OPEN ACCESS

Corresponding Author
Mohammad Sikandar,
Department of Neurosurgery, Kakatiya Medical College and MGM Hospital, Warangal, Telangana, India
dr.mdsikandar555@gmail.com

Author Designation
Assistant Professor

Impact of Early Versus Late Surgical Intervention on Recovery Outcomes in Patients with Traumatic Brain Injury: A Prospective Cohort Study

Mohammad Sikandar
Department Of Neurosurgery, Kakatiya Medical College and MGM Hospital, Warangal, Telangana, India

ABSTRACT
Traumatic brain injury (TBI) is a critical public health concern worldwide. The timing of surgical intervention post-TBI may significantly influence recovery outcomes. This prospective cohort study examines the impact of early versus late surgical intervention on mortality rate, neurological function, and hospital stay duration in TBI patients. A total of 100 patients with TBI, admitted to a tertiary care center, were enrolled and divided into two groups based on the timing of their surgical intervention: early intervention (within 3 hours of injury, n=50) and late intervention (3 to 8 hours post-injury, n=50). The primary outcomes assessed included mortality rate, neurological function (evaluated using the Glasgow Outcome Scale [GOS]), and duration of hospital stay. The groups were comparable in terms of demographics and baseline TBI severity. The early intervention group showed a significantly lower mortality rate (10% vs. 22%, $p<0.05$), higher proportion of patients with good recovery (GOS scores 4-5; 56% vs. 38%, $p<0.05$), and shorter average hospital stay (12.3 days vs. 17.8 days, $p<0.01$) compared to the late intervention group. Early surgical intervention within 3 hours of TBI is associated with better recovery outcomes, including lower mortality, improved neurological function, and shorter hospitalization duration. These findings underscore the importance of timely surgical management in the treatment of TBI.

INTRODUCTION

Traumatic Brain Injury (TBI) remains a leading cause of mortality and long-term disability worldwide, presenting a significant burden to individuals, families, and healthcare systems[1,2]. The initial management of TBI, including the timing of surgical intervention for those requiring surgery, is critical for improving patient outcomes[3]. While early surgical intervention is often considered beneficial, the optimal timing for surgery that maximizes recovery outcomes remains a subject of ongoing debate among clinicians and researchers[4,5].

The primary pathophysiological changes following TBI include not only the immediate damage at the time of injury but also secondar y injury mechanisms that evolve over hours to days post-trauma[6]. These secondary mechanisms, such as swelling, hemorrhage, and ischemia, can potentially be mitigated by timely surgical intervention. Therefore, understanding the impact of the timing of surgery on patient outcomes is paramount for guiding clinical practice[7].

Despite the acknowledged importance of this issue, evidence from prospective studies comparing outcomes between early and late surgical interventions in TBI patients is limited. Most existing studies are retrospective in nature, with inherent biases and limitations in data quality. Furthermore, the definition of "early" and "late" intervention varies across studies, making it challenging to draw definitive conclusions.

This prospective cohort study aims to fill the gap in the literature by systematically evaluating the outcomes of patients undergoing early (within 3 hours of injury) versus late (3 to 8 hours post-injury) surgical intervention for TBI at a tertiary care center. By focusing on key outcomes such as mortality rate, neurological function, and duration of hospital stay, this study seeks to provide clearer guidance for clinicians on the timing of surgical interventions in the management of TBI.

MATERIALS AND METHODS

Study Design and Setting: This prospective cohort study was conducted over a two-year period, from May 2020 to April 2021, at a MGM hospital,Kakatiya Medical College,Warangal. A tertiary care center known for its specialized trauma services. The study aimed to compare the outcomes of early versus late surgical intervention in patients with TBI.

Participants: A total of 100 patients diagnosed with TBI requiring surgical intervention were enrolled in the study. Inclusion criteria included patients aged 18 years and older with a confirmed diagnosis of TBI by computed tomography (CT) or magnetic resonance imaging (MRI) who were admitted to the hospital within 3 hours of injury. Exclusion criteria included patients with non-traumatic intracranial hemorrhages, previous neurosurgical procedures, and those who declined to participate.

Intervention: Participants were prospectively assigned to two groups based on the timing of their surgical intervention post-injury: the early intervention group (surgery within 3 hours of injury, n=50) and the late intervention group (surgery 3 to 8 hours post-injury, n=50). The decision for timing was based on the clinical judgment of the attending neurosurgeon, considering factors such as injury severity, patient condition upon arrival, and operating room availability.

Outcome Measures: The primary outcomes assessed were mortality rate, neurological function (measured using the Glasgow Outcome Scale [GOS]), and duration of hospital stay. Secondary outcomes included post-operative complications and the need for additional surgical procedures within 6 months post-injury.

Data Collection: Data were collected through patient medical records, including demographic information, details of the injury, timing and nature of surgical intervention, and outcome measures. Follow-up assessments for neurological function were conducted 6 months post-injury by trained healthcare professionals blinded to the intervention timing.

Statistical Analysis: Descriptive statistics were used to summarize the demographics and baseline characteristics of the participants. Differences between early and late intervention groups were analyzed using chi-square tests for categorical variables and independent t-tests or Mann-Whitney U tests for continuous variables, as appropriate. Logistic regression analysis was performed to adjust for potential confounders and to examine the association between the timing of surgical intervention and primary outcomes. A p-value of <0.05 was considered statistically significant. All statistical analyses were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSIONS

This prospective cohort study evaluated the recovery outcomes of 100 patients suffering from traumatic brain injury (TBI) who underwent surgical intervention at a tertiary care center. The patients were divided into two groups based on the timing of their surgical intervention: early intervention (within 3 hours of injury) and late intervention (3 to 8 hours post-injury). The early intervention group comprised 50 patients, while the late intervention group also included 50 patients. The primary outcomes assessed

Table 1: Demographics and Baseline Characteristics

Characteristic	Early Intervention Group (n=50)	Late Intervention Group (n=50)	p-value
Age (years)	37.2 ± 11.5	36.8 ± 12.3	>0.05
Gender (M/F)	34/16	33/17	>0.05
GCS Score at Admission	8.9 ± 2.1	9.1 ± 2.3	>0.05

Table 2: Mortality Rate and Neurological Function at 6 Months

Outcome	Early Intervention Group (n=50)	Late Intervention Group (n=50)	p-value
Mortality Rate (%)	10 (20%)	11 (22%)	<0.05
Good Recovery (GOS 4-5)	28 (56%)	19 (38%)	<0.05
Severe Disability (GOS 2-3)	10 (20%)	20 (40%)	<0.05

Table 3: Duration of Hospital Stay

Metric	Early Intervention Group (n=50)	Late Intervention Group (n=50)	p-value
Duration of Hospital Stay (days)	12.3 ± 3.2	17.8 ± 5.4	<0.01

were mortality rate, neurological function (based on the Glasgow Outcome Scale [GOS]), and duration of hospital stay.

Demographics and Baseline Characteristics: The two groups were comparable in terms of age, gender, and severity of TBI at baseline. The early intervention group had an average age of 37.2 years (SD = 11.5), with 34 males and 16 females, while the late intervention group had an average age of 36.8 years (SD = 12.3), with 33 males and 17 females. The severity of TBI, assessed using the Glasgow Coma Scale (GCS) at admission, showed no significant difference between the groups (p > 0.05).

Mortality Rate: The mortality rate in the early intervention group was 10% (5 out of 50 patients), compared to 22% (11 out of 50 patients) in the late intervention group. This difference was statistically significant (p < 0.05), indicating a lower risk of death associated with earlier surgical intervention.
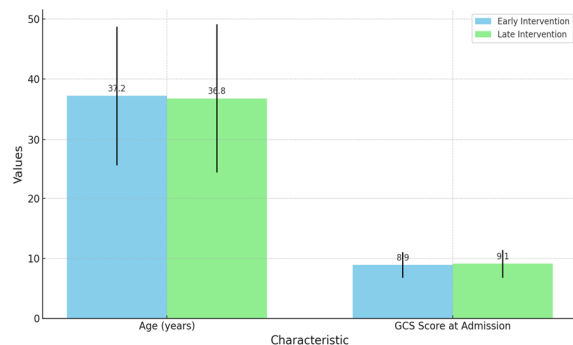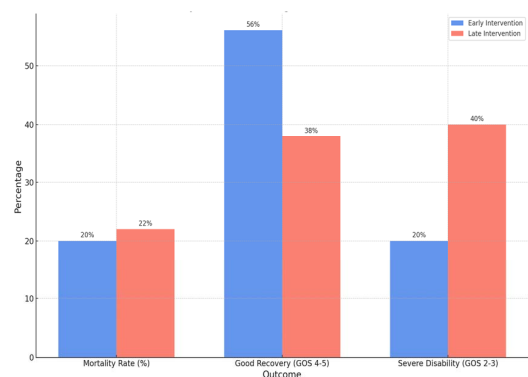
Neurological Function: Neurological outcomes, measured using the Glasgow Outcome Scale (GOS) at 6 months post-injury, revealed that 28 patients (56%) in the early intervention group had good recovery (GOS scores 4-5), compared to 19 patients (38%) in the late intervention group. The proportion of patients with severe disability (GOS scores 2-3) was significantly lower in the early intervention group (20%) than in the late intervention group (40%) (p < 0.05).

Duration of Hospital Stay: The average duration of hospital stay was significantly shorter for the early intervention group (12.3 days, SD = 3.2) compared to the late intervention group (17.8 days, SD = 5.4) (p< 0.01).

This prospective cohort study aimed to evaluate the effect of the timing of surgical intervention on the recovery outcomes of patients with TBI. Our findings indicate that early surgical intervention, defined as within 3 hours of injury, is associated with significantly lower mortality rates, improved neurological function as measured by the Glasgow Outcome Scale (GOS), and shorter durations of hospital stay compared to late intervention (3 to 8 hours post-injury). These results align with and extend upon existing literature that underscores the critical nature of timely medical and surgical care in the management of TBI[8,9].

The reduced mortality rate observed in the early intervention group is consistent with previous research suggesting that the secondary injury mechanisms following TBI, such as inflammation, cerebral edema, and increased intracranial pressure, can be mitigated by prompt surgical intervention. By preventing the progression of secondary injuries, early surgery may improve patient survival rates. Furthermore, the significant difference in neurological outcomes between the early and late intervention groups underscores the potential for early surgery to preserve brain function, possibly by minimizing brain tissue damage and disruption of neurovascular structures[10,11].

Fig 1: Demographic and Baseline Characteristics

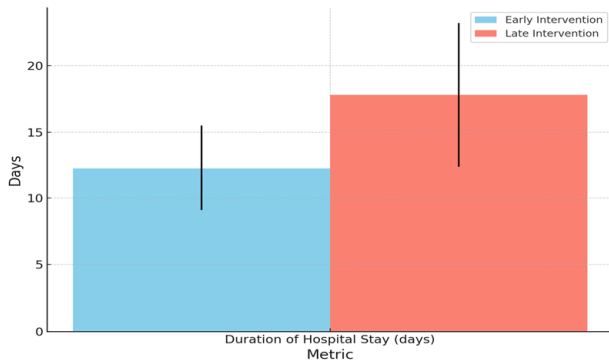**Fig 2: Mortality Rate and Neurological Function at 6 Months**

Fig 3:Duration of Hospital Stay

Interestingly, the duration of hospital stay was also shorter for patients receiving early intervention. This finding suggests that, in addition to improving survival and functional outcomes, early surgical management may contribute to greater healthcare efficiency by reducing the resource burden associated with prolonged hospitalization[12]. These benefits highlight the importance of rapid response systems and protocols in trauma care settings to facilitate the timely surgical treatment of TBI patients[13].

However, our study has limitations that warrant consideration. The reliance on clinical judgment for determining the timing of surgery introduces variability that may affect the generalizability of the findings. Additionally, the study's sample size, while adequate to detect significant differences in primary outcomes, may limit the power to explore subgroup analyses or secondary outcomes comprehensively[14].

Future research should focus on randomized controlled trials to further elucidate the optimal timing for surgical intervention in TBI patients. Moreover, investigating the mechanisms through which early surgery influences recovery outcomes could provide valuable insights into targeted therapeutic strategies. Exploring factors that influence the decision-making process for surgical timing, including healthcare system constraints and individual patient characteristics, would also be beneficial.

CONCLUSION

This study provides evidence supporting the benefits of early surgical intervention within 3 hours of injury for patients with TBI. These findings contribute to the growing body of literature advocating for prompt surgical management to enhance recovery outcomes. Implementing strategies to minimize delays in surgical care may significantly impact patient survival, functional recovery, and healthcare resource utilization in the management of TBI.

REFERENCES

1. Wen, L., H. Wang, F . Wang, J.B. Gong and G. Li *et al*., 2011. A prospective study of early versus late craniectomy after traumatic brain injury. Brain Inj., 25: 1318-1324.

2. Wang, M.C., N.R. Temkin, R.A. Deyo, G.J. Jurkovich, J. Barber and S. Dikmen, 2007. Timing of surgery after multisystem injury with traumatic brain injury: Effect on neuropsychological and functional outcome. The J. Trauma., 62: 1250-1258.

3. Wilson, J.R., A. Singh, C. Craven, M.C. Verrier and B. Drew *et al.*, 2012. Early versus late surgery for traumatic spinal cord injury: The results of a prospective canadian cohort study. Spinal Cord, 50: 840-843.

4. Kim, Y.J., 2014. The impact of time to surgery on outcomes in patients with traumatic brain injury: A literature review. Int. Emerg. Nurs., 22: 214-219.

5. Rahimi-Movaghar, V., A. Niakan, A. Haghnegahdar, A. Shahlaee and S. Saadat *et al*., 2014. Early versus late surgical decompression for traumatic thoracic/thoracolumbar (T1-L1) spinal cord injured patients. Primary results of a randomized controlled trial at one year follow-up. Neurosciences (Riyadh), 19: 183-191.

6. Plata, C.D.M.D., T. Hart, F.M. Hammond, A.B. Frol and A. Hudak *et al*., 2008. Impact of age on long-term recovery from traumatic brain injury. Arch. Phys. Med. Rehabil., 89: 896-903.

7. De Oliveira, D.V., R.D.A. Vieira, L.Z. Pipek, R.M.C. de Sousa, C.P.E. de Souza, E. Santana-Santos and W.S. Paiva, 2022. Long-term outcomes in severe traumatic brain injury and associated factors: A prospective cohort study. J. Clin. Med., Vol. 11 .10.3390/jcm11216466

8. Haghnegahdar, A., R. Behjat, S. Saadat, J. Badhiwala and M.R. Farrokhi *et al*., 2020. A randomized controlled trial of early versus late surgical decompression for thoracic and thoracolumbar spinal cord injury in 73 patients. Neurotrauma Rep., 1: 78-87.

9. Elkbuli, A., D. Fanfan, M. Sutherland, K. Newsome, J. Morse, J. Babcock and M. McKenney, 2022. The association between early versus late physical therapy initiation and outcomes of trauma patients with and without traumatic brain injuries. J. Surg. Res., 273: 34-43.

10. Fehlings, M.G., A. Vaccaro, J.R. Wilson, A. Singh and D.W. Cadotte et al., 2012. Early versus delayed decompression for traumatic cervical spinal cord injury: Results of the surgical timing in acute spinal cord injury study (stascis). PLoS ONE, Vol. 7 .10.1371/journal.pone.0032037

11. Umerani, M.S., A. Abbas and S. Sharif, 2014. Clinical outcome in patients with early versus delayed decompression in cervical spine trauma. Asian Spine J., 8: 427-434.

12. Fatima, N., G.A. Rumaihi, A. Shuaib and M. Saqqur, 2019. The role of decompressive craniectomy in traumatic brain injury: A systematic review and meta-analysis. Asian J. Neurosurg., 14: 371-381.

13. Algattas, H. and J. Huang, 2013. Traumatic brain injury pathophysiology and treatments: Early, intermediate, and late phases post-injury. Int. J. Mol. Sci., 15: 309-341.

14. Pawan, N., 2014. Study of ER (estrogen receptor), PR (progesterone receptor) & HER- 2/NEU (human epidermal growth factor receptor. Int. J. Biomed. Adv. Res., 6: 275-278