The epidemiology of surgically treated acute subdural and epidural hematomas in patients with head injuries: a population-based study

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Background: The purpose of this paper is to review the population-based epidemiology of surgically treated post-traumatic epidural hematomas (EDHs) and/or subdural hematomas (SDHs) among patients who presented to the single neurosurgical centre in Nova Scotia. **Methods:** We included all patients aged 16 years or older who presented to the tertiary care hospital with acute post-traumatic EDHs and/or SDHs between May 23, 1996, and May 22, 2005, and who were surgically treated. We generated an initial cohort from the provincial trauma registry and reviewed a total of 152 charts for possible inclusion; 70 (46%) patients met the study criteria. We performed a blinded, explicit chart review using a standardized data collection form, and we generated descriptive statistics. **Results:** Of the patients who had surgery, 34 (49%) presented with SDHs, 23 (33%) presented with EDHs and 13 (19%) presented with both conditions. The median age was 45 years, and 80% of the cohort was male. The major mechanisms of injury were falls (51%), motor vehicle collisions (30%) and assault (11%). More than half (61%) of patients were transferred from referring hospitals while the remainder (39%) arrived directly without an intermediate facility. There were 18 postoperative deaths (26%). Forty-four of 70 patients (63%) had associated good outcomes at 6 months (Glasgow Outcome Scale). **Conclusion:** Acute post-traumatic EDHs and/or SDHs are relatively rare (0.83/100 000 population per annum) and are generally associated with good outcomes. Death was more likely among older, more severely injured patients and among those who required surgery for SDH rather than EDH.

Contexte : Cet article vise à revoir l'épidémiologie représentative de l'hématome épidural (HED) et de l'hématome sous-dural (HSD) postraumatiques traités chirurgicalement chez les patients qui se sont présentés au seul centre de neurochirurgie de la Nouvelle-Écosse. **Méthodes :** Nous avons inclus tous les patients de 16 ans ou plus qui se sont présentés à l'hôpital de soins tertiaires avec un HED ou un HSD postraumatique entre le 23 mai 1996 et le 22 mai 2005 et qui ont été traités chirurgicalement. Nous avons produit une cohorte initiale à partir du registre provincial des traumatismes et nous avons étudié au total 152 dossiers; 70 (46 %) des patients satisfaisaient aux critères de l'étude. Nous avons procédé à une étude de dossiers explicite à l'insu en utilisant un formulaire normalisé de collecte de données et nous avons produit des statistiques descriptives. **Résultats :** Parmi les patients qui ont subi une intervention chirurgicale, 34 (49 %) se sont présentés avec un HSD, 23 (33 %), avec un HED, et 13 (19 %), avec les 2 problèmes. L'âge médian des patients s'établissait à 45 ans et la cohorte était de sexe masculin à 80 %. Les principales causes de traumatisme étaient les chutes (51 %), les collisions de véhicule à moteur (30 %) et les agressions (11 %). Plus de la moitié (61 %) des patients provenaient d'hôpitaux traitants tandis que les autres (39 %) se sont présentés directement sans passer par un établissement intermédiaire. Il y a eu 18 décès après l'intervention (26 %). Quarante-quatre des 70 patients (63 %) ont eu de bons résultats à 6 mois (échelle de Glasgow). **Conclusion :** Les HED et HSD post-traumatiques aigus sont relativement rares (0,83/100 000 habitants par année) et les patients se remettent généralement assez bien. La mort était plus probable chez les patients plus âgés et blessés plus gravement et chez ceux qu'il a fallu opérer pour traiter un HSD plutôt qu'un HED.

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Trauma is the leading cause of death in people aged younger than 45 years.[1] Head injury is the number one cause of trauma mortality and is directly associated with one-half of all deaths secondary to trauma.[1] It has been estimated that the financial burden of head injuries, in terms of both direct and indirect costs, is up to $25 billion per year in the United States alone.[2,3] Trauma of all types is responsible for more productive years of life lost than other major diseases, including cancer, heart disease and AIDS.[4,5] The care for survivors of head injuries represents a tremendous burden to society with respect to costs of rehabilitation, training and the maintenance of health needs, as well as treatment for major psychological and social sequelae. More than 50% of moderate head injuries[6] and more than 99% of severe head injuries lead to substantial degrees of long-term disability.[4,7]

The care of patients with head injuries begins immediately at the scene of injury with basic and advanced interventions performed by prehospital personnel and is strongly presumed to have a subsequent distinct impact on outcome.[8] The basic management of airway, breathing and circulation in the prehospital phase of care has been shown in other studies to correlate with improved outcomes.[9–14] Patients with traumatic brain injury (TBI) and hypotension have twice the mortality of those with matched TBI and normotension; compounding hypotension with hypoxemia results in a cumulative mortality of 75%.[7,11,15] For this reason, prehospital interventions such as managing a patient's airway and ensuring adequate oxygenation, coupled with reversing hypotension with fluids, have substantial potential to obviate morbidity and mortality.[16] Other tenets of advanced life support have not been as well supported in the literature.[14]

Within the spectrum of TBI, there are specific pathologic conditions that lend themselves to potential surgical correction and have been shown to improve outcomes with timely intervention.[4,9] This study is concerned with 2 such post-traumatic consequences: epidural hematomas (EDHs) and subdural hematomas (SDHs). The purpose of this study is to review the population-based epidemiology of these conditions in patients older than 16 years who had surgical decompression of an EDH and/or SDH within 24 hours of presentation to a tertiary care trauma centre. The outcomes we measured were mortality and Glasgow Outcome Scale (GOS) scores after 6 months.

Methods

We performed this study as a 9-year retrospective review of all patients who presented at or were transferred to the Queen Elizabeth II Health Sciences Centre (QEII HSC) in Halifax, Nova Scotia, between May 23, 1996, and May 22, 2005, and had surgery to treat acute EDHs and/or SDHs within 24 hours of injury. The QEII HSC is affiliated with Dalhousie University. It is the sole tertiary care neurosurgical/trauma centre in the entire province for those aged 16 years and older and the only hospital offering neurosurgical services in the province. We excluded patients with gunshot wounds and other penetrating head injuries, as well as patients whose time from trauma to surgery exceeded 24 hours. We opted for this 24-hour exclusion to clearly define the acutely injured population that could potentially benefit from a surgical intervention. Our study did not include patients with EDHs and/or SDHs who received nonsurgical treatment or who died before transport to the tertiary care centre.

Nova Scotia is a Canadian province with a population of about 940 000 and an area of 53 000 km^2, which gives it a population density of 18 persons per km^2; the province has large rural and wilderness areas.[17] All patients aged 16 years and older who have serious head injuries are transferred to this single adult tertiary care centre, giving this study the strength of a population-based investigation for this cohort.

The data source for identification of the study cohort was the Nova Scotia Trauma Registry, which was established in 1994. It collects and registers data on all major traumas with an Injury Severity Score (ISS) for blunt trauma of 12 or higher; this score is generally accepted to define major trauma and includes all patients with post-traumatic EDHs and/or SDHs.[18]

The data collected in the registry include the nature and severity of the injury, the nature of the trauma event, patient demographics, details of patient care and outcomes, final anatomic diagnoses, procedure codes and processes of acute care. The severity of an injury or injuries in an individual patient is indexed and measured using the Abbreviated Injury Scale (AIS) and the ISS. A team of health care professionals (e.g., nurses, paramedics and health records personnel) with training in the AIS, the trauma registry software, the World Health Organization International Classification of Diseases (ICD-10)[19] and Canadian Classification of Health Interventions (CCI) collects the data. The registry software (Collector Trauma Registry version 3.37.12, Digital Innovation Inc.) provides automated internal edit checks to ensure that dates and times are consistent and to ensure that no invalid codes are entered. The provincial trauma registry coordinator also visually examines the data consistency. A thorough reabstracting audit of 10% of randomly selected cases occurs regularly. Further, the National Trauma Registry, which is managed by the Canadian Institute for Health Information, generates an error report based on the data submitted from the Nova Scotia Trauma Registry to identify coding errors that were not identified through provincial screening protocols. The registry has been used to support previous peer-reviewed research.[20,21]

Following the compilation of the list of potential cases from the Nova Scotia Trauma Registry, the research coordinator screened all the patient records with regard to inclusion criteria and to locate the outcome data in the patients' charts. The participating neurosurgeon (D.B.C.) then reviewed all the included patient charts to independently determine the GOS score, which was not collected in the Nova Scotia Trauma Registry. Primary outcome measures included mortality and the GOS score after 6 months.

We generated statistics using SPSS 14.0 statistical software (SPSS Inc.) to describe the patient population. Statistical analysis in this study consisted of χ^2 analysis and *t* tests when appropriate. This review had the full approval of the institutional research ethics review board at the QEII HSC.

Results

General epidemiology

From the Nova Scotia Trauma Registry, we screened an initial 152 charts for possible inclusion, and we deemed them appropriate for further blinded review as per the inclusion criteria described previously. The majority of excluded patients had chronic subdural hematomas. Following the participating neurosurgeon's blinded review, 70 patients met our inclusion criteria.

Thirty-four patients (49%) presented with acute post-traumatic SDHs, 23 (33%) with EDHs and 13 (19%) with both conditions. The median age (and standard deviation [SD]) was 45 (19) years, with a range of 16–89 years. Male patients made up 80% (n = 56) of the cohort. The most common mechanisms of injury were falls (51%), motor vehicle collisions (30%) and assault (11%). Alcohol was an associated factor in 15 of 23 patients (65%) in whom alcohol levels were tested. Among these patients, 7 of the mechanisms of injury were falls, 5 were motor vehicle collisions and 3 were assaults. Two of the 15 alcohol-associated events also involved other illicit drugs, and 11 of these events occurred in male patients. Overall, 13 patients (19%) had at least 1 important comorbid medical condition.[22] Fifty-seven patients (81%) were recorded as having no comorbid medical conditions. The mean age of persons who fell was 55 (18.2) years, whereas the mean age of those involved in a motor vehicle collision was 32 (13) years ($p < 0.001$).

Places of injury were the home (33%, n = 23), the community (10%, n = 7), work (6%, n = 4), the street (33%, n = 23) and unspecified (19%, n = 13). The numbers of injuries were evenly distributed by month throughout the year.

Prehospital data

Of the total cohort, 43 patients (61%) were transferred from other hospitals; the remaining 27 patients (39%) were directly delivered to the tertiary care centre from the scene of the injury. Forty-nine patients arrived by ground ambulance (either directly from a scene or as an interfacility transport). Two patients arrived by air ambulance (rotor wing) directly to the tertiary care facility, and 16 were transported by air ambulance to the tertiary care centre after initial ground ambulance transfer to a regional hospital. The remaining 3 patients arrived by private vehicle or unknown mode of transport.

Intravenous administration of fluids had been started on 22 patients (39%) transported by air or ground ambulance. Mechanical ventilation was started at the sending facility in 23 patients (33%), in the QEII HSC emergency department in 22 patients (31%), or by paramedics at the scene of injury in 6 patients (9%).

The median time from injury to neurosurgical intervention was 485 (SD 275) minutes for 70% (n = 49) of the cohort. We were unable to document elapsed times accurately in 21 records because the time of injury was not known. The range of elapsed times was widened by 1 outlier of 1380 minutes.

Clinical data

The documentation of Glasgow Coma Scale (GCS) scores was particularly poor despite it being the standard measurement of the severity of head injuries in the emergency medical services system and the province's emergency departments. The median GCS score recorded at the scene of injury for 46 patients (69%) was 11 (SD 4.3) with a range of 3–15. The mean GCS score for 19 patients (27%) at the referring facility was 13 (SD 4) with a range of 3–15, and for 41 patients (59%) at tertiary care it was 10 (SD 4.8) with a range of 3–15. Thirty-two of the patients (46%) were hypertensive (blood pressure > 140/90 mm Hg) and no patients were hypotensive (systolic pressure < 90 mm Hg) on arrival at tertiary care, although documentation was incomplete. Emergency department trauma team assessment or trauma team leader consultation took place for 39 patients (55.7%). In 24 instances, the referring facilities performed computed tomography (CT) scans of the head before transfer (55.8%), half of which (12, 50%) were repeated on arrival at the tertiary care centre. In total, 45 CT scans were performed in the tertiary-care emergency department.

Outcome data were available for all patients and are presented in Table 1. We defined a "good" outcome as a GOS score of 4 or higher after 6 months; a poor outcome was a GOS score lower than 4 after 6 months (Box 1). There were 18 postoperative deaths (overall mortality of 26%). Of these, 12 were patients with SDHs. With respect to the outcome and nature of hematomas, 16 of 47 patients with SDHs (either alone or with an EDH) experienced moderate or severe disability or died. Of the 23 patients with an EDH alone, 2 died and 3 experienced moderate or severe disability. Forty-four of 70 patients (63%) had associated good outcomes after 6 months based on the GOS score.

The median ISS from our overall cohort was 25 (SD 7) with a range of 16–50. The difference between the median ISS for patients with a good outcome (20, SD 7) and those with a poor outcome (25, SD 8) was statistically significant ($p = 0.008$). The median ISS for the 18 patients who died was 18 (SD 9) with a range of 16–50, and the median age was 56 (SD 13, range 38–79) years. The median time from injury to craniotomy for those who died was 124 (SD 95, range 25–397) minutes. There were also statistically significant differences between patients who had good and poor outcomes with respect to age and GCS score at the tertiary care centre; however, there were no statistically significant differences in outcome in terms of the length of stay in hospital (overall and in intensive care) or time to surgery (Table 1).

Table 1

Outcome data and associated epidemiologic elements of 70 patients who presented to the neurosurgical centre in Nova Scotia with post-traumatic epidural hematomas, subdural hematomas or both

	Group; median* (SD)			
Parameter	Entire cohort	Good outcome (GOS 4 or 5)	Poor outcome (GOS < 4)	*p* value
Age, yr	45 (19) $n = 70$	35 (17) $n = 44$	54 (16) $n = 26$	< 0.001
Sex, male	80%			
GCS score at tertiary care	10 (5) $n = 41$	14 (5) $n = 28$	7 (5) $n = 13$	< 0.001
ISS	25 (7) $n = 70$	20 (7) $n = 44$	25 (8) $n = 26$	0.008
Time from admitting to OR, min	171 (241) $n = 68$	195 (287) $n = 43$	130 (104) $n = 25$	0.28
CT at referring facility	24 $n = 43$	19 $n = 27$	5 $n = 16$	0.004
Mean LOS in ICU, d	6.4 (6.5) $n = 70$	5.9 (5.8) $n = 44$	7 (7.7) $n = 26$	0.50
Mean LOS, d	24 (40) $n = 70$	21 (25) $n = 44$	30 (57) $n = 26$	0.36
Disposition, no.				0.001
Home	26	26	0	
Home hospital	6	4	2	
Rehabilitation	16	12	4	
Nursing home	3	1	2	
Dead	18	0	18	
Other†	1	1	0	

CT = computed tomography; GCS = Glasgow Coma Scale; GOS = Glasgow Outcome Scale; ICU = intensive care unit; ISS = Injury Severity Score; LOS = length of stay; OR = operating room; SD = standard deviation.
*Unless otherwise indicated.
†Includes patients who were discharged to a correctional facility, signed out against medical advice or discharged to another acute care facility.

Box 1. Glasgow Outcome Scale score

Score	Rating	Definition
5	Good recovery	Resumption of normal life despite minor deficits
4	Moderate disability	Disabled but independent; can work in sheltered setting
3	Severe disability	Conscious but disabled; dependent for daily support
2	Persistent vegetative	Minimal responsiveness
1	Death	Patient did not survive

The Glasgow Outcome Scale (GOS) scores reflect a qualitative scale used to evaluate the functional outcome of a head injury, varying from 1 (death) to 5 (return to full normal function postinjury). The GOS is most often used at 3, 6 and 12 months postinjury.[23]

Discussion

Among trauma patients, head injury is responsible for up to 50% of fatalities and for a large component of continuing care among survivors.[24,25] Head injury remains the most common cause of death and disability in young people.[11] Several types of head injury are amenable to neurosurgical intervention, and improved outcomes have been reported in patients receiving prompt treatment of post-traumatic extra-axial cerebral mass lesions, including EDHs and SDHs. This study is a population-based evaluation of patients older than 16 years who presented with head injuries requiring acute surgical evacuation of an EDH and/or SDH. Surgical intervention was at the discretion of the treating neurosurgeon.[26,27]

Although EDHs are relatively uncommon (fewer than 1% of all patients with head injuries and fewer than 10% of those who are comatose), they should always be seriously considered in any head-injury diagnosis.[5,24,28] Patients with EDHs who meet surgical criteria and receive prompt surgical treatment can have an excellent prognosis, presumably owing to limited underlying primary brain damage.[11,24,28,29] A review of EDHs and their full treatment spectrum (e.g., prehospital, hospital, surgical, rehabilitation) can serve as a useful surrogate marker for the efficacy of a trauma system.[10,26,30]

Subdural hematomas are much more common than EDHs; SDHs occur in about 30% of severe head injuries.[24,28] They normally cover the entire surface of the affected cerebral hemisphere, and the underlying brain damage is usually much more severe than with EDHs.[24,28,31] The higher mortality associated with SDHs can be lowered by very rapid surgical intervention and aggressive medical management. Thus this condition related to head injury is important to recognize and treat expeditiously.[10,31–33]

The decision to perform a surgery in a patient with a traumatic extra-axial hematoma is dependent on neurosurgical judgement. In some cases, such as the presence of a small EDH in a patient who is neurologically intact or in an elderly moribund patient, a decision may be made to treat conservatively.[26,27,34] In addition, the patient's postoperative outcome is directly related to preoperative neurologic status.[35] Our review examined only those individuals who had surgery within 24 hours of injury, and we made no attempt to analyze those treated conservatively or those who died before transfer to the QEII HSC.

More than 60% of our patients (61%) were transported from referring facilities to our single tertiary care neurosurgical site. This has important implications for our province, which has a large rural population and a single air medical transport system well integrated with a single primary ground ambulance response.[20,21] However, only 18 patients included in our study were transported by air during the study period, and their ISSs (median 25, SD 8) were the same as the overall cohort median (25). This suggests that the critical care air medical transport system could be better used to bring more critically ill patients to our sole tertiary care centre.

Overall postoperative mortality was 26%, which compares favourably with the literature. For EDHs, the literature supports the concept that outcome varies directly with level of consciousness at the time of surgery, which is also related to delay time in diagnosis and treatment; mortality rates of 0%–57% are reported, depending on these factors.[24,28] With SDHs, the outcomes are related to the timing of surgery, level of consciousness at the time of surgery, age and the presence of secondary brain injury; mortality rates of 36%–90% are reported, depending upon these factors.[2,24,28] The injury mechanism (falls and motor vehicle collisions) and the place of injury (home, community and work) in our study population correspond closely with other epidemiologic descriptions of cohorts with head injuries,[35,36] as do the sex (80% male) and median age (45 yr).

Time to surgery and integrated trauma system

About 65% of deaths from head injury occur before the individual even reaches hospital and, therefore, the majority of deaths due to TBI may be influenced by prehospital treatment or determinants.[37–40] Klauber and colleagues[41] reported in 1985 that advanced prehospital emergency medical services can substantially reduce mortality in patients with head injuries. Important components of prehospital care included early advanced airway management, hypotension management and rapid transport (especially air transport).[37,38,42–44]

Baxt and Moody[9] supported the concept of prehospital advanced care as a predictor of improved survival in patients with TBI. They concluded that patients rapidly transported by air and treated by advanced providers (physicians and nurses) have improved survival compared with a similar population transported by ground.

Stone and colleagues[45] published a retrospective study showing that patients with post-traumatic SDHs who were brought directly to a tertiary neurosurgical centre had better outcomes than those who were initially taken to non-neurosurgical institutions and then subsequently transferred. Fearnside and colleagues[42] examined prehospital variables, finding that a low GCS score, hypotension and lack of pupillary response were all correlated with poor outcome. However, more recent retrospective studies have failed to provide definitive evidence that prehospital intubation (with short urban transport times) in patients with severe head injuries improves outcome.[14,16,46,47]

Seelig and colleagues[48] showed that patients with acute SDHs whose hematomas were evacuated had improved outcomes. This seminal paper, published in 1981, established the concept of time to definitive treatment (hematoma evacuation) as a basic tenet of the surgical care of post-traumatic acute SDHs. Colohan and colleagues[49] demonstrated that differences in outcomes between 2 centres were owing to the absence in one centre of a prehospital care system that expedited delivery of patients. In 1991, Wilberger and colleagues,[31] although not reproducing the exact results of Seelig and colleagues, did report a trend to improved outcome with timely evacuation of SDHs. These authors pointed out that accompanying underlying parenchymal brain damage is of equal or greater importance with respect to outcome than the actual SDH.

Overall, support for time-related deterioration and timely surgical intervention is widely accepted in the trauma resuscitation literature.[13] Timeliness depends upon a well-integrated prehospital system with trained paramedics and established region-wide protocols, as well as rapid access to definitive imaging and surgical interventions. Paradoxically, we found a lack of significant difference in median time to surgery between patients with good and poor outcomes (time to surgery 130 min, range 25–445 among patients with poor outcomes v. 195 min, range 0–1315 among patients with good outcomes). In fact, there appeared to be a trend indicating that increased time to surgery was associated with a the good outcome group. Since this finding differs from what one would expect based on the literature, it may be that our cohort was too small to detect a difference in these parameters. Alternatively, a longer time to definitive treatment may constitute a selection bias, where some patients with hyperacute hematomas may not have survived. We found that a higher ISS correlated with a poorer outcome at 6 months (27 patients), as measured with GOS scores (Table 1).

Several recent papers have provided evidence that the establishment of a comprehensive trauma system at the state, regional or provincial level is an independent determinant of outcome in trauma and a laudable public health goal.[50,51] Indeed, Wald and colleagues[52] have documented this issue with respect to severe head injury in regions without trauma systems. This concept of improved outcomes with prompt delivery of traumatic brain injury to centres of expertise has also been shown by Wester and colleagues[53] and others,[54] as well as more recently by Härtl and colleagues.[44]

A trauma system is generally defined as a comprehensive process for trauma care from prevention to injury to rehabilitation. This includes advanced prehospital care with medical direction; regionalization bypass protocols; and an organized method of trauma resuscitation, care and rehabilitation in conjunction with a comprehensive trauma registry that includes quality-assurance standards and a dedicated research and injury-prevention component.[51] This type of system may take years to construct and mature. Nova Scotia has been and continues to be in the process of developing such a provincial trauma system, and this process was initiated during our study period.[55] Further studies of the effects of implementing this system are warranted with respect to this patient population and the general trauma population.[20]

Limitations

Limitations of our study include its retrospective nature relying on administrative databases, its small sample and the lack of complete documentation in the prehospital phase and initial receiving emergency departments.

Conclusion

This study has described the population-based epidemiology of surgically treated post-traumatic EDHs and/or SDHs in patients older than 15 years over a 9-year period in 1 province. Surprisingly, only 70 patients met our inclusion criteria. This represented an annual incidence of surgically treated acute EDHs and/or SDHs of 0.83 per 100 000 per annum. Patients who died were older, more severely injured and were more likely to have had surgery for an acute SDH than an EDH. The study of these patients with surgically treated acute EDHs or SDHs provides an opportunity to examine the integrity and efficacy of a trauma system and, more importantly, to identify relevant prehospital and hospital variables that can be used to develop strategies to improve care in this critically injured cohort.

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