Early prediction of outcome in head-injured patients

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The relationship between Glasgow Coma Scale (GCS) scores obtained during the 1st week after head injury and outcome at 1 year was analyzed in 170 patients. Seventy-two of 76 patients with initial GCS scores of higher than 7 had favorable outcomes. Only two of the 21 patients with initial GCS scores of 3 or 4 lived, and only one had a favorable outcome. Favorable and unfavorable outcomes were almost equally divided when the initial GCS scores were in the intermediate range of 5, 6, or 7. No patients with an initial GCS score in this intermediate range that subsequently worsened had a favorable outcome, while over 80% of those improving to a score higher than 7 had a favorable outcome. Only 12% of those persisting with a score of 5, 6, or 7 for 1 week had a favorable outcome.

Outcome predictions using the multiple logistic model were made for this intermediate group of patients based on GCS scores and data on midline shift derived from computerized tomography (CT). The patients with initial scores of 5, 6, or 7 with midline shifts of less than 4.1 mm on initial CT scanning had a significantly higher favorable outcome rate compared with patients with a larger shift. However, outcome predictions made by combining shift data and initial GCS scores are not significantly more accurate than predictions based solely on initial GCS scores. Combining 48-hour GCS scores and shift data significantly improves predictive accuracy based only on coma scores. The data obtained by combining GCS scores at 72 hours and 1 week and shift data is marginally significant for improving accuracy of outcome predictions. It is concluded that GCS scores and shift data are highly accurate indicators of outcome in head-injured patients.

KEY WORDS • head injury • prognosis • coma scale • computerized tomography

The Glasgow Coma Scale (GCS) is used in numerous neurosurgical units to evaluate head-injured patients. This report is a detailed statistical analysis of the relationship between GCS scores obtained during the 1st week following head injury and outcome at 1 year. The value of additional data obtained from computerized tomography (CT) scanning for improving accuracy of outcome predictions based on GCS scores is also assessed. The paper describes how, when, and with what accuracy outcome predictions can be made for the individual head-injured patient.

Clinical Material and Methods

This study consisted of 170 prospectively selected patients with the following types of injuries: penetrating missile wounds, intracranial hematomas, depressed skull fractures, and blunt head injuries causing major focal neurological deficits or unconsciousness for at least 6 hours. The 6-hour duration of unconsciousness was selected to provide comparability with other coma studies. There were 144 males and 26 females. The patients’ average age was 26.2 years, with a range between 2 and 84 years. Although the severity of brain injury varied, all patients required either surgical treatment or management in an intensive care unit. The definition of coma used in this study conformed to the recommendations of the Head Injuries Committee of the World Federation of Neurosurgical Societies, and is currently used in several large collaborative studies. Patients in coma spoke no recognizable words, did not obey commands, and did not open their eyes in response to any stimulus. Patients with initial GCS scores not accurately measuring the severity of brain injury were removed from the study. For example, patients who greatly improved after correction of anoxia or hypotension,
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Results

Based on distinct difference in outcome at 1 year, the 170 patients were divided for detailed analysis into three groups (Table 1): initial GCS score greater than 7, initial GCS score of 5, 6, or 7, and initial GCS score of 3 or 4. All but one of the 76 patients with an initial score greater than 7 lived, and only three had an unfavorable outcome. Only two of the 21 patients with an initial score of 3 or 4 lived. One made a good recovery after rapid removal of an acute epidural hematoma, and the other remained in a vegetative state. Only 36 of the 73 patients with an initial GCS score of 5, 6, or 7 had a favorable outcome. Twenty-four of the 37 with an unfavorable outcome died (Table 1).

Accurate outcome predictions cannot be made for the intermediate group with initial scores of 5, 6, or 7, because favorable and unfavorable outcomes occurred in almost equal proportions (Table 1). We therefore assessed whether adding midline shift data to the GCS score data improves accuracy of outcome prediction since midline shift, when considered alone, is a significant determinant of outcome when the patients are divided into two groups, shift less than 4.1 mm or 4.1 mm or greater, and outcome categories are combined into favorable or unfavorable groups. The patients with midline shifts of less than 4.1 mm on initial CT scan had a significantly higher favorable outcome rate compared with patients with a larger shift (Table 2). However, predictions made by combining shift data and initial GCS scores are not significantly more accurate than outcome predictions based solely on initial coma scores (coefficient ± SE: 0.60 ± 0.58).

Age, considered alone, was marginally significant for predicting outcome in this intermediate group (p = 0.09). The average age for the 36 patients with a favorable outcome was 22 years, and 28 years for the 37 patients with an unfavorable outcome. In addition, age category, when subdivided into those less than 15

### Table 1

<table>
<thead>
<tr>
<th>Initial GCS Score</th>
<th>No. of Cases</th>
<th>Favorable Outcome</th>
<th>Unfavorable Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-15</td>
<td>76</td>
<td>63</td>
<td>3</td>
</tr>
<tr>
<td>5-7</td>
<td>73</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>3-4</td>
<td>21</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>170</td>
<td>92</td>
<td>12</td>
</tr>
</tbody>
</table>

*GCS = Glasgow Coma Scale.

### Table 2

<table>
<thead>
<tr>
<th>Midline Shift (mm)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4.1</td>
<td>Favorable: 27, Unfavorable: 17</td>
</tr>
<tr>
<td>≥ 4.1</td>
<td>Favorable: 8, Unfavorable: 17</td>
</tr>
</tbody>
</table>

*χ²(1) = 5.5; p = 0.019.
Although adding data on midline shift to initial GCS score data does not increase accuracy of outcome predictions, at later intervals midline shift does become an important variable for improving outcome predictions (Tables 4 and 5). Combining 48-hour GCS scores and shift data significantly improves predictive accuracy. The data obtained by combining GCS scores at 72 hours and 1 week and shift data are marginally significant for predicting outcome. Patients persisting with a GCS score of 5, 6, or 7 or improving to a score higher than 7 by 48 hours and having less than 4.1 mm midline shift, fare considerably better than those patients with a shift greater than 4.1 mm.

**Discussion**

The Glasgow Coma Scale is of value not only as an objective and reproducible means of quantifying the degree of neurological impairment, but also as a basis for making early, accurate predictions of the likely outcome of head-injured patients. Initial GCS scores alone provide adequate information to make highly reliable outcome predictions for patients with initial scores either higher than 7 or less than 5. Ninety-five percent of patients with initial GCS scores greater than 7 had a favorable outcome, and 95% with initial scores of less than 5 had an unfavorable outcome. Correspondence between outcome and GCS scores at later time intervals does not improve for these two groups during the remainder of the 1st week.

Jennett, *et al.*, related GCS scores to outcome in several reports, and indicated that assessment of severity of injury “on admission or before resuscitation and early treatment” will bias outcome predictions.7 In Jennett’s view, comparable injuries could be mistakenly estimated to have a less favorable outcome if initial or worst state rather than “best state” is the basis for making the prediction. He indicated that using the best state observed during the first 24 hours more reliably predicts outcome. Our data show that the initial level of consciousness can be used to reliably predict the outcome in patients with an initial GCS score higher than 7 or less than 4. Waiting 24 hours to determine highest GCS score in the first 24 hours for this group of patients would not increase predictive accuracy when anoxia, hypotension, or alcohol intoxication are not contributing to the alteration of consciousness.

We found that assessing prognosis for patients in the intermediate group with GCS scores of 5, 6, or 7 was more complex. Initial scores did not provide sufficient information to make accurate predictions since outcomes were divided almost equally between the favorable and unfavorable categories. Accurate predictions for this group can be made only when the GCS score later changes to greater than 7 or less than 5. For example, when the initial GCS score improved to at least 8 during the first 24 hours, 88% had a favorable outcome. When deterioration to below 5 occurred, no patient survived. The earlier the patient im-

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**Table 3**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Percent of Cases at 24 Hours</th>
<th>48 Hours</th>
<th>72 Hours</th>
<th>1 Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>improved</td>
<td>88 (93)</td>
<td>84 (88)</td>
<td>83 (86)</td>
<td>83 (86)</td>
</tr>
<tr>
<td>remained same</td>
<td>20 (21)</td>
<td>17 (19)</td>
<td>9 (10)</td>
<td>12 (12)</td>
</tr>
<tr>
<td>worsened</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

*Percent with favorable outcome after the seven patients with penetrating missile wounds are excluded is shown in parentheses.

**Table 4**

<table>
<thead>
<tr>
<th>Data</th>
<th>Time Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24 Hours</td>
</tr>
<tr>
<td>improvement scale*</td>
<td>-3.79</td>
</tr>
<tr>
<td>shift</td>
<td>±0.85</td>
</tr>
<tr>
<td></td>
<td>1.15</td>
</tr>
<tr>
<td></td>
<td>±0.90</td>
</tr>
</tbody>
</table>

*Improvement scale: Glasgow Coma Scale (GCS) score > 7, remains at 5, 6, or 7, or falls below 5.

**Table 5**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Midline Shift</th>
<th>Time Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24 Hours</td>
<td>48 Hours</td>
</tr>
<tr>
<td>improved</td>
<td>no</td>
<td>94%</td>
</tr>
<tr>
<td>(GCS score &gt; 7)</td>
<td>yes</td>
<td>82%</td>
</tr>
<tr>
<td>stayed same</td>
<td>no</td>
<td>25%</td>
</tr>
<tr>
<td>(GCS score 5, 6, or 7)</td>
<td>yes</td>
<td>10%</td>
</tr>
<tr>
<td>worsened</td>
<td>no</td>
<td>1%</td>
</tr>
<tr>
<td>(GCS score &lt; 5)</td>
<td>yes</td>
<td>0%</td>
</tr>
</tbody>
</table>

*GCS = Glasgow Coma Scale.
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proves into the higher than 7 category, the more likely is a favorable outcome. The chances of having a favorable outcome reach a plateau at 24 hours for those patients with initial GCS scores of 5, 6, or 7 who improve to scores of greater than 7 (Table 3). The longer the patient remains in the intermediate category, the more likely is an unfavorable outcome. Patients remaining in the intermediate category (5, 6, or 7) at 1 week had only about one-half the chance of having a favorable outcome of those in this same category at 24 hours. No patient who was initially in the intermediate group and then deteriorated had a favorable outcome. Our data support Jennett's finding that the pattern of change in GCS score during the first 24 hours after injury is a key to more precise early outcome predictions within this group. Even more accurate predictions can be made at later intervals, but the favorable outcome percentages reach a plateau at the highest score in the first 24 hours.

Stablein, et al., recently detailed the statistical value of the logistic model for prediction outcome of head-injured patients. In their series, the most important prognostic factor was a requirement for surgical decompression. In a previous description of their standardized protocol for managing these patients, Becker, et al., indicated that patients having a 5-mm or more shift had surgical exploration and decompression. Although Stablein, et al., and Becker, et al., did not include penetrating missile wounds, our studies are comparable. Table 3 shows no significant difference in favorable outcome percentages after seven patients with penetrating missile wounds are excluded. Our data also emphasize the significant relationship between shift in the 4–5 mm range and outcome. In addition, we show the value of combining shift data with GCS score data for improving accuracy of outcome predictions for patients in the intermediate category.

Other factors, such as pupillary reactivity to light, brain-stem function, vital signs and hematocrit, age, and type of injury can be used as a basis to predict outcome following head injury. Our data suggest that adding any one or a combination of these other factors could only very slightly increase the already highly accurate outcome predictions of patients who are initially conscious or deeply comatose or who are in the intermediate group at 24 hours after admission. Our study shows that age, considered independently in the intermediate group, is a marginally significant variable for predicting outcome. However, after adjustment for initial coma score, age is not a significant variable for this group. Likewise, injury category when added to initial GCS score does not improve accuracy of outcome predictions (coefficient ± SE: 0.31 ± 0.21).

Stablein, et al., based their outcome predictions on 12 variables obtained initially after hospital admission. Ninety-one percent of their outcome predictions were correct. Sixty-nine percent of their predictions were made at a 0.90 confidence level. They showed that requirement for a surgical decompression (shift greater than 5 mm), age, vital signs and hematocrit, and motor response (a component of the GCS scale) are significant determinants of outcome. The other eight factors they considered, including pupillary light responses, pupillary size, and oculocephalic response, were either only marginally significant or not significant. We found that only one variable, the initial GCS score, is needed for an accurate prediction of outcome in patients deeply comatose or conscious. Accurate predictions using only the GCS score cannot be made a few hours after admission for patients with initial scores of 5, 6, or 7. However, by 24 hours, accurate outcome predictions based only on GCS scores are possible. Furthermore, adding only one variable, midline shift data, will significantly improve the outcome predictions made at later intervals. Our study shows that a short delay enables highly accurate predictions for the intermediate group without using so many variables that a computer is required for accurate predictions.

References


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