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Surgical versus conservative management for traumatic brain injury in elderly patients: A propensity-matched cohort study

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Abstract:

OBJECTIVE: The management of traumatic brain injury in elderly patients remains a topic of conflicting evidence in the literature. While some studies suggest that surgical intervention is beneficial, others indicate increased mortality and morbidity. Therefore, we conducted this retrospective matched cohort study to further investigate the role of surgical and conservative management for traumatic brain injury in elderly individuals.

METHODS: The authors conducted a retrospective review comparing patients with traumatic brain injury who underwent nonoperative management (NOM) versus those who underwent operative management (OM). Case matching was employed to create an artificial control group matched for age, sex, noncontrast computed tomography (NCCT) findings, and symptoms at a 1:1 ratio of treatment to control. The inclusion criteria included patients aged 60 years and above who presented to the emergency medicine department with head injuries resulting from various causes, such as road traffic accidents, falls, or assault, whereas the exclusion criteria included polytrauma, severe hypovolemic shock, and referrals to other institutions. The outcomes of interest included all-cause mortality and Glasgow Outcome Scale (GOS) scores, with statistical significance set at $P < 0.05$.

RESULTS: Optimal case matching was achieved for 52 out of 96 patients who underwent surgical management. There was no statistically significant difference in all-cause mortality between patients who underwent surgical management (32.69%) and those who did not (28.82%). Similarly, there was no statistically significant difference in the GOS score at 1 month between the two groups. A subgroup analysis based on the severity of traumatic brain injury and radiological diagnosis of intracranial injury revealed no difference between the OM and NOM groups, except for patients who underwent midline shift surgery.

CONCLUSION: There was no difference in all-cause mortality among elderly patients with traumatic brain injury regardless of whether they received conservative or surgical management, except for patients who underwent midline shift surgery.

Keywords:

All-cause mortality, Glasgow Outcome Scale, nonoperative management, propensity-matched cohort, traumatic brain injury in elderly individuals

Introduction

Traumatic brain injury (TBI) is the foremost cause of death and disability

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Box-ED section

What is already known about the study topic?

- Traumatic brain injury in the elderly requires a different treatment.
- Due to their physiological changes and comorbid conditions, their prognosis will be different from those of adults.

What is the conflict on the issue? Has it importance for readers?

- The role of surgical management for traumatic brain injury in the elderly is controversial. Some studies show favorable outcomes with surgical management, whereas some studies showed favorable outcome with conservative management.

How is this study structured?

- This was a single-center, retrospective propensity-matched cohort study that includes data from 96 patients.

What does this study tell us?

- There was no difference in all-cause mortality in elderly patients with traumatic brain injury regardless of whether they underwent operative or nonoperative management.
- However, patients with midline shift may benefit from operative management.

worldwide after injury. One common observation is that the world's population is aging; according to United Nations predictions, one in six individuals will be older than 65 by 2050. It is anticipated that by 2034, the number of Americans over 65 will surpass that of those under the age of 18 years.[1] Annually, an estimated 10 million individuals are affected by TBI. Despite this staggering impact, there has been minimal focus on TBI within the elderly population (>60 years of age). A study by the All India Institute of Medical Sciences revealed a 37% mortality rate among elderly individuals (>50 years of age) following TBI.[2] The elderly face heightened risks of mortality and disability due to various factors: (i) As age progresses, the dura mater becomes more adherent to the skull; (ii) cerebral atrophy and brain shrinkage occur with age, leading to increased intracranial space; (iii) many elderly patients, as part of routine management for comorbidities, take medications such as aspirin or other anticoagulants, potentially resulting in severe injury even from mild or moderate impacts; (iv) factors such as atherosclerosis could increase the risk of injury or cause secondary insults to the primary injury; and (v) reduced clearance of free radicals leads to heightened oxidative damage, increasing mortality and morbidity.[3,4]

The concepts of damage control surgery and the second hit phenomenon are receiving significant attention in surgical fields, prompting the exploration of damage control orthopedics, early appropriate care, and early total care. The current approach to conservative management for certain traumatic conditions is rooted in the concept of the second hit phenomenon. In this framework, the initial trauma constitutes the first hit, whereas subsequent surgery to address the trauma serves as the second hit, potentially exacerbating physiological imbalances.[5-7] This phenomenon may be particularly pronounced in the elderly population. Consequently, conservative treatments are increasingly favored. Our aim was to assess the impact of conservative and surgical treatments on all-cause mortality in elderly patients. Thus, the authors are undertaking this retrospective case review employing propensity score matching to examine the impact of surgical and conservative management on mortality and morbidity among elderly patients with traumatic brain injury.

Methods

Study design and setting

This study is a retrospective analysis of data from a prospective observational study conducted at a tertiary care center in southern India over 2 years, from January 2017 to December 2018. The institution, recognized for its postgraduate training, served as the setting for the research. The study was undertaken as part of a postgraduate (PG) dissertation.

Selection of participants

This study retrospectively analyzed data from a previously conducted prospective observational study spanning 2 years at our institution from January 2017 to December 2018, which is a tertiary care center in southern India and is part of a PG dissertation. Elderly patients were defined as patients aged more than 60 years according to their national identity card. The inclusion criteria comprised all elderly patients who presented to the emergency department with head injuries resulting from road traffic accidents (RTAs), falls, or assaults. Patients with polytrauma, severe hypovolemic shock, or who were referred to other institutions were excluded from the study. To address ethical considerations, propensity score matching was employed to categorize patients into two groups: Those receiving surgical treatment and those receiving conservative management. In the present study, TBI was classified based on the Glasgow Coma Scale (GCS), which assesses a patient's level of consciousness. The GCS scores range from 3 to 15, with higher scores indicating better neurological function. TBI is classified into three categories: mild TBI: GCS score of 13–15. Patients may experience brief loss of consciousness, confusion, or memory issues but usually recover quickly. Moderate TBI: GCS score of 9–12. Patients may have longer periods of unconsciousness, and cognitive or physical impairments may persist. Severe TBI: GCS score of 3–8. This indicates significant brain damage, often leading to coma or prolonged unconsciousness, with a higher risk of long-term disability or death.

Sample size estimation

The sample size for the original prospective study was calculated using the statistical formula for estimating a single population. The expected case fatality rate among geriatric traumatic brain injury in our population was 50%, and the sample size is estimated at 5% level of significance and 5% absolute precision. From this sample, propensity case matching was employed, and a sample size of 104 (52 in each arm) was arrived at as adequate case matching was possible for only 52 patients.

Interventions

The study compared two groups of elderly patients: those who received surgical intervention and those who were managed conservatively. Surgical treatment typically involved craniotomy with or without hematoma evacuation, and in select cases, burr-hole procedures were used. Patients in the conservative management group did not undergo any surgical procedures. No blinding of providers or outcome assessors was applied in this study due to its observational nature. The decision to operate or not was at the discretion of the attending neurosurgeon.

Methods and measurements

To address ethical considerations, propensity score matching was employed to categorize patients into two groups: those receiving surgical treatment and those receiving conservative management. Propensity score matching is a valuable way to control for bias and achieve pseudo-randomization. The matching criteria included age, sex, noncontrast computed tomography (CT) findings, and symptoms, facilitated by SPSS software, with a 0.25 cutoff serving as the caliper for optimal case matching. The authors used binary logistic regression to estimate the probability of receiving the treatment based on observed covariates in SPSS. A propensity score was derived from this binary logistic regression. The authors then used the propensity scores using the "Match Cases" procedure to match treated and control cases with a 0.25 cutoff serving as the caliper for optimal case matching. A 1:1 case matching was employed. Following this, the authors evaluated the balance of covariates between matched groups to ensure that the matching process effectively controlled for confounding variables. This involved comparing the distributions of covariates between the matched groups. After matching, the authors performed outcome analyses to evaluate the treatment effects using Chi-square test and another statistical test as needed. The inclusion criterion was patients aged 60 years and above who presented to the emergency medicine department with head injuries resulting from various causes, such as RTAs, falls, or assault, whereas the exclusion criteria included polytrauma, severe hypovolemic shock, and referrals to other institutions. Data, including demographic details, clinical signs and symptoms, comorbidity profiles, and outcome parameters such as death and Glasgow Outcome Scale (GOS) score, were extracted from case records.

Outcomes

The primary outcomes the authors aimed to analyze were all-cause mortality and GOS Scale scores in both groups. The patient was followed up for 1 year to assess the mortality. The authors focused on assessing all-cause mortality rather than TBI-related mortality because all-cause mortality provides a more comprehensive measure of patient outcomes. Even if a patient recovers from a TBI, they may still face complications related to the injury, such as sepsis, pulmonary embolism, or anesthesia-related issues. Therefore, all-cause mortality offers a broader perspective on the patient's overall health and trajectory, reflecting the full impact of the injury and its potential complications.

In this study, the GOS was used to assess the long-term outcomes and recovery levels in patients. It categorizes patients into five levels: (i) death: the patient does not survive. (ii) Persistent vegetative State: the patient is unresponsive and shows no signs of awareness. (iii) Severe disability: the patient is conscious but dependent on others for daily care due to significant physical or mental impairment. (iv) Moderate disability: the patient is independent in daily activities but may have some residual disabilities, such as cognitive or physical limitations. (v) Low disability/good recovery: the patient resumes normal life, though some minor deficits may remain. The GOS is a simple, yet effective tool for tracking patient recovery and functional outcomes postinjury. The GOS was measured at 1 year after the injury in the present study.

Data analysis

Propensity scores were calculated as per the abovementioned method. After matching, the balance of covariates between the two groups was evaluated to ensure effective control of confounding factors. The Chi-square test was used to compare categorical variables. The baseline variables were represented as percentages and proportions. The authors also aimed to perform a subgroup analysis of patient-level characteristics such as the severity of traumatic brain injury and radiological diagnosis of head injury. $P < 0.05$ was considered statistically significant for all analyses.

Ethical considerations

The study adhered to established ethical guidelines, securing ethical clearance from the Institute Ethics

Committee for Human Studies on the date 10.10.2016 with approval number of JIP/IEC/2014/8/357. Authorization was obtained from the hospital administration to collect data on medicolegal cases, and written informed consent was obtained from relatives before inclusion in the study. Stringent measures were taken to maintain confidentiality and anonymity throughout the data collection process, with the data exclusively utilized for research purposes.

Compliance with manuscript writing guidelines

The manuscript is written in accordance with the guidelines for reporting propensity score analysis, modified From the STrengthening the Reporting of OBservational studies in Epidemiology Statement.

Results

In the original prospective observational study, 384 patients were initially included and observed over time. Of these, 96 patients underwent surgical management, whereas the remaining 288 received conservative management. However, optimal case matching was feasible for only 52 patients treated with surgical intervention and 52 patients treated conservatively through propensity score matching. Baseline characteristics [Table 1] were mostly aligned between the two groups, except for symptomatology. Male sex predominated in both the surgical group (76.92%, 40/52) and the conservative management group (73.07%, 38/52). There was a balanced distribution among the three grades of TBI in both the surgical group (mild: 23% [12/52], moderate: 48% [25/52], and severe: 29% [15/52]) and the conservative management group (mild: 19% [10/52], moderate: 43% [22/52], and severe: 38% [20/52]). The incidence of vomiting, ear bleeding, nose bleeding, and seizures was significantly greater in the conservative management group than in the surgical management group. The comorbid status of the patients was also assessed. A total of 21% of patients had diabetes mellitus (22/104), 26% of patients had hypertension (27/104), 1% of patients had coronary artery disease (1/104), and 6% of patients had other comorbidities (6/104) such as chronic obstructive pulmonary disease, chronic kidney disease, and dementia. Only 1% of the patients had CAD for which the patient was on anticoagulants such as aspirin, clopidogrel, or warfarin. There was no association between comorbid status and mortality. Subdural hematoma (SDH) was the most common radiological finding in both groups (63% in the surgical group [33/52] and 69% in the conservative group [36/52]), followed by midline shift, which was observed in 32% of the surgical group (17/52) and 34% of the conservative group (18/52). Contusions, multiple CT findings, and fractures were subsequent findings.

Table 1: Baseline characteristics of the study participants

Demographics	Surgical management (*n*=52), *n* (%)	Conservative management (*n*=52), *n* (%)	*P*
Age			
60–69	43 (82)	41 (79)	0.875
70–79	6 (11)	7 (14)	
>80 years	3 (7)	4 (7)	
Gender			
Male	40 (77)	38 (73)	0.651
Female	12 (12)	14 (27)	
First aid			
Received	8 (15)	9 (17)	0.791
Not received	44 (85)	43 (83)	
Grading of TBI			
Mild	12 (23)	10 (19)	0.581
Moderate	25 (48)	22 (43)	
Severe	15 (29)	20 (38)	
Loss of consciousness			
Present	40 (77)	42 (81)	0.631
Absent	12 (23)	10 (19)	
Vomiting			
Present	12 (23)	23 (44)	0.022
Absent	40 (77)	29 (56)	
Ear bleed			
Present	10 (19)	22 (42)	0.011
Absent	42 (81)	30 (58)	
Nose bleed			
Present	5 (9)	13 (25)	0.038
Absent	47 (91)	39 (75)	
Seizures			
Present	0	5 (9)	0.022
Absent	52 (100)	47 (91)	
Diabetes mellitus			
Present	10 (19)	12 (23)	0.631
Absent	42 (81)	40 (77)	
Hypertension			
Present	11 (21)	16 (31)	0.263
Absent	41 (79)	36 (69)	
Coronary artery disease			
Present	0	1 (2)	0.315
Absent	52 (100)	51 (98)	
Other co-morbidities			
Present	2 (4)	4 (8)	0.400
Absent	50 (96)	48 (92)	
EDH			
Present	3 (6)	7 (13)	0.183
Absent	49 (94)	45 (87)	
SDH			
Present	33 (63)	36 (69)	0.534
Absent	19 (37)	16 (31)	
Contusion			
Present	31 (60)	34 (65)	0.543
Absent	21 (40)	18 (35)	
ICH			

Contd...

Table 1: Contd...

Demographics	Surgical management (n=52), n (%)	Conservative management (n=52), n (%)	P
Present	1 (2)	2 (4)	0.558
Absent	51 (98)	50 (96)	
SAH			
Present	9 (17)	5 (10)	0.250
Absent	43 (83)	47 (90)	
Multiple findings in CT			
Present	28 (54)	30 (58)	0.693
Absent	24 (46)	22 (42)	
Fracture			
Present	16 (31)	14 (27)	0.665
Absent	36 (69)	38 (73)	
Pneumocephalus			
Present	6 (12)	6 (12)	1.000
Absent	46 (88)	46 (88)	
Midline shift			
Present	17 (33)	18 (35)	0.836
Absent	35 (67)	34 (65)	

The baseline characteristics of the two groups include demographic, clinical, comorbid, and radiological features. There were no statistically significant differences between the groups, except for symptomatology. Vomiting, ear bleeding, nose bleeding, and seizures showed statistically significant differences between the two groups. TBI: Traumatic brain injury, EDH: Extradural hematoma, SDH: Subdural hematoma, ICH: Intracerebral hemorrhage, SAH: Subarachanoid hemorrhage, CT: Computed tomography

The primary outcome assessed was all-cause mortality [Table 2]. In the surgical group, 17 out of 52 patients (32.69%) died, whereas in the conservative management group, 15 out of 52 patients (28.82%) died. There was no statistically significant difference in all-cause mortality between the surgical and conservative groups ($P = 0.671$). In addition, the authors evaluated the GOS score between the two groups, and no statistically significant differences were observed [Table 3].

Furthermore, subgroup analysis [Table 4] was conducted to compare outcomes between patients managed conservatively and surgically, considering factors such as severity of mild TBI (17%, 9/52 vs. 8%, 4/52), severe TBI (15% 8/52 vs. 21% 11/52), and radiological profile, including extradural hematoma (EDH) (4%, 2/52 vs. 0%, 0/52), SDH (15%, 8/52 vs. 25%, 13/52), contusion (23%, 12/52 vs. 13%, 7/52), fracture (17%, 9/52 vs. 8%, 4/52), multiple findings (23%, 12/52 vs. 15%, 8/52), and midline shift (12%, 6/52 vs. 25%, 13/52). There was no statistically significant difference in all-cause mortality between patients managed conservatively or surgically across all subgroups, except in the midline shift subgroup, where patients managed conservatively in the presence of midline shift on CT showed an increased number of all-cause mortalities.

Discussion

In this retrospective propensity score-matched cohort study, the authors examined the effectiveness of surgical versus conservative management in elderly patients with traumatic brain injury. The study findings revealed no statistically significant difference in all-cause mortality between elderly patients who were managed conservatively and those who underwent surgical intervention for traumatic brain injury. In addition, there were no disparities in the GOS score among elderly patients treated with either approach.

Table 2: Primary outcomes

	Surgical management group (n=52), n (%)	Conservative management group (n=52), n (%)	P
Expired	17 (33)	15 (29)	0.671
Discharged home	35 (67)	37 (71)	

The number of patients with mortality in the surgical and conservative management groups. The all-cause mortality difference between the two groups was 4%, but this difference was not statistically significant

Choosing the appropriate treatment for older TBI patients is challenging because of their typically poor prognosis and the need to consider patient autonomy and quality of life.[8] Surgical interventions such as craniotomy or craniectomy for elderly patients may lack strong evidence-based support and pose complexities in decision-making, potentially resulting in survival with diminished quality of life or autonomy.[9,10]

When patients are deemed to have a reasonable chance of survival, neurosurgical interventions are often pursued. Conversely, in cases where the prognosis appears unfavorable regardless of treatment, a conservative approach is preferred.[10-12] Gan *et al*., Shimoda *et al*., and Taussky *et al*. suggested that surgical management in elderly TBI patients may carry risks, whereas conservative management may offer benefits, consistent with the findings of our study.[13-15] Similar observations were also made Gernsback *et al*. in their study of 18 elderly patients with acute subdural hematoma.[16] The STITCH trial, was the first randomized trial that evaluated conservative versus surgical management for traumatic intracerebral hemorrhage in all adult population. However, a subgroup analysis was performed with patients aged more than 50 years. They did not find any significant difference in mortality between the two groups.[17] Similar observations were made by the CENTER-TBI investigators. This study was a large, randomized control study including all adult patients who had a traumatic intracerebral hemorrhage. The patients were randomized into early surgery versus conservative management and a subgroup analysis with patients aged >65 years of age found no statistically significant difference between surgical and conservative management for all-cause mortality.[18] A study done by Aziz *et al*. on elderly patients (>70 years)

Table 3: Secondary outcomes

GOS	Surgical management group (*n*=52), *n* (%)	Conservative management group (*n*=52), *n* (%)	*P*
Death	17 (33)	15 (29)	0.533
Persistent vegetative state	6 (12)	5 (9)	
Severe disability	6 (12)	9 (16)	
Moderate disability	11 (20)	8 (14)	
Low disability	12 (23)	17 (32)	

The GOS measured at 6 months, which categorizes disability into five levels: Death: The patient does not survive. (ii) Persistent vegetative state: The patient is unresponsive and shows no signs of awareness, (iii) Severe disability: The patient is conscious but dependent on others for daily care due to significant physical or mental impairment, (iv) Moderate disability: The patient is independent in daily activities but may have some residual disabilities, such as cognitive or physical limitations, (v) Low disability/good recovery: The patient resumes normal life, though some minor deficits may remain. There was no statistically significant difference between the two groups in terms of their management strategies. GOS: Glasgow Outcome Scale

Table 4: Subgroup analysis

	Surgical management group (*n*=52), *n* (%)	Conservative management group (*n*=52), *n* (%)	*P*
Severity of TBI			
Moderate			
Expired	9 (17)	4 (8)	0.173
Discharged	16 (31)	18 (35)	
Severe			
Expired	8 (15)	11 (21)	0.922
Discharged	7 (13)	9 (17)	
Radiological profile			
EDH			
Expired	2 (4)	0	0.121
Discharged	1 (2)	7 (13)	
SDH			
Expired	8 (15)	13 (25)	0.284
Discharged	25 (48)	23 (44)	
Contusion			
Expired	12 (23)	7 (13)	0.109
Discharged	19 (37)	27 (52)	
Fractures			
Expired	9 (17)	4 (8)	0.127
Discharged	7 (13)	10 (19)	
Multiple findings			
Expired	12 (23)	8 (15)	0.195
Discharged	16 (31)	22 (42)	
Midline shift			
Expired	6 (12)	13 (25)	0.028
Discharged	11 (21)	5 (10)	

The subgroup analysis of the primary outcome. There was no statistically significant association between the severity of head injury and radiological findings, except for the presence of a midline shift. Among patients with a midline shift on CT scan, 25% of those managed conservatively died, compared to 12% of those managed surgically. The observed 13% difference in all-cause mortality was statistically significant. TBI: Traumatic brain injury, EDH: Extradural hematoma, SDH: Subdural hematoma, CT: Computed tomography

with traumatic subdural hematoma revealed that there was no significant difference in mortality and GOS at 6 months between patients who were managed conservatively and by operative intervention.[19] A study done by Haddad *et al*. concluded that elderly patients with traumatic brain injury who were managed with operative interventions had increased length of stay in hospitals and ICUs, had increased complications, and increased ventilator days but did not have increased mortality compared with patients who were managed conservatively.[20] A study by van Essen *et al*. where 1160 patients with acute traumatic subdural hematoma also showed no significant differences in functional outcome measured using GOS at 6 months after injury.[21]

In the present study, subgroup analysis revealed no significant difference in all-cause mortality between conservatively and surgically managed patients across subgroups with moderate and severe traumatic brain injury or among subgroups with specific radiological diagnoses such as EDH, SDH, and contusion. Similar observations were reported by Taussky *et al*., who reported increased morbidity and mortality associated with surgical management in patients with subdural hematoma.[15] In the present study, the authors observed that elderly patients with traumatic brain injury who underwent midline shift on CT had poor outcomes when treated conservatively. The study's observations were similar to other observations made by Chaurasia *et al*. and Chiewvit *et al*.[22,23]

Several studies, including those by Vollmer *et al*., Mosenthal *et al*., Joen *et al*., and Demelie *et al*., have identified age as an independent predictor of mortality in traumatic brain injuries.[24-27] In addition, Demelie *et al*. highlighted neurosurgical procedures as independent predictors of mortality.[27] Pastor *et al*. further emphasized the association between surgical procedures and prolonged hospitalization, potentially leading to hospital-related complications.[28] Thus, a combination of older age and surgical management can significantly impact mortality and morbidity, as shown in the present study.

Limitations

The present study is not without limitations. As a retrospective propensity score-matched case–control study, this study is subject to inherent limitations such as recall and selection bias.[29] Moreover, the decision to operate was at the discretion of the neurosurgery team, potentially introducing bias. Another limitation is related to the presence of concomitant injuries in our patient population. In addition, as a single-center study at a referral center, there is a possibility of missing mild and moderate traumatic brain injury cases, further limiting the generalizability of our findings. Furthermore, although comorbidities were included in the propensity score matching, the duration of the comorbidities and medication adherence were not accounted for, which might have also influenced all-cause mortality. In addition, the final sample size after propensity matching was very limited. This is one of the major limitations of the present study.

Conclusion

There was no difference in all-cause mortality among elderly patients with traumatic brain injury regardless of whether they received conservative or surgical management, except for patients who underwent midline shift surgery. Consequently, the authors conclude that conservative management can be safely considered for elderly patients with traumatic brain injury. Nevertheless, further prospective randomized controlled studies are necessary to validate these findings.

Author contributions statement

- GR, SM, AR – Conceptualization, Writing, Resources, and Editing and Reviewing
- RK, KPT– Resources, Writing, and Reviewing.

Conflicts of interest

None Declared.

Ethical approval

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