The epidemiological trends of head injury in the largest Canadian adult trauma center from 1986 to 2007

Clinical article

DAVID W. CADOTTE, M.SC., M.D., SHOBHAN VACHHRAJANI, M.D., AND FARHAD PIROUZMAND, M.D., M.SC., F.R.C.S.C.

Division of Neurosurgery, Sunnybrook Health Sciences Centre, University of Toronto, Ontario, Canada

Object. This study documents the epidemiology of head injury over the course of 22 years in the largest Level I adult trauma center in Canada. This information defines the current state, changing pattern, and relative distribution of demographic factors in a defined group of trauma patients. It will aid in hypothesis generation to direct etiological research, administrative resource allocation, and preventative strategies.

Methods. Data on all the trauma patients treated at Sunnybrook Health Sciences Centre (SHSC) from 1986 to 2007 were collected in a consecutive, prospective fashion. The authors reviewed these data from the Sunnybrook Trauma Registry Database in a retrospective fashion. The aggregate data on head injury included demographic data, cause of injury, and Injury Severity Score (ISS). The collected data were analyzed using univariate techniques to depict the trend of variables over years. The authors used the length of stay (LOS) and number of deaths per year (case fatality rate) as crude measures of outcome.

Results. A total of 16,678 patients were treated through the Level I trauma center at SHSC from January 1986 to December 2007. Of these, 9315 patients met the inclusion criteria (ISS > 12, head Abbreviated Injury Scale score > 0). The median age of all trauma patients was 36 years, and 69.6% were male. The median ISS of the head-injury patients was 27. The median age of this group of patients increased by 12 years over the study period. Motorized vehicle accidents accounted for the greatest number of head injuries (60.3%) although the relative percentage decreased over the study period. The median transfer time of patients sustaining a head injury was 2.58 hours, and there was an approximately 45 minute improvement over the 22-year study period. The median LOS in our center decreased from 19 to 10 days over the study period. The average case fatality rate was 17.4% over the study period. In multivariate analysis, more severe injuries were associated with increased LOS as was increasing time from injury to hospital presentation. Age and injury severity were independently predictive of mortality.

Conclusions. These data will provide useful information to guide future studies on the changing patterns of head injury, possible mechanisms of injury, and efficient resource allocation for management of this condition.

(DOI: 10.3171/2010.12.JNS10808)

Key Words • head injury • trauma • epidemiology

TRAUMATIC brain injury is a recognized public health problem that results in significant death and disability. A limited number of population-based studies have been conducted to address the characteristics of individuals most affected, associated etiological factors, and various outcome measures—all in an effort to better describe the current trends within a given population and identify risk factors and potential areas of intervention to save lives or diminish morbidity. Such studies have also been shown to result in tangible improvements in health care practices. In 1989, a report by Dykes et al. suggested that approximately 21% of pediatric deaths in Ontario were preventable. A decade later, the same group published a report stating that the preventable death rate has diminished to 7% of all pediatric trauma patients as a result of improved management both in the field and at trauma centers. Such improvement in health management systems comes from a rich understanding of the multifactorial processes that together optimize the management of acute trauma patients.

We conducted an epidemiological analysis of all head-injury trauma patients treated in a single large trauma center (SHSC) over a 22-year period. Analysis of these injuries by patient age, patient sex, injury severity, and mechanism of injury, as well as length of hospital stay

Abbreviations used in this paper: AIS = Abbreviated Injury Scale; HAIS = head AIS; ISS = Injury Severity Score; LOS = length of stay; SHSC = Sunnybrook Health Sciences Centre.

This article contains some figures that are displayed in color online but in black and white in the print edition.
Epidemiology of head injury

and mortality rate could provide direction for etiological research, resource allocation, and prevention efforts in this common group of trauma patients.

Methods

Study Design

We report the results of prospectively collected data pertaining to a group of trauma patients who presented to a Level I trauma center between January 1986 and December 2007. Data were recorded in the Sunnybrook Trauma Database at the time of patient presentation.

Population

The Sunnybrook Health Sciences Center (SHSC) is the regional trauma center serving Toronto, Ontario and surrounding areas. It is the leading academic adult trauma center in Canada and has the extensive experience, infrastructure, and appropriate government funding to maintain a high level of care for severely injured polysystem-trauma patients. This center has maintained a comprehensive registry data set on their trauma patient population for decades. Variables include detailed information on demographic characteristics, injury severity, prehospital and hospital care, and patient outcomes (including LOS in a tertiary center and fatality). A standardized trauma assessment form is used in data entry. All injuries are identified and coded. This comprehensive data set has been registered and maintained electronically as a coded computerized database since 1986. For the current study, we reviewed all cases involving trauma patients treated at SHSC between January 1986 and December 2007.

Definition of Trauma and Head Injury

The Injury Severity Score (ISS) is directly proportional to the systemic severity of injury and predicts mortality in trauma patients (details available online: www.trauma.org/archive/scores/iss.html). It has also been found to correlate with a variety of outcome measures such as hospital LOS and cost of treatment. The ISS is the sum of the squares of the Abbreviated Injury Scale (AIS) scores from the 3 most severely injured body regions.

The AIS is a subjective scale (scored from 1 to 6) that is applied to specific body regions (head, face, chest, abdomen, extremities [including pelvis], and external) and summarizes the degree of trauma to that region (details available at http://www.trauma.org/archive/scores/ais.html). The scale used for head injury is referred to as Head AIS (HAIS); 1 corresponds to minor injury; 2, moderate; 3, serious but not life threatening; 4, severe, life threatening but survival is probable; 5, critical and survival is uncertain; and 6, virtually unsurvivable.

Inclusion and Exclusion Criteria

We included all trauma patients with ISSs greater than 12 with associated head injury (HAIS > 0). Each of these belonged to one of the following groups: admitted to the hospital, treated in the emergency department but not admitted, or died in the emergency department after initiation of treatment.

Other Definitions

Elapsed time was recorded in 10-minute intervals and reported in hours unless otherwise stated; for example, 10 minutes was reported as 0.16 hours. If a patient was brought to the hospital in less than 10 minutes (according to paramedic reports), then the time elapsed since injury was recorded as 0 hours.

Data Analysis

Aggregate data related to all treated trauma patients were collected. Patients were grouped into 3 arbitrary time periods based on their admission date (1986–1992, 1993–1999, and 2000–2007) to allow assessment of any changes in trauma characteristics over time. For the purpose of outcome analysis, HAIS scores were categorized as low (1–2), medium (3–4), or high (5–6), corresponding, respectively, to mild, moderate, and severe head injuries.

To explore the effectiveness of care for trauma patients over the duration of the study period, 2 crude measures of outcome were selected. The first was LOS, used as a surrogate to predict the changing efficiency of treatment. The second measure was case fatality. The variables age, sex, mechanism of injury, injury severity (as measured by ISS), time to presentation (after the traumatic event), LOS, and case fatality were analyzed to identify their influence on the 2 outcome measures (LOS and case fatality).

Statistical Analysis

Descriptive statistics were used to report trends in age group, sex, mechanism of injury, severity of injury, time to presentation, LOS, and case fatality. Most of these factors were plotted against study periods to assess temporal trends for each variable. Comparison of medians was performed using the Wilcoxon rank-sum test.

Multivariate regression techniques were used to look for associations between LOS or death and predictor variables. Variables showing a trend toward association with the outcome variable in univariate analysis (p < 0.20) were included in the multivariate model. None of the predictor variables were found to be multicollinear.

Analyses were conducted as follows: Linear regression analysis was performed to demonstrate any association between LOS and sex, age, and ISS. Logistic regression analysis was used to model case fatality as a function of time to presentation, age, gender, and ISS for all head injury patients (HAIS Score 1–6), and the time period in which the patient presented to hospital.

Microsoft Excel 2008 for Mac, version 12.2.0 and SAS 9.2 (SAS Institute, Inc.) were used for graphing and statistical analysis.

Results

A total of 16,678 patients were treated at SHSC during the study period, and 12,869 (77.1%) of these patients were trauma patients with an ISS greater than 12. Of this trauma population, 9315 patients (72.3%) sustained a head injury (HAIS > 0). These patients constitute the study population for subsequent analyses reported in this paper.
Demographic Variables

Table 1 summarizes the distribution of age, sex, time to presentation, LOS, and case fatality rate for the study population as well as the frequency of head injury among these patients. This table also shows the frequency of cases based on time period, severity of head injury, and the mechanism of the traumatic event.

The median age of head-injured patients was 36 years. The median age is displayed on an annual basis in Fig. 1. Overall, there was approximately a 12-year increase in the median age of patients sustaining head injury over the 22 years of study.

Frequency

The absolute number of trauma patients sustaining a head injury is shown in Fig. 2. Three categories are presented: low HAIS score (1–2), medium HAIS score (3–4), and high HAIS score (5–6). In our study population, 35.7% of the patients had low HAIS scores, 33.1% had medium HAIS scores, and 31.1% had high HAIS scores. Each of the 3 categories has increased in frequency since 1986.

Mechanisms of Injury

Table 1 summarizes the mechanisms of head injury and relative frequency in the trauma population. One patient did not have a mechanism of injury recorded. The absolute number of each mechanism of injury for the study period is shown in Fig. 3. Motor vehicle accidents accounted for the greatest number of head injuries (60.3%).

The absolute number of all injury types has increased over the study period 1986–2007. The proportions of total trauma cases by mechanism of injury from 1986–1992 and 2000–2007 are presented in Fig. 4. Head injuries due to MVAs decreased by 11%, while recreational accidents not involving motorized vehicles increased by 7.1%. Assault-related head injury increased by 2.4%. The proportion of head injuries due to other mechanisms remained stable.

Transfer Time to SHSC

Figure 5 shows the trends in the time taken to transfer head-injured patients to SHSC. Note that transfer may have occurred via a primary care facility. The median time of transfer from either the scene of accident or a primary care hospital was 2.58 hours over the entire study period. Significant outliers were identified, as the maximum elapsed time to transfer was 4573 hours and patients presenting after such long delays are likely to be in a substantially different clinical condition from those presenting within a relatively short time of injury. Transfer time has decreased by approximately 45 minutes from 2.9 hours (1986–1992) to 2.1 hours (2000–2007) (data not shown). There was no statistically significant difference in transfer times according to the degree of head injury (data not shown).

Injury Severity Scores

The median ISS for all head-injury patients was 27,

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>age of head-injury pts (yrs)</td>
<td></td>
</tr>
<tr>
<td>median</td>
<td>36</td>
</tr>
<tr>
<td>range</td>
<td>8–96</td>
</tr>
<tr>
<td>ISS of all trauma pts†</td>
<td></td>
</tr>
<tr>
<td>median</td>
<td>26</td>
</tr>
<tr>
<td>range</td>
<td>13–75</td>
</tr>
<tr>
<td>ISS of head-injury pts‡</td>
<td></td>
</tr>
<tr>
<td>median</td>
<td>27</td>
</tr>
<tr>
<td>range</td>
<td>13–75</td>
</tr>
<tr>
<td>male sex (% of head-injury pts)</td>
<td>69.6</td>
</tr>
<tr>
<td>frequency of head injury (% of all trauma)</td>
<td>72.3</td>
</tr>
<tr>
<td>median time to SHSC for head-injury pts (hrs)</td>
<td>2.58</td>
</tr>
<tr>
<td>median LOS for head-injury pts (days)</td>
<td>12</td>
</tr>
<tr>
<td>case fatality rate for head-injury pts (%)</td>
<td>17.4</td>
</tr>
<tr>
<td>period characteristics (no. of head-injury patients treated)</td>
<td></td>
</tr>
<tr>
<td>1986–1992</td>
<td>2199 (23.6)</td>
</tr>
<tr>
<td>1993–1999</td>
<td>2782 (29.9)</td>
</tr>
<tr>
<td>2000–2007</td>
<td>4334 (46.5)</td>
</tr>
<tr>
<td>severity of head injury, 1986–2007</td>
<td></td>
</tr>
<tr>
<td>mild (HAIS Score 1–2)</td>
<td>3332 (35.7)</td>
</tr>
<tr>
<td>moderate (HAIS Score 3–4)</td>
<td>3088 (33.2)</td>
</tr>
<tr>
<td>severe (HAIS Score 5–6)</td>
<td>2895 (31.1)</td>
</tr>
<tr>
<td>mechanism of injury in head-injury patients</td>
<td></td>
</tr>
<tr>
<td>recreational accidents not involving motorized ve-</td>
<td>1111 (11.9)</td>
</tr>
<tr>
<td>hicles</td>
<td></td>
</tr>
<tr>
<td>bicycle accidents</td>
<td>208 (2.2)</td>
</tr>
<tr>
<td>pedestrian struck by vehicles</td>
<td>1402 (15.1)</td>
</tr>
<tr>
<td>MVAs (including recreational MVAs)</td>
<td>5615 (60.3)</td>
</tr>
<tr>
<td>industrial accidents</td>
<td>480 (5.2)</td>
</tr>
<tr>
<td>assaults (including stab wounds and gunshot</td>
<td>407 (4.4)</td>
</tr>
<tr>
<td>wounds)</td>
<td></td>
</tr>
<tr>
<td>other</td>
<td>92 (1.0)</td>
</tr>
</tbody>
</table>

* Values represent numbers of cases with relative percentage in parentheses, except as otherwise indicated. Abbreviations: MVA = motor vehicle accident; pt = patient.
† Trauma patients defined as those with ISS > 12.
‡ Head-injury patients defined as those with ISS > 12 and HAIS score > 0.
and no significant change was observed over the study period (Fig. 6). There was no difference in ISS based on the severity of head injury (HAIS Score 1–2, 3–4, or 5–6; data not shown).

Patient Outcomes

Length of Hospital Stay. Figure 7 shows the median LOS by year for all patients with head injuries. Over the study period, the median LOS has been reduced from a median of 19 days (1986–1992) to 10 days (2000–2007) (p < 0.0001).
Epidemiology of head injury

There was no significant difference in the LOS relative to the HAIS score (data not shown).

In multivariate analysis, increasing age was independently associated with increasing LOS (p = 0.0005). Similarly, more severe injuries were independently associated with longer LOS (p < 0.0001), and a longer time interval between injury and presentation to SHSC also was significantly associated with longer LOS (p = 0.0186). Patient sex was not found to be significantly associated with LOS (p = 0.2533).

Case Fatality. The overall case fatality rate for the entire study period was 17.4% for all trauma patients sustaining a head injury. Inspection of Fig. 8 suggests no change in this proportion over the 22-year study period. There was a strong association between case fatality and the severity of head injury. Overall case fatality was 4.6% for patients with low HAIS scores, 6.8% for those with medium HAIS scores, and 44.5% for those with high HAIS scores (Fig. 9).

Age was independently associated with case fatality in multivariate analysis (OR 1.029, 95% CI 1.026–1.032, p < 0.0001) as was injury severity (OR 1.088, 95% CI 1.083–1.093, p < 0.0001). A longer time interval between injury and presentation to SHSC appears to be independently associated with a reduction in case fatality, although only slightly (OR 0.989, 95% CI 0.983–0.994, p = 0.0001). The likelihood of death due to head injury decreased during the study period: patients presenting between 1993 and 1999 were significantly less likely to die as a result of their injuries (OR 0.756, 95% CI 0.643–0.888, p < 0.0007) and this protective effect was even more pronounced from 2000 through 2007 (OR 0.639, 95% CI 0.551–0.742, p < 0.0001) when compared with the first group of patients presenting from 1986 through 1992, inclusive. Patient sex was not independently associated with case fatality (p = 0.1849).

Hypothesis-Driven Analysis: Adjusting for the Time to Hospital (SHSC). As one of Canada's largest trauma centers, SHSC accepts long-distance referrals as well as patients from the immediate catchment area. A review of the distribution of time between injury and presentation at our center revealed a median time of 2.66 hours, and the 95th percentile at 12.84 hours. Choosing more practical cut-off values of 15 and 24 hours after injury, we found that, respectively, 414 (4.4%) and 276 (3.0%) of 9315 patients presented after these thresholds. Although this is a small portion of the study population, the skew in the transfer time is significantly greater than the median of 2.58 hours for all trauma patients (Fig. 5) and could bias the analysis. We hypothesize that this increased time-to-hospital (defined here as SHSC) will influence both LOS and case fatality. As such, we conducted the multivariate analysis (as described above) for both LOS and mortality with a time-to-hospital of “< 24 hours” and “< 15 hours.” The results are presented in Table 2.

Time-to-hospital remains a significant predictor for LOS where an increasing time to hospital results in a longer LOS. This is especially apparent when considering those patients that arrive within 24 and 15 hours of injury. Time-to-hospital is an even stronger predictor of case fatality when considering those patients who arrived within 24 and 15 hours, with a longer interval between in-
jury and hospital admission being associated with lower fatality rates.

**Discussion**

We describe the epidemiological trends related to head injury at Canada’s largest adult trauma center, reflecting the changing pattern in head injury over a 22-year period from 1986 to 2007. We observed a 12-year increase in the median age of persons sustaining head injury and an increase in the absolute number of head injuries each year, the result of centralization of regional trauma care services in Ontario. Motor vehicle accidents still account for the largest number of head injuries, but the relative percentage has fallen by 11% (Fig. 4), with a concurrent rise in the number of head injuries caused by recreational activities and assault. Injury severity remained stable over the study period, whereas the time for transfer to the hospital (that is, SHSC) has decreased.

We used LOS and case fatality as crude measures of outcome. The LOS decreased over the study period, and multivariate analysis revealed that age, injury severity, and a longer time interval between injury and presentation to SHSC were associated with a longer LOS. The case fatality rate remained stable over the study period (overall rate 17.4%), with patients suffering more severe injuries (HAIS Score 5–6) bearing most of the burden (fatality rate 44.5%). Multivariate analysis revealed that age and injury severity were associated with higher fatality rates. Interestingly, patient sex was not associated with either LOS or case fatality. Although the case fatality rate has remained unchanged over the 2 decades of study, the median age has increased by more than a decade. As older age was shown to be a significant predictor of fatality, it is conceivable that there has been improvement in the case fatality rate and patient care over time.

The majority of patients at SHSC present locally from the greater Toronto area with a minority of patients presenting from other locations in Ontario and outside Canada. The location of the traumatic event relative to the trauma center is not recorded in our database. This represents a potential source of bias in our analysis and we therefore conducted the multivariate analysis for both LOS and fatality in 3 ways: 1) including all patients in the database who met the study inclusion criteria; 2) including only those who presented within 24 hours; and 3) including only those who presented within 15 hours of the traumatic event. These time points are arbitrary and were chosen to reflect the nature of the traumatic event. Longer time periods to presentation at SHSC typically indicate that patients have been stabilized at a primary hospital, and those who suffered a severe injury requiring immediate specialized care and were initially treated at a primary hospital would have died before transfer to our institution could be accomplished. In either scenario the patients that present in a delayed fashion would be less critically ill. Our analysis confirmed this when evaluating patients presenting within 15 hours of injury, with longer time to presentation being more strongly associated with increased LOS. Similarly, in patients presenting within 15 hours of injury, time to presentation was associated with an increased fatality rate. A time to presentation at SHSC of longer than 15 or 24 hours suggests that the patient is less critically ill and would therefore require less time in a tertiary care center and also be less likely to die.

This report represents the most comprehensive study of head injury epidemiology in Canada. The 22-year-long
Epidemiology of head injury

...study period and the complete nature of the database represent the strengths of this study. There are, however, certain limitations. This report encompasses only single-institution data, and the identification of regional differences through comparison with other trauma centers would be prudent. Length of stay and fatality rates are crude outcomes and do not represent the spectrum of functional patient outcomes after head injury, many of which are meaningful for long-term outcome but are not captured in this database. At SHSC, linking this database to that maintained by the head injury clinic would be beneficial in this regard. To date, the volume of information has made this task difficult, although it represents an important future direction.

The results presented here will help to explain trends in head injury across Ontario, and therefore aid in planning at our hospital. Shorter LOS at SHSC, a tertiary care center, is likely to be the result of 2 complementary processes. It undoubtedly represents increased efficiency in health care dollars spent for specialized care. Resulting savings will improve accessibility for longitudinal care that is integral to ensuring improved functional outcome as time progresses after the traumatic event. For those with severe head injury, there is evidence to suggest improved outcomes after prompt enrollment into a rehabilitation program once their acute medical needs have been met.\textsuperscript{3,7} The evidence is less strong for patients with mild or moderate head injuries.\textsuperscript{4} Nonetheless, acute care hospital resources should be reserved for those in need and individual LOS consequently optimized. Expeditious discharge represents improved efficiency in the first of a long chain of events with the ultimate goal of reintegrating an injured individual back into society.

Additionally, the study period represents an era of tremendous growth in the multidisciplinary approach to trauma management. Centralization of specialized care in Ontario has resulted in more patients being triaged to trauma centers, and this is responsible for the increase in the absolute number of patients treated over the study period. The use of dedicated trauma teams facilitates the systematic identification of presenting injuries and ensuing complications, leading to aggressive and early treatment. This synergistically adds to decreased LOS and improved patient outcomes. Improvement in transfer times (time for transfer to a trauma center) also supports this paradigm shift. Focused statistical analysis of our data set supports this observed change in patient management. Analysis of covariance revealed not only the independent effects of time period and systemic and head injury severity on LOS, but also a significant interaction of these variables with respect to LOS (ISS with time period, \( p = 0.0017 \); HAIS score with time period, \( p < 0.0001 \)). In other words, the relationship of ISS and HAIS score to LOS changed over the 22-year study period, displaying decreased LOS over time even with more severe injuries. This statistically supports improved institutional efforts to discharge patients from acute care centers for prompt rehabilitation.

There have been distinct changes in the mechanisms of head injury over the course of our analysis period, which in turn partly explain the change in proportions of head injury severity. The enforced use of seat belts, installation of air bags, and public policy initiatives en-

\begin{figure}
\centering
\includegraphics[width=\textwidth]{fig7.png}
\caption{Length of hospital stay for all head-injury patients plotted against year (1986–2007).}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{fig8.png}
\caption{The case fatality rate for all trauma patients (ISS > 12) sustaining a mild (HAIS Score 1–2), moderate (HAIS Score 3–4), or severe (HAIS Score 5–6) head injury plotted against the year of presentation (1986–2007).}
\end{figure}
TABLE 2: Hypothesis-driven analysis: adjusting for time-to-hospital*

<table>
<thead>
<tr>
<th>Hypothesis and Statistic</th>
<th>All Head-Injury Pts</th>
<th>Head-Injury Pts Presenting in &lt;24 hrs</th>
<th>Head-Injury Pts Presenting in &lt;15 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>longer time-to-hospital correlates w/ longer LOS (p value)</td>
<td>0.0186</td>
<td>0.0113</td>
<td>0.0033</td>
</tr>
<tr>
<td>longer time-to-hospital correlates w/ reduced mortality rate</td>
<td>OR 0.989</td>
<td>0.866</td>
<td>0.836</td>
</tr>
<tr>
<td>95% CI</td>
<td>0.983–0.994</td>
<td>0.844–0.889</td>
<td>0.813–0.860</td>
</tr>
<tr>
<td>p value</td>
<td>0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

* Time-to-hospital defined as time from injury to presentation at SHSC.

suring safer roads and driving practices can be linked to a reduction in the percentage of head injuries caused by MVAs. Relative decreases in the proportion of those suffering severe head injuries contribute to this trend. At the same time, head injuries due to recreational accidents, assaults, and falls are on the rise; the increase in the relative proportion of these moderate head injuries will also influence these trends. Local governments in both Canada and the US have noted this fact. The Cochrane Collaboration recently published a systematic review outlining the efforts and effects of legislating helmets in children who ride bicycles. The results indicate that head injury rates are decreased in children who wear helmets compared with the adult population, for which no legislation exists. Decreases in mild head injury proportions are likely attributable to this, with many patients now not suffering head injury at all because of these simple protective measures. The Cochrane group acknowledges the lack of published evidence to support such policy initiatives, putting the onus on health care researchers to report the injuries they treat in specialized centers.

The changing proportions of head-injury severity are also explained by statistical regression to the mean. In absolute terms, the number of patients assessed at SHSC was 1.5 times higher between 2000 and 2007 compared with the period from 1993 through 1999, and was double the number managed during the 1986–1992 study period. Average and median HAIS scores for all mechanisms of injury were in the moderate head-injury range over the entire study period, but also within each 7-year window. Progressively increasing sample size only served, therefore, to contribute more patients to this sector of the head-injury spectrum, increasing its proportion relative to the mild and severe injury groups. This association between time and injury severity proportion is statistically significant ($\chi^2 = 58.31, p < 0.0001$). The risk of long-term deficits after moderate head injury coupled with its prevalence mandates resource allocation for the appropriate rehabilitation of this vulnerable patient population.

Changes in the age composition of the study group over time follow the previously discussed changes in the mechanisms of head injury, in addition to a probable small overall increase in the population at risk. Head-injury prevention programs such as Think First have a powerful presence in Ontario, and as the children in these programs get older, they are likely to follow safe practices that significantly decrease their risk of sustaining a head injury. This education at the lower end of the age spectrum likely contributes to the trend of increasing patient age observed over the course of the study period. Closer analysis of the mechanisms of head injury as a function of time reveals a significant contribution of falls to this changing age dynamic. The proportion of those suffering head injury as a result of a fall doubled from 6.5% to 13% between the first and last 7 years of the study. The patients were also older; during the last 7 years of the study, the mean age of the head-injury patients was 53 years. The age of patients with head injuries due to falls also increased during the study period, from a mean of 47 years during the first 7 years of the study to 55 years in the last 7 years. This undeniably impacts the observed age trends.

The analysis and interpretation of this information are based upon careful and planned prospective data collection. This should be continued and expanded in the future to ensure that we can identify appropriate areas for improvement (such as case fatality rate) and monitor the effects of any change in the management of patients with traumatic head injuries. These data could also be used to quantify the effect of societal achievements such as safer driving and to improve outcomes such as LOS.

Conclusions

Head injuries occur with an annual frequency of 72% in trauma patients with an ISS greater than 12. The case fatality rate for these patients, after presentation to a tertiary trauma center, is about 17% and has remained relatively unchanged over 2 decades of study. However, during this same period, the median age of these head-injury patients has increased by approximately a decade. The median LOS has been reduced about 50% for all head-injury patients, from 19 to 10 days. Increasing age and ISS are associated with increased fatality in multivariate analysis.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Pirouzmand, Cadotte. Analysis and interpretation of data: all authors. Drafting the article: Cadotte. Critically revising the article: all authors. Reviewed final version of the manuscript and approved it for submission: all authors. Statistical analysis: Pirouzmand, Vachhrajani. Administrative/technical/material support: Pirouzmand. Study supervision: Pirouzmand.

References

Epidemiology of head injury


Manuscript submitted May 27, 2010. Accepted December 6, 2010. Please include this information when citing this paper: published online January 28, 2011; DOI: 10.3171/2010.12.JNS10808. Address correspondence to: Farhad Pirouzmand, M.D., M.Sc., F.R.C.S.C., Division of Neurosurgery, Sunnybrook Health Sciences Centre, University of Toronto, Suite A131, 2075 Bayview Avenue, Toronto, Ontario, M4N 3M5, Canada. email: Farhad.Pirouzmand@sunnybrook.ca.