Brain and Spine 3 (2023) 101723

Contents lists available at ScienceDirect

Brain and Spine

journal homepage: www.journals.elsevier.com/brain-and-spine

Neurosurgical treatment in elderly patients with Traumatic brain injury: A 20-year follow-up study

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ARTICLE INFO

Handling Editor: Dr W Peul

Keywords:
Traumatic brain injury
Elderly
Neurosurgery
Clinical management
Outcome
Retrospective study

ABSTRACT

Introduction: Traumatic brain injury in the elderly population can have a substantial impact on patients' quality of life. In this regard, successful treatment strategies are hard to define to date.
Research question: In order to facilitate further insight, this study assessed outcomes following acute subdural hematoma evacuation in patients aged ≥65 years in a large patient series.
Material and methods: A manual screening of the clinical records of 2999 TBI patients aged ≥65 years, admitted to the University Hospital Leuven (Belgium) between 1999 and 2019, was performed.
Results: A total of 149 patients were identified with aSDH, of whom 32 underwent early surgery, 33 underwent delayed surgery and 84 were treated conservatively. Patients who underwent early surgery had the lowest median GCS, poorest Marshall CT scores, longest hospital and ICU stay, and highest intensive care unit admission and redo surgery rates. 30-d mortality was 21.9% in patients undergoing early surgery, 3.0% in patients undergoing late surgery and 16.7% in patients who were treated conservatively.
Discussion and conclusion: In conclusion, patients in whom surgery could not be delayed had the worst presentation and poorest outcomes as opposed in patients in whom delay was possible. Surprisingly, patients treated conservatively had worse outcomes than those treated with delayed surgery. These results might indicate that if the GCS at admission is still adequate, an initial strategy of waiting and seeing might be associated with better outcomes. Future prospective studies with sufficient sample size are warranted to draw more definitive conclusions on the value of early vs. late surgery in elderly patients with aSDH.

1. Introduction

The incidence of Traumatic Brain Injury (TBI) in elderly people (≥65 years old) has steadily increased over the past decades (Maas et al., 2017), which is likely to increase even more with ongoing demographic shifts (Benedetto et al., 2017).

Elderly patients with TBI frequently suffer from intracranial hematomas. In particular, acute subdural hematoma (aSDH) is the most common injury type in elderly admitted to hospital after TBI, often accompanied by cerebral contusions (Harvey and Close, 2012).

It has been demonstrated that elderly patients with TBI have higher mortality rates (Benedetto et al., 2017) and are less likely to function or live independently after TBI, compared to younger patients (Gan et al., 2004; Marquez de la Plata et al., 2008; Mosenthal et al., 2002). Specifically, lower Glasgow Coma Scale (GCS) scores (Benedetto et al., 2017; Marquez de la Plata et al., 2008), pre-existing systemic diseases (Mosenthal et al., 2002; Bus et al., 2019) systemic complications (Bus et al., 2019), closed basal cisterns (Paldor et al., 2020), midline shift (Paldor et al., 2020) and limited intensive care (De Bonis et al., 2011) are risk factors that have been found to contribute to poorer outcomes in elderly patients.

Treatment strategies in this context are difficult to decide, and surgeons may be faced with a clinical dilemma, or clinical equipoise due to the lack of high-level evidence specific to the elderly population. Although neurosurgical interventions are frequently applied in elderly patients with aSDH (Bus et al., 2019; Paldor et al., 2020), many researchers recommend a more conservative approach, because of the worse outcomes and higher mortality in elderly patients (Gan et al., 2004; De Bonis et al., 2011). High practice variation has been identified in the management of elderly patients with aSDH (van Essen et al., 2022), reflecting uncertainty and potential controversy (Thompson et al., 2008; McIntyre et al., 2013). Therefore, the current study compared the clinical

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https://doi.org/10.1016/j.bas.2023.101723
Received 16 November 2022; Received in revised form 8 February 2023; Accepted 22 February 2023
Available online 2 March 2023

outcomes of TBI patients aged ≥65 years who underwent immediate, delayed or no neurosurgical intervention for aSDH, with the aim of contributing to the creation of specific clinical guidelines for these patients in the future.

2. Methods

A manual screening of the clinical records of 2999 patients aged ≥65 years, diagnosed of TBI, admitted to the University Hospital Leuven (Belgium) between 1999 and 2019, was performed.

The list of patients provided to the authors by the hospital's reporting service was based on registered diagnostic codes, following the International Statistical Classification of Diseases and Related Health Problems (ICD) 9. Only patients with an Acute Subdural Hematoma (aSDH) were included in the present analysis. The aSDH volumes were calculated on the first CT scan taken at hospital admission using the ABC/2 formula (Won et al., 2018).

Patients were excluded if they were under 65 years old, presented with a chronic subdural hematoma (cSDH), had a diagnosis of Alzheimer's disease (AD), Parkinson's disease (PD) or suffered a cerebrovascular accident prior to TBI, had alcohol abuse, were under antithrombotic treatment or presented a Do Not Resuscitate (DNR) order.

All patients' relevant clinical data, including information on previous clinical history, accident, treatment, clinical characteristics and outcomes were manually registered in an Access 2016 database for all patients fulfilling the inclusion and exclusion criteria. This database was translated into a comma-separated values (csv) file for statistical analysis, which was performed using the Pandas, Numpy and Scikit-learn packages in Python.

Injury severity was defined using the Glasgow Coma Scale (GCS) (Teasdale and Jennett, 1974) and polytrauma was defined as an Injury Severity Score (ISS) ≥16 in multiple organ systems.

3. Results

Initially, 272 patients fulfilled our inclusion criteria, of whom 123 were excluded due to antithrombotic medication intake prior to the accident. Therefore, 149 patients were included in the study, all having sustained aSDH, and of whom 32 underwent early decompressive surgery (i.e. Craniotomy within 24h post-TBI), 33 underwent delayed surgery (later than 24h post-TBI, due to clinical deterioration or enlarging hematoma size) and 84 were conservatively treated. The patients' median age at injury ranged from 75 to 78 years. 40.6% of the patients who were treated with early surgery, 33.3% of those treated with delayed surgery and 40.5% of those treated conservatively were ≥80 years old. No statistically significant differences were found between age groups in the different studied groups.

None of the patients included in this cohort were taking antithrombotic medication prior to TBI. 26.2–42.4% of the patients had a history of cardiovascular diseases prior to TBI, 21.2–28.1% were under polypharmacy, 6.3–12.1% had a history of cancer and 6.0–9.4% had chronic obstructive pulmonary disease (COPD).

Patients treated with early surgery had the highest rate of diabetes (18.8%, $p < 0.01$). Moreover, 3.0% of the patients with delayed surgery and 2.4% of the patients who received conservative treatment were dependent for activities of daily living (ADL) prior to TBI.

The demographic characteristics of each of the included groups has been described in Table 1.

Table 1
Demographic characteristics of the patients included in the three studied groups.

	Neurosurgery		Conservative treatment (N = 84)	ANOVA p value
	Early surgery (N = 32)	Delayed surgery (N = 33)		
Female/Male (N (%))	21 (65.6)/ 11 (34.4)	12 (36.4)/ 21 (63.6)	41 (48.8)/43 (51.2)	0.06
Age at injury (median; IQR)	78; 7	75; 10	77; 14	0.72
≥80 years old (N (%))	13 (40.6)	11 (33.3)	34 (40.5)	0.63
Cardiovascular history (N (%))	13 (40.6)	14 (42.4)	22 (26.2)	0.14
Cancer prior to TBI (N (%))	2 (6.3)	4 (12.1)	7 (8.3)	0.95
COPD prior to TBI (N(%))	3 (9.4)	2 (6.1)	5 (6.0)	0.89
Diabetes prior to TBI (N (%))	6 (18.8)	2 (6.1)	2 (2.4)	<0.01
Dependency for ADL (N (%))	0 (0.0)	1 (3.0)	2 (2.4)	0.65
Polypharmacy (N (%))	9 (28.1)	7 (21.2)	20 (23.8)	0.80

NA = not applicable; COPD = chronic obstructive pulmonary disease; ADL = activities for daily living.

Table 2
Patients' injury characteristics.

	Neurosurgery		Conservative treatment (N = 84)	ANOVA p value p value
	Early surgery (N = 32)	Delayed surgery (N = 33)		
Fall accidents (N (%))	26 (81.3)	24 (72.7)	69 (82.1)	0.51
GCS (median; IQR)	10.0; 8	15.0; 1	14; 3	<0.01
Brain contusion (N (%))	6 (18.8)	6 (18.2)	28 (33.3)	0.13
Subarachnoid hemorrhage (N (%))	6 (18.8)	6 (18.2)	32 (38.1)	0.03
Epidural hematoma (N (%))	2 (6.3)	1 (3.0)	9 (10.7)	0.36
Intraparenchymal hemorrhage (N (%))	0 (0.0)	0 (0.0)	2 (2.4)	0.46
Skull fracture (N (%))	10 (31.3)	4 (12.1)	25 (29.8)	0.11
Midline shift (N(%))	21 (65.6)	20 (60.6)	19 (22.6)	<0.01
Midline shift (median; IQR)	5.9; 5	4.5; 6	0.0; 2	<0.01
aSDH hematoma volume (mL) (median;IQR)	13.2; 25	11.4; 16	3.1; 7	<0.01
Marshall CT score (median; IQR)	4; 3	3; 1	2; 1	<0.01

The main cause of TBI was fall accidents in all studied patients (72.7–82.1%). Patients who underwent early surgery had the lowest median GCS score at admission, while patients who underwent delayed surgery had the highest (GCS of 10 vs. GCS of 15). With regard to CT scan assessment, patients who underwent early surgery had the highest median midline shift, hematoma volume and Marshall CT score [Table 2], whereas patients who were treated conservatively more often had associated subarachnoid hemorrhage (38.1%, p = 0,03). There were no statistically significant differences among the studied groups for brain contusions, epidural hematomas, intracerebral hemorrhage (ICH) and skull fractures ($p = 0.13$, $p = 0.36$, $p = 0.46$, and $p = 0.11$, respectively). Early surgery was also associated with longer hospital stays, intensive care unit (ICU) admission rates, longest ICU stay and highest redo surgery rates ($p = 0.05$, $p < 0.01$, $p = 0.01$ and $p < 0.01$, respectively) [Table 3].

Within 30 days post-TBI, 21.9% of the patients who underwent early surgery, 3.0% of the patients who underwent delayed surgery and 16.7% of the patients who were treated conservatively died. However, the differences in mortality rates among the studied groups were not statistically significant ($p = 0.08$) [Table 4].

4. Discussion

The results obtained in the current study indicate that conservative

Table 3
Patients' clinical management.

	Neurosurgery		Conservative treatment (N = 84)	ANOVA p value
	Early surgery (N = 32)	Delayed surgery (N = 33)		
Timing of surgery post-TBI (days) (median; IQR)	0; 1	18; 22	–	<0.01
Hospitalization after TBI (N (%))	32 (100.0)	26 (78.8)	75 (89.3)	0.02
Hospitalization length (median;IQR)	26; 37	9; 19	9; 17	0.05
ICU admission (N (%))	20 (62.5)	10 (30.3)	26 (31.0)	<0.01
ICU stay length (median;IQR)	8; 0	0; 4	0; 2	0.01
Redo surgery (N (%))	5 (15.6)	3 (9.1)	0 (0.0)	<0.01

Table 4
Patients' mortality rates.

	Neurosurgery		Conservative treatment (N = 84)	ANOVA p value
	Early surgery (N = 32)	Delayed surgery (N = 33)		
Mortality 30 days (N (%))	7 (21.9)	1 (3.0)	14 (16.7)	0.08
Mortality 6 months (N (%))	8 (25.0)	5 (15.2)	25 (29.8)	0.27

treatment is the most often selected treatment strategy for elderly patients with aSDH. In our cohort, 56.4% of the patients were treated conservatively, 21.5% underwent a neurosurgical intervention within the first 24 h post-TBI, and 22.14% underwent delayed neurosurgery later than 24h post-TBI. Patients who received early surgery were clearly in a poorer state than those in whom the surgeons decided that there was time to delay surgical decompression. The highest mortality rate was observed in the early surgery group (21.9%).

Treatment strategies in patient with TBI are usually chosen based on clinical findings such as GCS, computed tomography (CT) results and intracranial pressure (ICP). However, treatment decision for elderly patients with TBI are not straightforward. Patient autonomy and Quality of Life need to be considered, and the prognosis of these patients is often rather poor (Mak et al., 2012). Hence, deciding on a surgical treatment such as craniotomy or craniectomy in elderly patients easily becomes a challenging decision with little ground for evidence-based support (Feliciano and De Jesús, 2008, 2008van Essen et al., 2019).

A neurosurgical intervention is often decided because the patient is judged to be able to survive, while a conservative treatment is chosen in occasions in which the outcome is thought to remain unfavorable whatever treatment is chosen (van Essen et al., 2017). The evacuation of a hematoma through a craniotomy can be life-saving, but at the same time may lead to the survival of a patient with a poor quality of life (QoL) or even absence of independent functioning (Cooper et al., 1976; Honeybul et al., 2013). Unfortunately, no elderly-specific prognostic tools exist to reliably predict outcomes. Decisions may then also be biased by other factors, such as surgeons' training, different hospital policies, and the intuition and personal opinions of the neurosurgeon (van Essen et al., 2017).

Currently, there is a tendency toward less aggressive treatments in the elderly (Mak et al., 2012). A recent instrumental variable analysis in aSDH in elderly showed no difference in outcomes between patients treated in an aggressive versus a more conservative center (opting for delayed surgery). In the present analysis, it cannot be discriminated whether these elderly individuals had a better outcome prognosis with initially conservative treatment versus immediate surgical treatment (Wan et al., 2016). Thus, the high mortality and morbidity among older patients with TBI can constitute a self-fulfilling prophecy and policy for early surgery (Wan et al., 2016).

Previous studies have shown controversial results regarding outcomes after neurosurgery in elderly patients with TBI. Shimoda et al. Wan et al. and *Brazinova* et al. reported improved functional outcomes and reduced mortality in patients who underwent neurosurgical interventions (Wan et al., 2016; Shimoda et al., 2014; Brazinova et al., 2010). However, other studies have reported better outcomes after conservative treatment (Trevisi et al., 2020).

The favorable results found in some previous studies might indicate that there is still hope for these patients and that indiscriminately rejecting a surgical approach might not always be the best solution. Nevertheless, this needs to be further investigated.

The main limitation of the study was the small sample size of the studied groups, which depended on the number of admitted patients who fulfilled our in-/exclusion criteria and was out of the authors' control. Future randomized clinical trials with larger sample sizes will be necessary to draw more consistent conclusions.

Furthermore, the presented data were retrospectively collected. Therefore, standardized functional outcome measurements were not available for all patients and mortality was the only possible outcome available in all. Future studies should also consider different outcome measures regarding the patients' dependency levels and Quality of Life after neurosurgical intervention and conservative treatment.

Despite these limitations, we believe that this study can positively contribute to reduce the existing research gap in the TBI research field around this matter.

The results obtained from this study seem to indicate that in those cases where the GCS score at admission is still adequate, waiting longer than 24h to perform the neurosurgical intervention can lead to better outcomes. However, these results are based on a low sample size and need to be carefully interpreted. Future prospective larger-size data collection for matched-pair analysis is necessary to draw conclusions. For the moment, individual case analyses should be performed to make clinical decisions. The development of specific prognostic tools and further investigations able to clarify which neurosurgical interventions would be useful for which patients should now be prioritized to improve outcomes and Quality of Life in elderly patients with TBI.

5. Conclusion

Patients who underwent early neurosurgical treatment had the highest 30-day mortality rates, but also presented with the most severe injuries at admission. Patients who underwent delayed surgery had a better outcome. Future prospective studies with a sufficient sample size are warranted to draw more definitive conclusions on the value of early vs. late surgery in elderly patients with aSDH.

Authorship confirmation statement

All authors contributed to the study conception and design. The data collection and analysis was performed by Rebeca Alejandra Gavrila Laic. The first draft of the manuscript was written by Rebeca Alejandra Gavrila Laic and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Author(s') disclosure statement(s)

The authors declare that they have no competing interests.

Funding statement

This work was supported by Fund for Scientific Research –Flanders

(FWO) and Helaers foundation.

Appendix

Appendix A. Variables registered in our digital database

Variable
Study ID
Gender
Marital status
Date of birth
Date of death (in case of deceased patients)
Age at death (in case of deceased patients)
Current age
Living place before TBI
Was the patient living alone before TBI?
ADL dependency before TBI
Previous history of hematological conditions
Previous history of cardiovascular conditions
Previous anticoagulant intake
Polypharmacy
Previous history of depression
Previous musculoskeletal problems
Previous walking aid
Date of accident
Age at the moment of the accident
Cause of TBI
Type of TBI
Polytrauma
Place of accident
Safety measures used during accident
Accident description
Brain injury type
Brain injury location
GCS (eyes, motor, verbal and total) at the moment of the accident
ICU admission
Date of ICU admission
Date of ICU discharge
Total number of days in ICU
Mortality in ICU
Hospitalization
Number of days between TBI and hospitalization
Date of admission to the hospital
GCS (eyes, motor, verbal and total) at hospital admission
Pupils' size at hospital admission
Pupils' reactivity at hospital admission
Face asymmetry during hospitalization
Tracheotomy
Intubation
Sedation
Paralysis
ICP monitoring
Date of brain surgery
Type of brain surgery
Date of second brain surgery
Type of second brain surgery
Rehabilitation during hospitalization
Type of rehabilitation during hospitalization
Disorientation at hospital admission
Decrease of consciousness at hospital admission
Speech problems at hospital admission
Amnesia after accident
Pain and type of pain at hospital admission
Mini Mental Score Extended (MMSE) during hospitalization
Date of hospital discharge
Total days of hospitalization
Presence of a "Do not attempt resuscitation" (DNR) code
DNR code date
Mortality during hospitalization
Mortality within 30 days after TBI
Mortality within 6 months after TBI
Transfer to an institution after hospital discharge
Date of transfer to an institution
Reason of transfer to an institution
Living place after TBI
Does the patient live alone after TBI?

(*continued on next column*)

(*continued*)

Variable
ADL dependency after TBI
Total number of hospitalizations after TBI
Motor disturbances after TBI
Walking aid use after TBI
Pain after TBI
Reason of pain after TBI
Depression/other psychological problems after TBI
Speech disturbances after TBI
Rehabilitation (and type of rehabilitation) after TBI
Stroke after TBI
Date of stroke after TBI
Number of registered accidents after TBI
Cause of accidents after TBI
Type of accidents after TBI
Place of accidents after TBI
Safety measures after TBI
Post-TBI accidents' description
Brain surgery after hospital discharge
Diagnose of neurodegenerative disorders after TBI
Date of neurodegenerative disorder diagnose
Number of years between TBI and neurodegenerative disease diagnose
MMSE score after hospital discharge
MMSE score date
MMSE score category
Glasgow Outcome Score Extended (GOS-E) 6 months post-TBI
ADL dependency post-TBI
Presence of epilepsy after TBI
Psychiatric problems after TBI

ID = identifier; TBI = Traumatic Brain Injury; GCS = Glasgow Coma Score; ICU=Intensive Care Unit; MMSE = Mini Mental Score Extended; DNR = Do not attempt resuscitation order.

Appendix B. Registered cardiovascular conditions

Type of cardiovascular condition
Arterial hypertension (AHT)
Hypotension
Tachy-brady syndrome
Arrhytmia
Pacemaker
Atrial fibrillation
Ventricle fibrillation
Venous thrombose
Peripheral vascular disease
Cardiomyopathy
Cardiomegaly
Aortic valve stenosis
Artificial heart valve implantation
Previous myocardial infarct
Angor pectoris
Aneurysma
Hypercholesterolemia
Thoracic pain syndrome
Ischemic heart disease
Ischemic coronary disease
Chronic total oclusion
Carotid stenosis
Cardiac insufficiency
Heart valves' insufficiency
Arterial insufficiency
Coronopathy
Supraventricular tachycardia
Decompensated heart failure (DHF)
Cardiac decompensation
Aortic valve stenosis
Ventricle hypertrophy
Alcoholic cardiomyopathy
Venous insufficiency
Inferior cava vein syndrome
Macroangiopathy
Coronary atheromatosis

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