Demographics, injury characteristics and outcome of traumatic brain injuries in northern Sweden

Introduction

Traumatic brain injury (TBI) is an important global health problem (1,2). The occurrence, causes and outcome vary greatly (1,2). In a review (3) of European investigations over the last 20 years, outcome and disability findings were mixed and inconsistent, and it was emphasized that further studies of the short- and long-term consequences of TBI are needed.

In Sweden, the incidence of TBI has been assessed in four studies. One included only children (4) and one reported an unusually high rate of TBI (5). The two remaining studies reported an annual rate of about 250/100,000 (6, 7), which is comparable with a European annual rate of 235/100,000 (3). External causes are reported in three Swedish studies (4, 5, 7). The two studies that included adults (5, 7) reported a decrease of traffic accidents and an increase of falls. There was also a decline in younger ages, whereas TBI among elderly people increased over time. Similar results have been reported from other Nordic countries indicating that a somewhat unique epidemiologic pattern may be developing in these countries (7–10).

Mild TBI has been the focus in three Swedish studies (11–13) and all indicated the potential risk for long-term disability. Some Swedish studies have focused specifically on severe TBI in association with initial care (14, 15) and found that overall outcome has improved (16, 17). This is suggested to be due to the adherence to the national policy that individuals with a significant TBI are referred to a neurosurgical unit, but also due to an improved neurosurgical care. As a consequence, individuals with TBI more often survive (18), leading to an increased need for rehabilitation (16, 17).

Even though these studies have increased our knowledge of TBI in Sweden, there is overall a dearth of information. The overall aim of this study was therefore to describe the demographics, injury characteristics and outcome for a group of individuals with a TBI referred to a Swedish hospital.
regional neurosurgical clinic over a 10-year period.

Material and methods

This retrospective study was carried out in Norrbotten, the northernmost and geographically largest county of Sweden. Of the entire Swedish population at the end of 2003 (8,975,670), 2.8% (or 252,585) were living in Norrbotten. Compared with the national average, a slightly larger proportion was in the age range 45–74 years (38%; national average 34%). The study comprised all individuals who had been transferred for neurosurgical care to the Neurosurgical clinic, Umeå University Hospital following a TBI during the period 1 January 1992 to 31 December 2001. The neurosurgical clinic is located about 160 km south of the county border and has been responsible for all neurosurgical care in northern Sweden over the last 25 years. All patients who subsequently required rehabilitation were transferred back to one of the hospitals in Norrbotten. The study was approved by the Research Ethics Committee of Umeå University, Sweden.

Demographics and injury characteristics

Using the ICD-9 codes 850–854 and ICD-10 codes S06–S09, a total of 340 individuals were identified in the University Hospital database. The medical records of five individuals were missing and another three individuals were excluded as their primary diagnosis was not one of the ICD codes. The final population comprised 332 individuals: 250 men (75.3%) and 82 women (24.7%). All the 332 individuals had a computer tomography-verified brain injury and brain injury symptoms (e.g. disturbed cognition or mobility or affected conscious) that required neurosurgical care. From their medical records, data on sex, age, year of injury, injury severity, cause of the injury, type of injury and length of stay (LOS) in the neurosurgical unit were obtained. The injury severity was defined by the Reaction Level Scale scores (RLS 85) (19) assigned at the site of the injury or at admission to the hospital. To allow for a comparison with data from other studies, the RLS 85 scores were transformed into Glasgow Coma Scale scores (GCS) (20–22). Based on the GCS score, all the 332 individuals were then grouped into the three commonly used TBI severity groups (23): mild (GCS 13–15), moderate (GCS 9–12) and severe (GCS 3–8). The cause of injury was defined from the description in the medical records and the complementary ICD codes as: a fall, traffic accident, assault or suicide attempt, sport and recreational activity, or other cause (not defined). Based on the initial computed tomography (CT), the type of injury was defined as isolated contusions, isolated subdural hematoma (acute or chronic) or mixed injury (a combination of two or more of the following: contusions, subdural hematoma, subarachnoidal hemorrhage, epidural hematoma and diffuse axonal injury).

Outcome

For each individual who survived the initial neurosurgical care and was transferred back to Norrbotten for rehabilitation, their medical records at one of the hospitals in Norrbotten were reviewed. Data on inpatient LOS, comorbidities, outcome at discharge (assessed with the Glasgow Outcome Scale, GOS) (24), discharge destination and need of care and/or assistance post-discharge were obtained. Inpatient LOS was defined as the total number of days of care in a general medicine and/or surgical ward and in a subsequent inpatient rehabilitation unit until discharge to outpatient rehabilitation or back home. A comorbidity, such as cardiovascular diseases, diabetes and previous cerebrovascular disorder, was defined to be present when a diagnosis (ICD code) before the TBI was present in the medical records.

Statistics

Descriptive data are presented as means, standard deviations, medians, minimum and maximum, where appropriate. Differences between groups, such as men and women, between subgroups, such as injury severity and over time, were analyzed using non-parametric tests (chi-square, Mann–Whitney, Kruskal–Wallis and chi-squared test of independence). Relationships between variables were analyzed with the Spearman rank correlation coefficient. A discriminant analysis was performed to determine possible subgroups of associated variables. In the first set of analysis, the dependent variable was the injury severity categories (mild, moderate and severe) and the independent variables were age, cause of the TBI and type of injury. In the second set of analysis, the dependent variable was the outcome (GOS) and the independent variables were age, total inpatient LOS, comorbidities and discharge destination. In the third set of analysis, the dependent variable was discharge destination (home or disability center/nursing home) and the independent variables were age, injury severity categories and total
inpatient LOS. All statistical analyses were performed using SPSS version 11.0. Exact significance levels are given for values in the range 0.001–0.05, whereas <0.001 represents significant levels less than 0.001. Significance levels above 0.05 are considered statistically not significant (NS).

Results

Demographics and injury characteristics

There was a higher occurrence of TBI in the older age groups (Fig. 1) with the highest number in the age group 70–79 years (71 persons; 21.4%). There were few women in the age groups 30–39 and 40–49 years. The occurrence of TBI varied from 21 in 1996 to 60 in 1999. The overall ratio between men and women was 3:1 and varied from 8:1 to 1:5:1.

There was no significant difference between the 250 men and the 82 women regarding their age (NS) and injury severity (Table 1). Almost 60% of the 332 individuals had sustained a mild TBI and about 25% a severe TBI (Table 1). During the treatment in the neurosurgical unit, 12 men (mean age 48.8, 13–76 years) and three women (mean age 31.3, 12–65 years) died: 13 of these individuals had sustained a severe TBI, one a moderate TBI and one a mild TBI. No significant variation in the number of deaths was detected over the 10-year period (NS).

Isolated contusions were present in 71 individuals (21.4%), isolated subdural hematoma in 170 individuals (51.2%; 86 of these, 50.6%, had a chronic subdural hematoma), and mixed injury in 87 individuals (26.2%). In four individuals (1.2%), no signs of intracerebral injury or hemorrhage were detected on CT. The mean LOS in the neurosurgical unit was 6.5 days (1–31 days; median 5.0); there was a significant positive relationship between the LOS and the injury severity ($\rho = 0.17; P = 0.002$).

The frequency of mild TBI increased markedly with increasing age, with the highest number in the age group 70–79 years (Fig. 2). The frequency of moderate TBI was similar across the population, whereas severe TBI were most common in the youngest age group (Fig. 2).

The main causes of TBI were falls (66.0%) and traffic accidents (25.3%). There were no significant differences between men and women regarding the causes of TBI (NS). Falls were the most common cause in the older age groups (Table 2); the highest occurrence of falls (64 individuals) was in the age group 70–79 years. Traffic accidents were most common in the younger age groups, with car accidents as the most common traffic accident. Assaults, suicide and sports and recreational injuries were uncommon but generally more common in the younger age groups than in the older.

![Figure 1. Distribution of age for 250 men and 82 women with traumatic brain injury.](image)

![Figure 2. Distribution of severity of traumatic brain injury for 250 men and 82 women.](image)

### Table 1 Age and injury severity of traumatic brain injury in 332 men and women

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Men (n = 250)</th>
<th>Women (n = 82)</th>
<th>Total (n = 332)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction Level Scale (RLS 85)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>55.8 (21.1)</td>
<td>56.5 (24.0)</td>
<td>56.0 (21.8)</td>
</tr>
<tr>
<td>Median</td>
<td>2–80</td>
<td>3–85</td>
<td>2–80</td>
</tr>
<tr>
<td>Glasgow Coma Scale (GCS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>2.9 (2.0)</td>
<td>2.6 (1.8)</td>
<td>2.8 (2.0)</td>
</tr>
<tr>
<td>Median</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Severity categories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild (GCS 13–15)</td>
<td>143 (57.2%)</td>
<td>48 (58.5%)</td>
<td>191 (57.5%)</td>
</tr>
<tr>
<td>Moderate (GCS 9–12)</td>
<td>44 (17.6%)</td>
<td>15 (18.3%)</td>
<td>59 (17.8%)</td>
</tr>
<tr>
<td>Severe (GCS 3–8)</td>
<td>63 (25.2%)</td>
<td>19 (23.2%)</td>
<td>82 (24.7%)</td>
</tr>
</tbody>
</table>
The discriminant analysis with injury severity (mild, moderate and severe) as the dependent variable showed 63.0% correct classification of the original group and 59.9% of the cross-validated group. The independent variables, age and type of injury, had the strongest discriminating power: mild TBI were associated with old age, falls and subdural hematoma, whereas severe TBI were associated with young age, traffic accidents and isolated contusions.

Outcome

A majority of the 317 surviving persons – 296 (94.3%) – were transferred back to Norrbotten for rehabilitation (Table 3). Of the remaining 21 individuals, two men and one woman (mean age 31.7 years, range 14–60) were transferred outside the northern region, two women (75 and 85 years of age) and one man (84 years of age) were transferred to a nursing home, and 11 men (mean age 49.7 years, range 20–76) and four women (mean age 33.3 years, range 18–52) were discharged directly back home.

The mean inpatient LOS in a general medicine and/or surgical ward for the 296 individuals was 10.6 days (SD 15.2, range 0–158 days) and in a rehabilitation unit 21.5 days (SD 42.5, range 0–320 days). The total mean inpatient LOS was 32.2 days (SD 50.3, range 1–376 days) (Table 3); there was no relationship between the age of the individuals and the LOS ($q = 0.04; NS$) but a significant relationship between the injury severity and the LOS ($q = 0.41; P < 0.001$). One or more comorbidities were present in 120 (53.6%) of men and 44 (61.1%) of women; there was a significant relationship between old age and comorbidities ($q = 0.50; P < 0.001$). The mean total LOS for individuals with one or more comorbidities was 29.6 days, (SD 42.0) and for those without comorbidities 35.4 days, (SD 58.9) (NS).

The overall mean and median GOS score was 3.7 and 4, respectively (Table 3), with no significant difference between men and women (NS). A majority of the individuals had a moderate disability at discharge (44%), more than a third a severe disability (37%) and not more than 14.5% a good recovery. Seven men but no woman died during the inpatient rehabilitation period. There was a significant relationship between age and GOS ($q = 0.30; P < 0.001$), between the injury severity and GOS ($q = 0.17; P < 0.01$) and between the total LOS and GOS ($q = 0.50; P < 0.001$). Individuals without comorbidities had a significantly ($P < 0.001$) better GOS than those with one or more comorbidities. The discriminant analysis with outcome (GOS) as the dependent variable showed 68.2% correct classification of the original group and 67.6% of the cross-validated group. Overall, a short LOS, no comorbidities and young age were associated with a better GOS, whereas a long LOS, one or more comorbidities and old age were associated with a worse GOS.

A majority of the 289 surviving individuals – 232 (80.3%) – were discharged back home (Table 4); 131 of the 289 individuals (45.3%) were discharged back home with no major changes in their physical or social environment, whereas 101 (34.9%) were discharged back with assistive devices, physical

### Table 3

<table>
<thead>
<tr>
<th>Age groups (years)</th>
<th>Men ($n=224$)</th>
<th>Women ($n=72$)</th>
<th>Total ($n=296$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>3 (2.5%)</td>
<td>2 (1.9%)</td>
<td>5 (1.7%)</td>
</tr>
<tr>
<td>Traffic accidents</td>
<td>18 (8.1%)</td>
<td>19 (26.4%)</td>
<td>37 (12.8%)</td>
</tr>
<tr>
<td>Assaults and suicide attempts</td>
<td>1 (0.5%)</td>
<td>6 (8.3%)</td>
<td>7 (2.4%)</td>
</tr>
<tr>
<td>Sports and recreational activities</td>
<td>5 (2.3%)</td>
<td>1 (1.4%)</td>
<td>6 (2.0%)</td>
</tr>
<tr>
<td>Other causes</td>
<td>0 (0.0%)</td>
<td>1 (1.4%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>27 (8.1%)</td>
<td>28 (8.4%)</td>
<td>55 (18.4%)</td>
</tr>
</tbody>
</table>

1Inpatient length of stay was defined as the total number of days of care in a general medicine and/or surgical ward and in a subsequent inpatient rehabilitation unit until the patient was discharged to outpatient rehabilitation or back home.

The mean inpatient LOS in a general medicine and/or surgical ward for the 296 individuals was 10.6 days (SD 15.2, range 0–158 days) and in a rehabilitation unit 21.5 days (SD 42.5, range 0–320 days). The total mean inpatient LOS was 32.2 days (SD 50.3, range 1–376 days) (Table 3); there was no relationship between the age of the individuals and the LOS ($q = 0.04; NS$) but a significant relationship between the injury severity and the LOS ($q = 0.41; P < 0.001$). One or more comorbidities were present in 120 (53.6%) of men and 44 (61.1%) of women; there was a significant relationship between old age and comorbidities ($q = 0.50; P < 0.001$). The mean total LOS for individuals with one or more comorbidities was 29.6 days, (SD 42.0) and for those without comorbidities 35.4 days, (SD 58.9) (NS).
adaptsions or personal assistance. A smaller proportion – 57 individuals (19.7%) (median GOS 3) – were discharged to a nursing home or disability center. The discriminant analysis with the dependent variable discharge destination (home or disability center/nursing home) showed 81.3% correct classification of the original group and 80.6% of the cross-validated group. Overall, old age and poor outcome (severe disability or vegetative state) was associated with discharge to a disability center or nursing home, whereas young age and good recovery was associated with a discharge home with no major changes.

Discussion

This study has shown that demographics, injury characteristics and outcome of the 332 individuals with a TBI transferred to the only neurosurgical clinic in northern Sweden were stable over a 10-year period. A majority were older men with a mild TBI due to falls. Younger individuals were fewer but had more often a severe TBI from traffic accidents. Most individuals received post-acute care and brain injury rehabilitation. A majority had a moderate or severe disability, but many were discharged back home with no major changes in their physical or social environment.

Even though this study was based on a selected sample (i.e. individuals with a TBI transferred for neurosurgical care and not all individuals with a TBI in the region), data on demographics and injury characteristics are in general agreement with previous Nordic and international studies (2). There was a strong association between young age, severe TBI and traffic accidents (25). However, the incidence was much lower compared with international studies (2). This supports results from other Nordic countries showing a decline in severe TBI following traffic accidents (7, 8). This, in turn, may indicate that a unique epidemiologic pattern is developing in these countries (10), possibly as a result of successful prevention of head injuries in adolescents and young adults (7, 8).

Furthermore, a large proportion was older men with a mild TBI from a fall. Recent trends point towards an increasing number of falls among the elderly as the main cause of TBI (7, 10, 26). About one quarter of the individuals in the present study had an isolated chronic subdural hematoma, a common consequence of falls in the older population (27, 28), and this explains the high proportion of older men with a mild TBI. These individuals constitute a specific subgroup of mild TBI and were included here for completeness, as they had brain injury symptoms that required neurosurgical care. Finally, there was no major trend in the annual number of TBI over the 10-year period. Other studies have shown a decline in the annual rate of TBI (29, 30). These studies were based on larger populations, which more easily detect trends in the incidence.

At the time of discharge from rehabilitation, a majority had a moderate or severe disability as assessed by GOS, despite that many had sustained a mild TBI. A majority of those with a mild TBI were older individuals, who also had one or more comorbidities. As suggested by the relationship between increased age and GOS, the older individuals were less likely to have a favorable outcome, partly due to the TBI and partly due to their comorbidities. This is consistent with previous studies which have shown increased mortality and worse functional outcome in older individuals despite lower injury severity (31, 32). With a worldwide growing older population, this will increase the need for community prevention, improved rehabilitation and changed living conditions as a result of TBI.

Nearly 50% of the individuals were discharged back home without any major changes in their physical or social environment. Based on the GOS score, which showed that only about 15% had a good recovery, this indicates that a significant proportion of the individuals may have returned home without sufficient support to resume their daily activities. However, the GOS is a rather crude outcome measure and is related to other factors than the severity of the TBI, and this may partly explain the findings. Further studies are therefore required to determine the long-term consequences on participation in daily activities after a TBI across all ages.

A factor often addressed in the study of TBI is sex/gender. As expected, men were in a majority, but there were no significant differences between men and women regarding their age and injury

Table 4 Discharge destination for the 289 surviving men and women with traumatic brain injury

<table>
<thead>
<tr>
<th>Discharge Destination</th>
<th>Men (n = 217)</th>
<th>Women (n = 72)</th>
<th>Total (n = 289)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home with no major changes</td>
<td>106 (48.8%)</td>
<td>25 (34.7%)</td>
<td>131 (45.3%)</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>50.2 (19.8)</td>
<td>46.6 (25.6)</td>
<td>49.5 (21.0)</td>
</tr>
<tr>
<td>Range</td>
<td>10–86</td>
<td>3–85</td>
<td>3–86</td>
</tr>
<tr>
<td>Home with assistive devices, physical adaptations or personal assistance</td>
<td>69 (31.8%)</td>
<td>32 (44.4%)</td>
<td>101 (34.9%)</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>59.6 (21.3)</td>
<td>62.5 (18.3)</td>
<td>60.5 (20.3)</td>
</tr>
<tr>
<td>Range</td>
<td>2–89</td>
<td>16–83</td>
<td>2–89</td>
</tr>
<tr>
<td>To a disability center or nursing home</td>
<td>42 (19.4%)</td>
<td>15 (20.8%)</td>
<td>57 (19.7%)</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>66.8 (18.9)</td>
<td>71.3 (17.8)</td>
<td>68.0 (18.6)</td>
</tr>
<tr>
<td>Range</td>
<td>21–90</td>
<td>12–83</td>
<td>12–90</td>
</tr>
</tbody>
</table>
severity. Some studies have indicated that women have a poorer outcome after a TBI (33); such a difference was not found here.

Retrospective studies have limitations that may influence the quality of the data. Less than 2% of the medical records in the neurosurgical clinic were missing, but the remaining medical records and those in the rehabilitation units were sufficiently complete to allow for inferences regarding the collected data on demographics, injury characteristics and outcome. Still, data on the site for TBI was incomplete and information about substance abuse was rarely verified by an analysis of blood. In addition, some demographic data, such as vocational situation and marital status were infrequently reported and not possible to record.

In conclusion, this study confirms previous studies regarding the relationship between age, cause of injury, injury severity and outcome in relation to TBI. The large number of older individuals with a mild TBI due to a fall and the relatively low number of young individuals with a severe TBI following a traffic accident underscore the need for continuous prevention. The overall outcome also confirms the importance of TBI as a major cause of disability, and the need for rehabilitation and long-term follow-up.

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