72±2.96	10.21±3.50
acute extradural hematoma	8	19.31	7.87±2.83	6.12±3.35
acute sub/extradural hematoma	3	7.31	5±0.0	5.4±0.6
Group 3: UDCS with subdural hematoma not requiring surgery (laminar subdural collection)	9	21.95	.65±2.29	5.71±2.62

(*) According to the second CT performed within 72 hours of injury.
(**) Unilateral diffuse cerebral swelling.

CT and operative findings, and the correlation between radiological/operative features and midline shift. Most commonly associated intracranial pathology was subdural hematoma, found in 68.29 % of patients. Epidural hematomas were found in 19.31 %, and epi-subdural hematomas were found in 7.31 % of patients. Those patients requiring evacuation of the extraaxial hematoma had a significantly increased incidence of postoperative ICP elevation (44.85 ± 24.88 mmHg).

All patients had careful monitoring of fluid balance, blood pressure, and blood gas levels. Six patients received mannitol and furosemide. The mean GCS score of the patients who received only hyperosmolar therapy was 7.21 ± 1.01. Thirtyfive patients were ventilated. Thirty patients underwent surgery for extraaxial hematoma. Fourteen patients required urgent surgery without a pre-operative CT scan, because of uncal herniation. Internal and/or external decompression was not performed. Thiopental was administered to four patients to control raised ICP, and all of these patients died.

Intracranial pressure was monitored in 13 patients, and on average, patients underwent 5 days of extradural ICP monitoring. Three of the monitored patients had a peak ICP of less than 20 mmHg while another 8 patients had sustained ICP peaks greater than 40 mmHg (uncontrolled with standard therapy). Two of the monitored patients had ICP between 20-40 mmHg. One of the patients with relatively normal ICP died from an embolic complication due to a long bone fracture while others survived with functional recovery. Between those patients with an ICP greater than 40 mmHg only one patient survived while others died. Although there was not a significant difference in the distibution of initial ICPs between the dead and the survivors, patients whose initial ICP was above 20 mmHg and was refractory to treatment had the worst overall outcome. In summary, the patients with initial ICPs less than 20 mmHg had a higher percentage chance of a good outcome and a lower mortality rate.

The mortality rate was 53.65 %, and 34.14 % of patients had functional recovery. Functional recovery is defined by the GOS as those patients with a good recovery or disabled yet functionally independent. 12.19 % of patients were severely disabled or in a vegetative state. The average age was 28.26±13.24 years for survivors and 38.18±16.98 years for those who died ($p=0.02$). The average GCS score was 6.15±1.30 among survivors and 4.59±0.86 among those who died ($p<0.0001$). Absence of pupillary light reflex and lateralization were associated with 63.63 % mortality rate ($p<0.01$) and 21.21 % functional recovery. Table III shows the clinical characteristics and outcome of unilateral cerebral swelling.

Table III. Clinical characteristics and outcome of posttraumatic unilateral cerebral swelling.

	No	Mortality(%)	p value	FS* (%)	p value
Total cases	41	53.65		21.95	
Sex					
Female	5	60		40	
Male	36	52.77		33.33	
GCS# score					
3-5	25	76		12	
6-8	16	18.75	< 0.01	68.75	< 0.01
Hpt/Hpx‡					
Present	16	75	31.25		
Absent	25	40	< 0.02	36	
PC/L§					
Present	33	63.63		21.21	
Absent	8	12.5	< 0.01	87.5	< 0.01
IMS&(mm)					
4-8	20	50		40	
9-12	12	41.66		41.66	
> 12	9	77.77		11.11	
ICP¥					
< 20 mmHg	3	33.33		66.66	
> 20 mmHg	10	70		10	

* Functional survival, # Glasgow coma scale, ‡ Hypotension/Hypoxemia, § Pupillary changes/Lateralization, & Initial midline shift, ¥ Intracranial pressure

DISCUSSION

Studies employing serial CT scanning in patients with closed-head injury have consistently shown progressive worsening or incomplete recovery in 35-65 % of the patients (2,13,14,26). The lesions present in these patients included ischemia, hemorrhage, and swelling. A review of our experience with patients with traumatic UDCS revealed that they formed 14.64 % of all severe head trauma cases recorded in our department. The incidence of traumatic UDCS in literatures has varied from 10 to 16 % (5,13). The definition of a UDCS is radiological. With the advent of CT, the diagnosis of traumatic UDCS has been simplified and delays in diagnosis have been reduced. The diagnosis was made by diffuse and massive expansion of a single hemisphere, causing marked midline shift without focal mass lesions such as brain contusion or intraparenchymal hematoma on the initial CT scan or follow up CT scans. Patients who showed marked midline shift after surgery for acute extraaxial hematoma are also included into this group.

Head injury continues to be a major cause of death in traumatically injured patients. Reports in the last decade suggest that outcomes in this patient population have improved as a result of more rapid diagnosis and neurosurgical treatment (6,22,27). However, among those patients with traumatic UDCS, about 50-90 % have died and most of the survivors are severely disabled (5,6,8,13,19). Lobato et al. (13) analyzed the clinical course and intracranial pressure changes in 55 patients with severe head injury presenting with bulk enlargement of one cerebral hemisphere within a few hours after trauma. These patients had the highest mortality (85 %), the shortest survival period, and the highest incidence of uncontrollable intracranial pressure. Nussbaum et al. (22) reported their experience with 10 patients suffering acute transtentorial herniation secondary to posttraumatic UDCS who were treated aggressively with temporal lobectomy. Their mortality was 30 %. In the series of Lobato et al. (13), it was associated with an ipsilateral subdural hematoma of variable size in 85 % of patients or with a large extradural hematoma in 9 % of patients or as an isolated lesion in 5.4 % of patients, while ten patients in the series of Nussbaum et al. (22) had both computed tomographic and clinical evidence of unilateral hemispheric shift and acute herniation without a significant subdural or epidural hematoma. Among major factors directly related to UDCS, acute subdural hematoma has been shown to have a large impact on the outcome in some cases; the patients with acute subdural hematomas have highly lethal injuries (7,8,12,13,17,22,28). Also, Eisenberg et al.(5) indicated that the volume of a mass lesion alone is not a particularly strong predictor of death. Our current study confirms this trend for patients with UDCS. The highest mortality rate is observed among patients with acute subdural hematoma (63.33 %) with overall series mortality being directly proportional to the number of subdural hematoma cases, as reported by Lobato et al. (13).

In the pre-CT era, some authors reported the correlation between traumatic extraaxial hematoma and cerebral swelling (8,18). However, these reports did not make a distinction between multifocal brain contusion, hematoma, and diffuse swelling as a cause of cerebral hemisphere enlargement, and these cases carried the highest mortality rates. The CT scan can be used to differentiate between these conditions, however CT scanning does not accurately distinguish whether hemispheric enlargement is due to increased water content or increased cerebral blood volume and can not differentiate between brain edema and early stages of infarction (13). Although magnetic resonance imaging is more sensitive to parenchymal abnormalities, the greater availability and practicability of CT make it still the mainstay of acute investigation in head injuries (10,27).

Some authors think that the efficacy of new therapeutic efforts is dependent on successful intervention in the patho-physiological mechanisms that occur early (in the first few hours) after injury (2). Once this cascade of biochemical, cellular and vascular events are understood, effective therapeutic intervention can be expected to follow. During the last decade several investigations have described changes in cerebral blood flow following severe traumatic brain injuries (3,16,21,24). These studies have shown that post-traumatic coma may be associated with marked variations in cerebral blood flow ranging from extremely low values to pronounced hyperemia. It has also been shown that defective autoregulation or impaired CO_2 reactivity may be encountered (3,19). In our cases, the high mortality in patients with posttraumatic hypotension/hypoxia, and the uselessness of hyperventilation on high ICP confirms that cerebral blood flow changes and defective auto-regulation or impaired CO_2 reactivity causes cerebral swelling.

Increased ICP and the consequent reduction in perfusion pressure is a frequent cause of death in patients with post-traumatic UDCS. After Lundberg introduced direct and continuous ICP monitoring into modern neurosurgery, monitoring and aggressive treatment of elevated ICP has become a routine procedure in the management of severely head-injured patients (1,3,11,15,16,23). Seelig et al., reported that in almost 24 % of patients with acute subdural hematoma, the postoperative ICP rises to uncontrollable levels (26). They also stated that almost half of their patients who died after evacuation of an acute subdural hematoma had uncontrollable ICP. In the Traumatic Coma Data Bank analysis, Marmarou et al. described elevated ICP in 72 % of patients with severe head injury (17). While a critical ICP level has not been definitely identified, it is probably not only the degree of elevation but also the persistence of increased ICP is important. In our series of 41 patients, ICP was monitored in 31.7 % of patients. ICP was nearly always (11 out of 13 patients: 84 %) increased in the 13 patients with ICP monitoring. Thus, adequate control of ICP must be one of the most important goals in patients with posttraumatic UDCS.

In summary, serial CT scanning can be used to define and monitor the development of post-traumatic unilateral diffuse cerebral swelling in the clinical setting. Furthermore, we believe that patients who are likely to exhibit brain swelling can be identified within the first few hours after head trauma. Patients at greatest risk of developing unilateral diffuse cerebral swelling are those with most severe head and systemic injuries, especially if major chest trauma or hypotension is involved. These patients are likely to have acute subdural hematoma on the initial cranial CT scan, a low post-resuscitation GCS score, or one or more abnormal pupils. Rapid transport from the scene of the accident, quick diagnosis, prompt surgical treatment, and aggressive therapy for intracranial hypertension must continue to be the goals in the management of all patients with post-traumatic unilateral diffuse cerebral swelling.

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