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Computerized Tomography in Acute Severe Head Trauma

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Abstract

CT findings in 59 cases of acute severe head trauma are presented. CT enabled an accurate differentiation between epidural and subdural hematomas in 100% of the cases. Not a small proportion of subdural hematoma cases was of the fulminant type which had a fatal outcome in one to 2 days after injury, in spite of intensive treatment.

In some cases traumatic intracerebral hematomas were not formed within 6 hours after injury and were demonstrated by CT more than 12 hours after causative trauma.

Cerebral contusion showed four types of CT findings, low density, high density, and isodensity with or without mass sign. Whereas many of the cases showing an area of high density on CT had poor outcomes, those with other types of CT findings had favorable prognosis.

Traumatic intracerebral hematoma should not be dealt with as an independent entity distinct from cerebral contusion but should be regarded as a variety of the latter. Accordingly, these two conditions were designated together as traumatic intracerebral lesion (TIL).

Key words: Computed tomography, head trauma, intracranial hematoma, cerebral contusion.

Introduction

In their work concerning CT of head trauma, Merino-deVillasante and Taveras, in 1976,[6] stated that CT combined with plain skull X-ray was sufficient and that angiography was unnecessary to render diagnosis in acute head trauma. At that time, having little experience with CT, the authors simply could not agree with this conclusion. At present, reviewing our data concerning the diagnostic use of CT in a series of 59 cases of acute severe head trauma, we must admit that their statement was quite correct.

The present paper describes CT findings in various types of acute severe head trauma. Reference is also made to a new concept regarding brain tissue damage which had been demonstrated for the first time by the use of CT.

Methods and Materials

From a series of patients with severe head trauma who were admitted to the Neurological Institute of Tokyo Women's Medical College during the period from September 1975 through December 1977, 59 patients who were subjected to CT during the acute stage of head injury were selected for the study. Those in whom preoperative CT was infeasible and who, accordingly, underwent operation immediately after angiography were excluded.

The clinical diagnoses based on CT findigs in this series of 59 cases were epidural hematoma in 9 cases, subdural hematoma in 7 cases, intracerebral hematoma in 10 cases and cerebral contusion in 33 cases (Table 1). The subjects ranged in age from 10 months to 76 years (average, 45 years) and consisted of 47 males and 12 females. The age distribution in individual diagnostic categories is given in Table 2.

In 24 of 26 cases of intracranial hematoma, the hematoma was confirmed at opertion. In 7 of 33 cases of cerebral contusion, operation was performed for the purpose of decompression, at which time it was ascertained that intracranial hematoma was absent or exceedingly small.

Table 1 Cases of acute head trauma and accompanying lesion

		with SDH	with ICH	with CC
Epidural hematoma (EDH)	9		(1)*	3
Subdural hematoma (SDH)	7		(2)**	4
Intracerebral hematoma (ICH)	10			7
Cerebral contusion (CC)	33	4	2	

*case of EDH with CC and ICH.
**cases of SDH with CC and ICH.

Table 2 Age group of acute head trauma cases

	Age				
	< 1	1 to 5	6 to 15	16 to 60	60 <
EDH		1	1	5	2
SDH				5	2
ICH	1		1	4	4
CC		5	6	15	7

For CT examination, EMI-scanner Mark I (160 × 160 matrix) was employed in most cases. In cases requiring coronal section, an EMI-scanner, CT 5005 (256 × 256 matrix) was used.

The time interval between trauma and CT examination was less than 6 hours in 13 cases, 6 to 24 hours in 19 cases, 24 to 72 hours in 13 cases and 3 to 7 days in 13 cases (Table. 3). In 24 cases, CT follow-ups were made one to 5 times during a period of one day to 2 months from the first CT scanning, for a total of 34 scans. These cases are also included in the present study.

Results

a) Epidural hematoma

In all 9 cases of this type of hematoma, CT scanning provided the diagnosis of epidural hematoma, which was confirmed by operation.

Epidural hematomas, insofar as they were in the acute stage, were visualized as a bicrescent-shaped high density area on CT scan and their diagnosis, including differentiation from subdural hematomas, could be made with ease and certainty (Fig. 1). However, as the example shown in Fig. 2 indicates, an epidural hematoma in high level of convexity was not identified with reasonable accuracy by the trasverse CT section alone and a definitive diagnosis could only be obtained by the use of coronal CT section.

These 9 cases of epidural hematoma were all due to coup injury. Three of them had cerebral contusion due to contrecoup injury, and one of these with intracerebral hematoma (Table 1).

All the 9 cases underwent surgery and 8 of them have been rehabilitated without residual

Table 3 Interval between trauma and CT examination

	< 6 hrs	6 to 24 hrs	24 to 72 hrs	72 hrs to 7 days
EDH	1	3	3	2
SDH	6	1		
ICH	1	2	4	3
CC	5	13	6	8

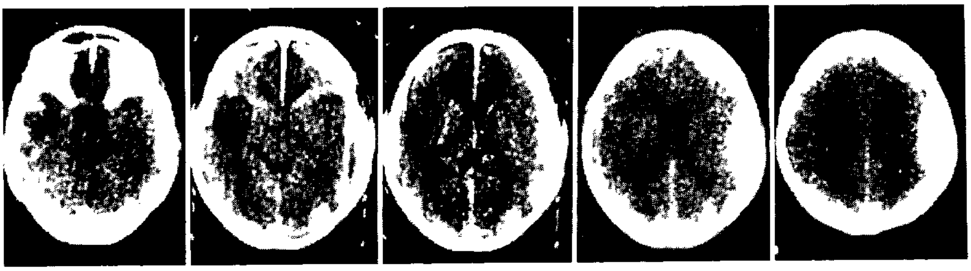

Fig. 1 Epidural hematoma. 50-year-old male. CT was taken 7 days after trauma. A characteristic biconvex appearance in the fronto-temporal area on the right side and a low density contusion, probably due to contre-coup injury, in the left temporal lobe are shown.

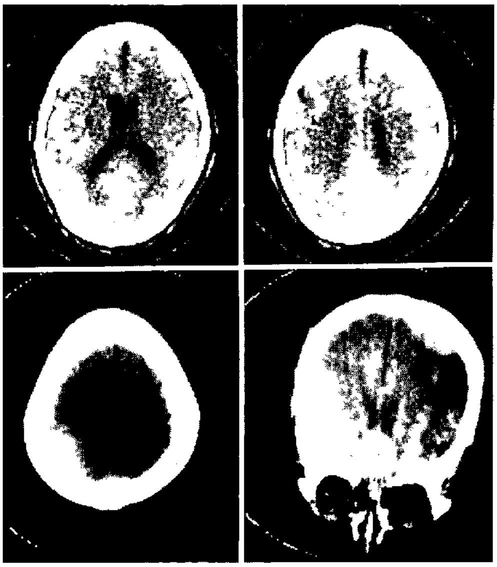

Fig. 2 Epidural hematoma. 66-year-old male. Transverse CT was performed one day and coronal CT was done 2 days after trauma. An epidural hematoma of high convexity cannot be identified with reasonable accuracy by the transverse section scan alone. A characteristic biconvex appearance is clearly visible only by the use of coronal section scan.

neurological deficit (Table 4). The remaining one case with concurrent cerebral contusion and intracerebral hematoma, died without any improvement of consciousness after the operation (Fig. 8).

b) Subdural hematoma

Seven cases of subdural hematoma could be accurately diagnosed by CT. Acute subdural

Tabel 4 Outcome of acute head trauma

	ADL				
	Excellent	Good	Moderate	Poor	Died
EDH	8				1
with CC	2				1
SDH	2				5
with CC					1
ICH	3	4		2	1
with CC	2	2		2	
CC	19	6	4	2	2
with SDH	3		3		

Excellent: social work possible
Good: domestic work possible without help
Moderate: domestic work possible with help
Poor: hospitalization or vegetative state

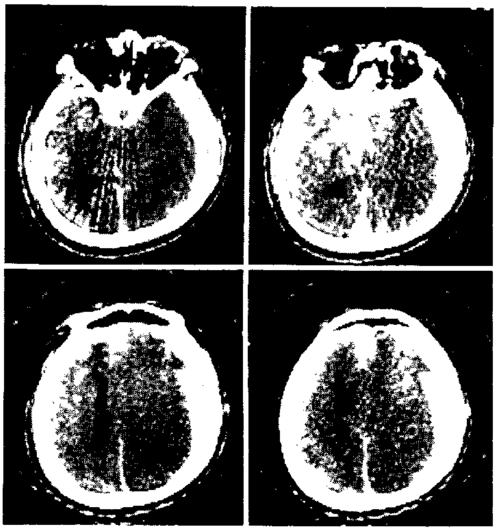

Fig. 3 Subdural hematoma. 52-year-old male. CT was performed 2 hours after trauma. A typical crescent-shaped high density area is seen on the right side. The right lateral ventricle is compressed and cannot be seen. All basal cisterns cannot be identified. Angiogram showed non-filling phenomenon.

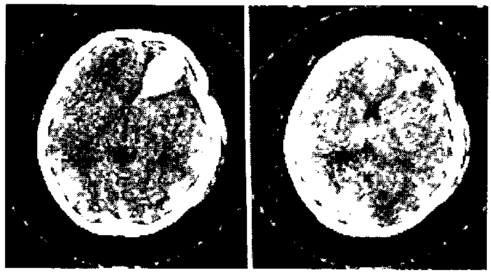

Fig. 4 Intracerebral hematoma. 12-year-old male. CT was performed 3 days after trauma. A characteristic wedge-shaped high density area is seen in the right frontal area.

hematoma, unlike epidural hematoma, appears as a crescent-shaped high density area on CT scan (Fig. 3).

Of these 7 cases, 6 underwent CT 2 to 4 hours after head injury, followed immediately by surgical evacuation of the hematoma. In 5 of these 6 cases the patients expired within 2 days after operation. The remaining 2 patients survived and returned to their jobs (Table 4).

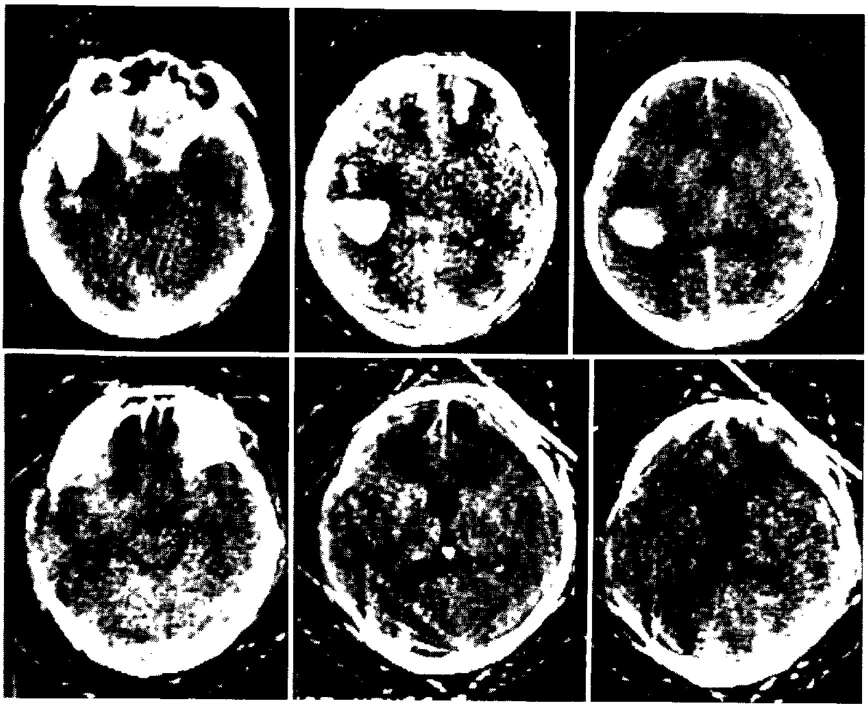

Fig. 5 Intracerebral hematoma. 49-year-old male. Three intracerebral hematomas, in the left temporal lobe and both frontal lobes are shown by CT, performed 3 days after trauma (upper). An operation was carried out immediately after the first CT examination and the hematoma was evacuated from the left temporal lobe. CT, performed 10 days after the operation, shows lesions visible as low density areas (lower).

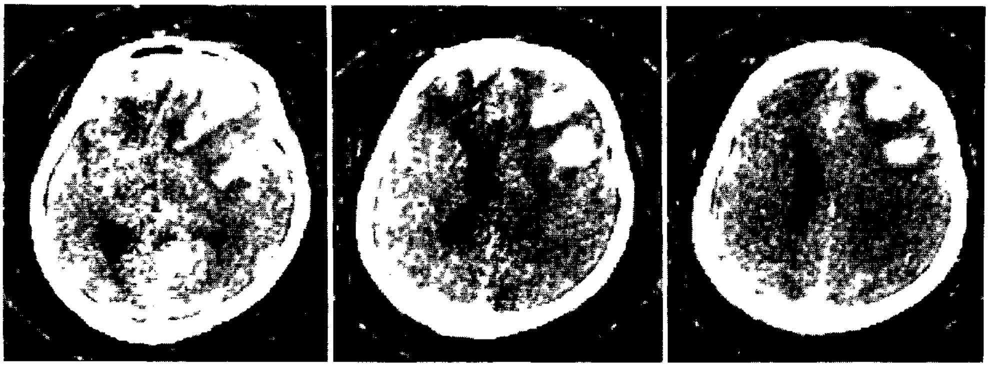

Fig. 6 Intracerebral hematomas. 59-year-old male. CT was performed 3 days after trauma. Two large hematomas with wedge-shaped appearance can be seen in the right frontal area. Some small hemorrhages can also be recognized in the left frontal area.

In 4 of the 7 cases there was a concurrent cerebral contusion and it was further complicated by intracerebral hematoma in 2 (Table 1).

c) Intracerebral hematoma

Traumatic intracerebral hematomas were visualized on CT as a fan-shaped (or the so-called wedge-shaped) high density area extending from the white matter to the gray matter (Figs. 4 and 6), which were dissimilar to intracerebral hematomas resulting from hypertensive cerebrovascular diseases. The hematoma appeared as an area of heterogenous high density and its margin was rather blurred compared to hypertensive intracerebral hematoma.

Traumatic intracerebral hematoma was frequently multiple; in 6 of 10 cases (Fig. 6), was bilateral in 3 cases (Fig. 5), and was complicated by cerebral contusion in 7 of 10 cases (Table 1).

In one case intracerebral hematoma was identified by CT within 6 hours after head injury, while in 2 others, as shown in Fig. 7, CT provided definitive diagnostic evidence of intracerebral hematoma more than 12 hours after injury.

Changes of CT findings by conservative treatment were investigated in 2 nonoperative cases (Figs. 9, 10), and it became obvious that a decrease in the density of hematoma and blurring of its margins began one to 2 weeks after injury. The high density changed into isodensity or low density in 2 to 4 weeks. This pattern of change was essentially identical with that of hypertensive intracerebral hematoma.[7]

A study of the outcome of CT-diagnosed cases of intracerebral hematoma (Table 4) showed that in 7 of the 10 cases, including 2 nonoperative cases, the patients were successfully rehabilitated or became capable of domestic work without help. There was only one fatal case; the patient was a 10-month-old female, who was first seen 4 days after sustaining injury and immediately underwent operation.

d) Cerebral contusion

Diagnostic features of cerebral contusion provided by CT consist of two factors, i.e., change in density and mass sign. CT findings in cerebral contusion were classified into the following four types: low density, high density, and isodensity with or without mass sign (Figs. 11, 12, 13). Of the entire 33 cases of cerebral contusion, 16 (48%) were classified as low density, 10 (30%) as high density, 3 (9%) as isodensity with mass sign and the remaining 4 (12%) as isodensity without mass sign.

Table 5 gives the ADL grading at the time of discharge or 3 months after injury in relation to the classification of CT scan density of lesion. As can be seen, whereas only 4 of 10 cases with high density had a favorable outcome, 21 of 23 cases with low density or isodensity had a similar outcome. Of the 4 cases in which CT scans were free from abnormality, 3 were successfully rehabilitated. In the remaining one case, the patient being elderly, died of supervening acute heart failure 17 days after head injury.

A comparative study was made concerning relation between the mass sign on CT and the

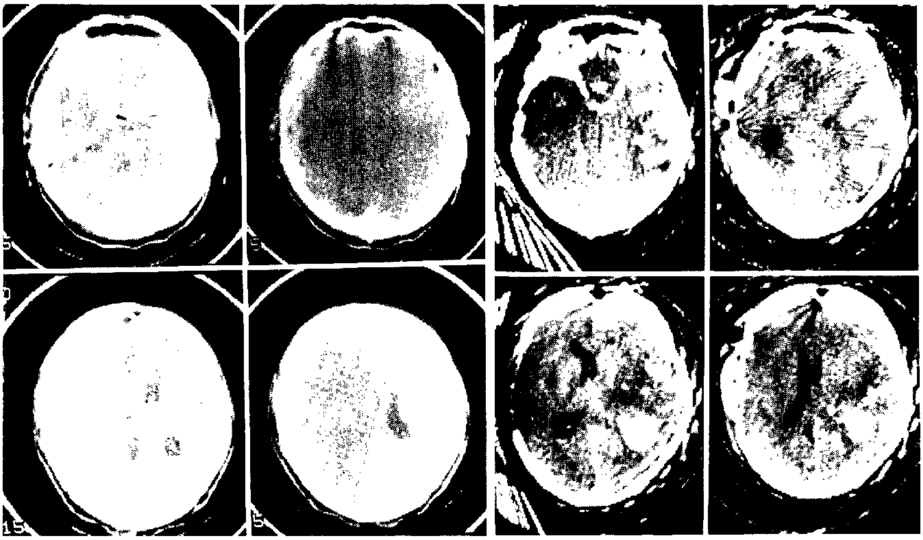

Fig. 7 Subdural and intracerebral hematomas. 52-year-old male. A characteristic crescent appearance of subdural hematoma with severe midline shift is seen on CT, taken about 4 hours after trauma (A). An emergency operation was done and the subdural hematoma was evacuated. Postoperative CT, taken after 13 hours after trauma, shows no subdural hematoma but large intracerebral hematomas on the right side (B).

level of consciousness. The level of consciousness was classified into three grades.[2] The degree of mass sign was graded as follows: absent, (−); a part of the lateral ventricle displaced or the cortical sulci partially obliterated, but with no midline shift, (+); the whole lateral ventricle displaced with mild midline shift, (+ +); marked midline shift and the whole ventricular system displaced or reduced in size, (+ + +) (Fig. 12). A comparison of the level of consciousness and the

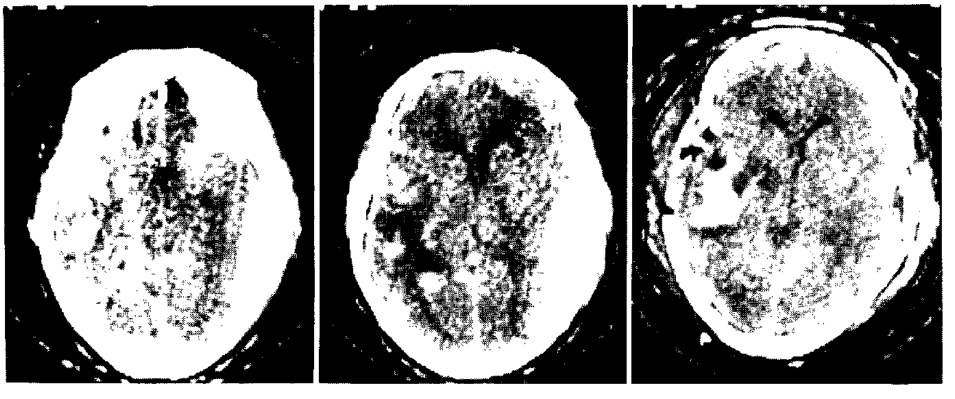

Fig. 8 Epidural hematoma and intracerebral hematoma. 31-year-old male. A subdural hematoma on the right side and several small hemorrhages in the left temporal lobe, which were considered as a contusion at this stage, can be seen on CT, examined 14 hours after trauma (left, middle). As an emergency operation, removal of the epidural hematoma on the right side and external decompression on the left side, were performed. CT taken a day after the operation revealed that the intracerebral hematoma became larger than when previously examined (right).

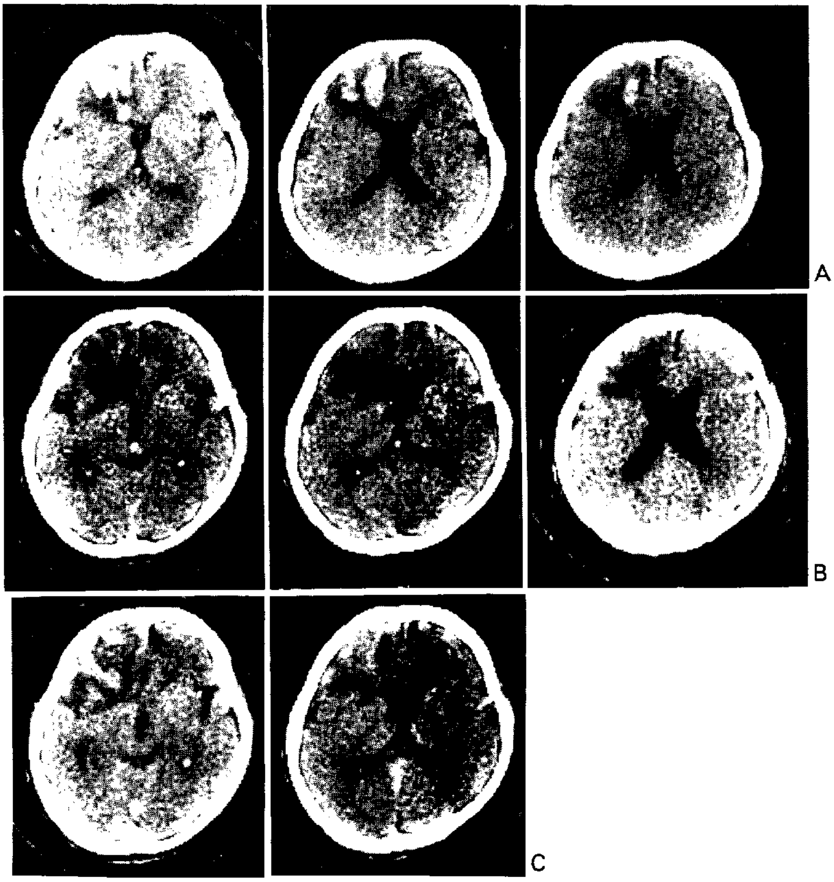

Fig. 9 Intracerebral hematoma. 50-year-old male. Multiple hematomas in the left frontal lobe are identified by CT, taken 4 days after trauma (A). CT, taken 18 days after trauma, shows that the hematoma visible as low density area (B). Density of the low density area was raised remarkably by intravenous contrast material injection (C).

degree of mass sign, is given in Table 6. As is obvious, a correlation between the level of consciousness at the time of CT and the degree of mass sign exists.

Of 10 cases exhibiting an area of high density on CT, 6 were subjected to external decompression, with 5 of them undergoing further removal of contused brain tissues. However, so

Fig. 10 Intracerebral hematoma. 72-year-old female. CTs were taken 2 days, 9 days, 21 days, 31 days and 41 days after trauma, respectively. A decrease in density of the hematoma becomes noticeable on the third examination and changes into isodensity or low density occured on the fourth and fifth examinations.

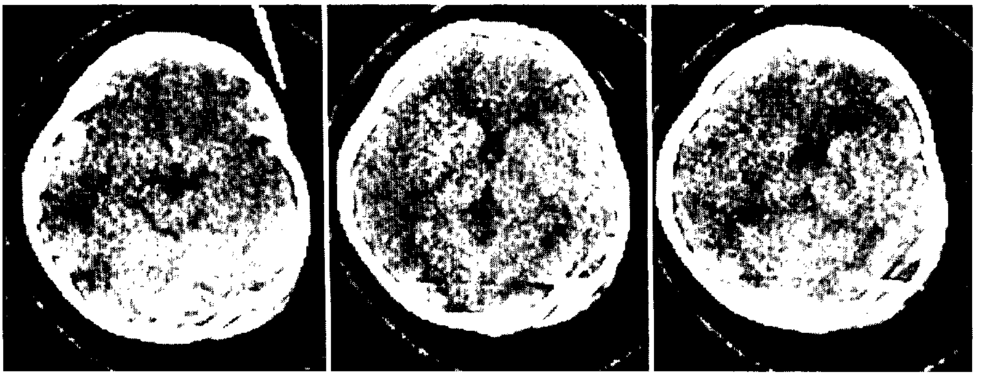

Fig. 11 Cerebral contusion. 6-year-old boy. CT was taken a day after trauma. Ill-defined low density areas are seen in the white matter of both frontal lobes. This pattern is called "poodle's face appearance" (center of the pictures).

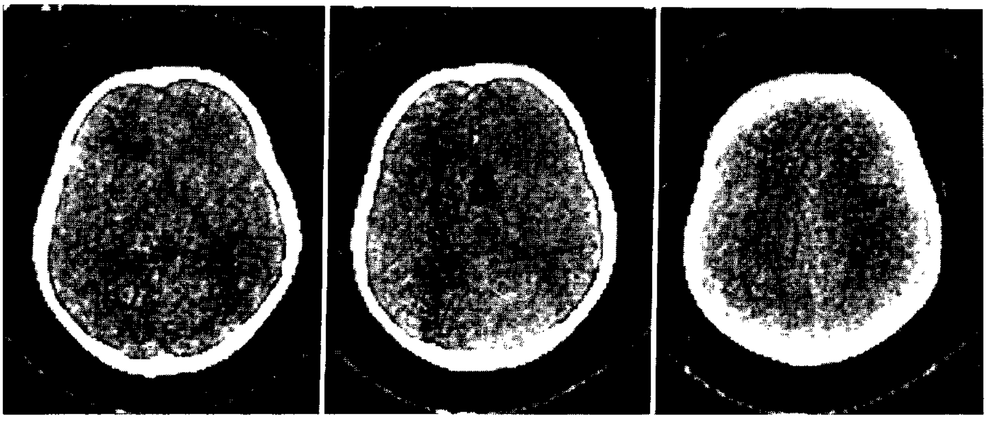

Fig. 12 Cerebral contusion. 5-year-old boy. CT examined within 24 hours after trauma, demonstrates the so-called small ventricle pattern.

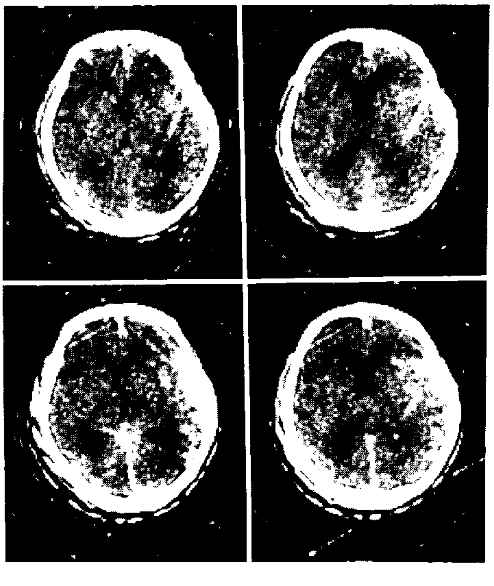

Fig. 13 Cerebral contusion. 61-year-old female. A patchy high density area can be recognized in the right frontotemporal area (upper), which is enhanced by intravenous contrast material injection (lower). CT was taken about 2 hours after trauma.

far as the present series of cases is concerned, surgical treatment proved to be of no particular benefit.

Discussion

The diagnostic significance of CT[2] in acute severe head trauma may be summarized as follows:[1,4,5] 1) CT is a nontraumatic procedure; 2) CT can cover almost all portions of intracranial structures; 3) CT enables accurate

Table 5 Outcome of cerebral contusion

	A.D.L.				
CT findings	Excellent	Good	Moderate	Poor	Died
No abnormal finding	2	1			1*
Low density	12	3(1)			1
High density	4(2)		4(3)	2(1)	
Normo-density	1	2			

The grading of ADL is the same as Table 4.
*due to heart failure.

diagnosis of all varieties of intracranial hematoma. Especially in the differential diagnosis of epidural and subdural hematomas this procedure proves to be of far greater value than angiography, since it can afford most characteristic scan findings by using properly selected slice levels; and 4) the procedure makes it possible to differentiate intracerebral lesions, whether intracerebral hematoma or cerebral contusion. In fact angiography was performed in addition to CT in 33 cases. However, dural arteriovenous fistula in one case and nonfilling in 2 cases were the only additional findings provided by angiography. This additional information is not essential to formulate therapeutic regimen for the acute stage of head trauma.

Epidural hematoma could be properly diagnosed by CT in all instances and, with the exception of one case with a fatal complication, all cases had a favorable outcome regardless of whether there was an associated cerebral contusion. Of the 7 cases of subdural hematoma, on the other hand, 5 progressed rapidly to a fatal outcome. Thus, it seems that among subdural hematoma cases there is a distinct fulminant type group. In the cases of subdural hematoma, however, there are subacute or chronic types having a free interval after head injury. For example, as illustrated in Fig. 14, the authors experienced a case in which a thin acute subdural hematoma formed immediately after surgical removal of a contralateral cerebello-pontine angle meningioma that developed into a chronic subdural hematoma after a long interval. Although chronic subdural hematoma, does not necessarily develop following such a course, this case is of particular interest because of its pathogenetic implications.

Traumatic intracerebral hematoma differs from hypertensive intracerebral hematoma in the process of development. The latter type of hematoma arises from a tear of a blood vessel. Of course, some traumatic intracerebral hematomas could also form in such a way. In the former type of hematoma formation, on the other hand, there is a contusion of brain tissue at the onset and small areas of bleeding thus caused in the brain tissue become confluent then to form a large hematoma. This pathogenetic mechanism is implicated by the fact that traumatic intracerebral hematoma is of multiple occurrence and, moreover, is delayed in onset.

As obvious from the above-mentioned, traumatic intracerebral hematoma originates always

Table 6 Correlation between mass sign on CT and level of consciousness

Level of consciousness	Degree of mass sign			
	(−)	(+)	(+ +)	(+ + +)
I (1–3)	3	4	1	
II (10–30)	3	4	3	1
III (100–300)	1	2	4	2

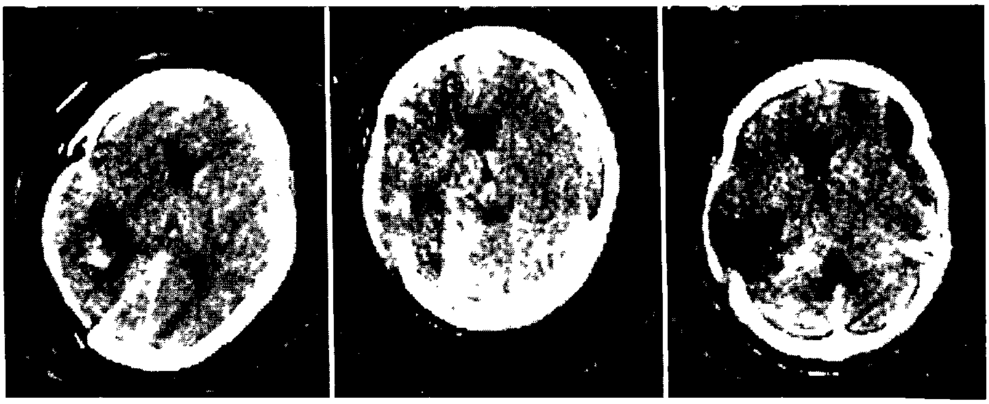

Fig. 14 Subdural hematoma. 63-year-old female. A thin acute subdural hematoma (A) formed immediately after surgical removal of a contralateral cerebello-pontine angle meningioma developed into a chronic subdural hematoma about 5 weeks after the operation (B,C). Scans were taken 2 days, 14 days and 36 days after the operation.

from a contused lesion (contusional hemorrhage) and the authors think it would be more rational to regard traumatic intracerebral hematoma as a kind of cerebral contusion.

Contused cerebral tissue can be defined pathologically as a mixture of nerve cell necrosis, nerve fiber swelling, brain edema and petechial hemorrhage. Low density on CT is attributable to the former three, while high density represents hemorrhage (Fig. 15). The reason why contused lesion is visualized as a low density area in some cases and as a high density area in other cases is explained by the fact that actual brain lesions contain varying proportions of necrosis, swelling, edema and hemorrhage. The intracerebral hematoma can be considered to be a type of cerebral contusion showing high density on CT scan. Therefore, the authors call cerebral contusion and intracerebral hematoma as traumatic intracerebral lesion (TIL).

With the advent of CT, the diagnosis in acute severe head trauma has made remarkable progress. However, our present study does not permit us to make any conclusive statement about operative indication in TIL under investigation. Indeed, it is true that external decompression brought about marked symptomatic improvement in some of cases with an established diagnosis of cerebral contusion on CT, but even where the diagnosis of intracerebral hematoma seems to be unquestionable in the presence of a high density area, it is imprudent and even dangerous to hastily consider that operation is indicated. There were cases in which, despite the presence of a fairly large intracerebral high density area, the patients were able to successfully return to social life by conservative therapy, as shown in Figs. 9 and 10. On the other hand, surgical intervention resulted adversely in enlargement of intracerebral hematoma as exemplified by the case shown in Fig. 8. Therefore, these facts should always be kept in mind in evaluating the indication for operation in TIL.

Fig. 15 Pathology of cerebral contusion

Low density ←——————→ High density → ICH

Cell destruction — Hemorrhage
Edema
Swelling of nerve cell and fiber

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