Outcome after severe head injury

Relationship to mass lesions, diffuse injury, and ICP course in pediatric and adult patients

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A consecutive series of 330 severely head-injured patients was studied prospectively. All of the patients were treated with the same protocols by the same physicians and staff in the same intensive care unit. All of the patients had intracranial pressure (ICP) monitoring. Of the 330 patients, 100 were in the pediatric age group (0 to 19 years of age) and 230 were in the adult group (20 to 80 years of age). Statistical analyses were performed with regard to outcome, Glasgow Coma Scale (GCS) score, ICP course, and incidence of surgical lesions. The average emergency room GCS score as well as the 24-hour GCS score for each group was the same. The percentage of patients having ICP that was normal, increased but reducible, and increased but not reducible in each group was the same.

The pediatric patients had a significantly higher percentage of good outcomes (43%) than the adult patients (28%) (p < 0.01). They also had a significantly lower mortality rate (24%) than the adult patients (45%) (p < 0.01). At 1 year following injury, 55% of pediatric patients had a good outcome compared to 21% of adults (p < 0.001); this trend was evident at 3 months, with the same p value. Pediatric patients with normal ICP had a higher percentage of good outcomes (70%) than the adult patients with normal ICP (48%) (p < 0.05). There was no significant difference in outcome in pediatric and adult patients with mass lesions or with increased ICP, regardless of whether or not the pressure was reducible. There was a much higher incidence of surgical mass lesions in adult patients (46%) than in pediatric patients (24%) (p < 0.001).

KEY WORDS • head injury • intracranial pressure • mass lesion • children • outcome

It has been a widely held tenet that, after sustaining a similar insult, children are more resilient and recover better than adults. This thinking is certainly prevalent in the literature on head injury. Several reports have appeared in the literature that suggest that children do better than adults following severe head injury.\textsuperscript{2,7,8,12,15,20,23,25,31} Miller, et al.,\textsuperscript{23} showed a steady increase in mortality rate with age. Pazzaglia, et al.,\textsuperscript{25} have suggested that age clearly influences the clinical course with regard to both mortality rate and quality of survival. In 1978, Bruce, et al.,\textsuperscript{7} reported a remarkable 6% mortality rate in the pediatric population. Gruszkiewicz, et al.,\textsuperscript{12} and more recently Berger, et al.,\textsuperscript{2} have reported a lower incidence of mortality in children than in adults after severe head injury. However, in most of the previously reported series, patients in a pediatric group have been compared to an independently treated group of adult patients, often in another facility. Certainly, treatment protocol, monitoring, and the management of intracranial pressure (ICP) have varied considerably from series to series. To make sound conclusions from a comparison of pediatric and adult patients with severe head injury, one would obviously want to minimize the effect of as many variables as possible. The situation at our institution has afforded a unique opportunity to compare outcome from head injury in pediatric and adult patients.

The Medical College of Virginia (MCV) Hospital contains a complete pediatric service within the same facilities. Our formula for management of severe head injury has been consistently applied to all patients regardless of age. As reported previously,\textsuperscript{12} it includes immediate diagnosis and surgical intervention when indicated, management in a neurosurgical intensive
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care unit (ICU), ICP monitoring, and aggressive treat-
ment of elevated ICP. All patients in this series were
initially evaluated in the trauma emergency room. Al-
though separate ICU’s for pediatric patients exist at the
MCV Hospital, all patients with severe head injury were
admitted to the neurosurgical ICU regardless of age.
Therefore, all patients were evaluated and treated by
the same physicians, nursing personnel, and staff in the
same ICU setting.

The purpose of this study was to compare pediatric
and adult patients with severe head injury treated in a
similar way, and to identify any factors that may have
been responsible for or associated with any difference
in outcome. Analysis of outcome was performed in
relation to patients’ age, presence of diffuse injury or
mass lesion, ICP distribution, and the temporal course
of outcome. In addition, the incidence of surgical mass
lesions was determined. Depressed skull fractures were
not considered surgical mass lesions.

Clinical Material and Methods

This series consisted of 330 severely head-injured
patients who were seen at the MCV Hospital between
May, 1976, and June, 1984. Criteria for admission to
this study were that the patient have a Glasgow Coma
Scale (GCS) score of 7 or below, with GCS score
compatibility. These GCS criteria, as reported by Jen-
nett and Teasdale, included no eye opening to pain-
ful stimuli, no verbal response, and failure to obey
commands for at least 6 hours following injury or
subsequent deterioration. The patients reported in this
study are actually a subset of severely head-injured
patients treated at our institution. This is because the
strategy for study at our institution only includes the
failure to follow commands at 6 hours, which in the
strictest sense would not be GCS-compatible. There-
fore, only the subset of patients meeting the criteria of
GCS compatibility is reported in this study.

All patients were studied prospectively. The details
of data collection and follow-up evaluation have been
reported previously. Of the 330 patients, 100 were
in the pediatric age group (0 to 19 years of age) and 230
were in the adult group (20 to 80 years of age). The
mean ages of patients in the pediatric and adult groups
were 13.39 and 38.59 years, respectively. Most patients
were male (79% of the adult group and 71% of the
pediatric group). It is interesting that there was a male
predominance even in the youngest patients (Fig. 1).

All patients were seen by a neurosurgeon in the
emergency room where stabilization and initial neuro-
logical evaluation were carried out. In conjunction with
general surgical clearance, all patients were intubated,
mechanically hyperventilated, given mannitol (1 gm/kg),
and immediately taken for computed tomography (CT) scanning.
Patients with mass lesions causing a midline shift of
greater than 5 mm were immediately taken to the
operating room for evacuation of the lesion. In every

case either a ventricular catheter or a subarachnoid bolt
was placed for the continuous measurement of ICP. All
patients were admitted to the neurosurgical ICU. Those
with ICP’s greater than 20 mm Hg underwent phar-
macological paralysis, morphine sedation, hyperventi-
lation, cerebrospinal fluid (CSF) drainage, mannitol
administration, and barbiturate coma as needed to re-
duce their ICP to below 20 mm Hg. Details of the man-
agement protocol have been reported previously.

Results

Patient Population

The average GCS score in the emergency room and
at 24 hours was determined for each group (Table 1).
No statistically significant difference between the pedi-
atriic and the adult groups of patients was noted, sug-
uggesting that the severity of the head injury in each group
was similar. It can be seen that both the pediatric and
adult groups showed a slight deterioration in GCS score
at the 24-hour determination. This demonstrates that
the series was not composed of a large number of
patients in light coma who quickly went on to recover.
Twenty-five percent of our pediatric patients and 28%
of the adult patients had a GCS score of 3 or 4 on
admission.

The time delay from onset of injury until evaluation
and treatment by a neurosurgeon was recorded for all
patients (Table 2). Eighty percent of all patients were
seen within 5 hours following their injury. The mean

![Fig. 1. Graph showing the sex distribution among the 100 pediatric patients with severe head injury. The mean age of these patients was 13.39 years.](image-url)

| TABLE 1
<table>
<thead>
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<tr>
<td>Patient Group</td>
<td>Emergency Room GCS Score</td>
<td>24-Hr GCS Score</td>
</tr>
<tr>
<td>pediatric (0-19 yrs)</td>
<td>5.86</td>
<td>5.61</td>
</tr>
<tr>
<td>adult (20-80 yrs)</td>
<td>6.02</td>
<td>5.37</td>
</tr>
</tbody>
</table>

* GCS = Glasgow Coma Scale.
between pediatric and adult patients was 20 minutes. Percentages are a mean delay of 3 hours 4 minutes. The difference in mean time delay was not significant.

An analysis of the ICP distribution was also undertaken. Patients were grouped into one of three categories: 1) ICP less than 20 mm Hg; 2) ICP above 20 mm Hg but reducible with treatment; and 3) ICP above 20 mm Hg but not reducible with treatment. As can be seen in Fig. 2, there existed no significant difference in the distribution of ICP's between the pediatric and adult groups. This again would suggest that the severity of injury in each group as reflected by the ICP distributions is quite similar.

**Age and Outcome**

Outcome was assessed according to the Glasgow Outcome Scale. Briefly, there are five outcome categories in this scale. A good recovery is one in which there is resumption of preinjury activities with no or minimal neurological deficits or apparent change in personality or school performance. A moderate disability is one in which the patient is able to function independently at a reduced level because of personality, intellectual, or physical differences compared with preinjury status. A severe disability is one in which the patient is unable to function independently and requires substantial care at home or in an institution as a result of physical or intellectual impairment. The last two categories are vegetative state and dead.

When comparing outcome of the pediatric and adult populations over a 3-month to 8-year follow-up period, pediatric patients had a higher percentage of good outcome and a lower mortality rate than adult patients (that is, the good-outcome and dead categories) and compares them to age, a strong linear relationship emerges (Fig. 4 upper). As expected, good outcome decreases with age and mortality increases with age. These trends were statistically significant (p < 0.001).

There is no statistically significant difference between the two patient populations in the middle three outcome categories (moderately disabled, severely disabled, and vegetative state). If one looks at only the categories with a significant difference between the pediatric and adult patients (that is, the good-outcome and dead categories) and compares them to age, a strong linear relationship emerges (Fig. 4 upper). As expected, good outcome decreases with age and mortality increases with age. These trends were statistically significant (p < 0.001). If these trends were to hold true over all age groups, one would expect the very youngest patients to have the best outcome; however, our data did not reflect time delay for pediatric patients was 2 hours 44 minutes and for adults 3 hours 4 minutes. The difference in the time delay was not significant.

An analysis of the ICP distribution was also undertaken. Patients were grouped into one of three categories: 1) ICP less than 20 mm Hg; 2) ICP above 20 mm Hg but reducible with treatment; and 3) ICP above 20 mm Hg but not reducible with treatment. As can be seen in Fig. 2, there existed no significant difference in the distribution of ICP's between the pediatric and adult groups. This again would suggest that the severity of injury in each group as reflected by the ICP distributions is quite similar.

**Table 2**

<table>
<thead>
<tr>
<th>Time Delay (hrs)</th>
<th>Pediatric Group (%)</th>
<th>Adult Group (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>1-2</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>2-3</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>3-4</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>4-5</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>5-6</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6-9</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9-12</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12-24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 24</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

*In the pediatric group (ages 0-19 years) there was a mean delay of 2 hours 44 minutes; in the adult group (ages 20-80 years) there was a mean delay of 3 hours 4 minutes. The difference in mean time delay between pediatric and adult patients was 20 minutes. Percentages are of the 100 patients in the pediatric group and the 220 patients in the adult group.

**Fig. 2.** Graph showing the distribution of intracranial pressure (ICP) in the pediatric (age 0-19 years) and adult (age 20-80 years) groups. Patients were grouped into three categories: 1) ICP < 20 mm Hg (normal); 2) ICP > 20 mm Hg but reducible with treatment (inc. but red.); and 3) ICP > 20 mm Hg but not reducible with treatment (inc. not red.).
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Fig. 4. Graph showing the relationship between patients' age and the incidence of good outcome and death.

Fig. 3. Graph showing the relationship between age and outcome at different follow-up times as assessed by the five categories of the Glasgow Outcome Scale. Mod. dis. = moderate disability; severe dis. = severe disability; veg = vegetative state.

this (Fig. 4 lower). The trend continued down to the 5- and 9-year-old age group. This group had the highest percentage of patients with a good outcome (61%), and a 22% mortality. However, in the very youngest patients (0 to 4 years of age), the relationship appeared to break down, with 17% good outcome and 17% mortality. There were only six patients in the 0- to 4-year-old age group, and therefore no statistically significant conclusions could be drawn.

Intracranial Pressure and Outcome

As was mentioned previously, there was no significant difference in the distribution of ICP's between the pediatric and adult groups (see Fig. 2). Among patients with ICP's below 20 mm Hg, once again pediatric patients did better than adult patients, with a 70% good outcome versus 48% in the adult group, and a 6% pediatric mortality rate versus 28% in adults (Fig. 5 upper). These differences were significant (p < 0.05). There were no differences between the pediatric and adult groups in the middle three outcome categories. In patients whose ICP was above 20 mm Hg but which was reducible with treatment, there was no difference in the rate of poor outcome of pediatric and adult patients (Fig. 5 center). The pediatric mortality rate was slightly lower but this was not statistically significant (p < 0.13). Patients whose ICP was elevated above 20 mm Hg and was refractory to treatment had the overall worst outcome, with no difference between the pediatric and the adult patients (Fig. 5 lower). There was an 8% good outcome in the pediatric group and a 0% good outcome in the adult group, with respective mortality rates of 92% and 95%. In summary, pediatric patients with ICP's less than 20 mm Hg had a higher percentage of good outcome and a lower mortality than adult patients with low ICP's. There was no difference in the incidence of poor outcomes in pediatric and adult patients with increased ICP, whether or not it was treatable.

Diffuse Injury and Outcome

Comparisons of all patients with diffuse injury revealed once again that pediatric patients had a higher
percentage of good outcomes than adults (51% vs. 39%) and a lower mortality rate (16% vs. 31%) (Fig. 6 lower). These trends were significant (p < 0.05). There was no difference in the moderately disabled, severely disabled, and vegetative groups.

**Mass Lesion and Outcome**

In patients with mass lesions, there was no statistically significant difference between adult and pediatric patients in any of the outcome categories. Overall outcome was poor, with a good outcome in 20% of pediatric patients and 15% of adult patients, with respective mortality rates of 48% and 60% (Fig. 6 upper). There were only 24 pediatric patients with mass lesions in the series. Had numbers been larger, significant trends may have emerged.

**Incidence of Surgical Lesions**

The overall incidence for the entire group of mass lesions requiring surgery was 39% (Table 3). The incidence of surgical mass lesions between the two patient populations was different, with pediatric patients having a much lower incidence. In the adult group, 46% of the patients presented with mass lesions requiring surgery as opposed to only 24% of the pediatric patients.

**Mechanisms of Injury**

The mechanisms that produced the severe head injury were recorded and assigned to one of seven categories: motor vehicle, pedestrian, cycle, work, assault, domestic, and other (Table 4). Patients in the motor vehicle, pedestrian, and cycle categories (referred to as motor vehicle-related) had a higher proportion of diffuse injuries (63% as a group), while patients in the work, assault, domestic, and other categories (referred to as non-motor vehicle-related) had a higher proportion of surgical mass lesions (75% as a group). A comparison of the mechanisms of injury in the pediatric and adult groups (Table 5) shows that the majority of all severe head injuries were secondary to motor...
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TABLE 3
Incidence of surgical mass lesions*

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>Surgical Mass Lesions (%)</th>
<th>Non-Surgical Lesions (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pediatric</td>
<td>24</td>
<td>76</td>
</tr>
<tr>
<td>adult</td>
<td>46</td>
<td>54</td>
</tr>
<tr>
<td>all patients</td>
<td>39</td>
<td>61</td>
</tr>
</tbody>
</table>

* The trend toward a higher incidence of surgical lesions in adult patients than in pediatric patients was significant at p < 0.001.

TABLE 4
Incidence of operative lesions compared to mechanism of injury

<table>
<thead>
<tr>
<th>Mechanism of Injury</th>
<th>Surgical Lesions (mass lesions)</th>
<th>Non-Surgical Lesions (diffuse injury)</th>
</tr>
</thead>
<tbody>
<tr>
<td>motor vehicle-related</td>
<td>37%</td>
<td>63%</td>
</tr>
<tr>
<td>motor vehicle</td>
<td>27%</td>
<td>73%</td>
</tr>
<tr>
<td>pedestrian</td>
<td>29%</td>
<td>71%</td>
</tr>
<tr>
<td>cycle</td>
<td>24%</td>
<td>76%</td>
</tr>
<tr>
<td>non-motor vehicle-related</td>
<td>75%</td>
<td>25%</td>
</tr>
<tr>
<td>work</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>assault</td>
<td>71%</td>
<td>29%</td>
</tr>
<tr>
<td>domestic</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>other</td>
<td>68%</td>
<td>32%</td>
</tr>
</tbody>
</table>

Further experience as reported by Miller, et al.,23 is more consistent with the current data, with strong linear relationships emerging. Our pediatric mortality rate of 24% is lower than the 33% rates reported by Berger, et al., as well as Gross, et al.,11 but not nearly as low as the 6% rate reported by Bruce, et al.7 Hendrick and coworkers16 reported an increased mortality in infants as opposed to adolescents, which may very well coincide with the trend of increasing mortality that we saw in the 0- to 4-year-old group. Humphreys, et al.,7 reported that 68% of the deaths in their series occurred in children less than 5 years of age. Likewise, Teasdale, et al.,31 demonstrated increasing mortality with age in patients over 5 years old. Braakman, et al.,3 considered age to be a strong prognostic feature; however, they did show a slightly higher mortality rate of 35% in their 0- to 10-year-old age group as opposed to 33% in their 11- to 20-year-old age group. They did not report the breakdown of age distribution in the 0- to 10-year-old age group, which may have reflected a higher mortality in the youngest patients.

Gross, et al.,11 noted the need for a study comparing pediatric and adult patients, citing small patient populations and the lack of a comparative adult group. They reported just such a set of patients from the Pilot Traumatic Coma Data Bank.11 Their series consisted of 58 patients aged 1 to 14 years of age and 523 patients aged 15 to 89 years of age (all with a GCS score of 8 or below), collected similarly from six different institutions participating in the Pilot Traumatic Coma Data Bank. This series differed from ours in that our patients who ranged in age from 15 to 19 years were included in the pediatric group rather than the adult group, and our criterion for inclusion in the series was that the patients have a GCS score of 7 or below. Their data regarding good outcome and mortality were similar to ours (Table 6). A small percentage of our patients (approximately 9% of our pediatric population and 23% of our adult population) is in fact doubly reported in each series because our institution participated in the Pilot Traumatic Coma Data Bank. Had our series only included patients aged 0 to 14 years in the pediatric group, it is reasonable to assume that the MCV Hospital percentage

Discussion

Our data provide further support to the premise that children fare better than adults following a severe head injury. A lower mortality rate and better outcome is seen in the pediatric population, and there is a significant relationship between age and outcome and between age and mortality (see Fig. 4). Berger, et al.2 did not find a statistically significant relationship between age and outcome, but they did find that a higher percentage of younger than older children achieved independence. Had their series been larger, they may well have seen the relationship between age and outcome that we have observed. Earlier experience with some of these same patients, as reported by Becker, et al.,1 showed an increased mortality rate with age and a decrease in the proportion of patients making a good recovery. However, the relationships were not nearly as linear as seen in the current data. This may be accounted for in part by a larger patient population. The

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of good outcomes and the mortality rate would have improved slightly in the pediatric group over those values reported in Table 6. Likewise, had we included patients with a GCS score of 8, it is reasonable to assume that outcome and mortality for both the pediatric and adult groups would have improved slightly. When considering both of these series together, the overwhelming evidence is that children do indeed fare better than adults following a severe head injury. The problem still remains to try to identify the factors responsible for or associated with these differences.

Part of the explanation may lie in the mechanism of injury. Bruce, et al.,7 believed that the presence of a mass lesion did not influence outcome, since 11 of their 12 patients harboring a mass lesion achieved a good recovery or had only moderate disability. In contrast, in our series only 40% of children with a mass lesion achieved a good recovery or only moderate disability. Our data also suggest that patients with a surgical mass lesion have a worse prognosis than those with a diffuse injury (Fig. 6). At the same time, adult patients had a higher incidence of surgical mass lesions (46% vs. 24% in the pediatric group, Table 3). Humphreys, et al.,17 reported a higher incidence (35%) of mass lesions in children. The different incidence of mass lesions between pediatric and adult patients seems to be due to the fact that a higher proportion of adult patients sustained a non-motor vehicle-related head injury. It is noteworthy that, according to our data, a patient with a severe head injury (GCS score of 7 or below) has a 75% chance of needing surgical intervention if the injury was not motor vehicle-related (that is, not involving a motor vehicle, pedestrian, or cycle). These findings may be explained by the fact that head injury associated with work, assault, domestic, and other categories generally results from either a blow to the head or from acceleration of the head against a fixed object such as in a fall, whereas motor vehicle-related injuries are due to a combination of acceleration/deceleration as well as direct blows to the head. The fact that pediatric patients had fewer non-motor vehicle-related accidents, which are more likely to produce a mass lesion requiring surgery and subsequently result in a poor outcome, may have accounted for some of the difference in the overall mortality and outcome. In support of this, Gennarelli, et al.,10 have reported that the type of lesion is as important as the GCS score in determining outcome. They pointed out that, in patients with the same GCS score, the outcomes were markedly different depending on the causative lesion.

Our patients with mass lesions did not do well as a group, with a 33% combined good outcome or moderate disability rate. Berger, et al.,2 reported a 53% incidence of a good outcome or moderate disability, which may again have differed from our data because of small numbers. Various series of acute subdural hematoma have reported mortality rates from 60% to 90%,5,10,13,14,26,28 Seelig, et al.,28 found the single most important variable associated with mortality in acute subdural hematoma to be the time delay from injury to operation. They found that the mortality rate increased from 30% in patients who underwent surgery within the first 4 hours following injury to 90% in those who had surgery after 4 hours. Approximately 75% of our patients had reached the hospital by 4 hours. With 39% of our patients harboring a mass lesion (the vast majority being acute subdural hematomas), the importance of prompt transportation to a hospital that can deliver immediate neurosurgical care cannot be stressed enough.

It has also been suggested by Bruce, et al.,6,7 that the pathophysiology of diffuse brain injury in children is different than in adults. In approximately 41% of cases in their severe pediatric head injury series, they found diffuse swelling with obliteration of the CSF spaces and increased density on CT scanning of the deep frontal white matter. In six of these patients in whom cerebral blood flow (CBF) measurements were taken, there was an increase in CBF. These findings were attributed to vasodilatation and initial hyperemia. While this phenomenon does occur in certain patients, it does not appear to be the case in the majority of pediatric patients. Whether increased ICP is due to hyperemia with increased cerebrovascular volume in children is still open to debate. In work done at the MCV Hospital (JP Muizelaar, personal communication, 1987), CBF was measured in a series of 32 children during the first few days after injury. There were only three patients with CBF values above normal (± standard deviation at normal PaCO2). These three patients also had the lowest pressure-volume index (PVI),21 indicating that they had the least compliant brains. For the other 29 children, however, no relationship was apparent between the CBF and ICP or PVI. A large number of these patients would be considered hyperemic by the very generous definitions set forth by Obrist, et al.24

Pediatric patients in the diffuse injury subgroup as well as the pediatric patients with ICP's less than 20 mm Hg did better than adults. These two subgroups, therefore, have also partly contributed to the overall better outcome and lower mortality in the pediatric patients. No proposal other than the resiliency and plasticity of the pediatric nervous system and its ability to handle injury has emerged to explain these differ-

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**TABLE 6**

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>Good Outcome</th>
<th>Mortality</th>
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<tbody>
<tr>
<td></td>
<td>MCV</td>
<td>PCDB</td>
</tr>
<tr>
<td>pediatric†</td>
<td>43%</td>
<td>33%</td>
</tr>
<tr>
<td>adult</td>
<td>28%</td>
<td>18%</td>
</tr>
</tbody>
</table>

* MCV = Medical College of Virginia series; PCDB = Pilot Traumatic Coma Data Bank.†

† In our present study at MCV, patients aged 19 years old or under were included in the pediatric group.
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ences. It appears, however, that the pediatric nervous system is no better equipped than that of the adult to handle increased ICP, as was evidenced by similar outcome and mortality regardless of age in the subgroups with elevated ICP. Patients with an increased ICP had a poor outcome, regardless of age or whether the ICP was reducible with treatment; untreatable ICP patients had the worst outcome of all.

It may well be that mass lesions and increased ICP may be markers of more severe injuries. It intuitively makes sense that children should do better across all subgroups, but they do not. Perhaps, in fact, mass lesions and increased ICP are associated with an injury level that along the continuum of severity is irreversible by current treatment modalities. Thus, a level of injury severe enough to produce some extent of irreversible neural damage may explain the lack of difference in outcome between pediatric and adult patients who sustain a mass lesion or who exhibit increased ICP.

In order to further reduce the incidence of mortality and to improve outcome, it would seem that the subgroups with increased ICP should be targeted for improved treatment modalities. By the time a severe injury has manifested itself with an increased ICP, it may already be too late to effect an improved outcome. The difference in outcome and mortality seen between the increased ICP but treatable group and the increased ICP but untreatable group would suggest that treatment of increased ICP has improved the outcome and mortality rate in these patients. However, a good outcome in 27% of these patients who had treatable intracranial hypertension is still quite dismal. Perhaps we should be treating ICP problems before they occur by determining the intracranial compliance based on the PVI to identify those patients who might be at risk for developing intracranial hypertension. Treatment could then be initiated prior to the development of increased ICP wherever possible. Such prophylactic treatment regimens, if utilized, might further reduce mortality and improve outcome in patients of all ages.

Lastly, it can be seen from the temporal course of our patient populations that vast functional improvements occur in severely head-injured patients in the 1st year following injury. Brink, et al., found in some pediatric cases that physical and psychological improvement continued for as long as 3 years after injury. This can be important information for rehabilitative planning as well as for the family in their efforts to deal with these devastating problems.

Conclusions

After severe head injury, a higher proportion of pediatric than adult patients achieve a good outcome. Conversely, pediatric patients have a lower mortality rate than adult patients. In general, good outcome decreases with age with the exception of the very young (0 to 4 years of age), and the mortality rate increases with age. These better results in the pediatric population may be explained in part by several factors, including a lower incidence of surgical mass lesions in the pediatric group, coupled with better outcome in the pediatric subgroups with diffuse injury or with low ICP. There was no difference in the incidence of poor outcome of pediatric and adult patients with surgical mass lesions or with increased ICP, whether or not it was treatable. Both adult and pediatric patient groups continue to improve with time, but the most dramatic difference between the pediatric and adult populations is achieved at 1 year postinjury.

References


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