Traumatic Brain Injury in the Elderly: A Significant Phenomenon

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Abstract Introduction: Traumatic brain injury (TBI) in the elderly is becoming an increasingly frequent phenomenon. Studies have mainly analyzed the influence of age as a continuous variable and have not specifically looked at geriatric patients as a group. The aim of this study is to map the magnitude and characteristics of geriatric TBI and to identify factors contributing to their poorer outcome.

Material and Methods: Based on the ICD-9 register of the University Hospitals Leuven demographic and clinical variables of TBI were analyzed (2002–2008). The influence of older age on physiological variables was assessed using the Brain-IT database.

Results: The elderly (aged ≥ 65 years) accounted for 38.2% of non-concussion TBI and 32.6% of ICU admissions, representing the largest age group. The elderly had a significantly lower ICP (median 10.06 mmHg versus median 14.52 mmHg; $p=0.048$), but no difference in their measure of autoregulation (daily mABP/ICP correlation coefficient) compared with 20–35 year-olds. TBI was caused by a fall in 78.9% of elderly patients and 42.3% suffered a mass lesion. 72.1% had cardiovascular comorbidity. Complications did not differ from their younger counterparts.

Discussion: Geriatric TBI is a significant phenomenon. Poorer outcomes are not yet sufficiently explained by physiological monitoring data, but reduced vascular versatility is likely to contribute. More research is needed in order to develop specific management protocols.

Keywords Traumatic brain injury • Age • Geriatric • Outcome • Intracranial pressure • Autoregulation

Introduction

While it is well known that outcome after traumatic brain injury (TBI) negatively correlates with age, studies on geriatric TBI – i.e. TBI in patients of 65 years of age or older – are scarce. Czosnyka et al. investigated the influence of age on monitoring data in a group of 258 patients with head injury and found a tendency for intracranial pressure (ICP) to decrease and for cerebral perfusion pressure (CPP) to increase with age. Indices of autoregulation indicated worsening of cerebrovascular control with age [1]. In 2005 it was reported by Kiening et al. that intracranial compliance at high ICP, as monitored by using the Spiegelberg probe, decreased with advancing age [4]. A limitation of these studies is that they analyzed the influence of age in groups of patients in which the number of geriatric patients was relatively low.

The aim of the present study is to explore the magnitude of geriatric TBI and investigate factors contributing to its poorer outcome by analyzing accident, injury, physiological and clinical characteristics dichotomizing between geriatric patients and younger counterparts.

Materials and Methods

The University Hospitals Leuven ICD-9-based registry was queried for all TBI-relevant codes in the period 2002–2008. Resultant patient codes were then screened for all concomitant diagnoses in the same registry. These concomitant diagnoses were subsequently categorized into pre-injury morbidity, simultaneous other injuries and complications for the age groups 20–35 years and ≥ 65 years. The patient charts of these two age groups could be retrospectively reviewed for the period 2002–2005 for demographics, comorbidity, accident circumstances, Glasgow Coma Score (GCS) on admission, interventions and Glasgow Outcome Score (GOS). The admission head CT was reviewed for each case in order to be scored according to the Marshall classification [5] and for identifying all relevant lesion types. An electronic registry of

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treatment withdrawal codes has been available since 2007 and was consulted for all admitted TBI patients in the period 2007–2008.

Road traffic accident data from the database of “Statistics Belgium” was explored for age relations. This information was available for the period 1995–2008 [7].

The Brain-IT database, which is a multicenter standardized prospective database containing a core dataset including minute-by-minute monitoring data on 200 monitored TBI patients, was explored for the effect of age on intracranial pressure (ICP), mean arterial blood pressure (mABP), cerebral perfusion pressure (CPP), cerebrovascular pressure reactivity and outcome. For that purpose the following variables were assessed: daily mean ICP, number of ICP events, daily mean mABP, daily mean CPP, daily correlation coefficient of ICP and mABP and extended Glasgow Outcome Score (GOSe). In order to obtain some degree of validation of the daily correlation coefficient of ICP and mABP as a surrogate measure of pressure reactivity, this variable was correlated with outcome, expressed as GOSe. In addition, a linear multiple regression analysis was done with the first five listed variables as independent and GOSe as dependent variables. The effect of age was then analyzed by calculating the Pearson correlation coefficient between age and the listed variables. Finally, the listed variables were compared for the age groups 20–35 years and ≥ 65 years using Mann–Whitney U tests.

Results

Epidemiological Data

A total of 422 patients aged ≥ 65 years with nonconcussion TBI (i.e., presence of CT abnormalities) were admitted to the University Hospitals Leuven between 2002 and 2008. This geriatric group represented 38.2% of all (nonconcussion) TBI admissions and peaked above other age groups (Fig. 1). The elderly accounted for 32.6% of TBI patients admitted to the ICU.

Physiological Data

The Brain-IT database consists of 200 patients with a mean age of 36.1 years (range 4–83 years). The daily correlation coefficient ICP/mABP negatively correlated with GOSe (Spearman $r = -0.12$, $p < 0.05$). In the multivariate analysis age ($p < 0.001$), daily mean ICP ($p = 0.047$) and daily ICP/mABP correlation coefficient ($p = 0.025$) came out as independent predictors of outcome ($R^2 = 0.119$). The significant negative relation between the daily correlation coefficient ICP/mABP and outcome supported its further use in the analysis as a

Fig. 1 Traumatic brain injury-related admissions to the University Hospitals Leuven in the period 2002–2008: numbers of patients categorized into age groups

potential surrogate measure of pressure reactivity. As for age correlations, the number of ICP events decreased slightly with increasing age ($r = -0.09$, $p = 0.003$). The daily mean mABP and daily mean CPP tended to increase with increasing age ($r = 0.09$ and $p = 0.002$ for both). The daily mean ICP and the daily ICP/mABP correlation coefficient did not significantly correlate with age. The comparison of the 20–35-year age group ($n = 69$) and ≥ 65 -year age group ($n = 18$) demonstrated lower average ICPs in the elderly (median 10.06 mmHg [9.12–16.03 mmHg] versus median 14.52 mmHg [11.43–17.89 mmHg]; $p = 0.048$). The other variables did not significantly differ between the two age groups (Fig. 2).

Accident and Clinical Data

The analysis of road traffic casualty data in Belgium between 1995 and 2008 showed that on average 7.9% of the casualties in that period were older than 65 years.

Charts were available for review in 175 elderly and in 76 patients from the 20 to 35 age group who sustained TBI with CT abnormalities in the period 2002–2005. Mean ages are 78.0 (range 65–95) for the elderly and 27.6 (range 20–35) for the younger group. The results of the analysis are shown in Table 1.

Fig. 2 Boxplot of average intracranial pressure (ICP) (a) and average cerebral perfusion pressure (CPP) (b) for the age groups of 20–35 years and ≥ 65 years

Concomitant diagnoses were analyzed in the hospital registry for all TBI patients in the 20–35 and ≥ 65 age groups admitted to the intensive care unit. There were 111 patients in the younger age group and 179 patients in the older age group. Pre-injury comorbidity and complications are shown in Fig. 3.

Simultaneous extracranial injuries were present in 33.5% of the elderly (chest trauma in 8.4%, blunt abdominal injury in 0.5% and fractures in 29.6%), as opposed to 58.6% of the younger age group (chest trauma in 32.4%, blunt abdominal injury in 15.3%, urinary tract injuries in 5.4% and fractures in 53.2%).

Table 1 Injury and outcome characteristics of the chart-reviewed traumatic brain injury (TBI) patients

		20–35 years <i>n</i> = 76 (%)	≥65 years <i>n</i> = 175 (%)
Gender	Female	20 (26.3)	89 (50.9)
	Male	56 (73.7)	86 (49.1)
Accident mechanism	Pedestrian	3 (3.9)	10 (5.7)
	Pedal cyclist	17 (22.4)	19 (10.9)
	Motor vehicle	29 (38.2)	2 (1.1)
	Fall	24 (31.6)	138 (78.9)
	Unknown	3 (3.9)	6 (3.4)
GCS on admission	13–15	36 (47.4)	108 (61.7)
	9–12	7 (9.2)	20 (11.4)
	3–8	28 (36.8)	26 (14.9)
	Unknown	5 (6.6)	21 (12.0)
Admission head CT	Diffuse 1	8 (10.5)	1 (0.6)
Marshall classification	Diffuse 2	38 (50.0)	88 (50.3)
	Diffuse 3	17 (22.4)	6 (3.4)
	Diffuse 4	4 (5.3)	3 (1.7)
	Mass lesion	9 (11.8)	74 (42.3)
	Unknown	0 (0)	3 (1.7)
Lesion type	Subarachnoid	23 (30.3)	61 (34.9)
	Extradural	15 (19.7)	29 (16.6)
	Subdural	25 (32.9)	99 (56.6)
	Contusion/ICH	31 (40.8)	77 (44.0)
	Diffuse axonal injury	17 (22.4)	4 (2.3)
GOS	5	39 (51.3)	46 (26.3)
	4	17 (22.4)	26 (14.9)
	3	2 (2.6)	18 (10.3)
	2	3 (3.9)	2 (1.1)
	1	9 (11.8)	58 (33.1)
	Unknown	6 (7.9)	25 (14.3)

GCS Glasgow Coma Score, GOS Glasgow Outcome Score, ICH intracerebral hematoma

In the 2007–2008 period a decision to withdraw treatment or not to expand treatment was taken in 30.0% of the older TBI patients (*n* = 120) and in 2.0% of the younger group (*n* = 50).

Discussion

According to prognostics from the National Institute of Statistics in Belgium, the proportion of the Belgian population that is 65 years of age or older will grow from 17.2% at present to 26.3% in 2060 [3]. We found that the elderly already account for more than one-third of hospitalizations for TBI in our hospital. It is not just likely, but certain that

numbers of geriatric TBI will increase in western societies in the future. Hence, there is a strong incentive to look into the phenomenon of geriatric TBI, given that literature on TBI in this specific age group is limited. It is a well established fact that outcome after TBI negatively correlates with age. Figures of mortality after severe head injury in the elderly exceed 70% [6]. And while this feels plausible, a satisfying explanation is still lacking.

The present study demonstrates that geriatric TBI is mostly due to falls and that the vast majority of these falls occur at home. Admission GCS is usually high, meaning that many of these patients arrive in the hospital well and deteriorate subsequently. More mass lesions are seen in the elderly. More than half of the elderly patients suffered a subdural hematoma and over 40% had a contusion or intracerebral hematoma. We showed in a previous study that contusions evolve to larger volumes in the elderly compared with their younger counterparts [2]. The higher incidence of subdural hematomas and (larger) contusions most likely contributes to poorer outcomes, possibly in combination with the reported decrease in intracranial volume challenge compensation with advancing age [4]. In-hospital complications did not really differ between age groups, although the physiological effect of these complications may well have been more severe in the elderly. As expected, pre-injury comorbidity was more frequent in the elderly, most compelling being the high incidence of cardiovascular morbidity. Finally, the outcome in numbers is inevitably affected by the higher incidence of treatment withdrawal decisions in the elderly.

As for the physiological part of the present study, in which 18 elderly patients were compared with a younger age group, it was found that ICP was lower in the elderly and that the surrogate measure of pressure reactivity did not differ. Our assessment of autoregulation may have been limited by the lack of high frequency data. Czosnyka et al. reported a reduction in autoregulation capacity after TBI with increasing age [1]. A limitation of the latter study was the actual low number of elderly patients in the analysis. Nevertheless, it may well be that impaired autoregulation capacity goes hand in hand with cardiovascular morbidity, as an indicator of reduced vascular resilience.

Outcome inevitably results from many factors and decisions taken during the course of treatment. The paucity of data on the subject of geriatric TBI in the literature probably illustrates a pessimistic view. As considerations of the quality of life and subsequent treatment withdrawal decisions are obviously justified in this specific age group, there is a need for better outcome prediction instruments in order to help clinicians in decision-making. On the other hand, there is a strong need for more basic physiological research on geriatric TBI in order to fine tune management strategies and thresholds in those elderly patients who are judged to have a chance of a favorable outcome.

Fig. 3 Pre-injury comorbidity (a) and complications (b) in traumatic brain injury patients of both age groups admitted to the intensive care unit in the period 2002–2008. *N*=111 for the 20–35 age group and *N*=179 for the ≥65 age group. *UTI* urinary tract infection

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Conflict of interest statement We declare that we have no conflict of interest.

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