Absent or compressed basal cisterns on first CT scan: ominous predictors of outcome in severe head injury

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The relationship of outcome to the appearance of the basal cisterns as seen on initial computerized tomography (CT) scanning was assessed in 218 consecutive severely head-injured patients entered into the second phase of the National Pilot Traumatic Coma Data Bank. Outcome could be directly related to the status of the basal cisterns on the initial CT scan. The mortality rates were 77%, 39%, and 22% among those with absent, compressed, and normal basal cisterns, respectively. This association between cisterns and outcome was shown to be strong after adjusting for Glasgow Coma Scale (GCS) score (p < 0.001).

The state of the cisterns was more important for those with higher GCS scores (scores 6 to 8) than for those with lower scores (scores 3 to 5). Patients with GCS scores of 6 to 8, with cisterns absent or not visualized, suffered nearly a fourfold additional risk of poor outcome, compared to those with normal cisterns. This indicates that the status of the cisterns can be used as an early noninvasive method of identifying patients at high risk of death or severe disability, in whom the initial neurological examination would potentially suggest otherwise.

KEY WORDS • basal cistern • computerized tomography • intracranial pressure • National Traumatic Coma Data Bank • outcome • severe head injury

In a companion paper, we have described the use of a variety of factors to predict the presence or absence of increased intracranial pressure (ICP) in patients suffering severe head injury. Others have attempted to predict clinical course and outcome on the basis of patient’s age, clinical presentation, duration of coma, and computerized tomography (CT) appearance. With the exception of a brief presentation by Murphy, et al., and the recent publication by van Dongen and his colleagues, the importance of the absence of the basal cisterns in outcome prediction in head-injured patients has not, to our knowledge, been previously described.

A multivariable analysis of data recorded by the National Pilot Traumatic Coma Data Bank during the first 24 hours of patient observation was conducted in an attempt to predict the occurrence of ICP values over 30 mm Hg during the subsequent 48 hours. Patient’s age, lowest Glasgow Coma Scale (GCS) score, highest ICP level, amount of shift of brain structures visualized on CT, ventricular size as determined on CT scanning, hypoxia (pO₂ < 60 mm Hg), hypo- or hypercarbia (pCO₂ in categories of 30 mm Hg or less, 31 to 49 mm Hg, and 50 mm Hg or more), shock (systolic blood pressure under 90 mm Hg), bradycardia (heart rate less than 45 beats/min), and number of seizures were considered as possible predictors. The best predictor by far was the highest ICP during the first 24 hours (p < 0.0001). This, however, requires an invasive monitoring procedure. A noninvasive method of prediction would be highly desirable. Shock and abnormal ventricles were the only other predictors that were of statistical significance at the 10% level (p = 0.045 and p = 0.086, respectively).

Although data on the basal cisterns was not available on the initial 325 patients entered into the National Pilot Traumatic Coma Data Bank, revisions in the forms used to categorize CT scan findings provided this information during the second phase of the study. The present paper describes the value of the appearance of the basal cisterns in early prediction of outcome in severe head injury.

Clinical Material and Methods

In an effort to study severe head injury in patients with a GCS score of 8 or less, the National Institute of
Neurological and Communicative Disorders and Stroke (NINCDS) and six medical centers have joined in a cooperative study. During the pilot phase of the National Traumatic Coma Data Bank (January 1, 1980, to May 31, 1982), data were collected on 581 patients and stored in a common computerized data base. Patients with initial GCS scores exceeding 8 must have deteriorated to the 3 to 8 range within 48 hours of admission to have been included in the Data Bank. After entry of the first 325, patient data collection forms were revised to include information on the appearance of the basal cisterns as seen on the first CT scan. The basal cisterns were classified as absent, compressed (Fig. 1 left), normal (Fig. 1 right), or not visualized. The “not visualized” category was used in instances where the CT scan was believed not to be of sufficient quality to allow for absolute determination of the status of the cisterns.

Records of all patients undergoing at least one CT scan within 48 hours of admission to the treating Center were retrieved from the Data Bank, for a total of 218 patients. In 29 patients no CT scan was available; all of these patients died within 72 hours of hospitalization. In an additional nine cases the CT scan was performed more than 48 hours after admission. These patients were excluded from this analysis because our major goal was to assess the value of basal cistern appearance in the early prediction of outcome.

Outcome was scored according to the Glasgow Outcome Scale (GOS): 1) good recovery; 2) moderate outcome; 3) severely disabled; 4) vegetative; and 5) dead. A poor outcome was defined as a GOS score of more than 2. The Mantel-Haenszel procedure was used to test for association between cistern status and outcome, adjusted for the initial GCS score. The analysis was performed both excluding patients whose cisterns were “not visualized,” and also including them with the absent cistern group.

**Results**

Figure 2 shows a strong relationship between the appearance of the cisterns on the first CT scan and outcome determined either at the time of death or 90 days or more following injury. The rates of poor outcome were 85%, 64%, and 44% among those with absent, compressed, and normal basal cisterns, respectively. Figure 2 also shows that the group with nonvisualization of the cisterns did only slightly better than the patients in whom the cisterns were absent. The strikingly better rate of survival of patients with better CT appearance of their cisterns is exemplified by the fact that the mortality rate was approximately twice as high for patients with compressed cisterns compared with normal cisterns (39% versus 22%) and approximately twice the percentage of patients died from the group with absent cisterns compared with those with compressed cisterns (77% versus 39%, Fig. 2).

All 29 patients who did not have CT scans died, indicating that the absence of these patients from the data set may underestimate the mortality rate for those with absent cisterns. As we have noted previously, the patients who did not have CT scans were those for whom the treating neurosurgeon thought that the prognosis was so poor that nothing could be gained from aggressive investigation or therapy, or those who died before CT scans could be obtained.

After the initial GCS score was taken into account (using the Mantel-Haenszel procedure), there still was a highly statistically significant association between outcome and cistern status (p < 0.001, whether or not patients whose cisterns were “not visualized” were included). Figure 3 shows the relatively greater importance of cisterns in the risk of a poor outcome among those with a GCS score of 6 to 8.
In the 18 patients with CT evidence of a shift of brain structures exceeding 15 mm in association with absent cisterns there was not a single survivor, whether the patient was treated surgically or nonsurgically. Furthermore, none of the 10 nonsurgical patients with any shift on CT scanning survived.

In 25 (74%) of 34 patients in whom the ICP was monitored and in whom the cisterns were absent, severe intracranial hypertension (ICP exceeding 30 mm Hg) was observed. This is a demonstration of the dynamic process which absent cisterns connote, and indicates that the likelihood of elevated ICP in this group of patients is extremely high. Moreover, because of the implication of cistern appearance as to outcome, these data indicate that elevated ICP is a likely cause of subsequent deterioration and death in a substantial number of the patients with an initial GCS score of 6 to 8.

In 23 patients with absent cisterns on their first CT scan, who underwent craniotomy for evacuation of an acute intracranial hematoma, the evacuation of the clot did not reduce the incidence of severe intracranial hypertension (ICP greater than 30 mm Hg) in the postoperative period. Seventeen (74%) of these 23 patients had postoperative ICP's greater than 30 mm Hg. This is in keeping with the observation of Rea and Rockswold12 that high ICP characterizes the postoperative course in the majority of severely head-injured patients.

Discussion

Computerized tomography scanning is indispensable in the diagnostic and serial evaluation of patients suffering significant head injuries, and should be used as a tool for assessing outcome in such patients. The value of using the first CT scan in yielding early prognostic information in patients has not been studied in detail. Sweet, et al.13 showed an association between bilateral hyperdense lesions and poor outcome. Cordobes, et al.,4 found a 76% mortality rate associated with the presence of intraventricular hemorrhage (IVH). As all patients in this group, except one survivor in good condition, had associated lesions of major significance (such as hematomas or contusions), the predictive value of IVH alone is uncertain.

Recently, Murphy, et al.,11 reported an association between absent basal cisterns and ICP exceeding 25 mm Hg. The present study confirms, in a much larger sample, the powerful relationship between the appearance of the basal cisterns and outcome reported by van Dongen, et al.14 However, one difficulty in comparing the two series is the fact that the Dutch group used CT scans obtained at varying times following injury in their prognostic model,14 while the present study utilized the initial CT scan. As cistern appearance reflects a dynamic process, the time interval from injury to CT scan used to predict outcome is likely to be critical. Obviously, the earlier the CT scan can be obtained the more likely it is to be relevant to an early prediction, and to be of greater potential value in changing therapeutic approaches.

In the group of patients in whom the basal cisterns were not visualized, the outcome results are only slightly better than those observed in patients with absent cisterns. We presume that the cisterns were indeed absent for most of the patients in this group.

By adjusting for GCS scores in the data analysis we were able to show that outcome was likely to be affected by the state of the cisterns for those patients within each GCS score group. This indicates that, with the exception of those patients who were flaccid or decerebrate following resuscitation, basal cistern appearance can be an independent and potent predictor of outcome within the first few hours of injury. This is a disturbing observation, for it suggests that in patients whose likelihood of survival should be high (namely, patients with GCS scores of 7 or 8) there is in fact a very high mortality rate because of the progression of the dynamic process which the status of the cisterns reflect.

It is now apparent that, in addition to the clinical examination, we have one noninvasive highly significant radiological predictor of outcome. If the basal cisterns are absent or compressed on first CT, the outcome is much more likely to be poor. These patients should be targeted for early aggressive therapy. Given the fact that the patients described here were managed at medical centers highly committed to the care of severe head injury, this study should serve as a starting point for reassessment of our methods of treatment in patients with a predictable poor outcome based on the first CT scan.

It appears that present therapeutic regimens are in-
adequate to yield useful survival in the great majority of patients in whom the basal cisterns are absent on first CT, and that there is certainly room for improvement in outcome in those patients in whom the basal cisterns are revealed on the CT scan to be compressed. While in some patients this may be a product of irreversible biomechanical injury from impact, it is apparent that there are patients in the present data set who deteriorated because of intracranial hypertension which the absent or compressed basal cisterns reflected. In these patients, earlier therapy might alter their course. For patients in whom a surgical lesion is present, more rapid evacuation of hematomas prior to neurological deterioration should be seriously considered. In the nonsurgical group more aggressive therapy of patients with ICP in the 15- to 20-mm Hg range might be useful. Further analysis of patients treated in such a manner and collected within the Full-Phase National Traumatic Coma Data Bank should address these issues.

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