CT CORRELATION WITH SEVERITY AND OUTCOME IN TRAUMATIC HEAD INJURY PATIENTS IN SAKONNAKHON HOSPITAL, THAILAND.

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ABSTRACT

OBJECTIVE: To evaluate which features on the admission CT scan might add significantly to the neurologic status for predicting the outcome in patients with head injury.

MATERIALS AND METHODS: 95 CT scans of patients with all grades of traumatic head injuries were retrospectively reviewed for roentgen findings on admission. Details from the CT scan on hemorrhage (type, number and size) and midline shift were correlated with neurologic status (assessed with Glasgow Coma Scale [GCS]) and patient outcome at discharge time (assessed with the Glasgow Outcome Scale [GOS]).

RESULTS: GCS score was significantly lower in patients with subarachnoid hemorrhage, subdural, intracerebral hemorrhage, midline shift and associated primary brain injury. GCS changed as a function of hematoma size ($P<.001$) in the patient with focal hemorrhage. The presence of subarachnoid hemorrhage, subdural, intracerebral hematoma and midline shift were also significantly associated with poor outcome. Patients with normal CT scan were significantly more likely to have no or mild neurologic dysfunction and good outcome than those with intracranial hemorrhage ($P<.001$).

CONCLUSION: CT findings, including type and number of intracranial hemorrhage, location, bleeding size, associated brain injury and midline shift have been the essential factors to predict the clinical outcome.

INTRODUCTION

Craniocerebral injuries are a common cause of Sakonnakhon hospital admission following trauma. CT remains to be essential for detecting lesions that require immediate neurosurgical intervention as well as those that require in-hospital observation and medical management. In patients with traumatic head injury, previous studies suggested that factors predictive of patient's outcomes included age, Glasgow Coma Score (GCS), pupil score, injury severity score and the results of CT scan of brain.[1,2] There have been interests in the correlation between the results of the CT scan of brain and the severity of injury and the outcome of patients.

This study aims to investigate the association between abnormalities seen on CT scan of brain and the severity and outcome of injury. Specific CT abnormalities of interest are the type, number and amount of bleeding, together with the magnitude of midline shift. Severity of injury is represented by the Glasgow Coma Scale, and patient's outcome are assessed in correlation with the Glasgow Outcome Scale.

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MATERIALS AND METHODS

95 patients with all grades of traumatic head injury, admitted to Sakonnakhon Hospital during 1 December 2007 to 1 January 2008, comprised for the head injury data base. These patients, aged range from 2 to 77 years (median age, 31 years), had minimal systemic injury (ie, they had no intraabdominal or intrathoracic injury, although some had bone fractures).

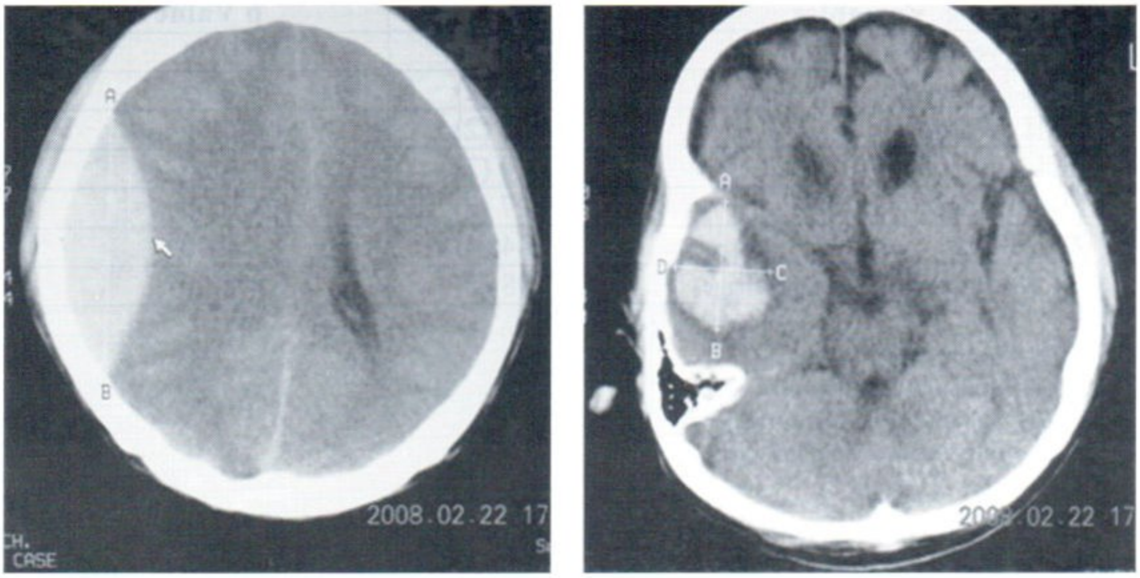
CT scans were obtained with the available scanner (Philips SR7000) shortly after admission to the hospital. All scans were contiguous, 10 mm.-thick sections from external auditory meatus to the vertex. No contrast medium was administered. The scanner was operated at 120 kvp and 150 mA for 2 seconds. All CT scans were read blindly by one radiologist and were categorized according to whether the scan revealed lesions or appeared normal. The abnormalities were recorded for the number and type of any hemorrhage (table 1): epidural hematoma (EDH), subdural hematoma (SDH), subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH); and the presence of midline shift. The severity of the head injury and the patient's outcome were determined with standard methods: The Glasgow Coma Scale (GCS), which incorporates measures of the best motor and verbal responses and eye opening, was used to assess the neurologic function. Neurologic abnormalities were scored as follows: 8 or less, severe; 9-12, moderate; and 13-15, mild. The patient's outcome was used to classify the patient's status at the time of discharge into two main groups as good (good recovery and moderately disabled) and poor outcome (severely disabled, persistent vegetative state and death).

Table 1 Summary of key abnormalities sought on CT Scans

Variable	All 95 patients
EDH	
YES	7 (7.36)
NO	88 (92.64)
SDH	
YES	18 (18.95)
NO	77 (81.05)
SAH	
YES	14 (14.74)
NO	81 (85.26)
ICH	
YES	23 (24.21)
NO	72 (75.79)
Midline shift	
YES	12 (12.63)
NO	83 (87.37)
location	
0 location	45 (47.37)
1 location	12 (12.63)
2 locations	38 (40.00)
CT finding	
YES (normal)	45 (47.37)
NO (hemorrhage)	50 (52.63)

Values in parentheses are percentage.
EDH = Epidural hematoma
SDH = Subdural hematoma
SAH = Subarachnoid hemorrhage
ICH = Intracerebral hemorrhage

The volume of each hemorrhage was calculated in several steps. First, the CT section on which the hemorrhage appeared to be the largest was chosen. The largest diameter was measured and considered to be the length (Fig1). Second, the width was measured perpendicular to the length where the width appeared to be the greatest. Third, the height was calculated by adding together the number of sections on which the hemorrhage appeared. The thickness of the top and the bottom sections was assigned at a value of 8 mm. (because it was not clear whether the lesion extended through the entire section), while the ones in between were assigned at a value of 10 mm. Whenever a lesion was seen on only one section, its height was estimated to be 6 mm. Fourth, the length, width, and height were used to estimate the volume of the lesion, which was modeled as an ellipsoid. Patients with diffuse bleeding (SAH, SDH along tentorium and falx) were excluded from blood volume analysis.



(a) (b)

Fig. 1 Measurement of intracranial hemorrhages. (a) Single intracraniocerebral hematoma, (b) Single EDH. A-B distance indicates length; C-D distance indicates the width

Data analyses

$\chi 2$ tests were used to investigate any associations between GCS total score on admission with each of the features on the CT scans. The relationships between hematoma size and GCS was studied with regression methods. A linear regression model was used for analysis of GCS scores. Patients in whom CT scans appeared normal were assigned a nominal lesion size (0.3 of a voxel), so that their scores could be represented in figure 2. Statistical significance was assessed with $\chi 2$ tests on the basis of the Pearson distribution.

Logistic regression modeling was used to assessed the prognostic significance of the features on CT scans and the two groups of patient outcome.

RESULTS

Fifty of the 95 patients with head injury had intracranial hemorrhages. Motor vehicle accidents comprised 41 of the injuries (82%); the 9 other injuries were caused by accidentaly fall (n=4 [8%]), assaults (n=5[10%]). The median age of the 45 patients with normal CT scans was 30 years. 6% of the patients with normal CT scans was older than 60 years, whereas, 12% of the 50 patients with intracranial hemorrhage were older than 60 years.

Relationship between the appearance of the CT scans and GCS.

Table1, summarises the features visible on all 95 CT scans. The association between the CT features and GCS was very similar to the association of CT features with grade of the injury and therefore the detailed results are reported for GCS only (table2). Patients with subarachnoid hemorrhage, subdural hematoma, intracerebral hemorrhage and midline shift had significantly lower GCS scores ($P<.05$). The presence of epidural was not associated with GCS total.

Table 2 Association between Glasgow Coma Scale and abnormalities sought on CT Scans

Variables	χ^2 Test (df)	p Value
EDH (yes/no)	2.14 (2)	0.34
SDH (yes/no)	7.36 (2)	< 0.05
SAH (yes/no)	8.33 (2)	< 0.05
ICH (yes/no)	2.70 (2)	< 0.05
Midline shift (yes/no)	9.27 (2)	< 0.05
2 locations	21.44 (4)	< 0.001
CT finding (normal /hemorrhage)	17.98 (2)	< 0.001

EDH = Epidural hematoma
SDH = Subdural hematoma
SAH = Subarachnoid hemorrhage
ICH = Intracerebral hemorrhage

In the 40 with focal intracranial hemorrhage (subarachnoid hemorrhage, interhemispheric and tentorial subdural hematomas were excluded) and the 45 with normal CT scans, the results of a regression analysis of GCS and the lesion size revealed that the GCS scores changed as a function of lesion size. The slope coefficien of this scatter diagram was statistically significant. ($P<.001$), (Fig 2).

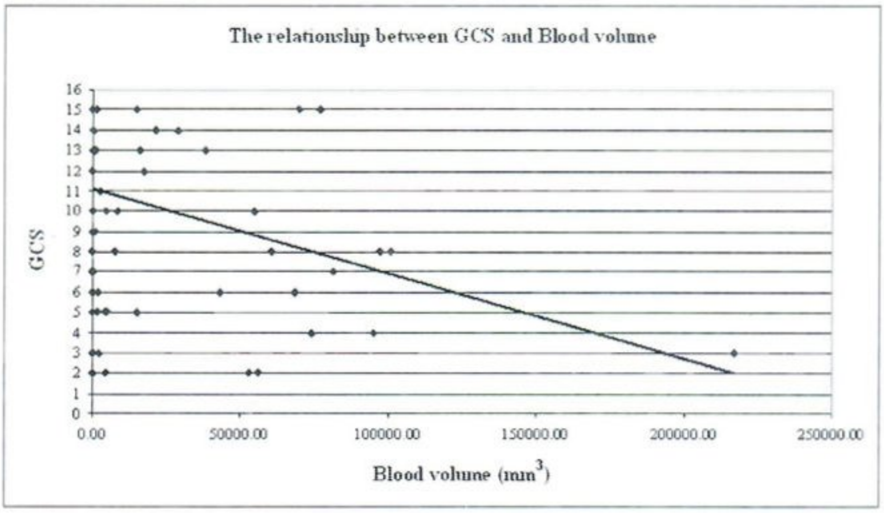


Fig. 2 Scatter diagram show the relationship between GCS and hematoma size (expressed in cubic millimeters (Blood volume))

Patients with normal CT scans at the time of admission were significantly more likely to have no or mild neurologic dysfunction (GCS scores of 13-15) than those with intracranial hemorrhage ($\chi 2 = 16.31$, $df = 2$, $P < .001$).

The difference between patients with normal CT and those with intracranial hemorrhage was also present in their outcomes. Ninety-eight percent of the group with normal CT scans (n = 44/45) had either good recoveries or moderate disabilities versus 54% of those who had intracranial hemorrhage (n = 27/50), ($\chi 2 = 24.04$, $df = 1$, $P < .001$). However, a normal CT scan did not necessarily imply that the patient recovered fully; nine of these patients (20%) remained moderately or severely disabled. Nevertheless, no patient in the group with normal CT scans become persistently vegetative or died compared with 21 patients (42%) with intracranial hemorrhage.

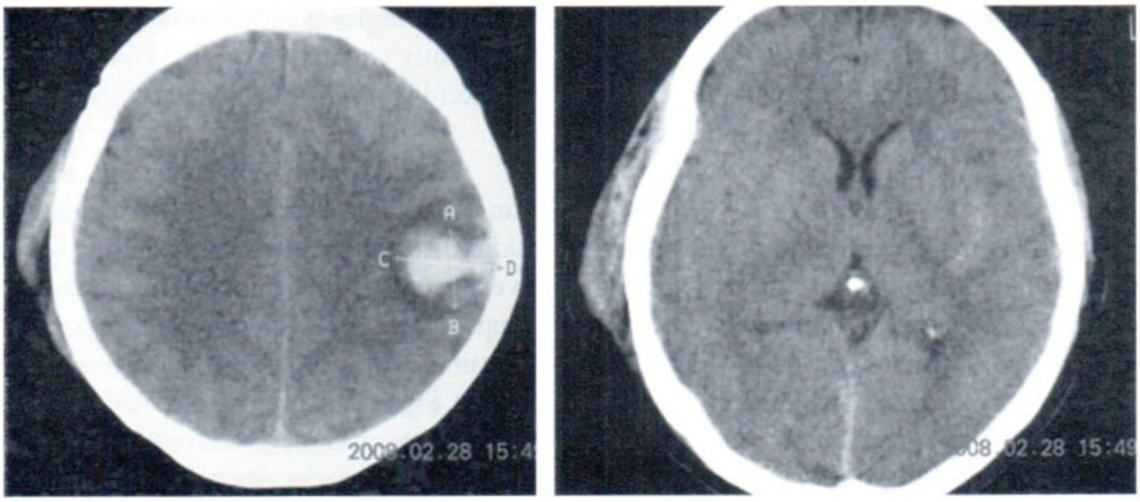
Relationship between the appearance of CT scan and clinical outcome at discharge time were studied. Logistic regression modelling was used to investigate the associations between the two main groups of the patient's outcome (good or poor outcome) at the time of discharge with the features on CT scans (table3). Significant positive associations were found between poor outcome and subarachnoid hemorrhage, subdural hematoma, intracerebral hemorrhage, midline shift and associated intracranial hemorrhage. Negative association was found between poor outcome and the presence of epidural hematoma.

Table 3 Logistic regression model with P values for sequential tests. Odds ratios (ORs) and 95 % confidence intervals (95 % CIs) for predicting outcome for 95 patient on CT Scans. Estimated OR > 1 indicates a poor outcome, estimated OR < 1 indicates improved outcome.

Variables	P Value	OR	95% CI
EDH (yes/no)	0.78	0.68	0.04 – 10.60
SDH (yes/no)	< 0.01	11.04	2.52 – 48.30
SAH (yes/no)	< 0.05	8.67	1.67 – 45.07
ICH (yes/no)	< 0.001	6.54	1.59 – 26.96
Midline shift (yes/no)	< 0.001	1.10	0.32 – 1.44
2 locations (yes/no)	< 0.001	10.35	3.66 – 29.23
CT finding (normal / hemorrhage)	< 0.001	28.69	3.56-231.10

EDH = Epidural hematoma
SDH = Subdural hematoma
SAH = Subarachnoid hemorrhage
ICH = Intracerebral hemorrhage

Among the 50 patients with intracranial hemorrhage, 11 patients who had more than one bleeding site, such as subarachnoid hemorrhage and intracerebral hemorrhage (Fig3), significantly had lower GCS ($P < .001$) and poor outcome ($P < .001$).



(a) (b)

Fig 3 CT scans of a 41-year-old woman with admission GCS score=10. Axial non- enhanced CT revealed an intracerebral hematoma of cortical left frontoparietal lobe (a). Associated minimal subarachnoid hemorrhage was also detected as increase attenuation of sylvian fissures (b).

GCS = Glassgow Coma Scale **GOS** = Glassgow Outcome Scale

DISCUSSION

CT was paramount important as one of the influential factors to determine neurological status and patient outcome. In regard to this study, SAH, SDH, ICH, midline shift and associated intracranial hemorrhages were associated with GCS and poor outcome in which they were concordant with prior study.[1] Thus it would be possible to identify these more severely injured patients with worse prognosis by noting these easy to identify features on the CT, and target their management accordingly. The presence of EDH was not significantly associated with severity of injury and poor outcome, however.[1]

Acute SDH remains one of the most lethal of all head injury and the extent of primary underlying brain injury is more important than the SDH itself in dictating the outcome. Many patients with SDH showed immediate post-traumatic coma, and mortality among them was greater when compared to those that did not have immediate coma.[3] In this study, 12 of 18 patients with SDH account for severe head injury (GCS of 8 or less), and 10 of these 12 patients developed poor outcome. SDH is commonly associa ted with extensive primary brain injury (brain contusion, diffuse axonal injury, SAH).[4,5]

SAH was frequently diagnosed in patients with head injury and became significance in order to assess severity and outcome. Interestingly, diffuse axonal injury and diffuse cerebral swelling were found in patients with SAH more than those without SAH.[6] The SAH appeared on CT scan in this study was categorized as minimal and larger extent, which the latter had lower GCS and poorer outcome.[7] Half of the patients who died in this study had SAH on CT scan (8 of 16 patients).

Intracerebral hematomas were collections of blood within the brain itself. In the traumatic setting, they result from coalescence of contusions. Increased intracranial pressure, herniation and brain stem failure can subsequently develop, particularly with contusions in the temporal lobes.

Factors affecting prognosis of intracerebral hematoma that had been previously studied, were the presence of associated lesion, actual midline shifted of 4.5 mm or more on initial CT scan, obliteration of suprasellar cistern.[8] In this study, intracerebral hemorrhage had low GCS and poor outcome in particular if associated with other types of primary brain injury. In addition, those having coexisted midline shift, the mortality rate was greatly increased (6 of 7 patients died in this study).

For EDH, it has not associated with GCS and poor outcome.[1,9,10] As 6 of 7 patients diagnosed EDH yet had good outcome, only one patient with the age of 62, with GCS at 8, had a large EDH and midline shift was deceased. Parameters influenced poor prognosis in patients with EDH were age more than 55, low GCS, larger bleeding site, associated primary brain injury and midline shift. Motality rates are essentially nil for patient not in coma preoperatively and approximately 20% for patients in deep coma.[9]

About the size of focal hematomas, the CT scan was used to evaluate the amount of volume of bleeding. The lower GCS has been significantly correlated with larger extent of hematoma (P<.001), similar to previous study.[11] This may not surprising because increasing lesion size should compress and distort vital structures in the diencephalons and upper brain stem and increase degree of cerebral swelling. However, the severity of head injury and the patient's outcome may arise from other factors rather than bleeding site and size. Therefore, it is necessary that we have to consider other various important factors such as associated brain contusion, diffuse axonal injury, brain swelling or brain herniation.

Twelve percents of patients in this study with intracranial hemorrhage still had full GCS, a bit higher than that of overseas studies.[12,13] Haydey, et al identified patients with mild head injury who should undergo CT scan based on clinical findings (headache, vomiting, age over 60 years, drug or alcoholic intoxication, deficits in short-term memory, physical trauma above the clavicles and seizure) and , thus, did not recommend CT scan in all patients with mild head injury.[12]

EDH = Epidural Hematoma
SDH = Subdural Hematoma
SAH = Subarachnoid Hematoma
ICH = Intracerebral Hematoma

There were a few limitations of this study. First, it was a small sample sizes, the second was some factors that occasionally missed in the GSC evaluation for instances, alcoholic drinkers, third, how GOS was assessed (Grading of GOS was categorized at the time patients have left the hospital instead of the standard at 6 or 12 months interval after injury), and fourth, the size of hematomas in this study may not exactly accurate, due to the amount of SAH, at the tentorial and interhemispheric SDH were not calculated.

CONCLUSION

CT features in patients with head injury have been associated with severity and treatment outcome. Hence, radiologists should pay special attention to such CT findings including type and number of intracranial hemorrhage, location, bleeding extent, associated primary and secondary brain injury and midline shift because any of those findings have been contemplated as the essential factors to determine the clinical results.

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