Risk factors predicting operable intracranial hematomas in head injury

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A study was performed to examine the incidence of operable traumatic intracranial hematomas accompanying head injuries of differing degrees of severity, and to see if factors predicting operable mass lesions could be identified. Logistic analysis was used to identify independent predictors of operable traumatic intracranial hematomas.

Data were gathered prospectively on 1039 patients admitted with head injury between January, 1986, and December, 1990. Patient age, Glasgow Coma Scale (GCS) score, pupillary inequality, and injury by falling were all independent predictors of the presence of operable intracranial hematomas (p = 0.0000, 0.0000, 0.0182, and 0.0001, respectively). Injury to vehicle occupants was less likely to result in operable mass lesions (p = 0.0001) than injury by other means. The incidence of traumatic intracranial hematomas in patients over 50 years old was three to four times higher than in those under 30 years of age. Not surprisingly, the incidence of operable hematomas increased with decreasing GCS scores. However, even at a GCS score of 13 to 15, patients with other risk factors had a substantial incidence of operable mass lesions. There was a 29% incidence of operable intracranial hematomas for patients with a GCS score of 13 to 15, aged over 40 years and injured in a fall.

It is suggested that patients who are middle-aged or older, or those injured in falls, are at particular risk for traumatic intracranial hematomas even if their GCS score is high. These patients should have early definitive investigation with computerized tomography in order to identify operable hematomas and to initiate surgical treatment prior to neurological deterioration from mass effect.

KEY WORDS • head injury • traumatic intracranial hematoma • prognosis • risk factor

There is considerable evidence to suggest that early recognition and surgical evacuation of traumatic intracranial hematomas prevent death and disability, especially in patients who talk and then deteriorate neurologically. The widespread availability of computerized tomography (CT) scanning provides the means to recognize operable mass lesions before overt neurological deterioration takes place. This study was conducted to determine risk factors that might predict the presence or absence of operable traumatic intracranial hematomas in head-injured patients. It is hoped that the results of this investigation will help to identify those patients presenting with mild or moderate injuries who may be harboring an intracranial hematoma, and are therefore at risk for neurological deterioration. The results may also assist surgeons with the appropriate selection of diagnostic and emergency treatment procedures in multiply-injured patients with closed head injury.

Clinical Material and Methods

Patient Population

Data were collected prospectively on 1039 consecutive patients admitted to our hospital with a head injury (loss of consciousness or skull fracture) between January, 1986, and December, 1990. St. Michael's Hospital is a tertiary referral center and regional trauma unit. Pediatric patients (< 16 years old) are not treated at our hospital. Patients with all degrees of head-injury severity were included in this study. Approximately two-thirds of patients were referred from other hospitals,
and one-third were admitted directly from the accident site. Patients with chronic subdural hematomas were excluded, unless there was a significant coexisting acute subdural hemorrhage (requiring craniotomy for evacuation) and a history of acute injury.

**Patient Evaluation**

Computerized tomography scans of the head were performed on all patients. Patients who were taken to the operating room for evacuation of an intracranial hematoma were considered to have traumatic intracranial hematomas, as were those who were moribund and who did not undergo surgery, but who had an intracranial mass lesion associated with a midline shift greater than 5 mm on CT scan. Possible risk factors observed on patient medical histories and physical examination at the time of admission to our hospital were investigated using logistic analysis. The factors were: age, Glasgow Coma Scale (GCS) score, anisocoria, unilateral or bilateral fixed pupils, sex, alcohol intoxication, presence of multiple systemic injuries, and etiology (including assault, injuries to cyclists, falls, gunshot wounds, motorcycle injuries, injuries to motor-vehicle occupants, and injuries to pedestrians struck by vehicles).

Patients were considered to have multiple injuries if their Injury Severity Score (I) exceeded 25. The score of 25 was chosen as an indicator of the presence of multiple injuries to exclude the effects of severe nonfatal head injury on the Injury Severity Score. The latter score is calculated by summing the squares of the Abbreviated Injury Scale codes to a maximum of 75 for the three most severely injured body regions (for example, the head and neck or the abdomen and pelvis). The Abbreviated Injury Scale is an anatomical injury classification scheme and varies from 1 to 5 for least-to-greatest severity. Immediately fatal injuries are graded as 6. An Injury Severity Score of 75 is arbitrarily awarded if any single body system injury is coded as 6. No such patients were included in this study.

**Results**

This study analyzed a total of 1039 patients, 276 of whom had traumatic intracranial hematomas. The age distribution of the patients is shown in Fig. 1 left. The largest proportion of patients were in their third or fourth decades. The distribution of patients by injury severity (GCS score) is shown in Fig. 1 right. Patients with minor injuries formed the largest group in the study. The GCS scores for the rest of the patients were relatively evenly distributed between 3 and 13; 364 patients (35%) had severe injuries (GCS score 3–8).

Figure 2 shows the causes of the head injuries. The largest proportion of the injuries were the result of traffic accidents, the majority of which involved injuries to motor-vehicle occupants. One-quarter of the traffic accidents were pedestrian injuries. The second most frequent cause of injury was falling. Most of the falls occurred from low heights in and around the home. Together, injuries to motor-vehicle occupants and to patients who fell constituted 61% of the etiology for all patients in the study.

The types of operable mass lesions found in the study patients are shown in Fig. 3 left. As in other studies, acute subdural hematomas, often in association with a
Risk factors predicting operable hematomas

![Graph showing incidence of operable intracranial mass lesions by type.](image)

**Fig. 3.** Left: Incidence of operable intracranial mass lesions by type. The cross-hatched bars indicate the incidence of each type of isolated hematoma, and the solid bars indicate the total incidence, including combinations of hematoma types. The "Combined" bar represents all patients with combined injuries of all types; "SDH + ICH/Cont" shows only those patients with acute subdural hematoma (SDH) and cerebral contusions (Cont) or intracerebral hematoma (ICH). Right: Incidence of operable hematomas by injury etiology. Ast = assault; Bicycle = bicycle; Mcycle = motorcycle; MVA = motor-vehicle accident; Ped = pedestrian. The bars show the proportional incidence; the table below shows the actual number of patients in each category.

Cerebral contusion, represented the most frequent type of operable intracranial hematoma. The highest incidence of mass lesions occurred as a result of a fall (Fig. 3 right). There was a relatively low incidence of operable intracranial hematomas following injury to motor-vehicle occupants. Logistic analysis showed that injury in a fall is a significant independent predictor of operable mass lesions (p = 0.0001), while there was significantly less likelihood of motor-vehicle occupants sustaining operable intracranial hematomas compared to patients injured by other means (p = 0.0001). The incidence of operable mass lesions was greater in patients injured in falls than in motor-vehicle occupants at any level of injury severity (GCS score) (Fig. 4 upper left) and at any age (Fig. 4 upper right).

Logistic analysis also showed that age (p = 0.0000) and GCS score (p = 0.0000) were independent predictors of operable traumatic intracranial hematomas. Operable hematomas were more likely with a lower GCS score and in older patients. However, even in the presence of a GCS score of 13 or greater, if other risk factors such as a fall or increased age were present the incidence of operable mass lesions was high. There was a 20% overall incidence of operable hematomas in all patients with a GCS score of 13 or greater who fell (Fig. 4 upper left). In middle-aged or older patients there was a substantial incidence of operable mass lesions, even in patients with minor injuries (GCS score 13-15). In this group of patients, the incidence of operable traumatic intracranial hematomas doubled from 10% in the second to fourth decades, to 20% in the fifth to seventh decades, and to 40% in those aged 70 years or older. Figure 4 lower shows the interaction of age and GCS score in predicting the incidence of operable mass lesions. When one looks at the combined effect of injury in a fall and increased age, the incidence of operable intracranial hematomas was 35% to 65% if patients were in their fourth decade or older and were injured in a fall (Fig. 4 upper right).

Anisocoria is predictive of the presence of operable traumatic intracranial hematomas (p = 0.0182). Eighteen percent of patients with diffuse injury had unequal pupils on admission, whereas 34% of patients with mass lesions had pupillary inequality on admission. Unilateral or bilateral fixed pupils were not a predictor of operable hematomas.

Table 1 summarizes the risk factors that were examined for prediction of operable traumatic intracranial hematomas and their significance as independent predictors.

**Discussion**

Using logistic analysis, this study has demonstrated that increasing age, a low GCS score at admission, injury in a fall, injury to motor-vehicle occupants, and

**TABLE 1**

Risk factors examined for prediction of operable traumatic intracranial hematomas

<table>
<thead>
<tr>
<th>Factor</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>age</td>
<td>0.0000</td>
</tr>
<tr>
<td>Glasgow Coma Scale score</td>
<td>0.0000</td>
</tr>
<tr>
<td>injury due to fall</td>
<td>0.0001</td>
</tr>
<tr>
<td>injury to motor-vehicle occupant†</td>
<td>0.0001</td>
</tr>
<tr>
<td>pupillary inequality</td>
<td>0.0182</td>
</tr>
<tr>
<td>unilateral fixed pupil</td>
<td>NS</td>
</tr>
<tr>
<td>bilateral fixed pupils</td>
<td>NS</td>
</tr>
<tr>
<td>other causes of injury</td>
<td>NS</td>
</tr>
<tr>
<td>multiple systemic injuries</td>
<td>NS</td>
</tr>
<tr>
<td>sex</td>
<td>NS</td>
</tr>
<tr>
<td>alcohol intoxication</td>
<td>NS</td>
</tr>
</tbody>
</table>

* The p value is derived from logistic analysis; NS = not significant.
† Injury to motor-vehicle occupants predicts the absence of traumatic intracranial mass lesions compared with other causes of injury.
pupillary inequality are independent predictors of the presence or absence of operable traumatic intracranial mass lesions. The findings of this study also suggest that there is a significant incidence of operable mass lesions in patients with minor injury (GCS score 13–15) who have one or more risk factors for traumatic intracranial hematoma.

**Type of Injury**

This study had a relatively greater proportion of patients admitted after a fall (34%) compared to most other series, but that figure was similar to the incidence published by Cooper, et al. In both cases, the patients were derived from densely populated urban areas. The community immediately surrounding our hospital includes a significant number of elderly individuals, people with substance abuse problems, and a large amount of poverty.

The finding that injury in a fall predicts traumatic intracranial hematomas while injury to motor-vehicle occupants predicts its absence has been described previously. Gennarelli and Thibault found a 3:1 ratio of acute subdural hematomas following falls versus vehicular trauma in a small series of patients, 80% of whom had severe injuries (GCS score ≤ 8). Experimental work described in the same paper showed that the rate of onset of angular acceleration (strain rate) was the critical determinant of acute subdural hemorrhage. The strain rate is higher in injury by falling than it is in motor vehicle-related trauma. The present series confirms the increased incidence of operable intracranial hematomas in patients injured in falls within a larger group of patients. It also shows that the discrepancy in incidence widens with diminishing severity of injury. In the present series, for patients with a GCS score of 9 or greater, the incidence ratio of operable traumatic intracranial hematomas for falls versus vehicle occupants is 5.6:1 (28% vs. 5%). For patients with a GCS score of 8 or less the incidence ratio is 3.7:1 (78% vs. 21%). In addition to differences in strain rates between falls and motor-vehicle occupant injuries, falls are also more likely to result in contact phenomena such as skull fracture with epidural hemorrhage. The argument that falls are associated with a disproportionate incidence of traumatic intracranial hematomas because of their tendency to occur in the elderly or because of their association with more severe injuries is invalidated by the demonstration in Fig. 4 upper left and right that, at any given injury severity and at any age, injuries due to falls had a greater incidence of operable intracranial hematomas than did injuries to motor-vehicle occupants. Although falls and motor-vehicle occupant

![Diagram](image_url)

**Fig. 4.** Upper Left: Incidence of operable hematomas by Glasgow Coma Scale (GCS) score for victims of motor-vehicle accidents (MVA's) and patients injured in falls. The incidence is normalized to 100% at each level of the GCS. Upper Right: Incidence of operable hematomas by age for MVA victims and patients injured in falls. The incidence is normalized to 100% for each decade. Lower: The interaction of age and GCS on the incidence of operable intracranial hematomas. The height of the bars represents the incidence of operable hematomas normalized to 100% in each category of age and GCS. The incidence steadily increases with both increasing age and head-injury severity.
Risk factors predicting operable hematomas

Injuries were the only statistically significant predictors of the presence or absence of operable intracranial hematomas among the etiologies examined, these two causes of injury were responsible for 61% of injuries in the present series and also predominate in other series of blunt head injury.2,6,11,14,17

Age Group

The age distribution of patients in this study is similar to that seen in other studies.2,6,11,14,17 It has been noted previously that traumatic intracranial hematomas occur more often in older age groups.1,13,15 It is not clear from these studies whether age is an independent predictor of traumatic hematoma or is interacting with the high incidence of falls in the elderly.1 This study shows that increased age is an independent risk factor for acute traumatic intracranial hemorrhage. Possible reasons include cerebral atrophy with an increased propensity for bridging veins to tear and/or increased friability of vessels secondary to atherosclerotic or amyloid change.

Severity of Injury

Our study confirms that increasing severity of injury as reflected by a low GCS score is associated with the presence of traumatic intracranial hematomas. No causal relationship between injury severity and traumatic intracranial hematomas can be inferred from this study. Given the relatively small incidence of patients with severe injuries who have observed neurological deterioration as the result of mass lesions (12% to 17%)19,21,22 and the high incidence of histological evidence of diffuse axonal injury in patients dying with acute subdural hematomas,23 it is possible that in many patients with severe injuries traumatic intracranial hematomas are an epiphenomenon associated with low GCS scores, rather than the cause of low GCS scores.

Pupillarity Findings

Anisocoria has been found to correlate with traumatic intracranial hematomas in previous studies.12,13 Our findings confirm that pupillary size asymmetry can predict operable traumatic intracranial hematomas. Interestingly, the presence of unilateral or bilateral fixed pupils was not predictive of operable mass lesions. This may be due to the confounding effects of traumatic mydriasis in the absence of severe head injury, and the presence of unilateral or bilateral nuclear third nerve palsies in patients with very severe diffuse injuries. Importantly, two-thirds of patients with mass lesions did not have pupillary inequality. This undoubtedly reflects the combination of the tendency of third nerve palsy to occur late in the course of deterioration from mass effect and our ability to diagnose intracranial hematomas in a timely manner (prior to the onset of third nerve compression) with CT.

Patients Who Talk and Deteriorate

We hope the results of this study will help to identify patients who might otherwise “talk and deteriorate” from undiagnosed mass lesions. Klauber, et al.,18 have suggested that recognition and effective management of the “low-risk” head-injured patient (one who has a high GCS motor score, but is at risk for deterioration) is the best way to improve the rate of survival following closed-head injury. In their series, differences between survival following head injury in different centers tended to occur in this type of patient, rather than in those patients who were clearly severely injured. The potentially beneficial effect on survival of the early recognition and treatment of patients who “talk and deteriorate” has been pointed out in several studies.6,19,20 Feuerman, et al.,7 have shown that there is a low incidence of traumatic intracranial hematoma in patients whose injuries resulted in only mild disturbance of consciousness (GCS scores of 13-15). In that series the incidence of operable hematomas was 1.3%; however, the mean age of the patients was 25 to 35 years and injury etiology was not included in the analysis. The present study showed a substantial proportion of patients with a relatively high GCS score (≥ 13) who had operable traumatic intracranial hematomas. Factors other than injury severity that predict operable mass lesions (falls and/or increased age) were prominent in this group of patients. These results suggest that head-injured patients with minimal or no neurological deficits, but who are middle-aged or older, and/or have fallen, are at high risk for traumatic intracranial hematomas and warrant investigation with CT scans of the head.

Multiple Injuries

These results may also assist physicians charged with the care of polytrauma victims who have sustained closed head injuries. As suggested by the results of a previous study, injury to young motor-vehicle occupants, particularly in the presence of signs of circulatory compromise, should prompt a search for serious injuries to the chest, abdomen, or pelvis.30 The likelihood of traumatic intracranial hematoma in this circumstance is quite low. On the other hand, in the hemodynamically stable patient who has suffered a fall and who may or may not have other risk factors (such as anisocoria or increased age), a CT scan of the head and neurosurgical consultation should be expedited in the interests of the earliest possible surgical treatment of intracranial mass lesions.

Conclusions

The results of this study show that increased age, injury due to a fall, a low GCS score, and anisocoria are all independent predictors of the presence of operable traumatic intracranial hematomas, while injury to motor vehicle occupants is significantly less likely to result in operable mass lesions. A history of injury in a fall in patients who are middle-aged or older identifies patients with less severe injuries who are at particular risk for traumatic intracranial hematomas and subsequent deterioration. These patients should undergo CT.
scanning of the brain, even in cases of apparently minor injury.

References


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Manuscript received August 6, 1991. Accepted in final form December 11, 1991. Address reprint requests to: Richard J. Moulton, M.D., Division of Neurosurgery, 38 Shermer Street, Toronto, Ontario M5B 1A6, Canada.