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COMPUTED TOMOGRAPHY FEATURES IN PREDICTING THE ADVERSE PROGNOSIS AFTER MILD TRAUMATIC BRAIN INJURY BASED ON THE CLINICAL EVALUATION

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ABSTRACT

Background: Mild traumatic brain injury (mTBI) is a common clinical problem with significant variability in patient outcomes. Early prediction of adverse prognosis in mTBI patients can guide management and improve outcomes. This study aimed to identify computed tomography (CT) features that predict adverse prognosis in patients with mTBI based on clinical evaluation.

Material and Methods: This prospective cohort study was conducted over one year (April 2023 to March 2024) in the Department of Radiodiagnosis at Trichy SRM Medical College Hospital and Research Centre, Irungalur, Tiruchirapalli. A total of 150 consecutive head injury patients with abnormal CT findings and a Glasgow Coma Scale (GCS) score greater than 12 were included. Data were collected on demographics, mode of injury, clinical examination, CT findings, management, and follow-up outcomes using the Glasgow Outcome Scale Extended (GOS-E) score. Statistical analysis was performed using SPSS version 26.0.

Results: Among the 150 patients, 73 (48.7%) experienced adverse outcomes (disability), and 77 (51.3%) had good recovery. Adverse outcomes were significantly associated with clinical symptoms such as vomiting (41.1% vs. 23.4%, p=0.019), loss of consciousness (6.2 ± 2.3 minutes vs. 4.1 ± 2.8 minutes, p<0.001), cerebellar signs (19.2% vs. 6.5%, p=0.015), focal neurological deficits (41.1% vs. 14.3%, p<0.001), and ENT bleed (20.5% vs. 9.1%, p=0.048). CT findings such as contusion (OR 4.58, 95% CI: 2.28 - 9.17, p<0.001), subarachnoid hemorrhage (SAH) (OR 2.45, 95% CI: 1.24 - 4.81, p=0.03), subdural hematoma (SDH) (OR 3.22, 95% CI: 1.55 - 6.68, p=0.02), midline shift (OR 9.31, 95% CI: 2.63 - 32.93, p<0.001), and basal cisterns effacement (OR 3.72, 95% CI: 1.27 - 10.85, p=0.01) were significant predictors of adverse outcomes.

Conclusion: CT imaging features, particularly contusion, SAH, SDH, midline shift, and basal cisterns effacement, are significant predictors of adverse prognosis in mTBI patients. Early identification of these high-risk patients can facilitate timely interventions and improve clinical management. Further multi-center studies are recommended to validate these findings and explore advanced imaging modalities for better risk stratification.

Keywords: Mild traumatic brain injury, Computed tomography, Adverse prognosis, Glasgow Outcome Scale Extended, Predictive features, Clinical evaluation.

INTRODUCTION

Mild traumatic brain injury (mTBI), commonly referred to as concussion, is a prevalent public health issue that poses significant challenges due to its high incidence and potential for chronic neurological impairments.[1] The Centers for Disease Control and Prevention (CDC) estimate that approximately 2.8 million people in the United States sustain a TBI each year, with mTBI accounting for the majority of these injuries.[2] While mTBI is typically characterized by a brief alteration in consciousness and often considered benign, a subset of patients experiences persistent symptoms and cognitive deficits, leading to substantial personal, social, and economic burdens.[1]

The early and accurate prediction of adverse outcomes following mTBI is critical for effective patient management. Adverse prognoses can include prolonged post-concussion syndrome, cognitive impairment, emotional disturbances, and even functional disability.[3] These outcomes necessitate early intervention strategies and long-term rehabilitation efforts. Therefore, identifying reliable prognostic indicators is of paramount importance.[3]

Computed Tomography (CT) is a cornerstone in the acute evaluation of mTBI due to its widespread availability, rapid imaging capabilities, and high sensitivity for detecting acute intracranial pathologies.[4] CT imaging provides detailed information on structural brain abnormalities such as hemorrhages, contusions, skull fractures, and brain edema.[4] The role of CT in mTBI extends beyond initial diagnosis to potential prognostic applications, where specific imaging features might correlate with adverse clinical outcomes.[5]

Previous research has identified various CT features that may be indicative of poor prognosis in mTBI patients.[6,7,8] These features include but are not limited to the presence of intracranial hemorrhage (ICH), subarachnoid hemorrhage (SAH), midline shift, contusions, and diffuse axonal injury (DAI).[8] Despite these associations, the predictive value of CT imaging alone is not definitive.[7] Studies have shown that while certain CT findings are associated with worse outcomes, many patients with normal CT scans still experience significant post-concussive symptoms.[6,7]

In addition to CT imaging, comprehensive clinical evaluation is essential in the management of mTBI.[9] Clinical assessment involves a detailed neurological examination, cognitive testing, and evaluation of patient-reported symptoms such as headache, dizziness, and memory problems.[10] The Glasgow Coma Scale (GCS) is commonly used to assess the severity of TBI at presentation, but its prognostic utility in mTBI is limited. Integrating clinical data with CT findings can enhance the predictive accuracy for adverse outcomes.[10]

So, the present study was conducted with an aim to assess the imaging characteristics of primary brain injury on the initial CT scan, and predict the clinical outcome based on the individual CT feature or combination of the various CT features.

MATERIALS AND METHODS

Study Design

This study was designed as a prospective cohort study conducted over a period of one year, from April 2023 to March 2024. The study was carried out in the Department of Radiodiagnosis at Trichy SRM Medical College Hospital and Research Centre, Irungalur, Tiruchirapalli, after obtaining the ethical approval from institutional review committee.

Sample Size

The sample size for this study was determined based on a previous study by Yuh et al., which evaluated the Glasgow Outcome Scale Extended (GOS-E) score in relation to initial CT findings, reporting an odds ratio of 2.6.[11] Assuming a similar effect size, a sample size of 150 patients was calculated to provide 80% power at a 5% level of significance.

Study Population

In this study, patients referred for a non-contrast CT study of the brain as part of the initial evaluation for mild traumatic brain injury, specifically those with CT findings indicative of acute injury, were included. The exclusion criteria comprised patients younger than 18 years old, those with open fractures of the skull, polytrauma cases, a Glasgow Coma Scale (GCS) score of less than 13, a history of previous head trauma, and referrals from other institutions. Patients presenting to the Department of Radiodiagnosis for this purpose were recruited consecutively. Follow-up evaluation was done in the department of Neurosurgery. The study population consisted of 150 consecutive head injury patients with abnormal CT scan findings and a GCS score greater than 12.

Data Collection

Data were meticulously collected on various parameters for each patient. Demographic information included age and sex. The mode of injury was categorized into road traffic accidents (pedestrian, two-wheeler, and four-wheeler), self-fall, and assault. Clinical examination details covered several aspects: patient complaints such as headache, vomiting, and loss of consciousness (measured in minutes); the admission Glasgow Coma Scale (GCS) score, which ranged from 13 to 15; the presence or absence of cerebellar signs; the occurrence of seizures post-trauma; focal neurological deficits; bleeding from the ears, nose, or throat (ENT bleeding); and external injuries to the skull or face, including abrasions, cut injuries, and hematomas.

CT findings were documented extensively, noting the presence and location of contusions,

subarachnoid hemorrhages, subdural hematomas, intraventricular hemorrhages, petechial hemorrhages, and epidural hematomas. Additional CT findings included the presence and extent of any midline shift, and the condition of the basal cisterns, specifically whether they were effaced or compressed.

Management strategies were recorded, distinguishing between medical and surgical interventions, along with the specific indications for surgical management. Follow-up evaluations used the Glasgow Outcome Scale Extended (GOS-E) score at intervals of 1 week, 1 month, 3 months, and 6 months post-injury.[12]

Other outcomes tracked included the duration of the hospital stay and mortality data, specifying the date and number of days post-injury at which death occurred. This comprehensive data collection aimed to provide a detailed understanding of the patient profiles, injury characteristics, management approaches, and outcomes in the study cohort.

Statistical Analysis

Data analyses were performed using the SPSS statistical package (IBM version 26.0). The normality of continuous variables was assessed using appropriate statistical tests. Descriptive measures such as mean, standard deviation (SD), and range values were calculated for normally distributed data. Comparisons of mean values were conducted using students T-tests. Skewed data were presented as frequencies and percentages. Categorical data were analyzed using Chi-square tests. The association between CT findings and GOS-E scores was computed as odds ratios (ORs) with 90% confidence intervals (CIs). For all statistical tests, a two-sided probability of $p < 0.05$ was considered significant.

RESULTS

The study included 150 patients with a mean age of 35.8 ± 15.2 years. Out of 150 patients, 77 patients (51.3%) had GOS-E Score of 7-8 i.e. good recovery (were able to resume normal activities with or without minor symptoms) at the end of 6 months follow-up while 73 patients (48.7%) had GOS-E Score of 1-6 at the end of 6 months follow-up i.e. Disability including mortality. Among disability group, moderate disability was observed in 70 patients (46.7%), and severe disability including mortality was observed in 3 patients (2.0%). Those with disability were slightly older (38.2 ± 14.9 years) compared to those with good recovery (33.6 ± 15.3 years), but this difference was not significant (p=0.12). In terms of sex, 65.3% were male and 34.7% were female, with no significant difference in sex distribution between the disability (61.6% male) and good recovery groups (68.8% male) (p=0.34). The most common mode of injury was two-wheeler road traffic accidents (RTAs) (50.7%), followed by self-falls (22.7%), pedestrian RTAs (12.0%), assaults (8.7%), and four-wheeler RTAs (6.0%), with no significant differences between the two groups (p>0.05 for all comparisons). Admission Glasgow Coma Scale (GCS) scores were 21.3% (GCS of 13), 31.3% (GCS of 14), and 47.3% (GCS of 15), with no significant differences between the groups (p>0.05). Headache was reported by 58.7% of patients, with no significant difference between the disability (57.5%) and good recovery groups (59.7%) (p=0.76). Vomiting was more common in the disability group (41.1%) compared to the good recovery group (23.4%) (p=0.019). The disability group had a longer mean duration of loss of consciousness (6.2 ± 2.3 minutes) compared to the good recovery group (4.1 ± 2.8 minutes) (p<0.001). Cerebellar signs were more frequent in the disability group (19.2%) than in the good recovery group (6.5%) (p=0.015). A history of post-trauma seizures was more common in the disability group (11.0%) than in the good recovery group (3.9%), but this was not statistically significant (p=0.08). Focal neurological deficits were significantly more common in the disability group (41.1%) than in the good recovery group (14.3%) (p<0.001). ENT bleeding was more frequent in the disability group (20.5%) compared to the good recovery group (9.1%) (p=0.048). External injuries to the skull or face were observed in 22.0% of patients, with no significant difference between the groups (p=0.45). [Table 1]

The study evaluated various CT findings and their association with outcomes. Contusions were present in 43.3% of the patients, significantly more frequent in the disability group (61.6%) compared to the good recovery group (26.0%) (p<0.001). Subarachnoid hemorrhage (SAH) was observed in 37.3% of patients, with a higher prevalence in the disability group (47.9%) compared to the good recovery group (27.3%) (p=0.009). Subdural hematoma (SDH) was present in 31.3% of patients, more common in the disability group (43.8%) than in the good recovery group (19.5%) (p=0.001). Intraventricular hemorrhage was noted in 11.3% of patients, with no significant difference between the disability (15.1%) and good recovery groups (7.8%) (p=0.14). Petechial hemorrhage occurred in 8.7% of patients, with similar frequencies in the disability (11.0%) and good recovery groups (6.5%) (p=0.35). Epidural hematoma (EDH) was seen in 14.0% of patients, with no significant difference between the disability (16.4%) and good recovery groups (11.7%) (p=0.37). Midline shift was present in 15.3% of patients, significantly more common in the disability group (27.4%) compared to the good recovery group (3.9%) (p<0.001). Basal cisterns effacement was observed in 13.3% of patients, more frequent in the disability group (20.5%) than in the good recovery group (6.5%) (p=0.015). [Table 2]

The study evaluated the location of CT findings and their association with outcomes. Frontal contusions were significantly more frequent in the disability group (24.7%) compared to the good recovery group

(9.1%) (p=0.006), as were temporal contusions (20.5% vs. 6.5%, p=0.015). Parietal contusions were more common in the disability group (13.7% vs. 6.5%, p=0.13), though not significantly. Occipital contusions showed no significant difference (2.7% vs. 3.9%, p=0.67). Frontal SAH was slightly higher in the disability group (16.4% vs. 10.4%, p=0.28), with temporal SAH more common (13.7% vs. 6.5%, p=0.13), though not significant. Parietal and occipital SAH had similar distributions between groups. Frontal SDH was significantly higher in the disability group (15.1% vs. 5.2%, p=0.04), while temporal, parietal, and occipital SDH showed no significant differences. EDH was rare, with no significant differences in any location. [Table 3]

The study assessed management strategies and follow-up outcomes. Medical management was more common overall (78.7%), with a higher prevalence in the good recovery group (85.7%) compared to the disability group (71.2%) (p=0.03). Surgical management was required in 21.3% of cases, significantly more frequent in the disability group (28.8%) than in the good recovery group (14.3%) (p=0.02). The duration of hospital stay was significantly longer in the disability group (16.5 ± 8.0 days) compared to the good recovery group (9.1 ± 4.0 days) (p<0.001). Mortality was observed in 0.7% of the total population, occurring exclusively in the disability group (1.3%) (p<0.001). Glasgow Outcome Scale Extended (GOS-E) scores at 1 week, 1 month, 3 months, and 6 months were consistently lower in the disability group compared to the good recovery group, with all differences being statistically significant (p<0.001 for all time points). At 1 week, the mean GOS-E score was 4.5 ± 1.2, with the disability group scoring 3.2 ± 1.1 and the good recovery group scoring 5.7 ± 0.8. At 1 month, the mean score was 5.1 ± 1.5, with the disability group at 3.8 ± 1.4 and the good recovery group at 6.3 ± 0.9. At 3 months, the mean score was 5.6 ± 1.6, with the disability group at 4.1 ± 1.5 and the good recovery group at 6.8 ± 0.8. At 6 months, the mean score was 6.0 ± 1.8, with the disability group at 4.5 ± 1.7 and the good recovery group at 7.2 ± 0.9. [Table 4]

The study analyzed the association between CT findings and adverse outcomes. Contusions were associated with a significantly higher risk of adverse outcomes, with an odds ratio (OR) of 4.58 (95% CI: 2.28 - 9.17, p<0.001). Subarachnoid hemorrhage (SAH) also indicated a higher risk (OR: 2.45, 95% CI: 1.24 - 4.81, p=0.03). Subdural hematoma (SDH) had a significant association with adverse outcomes (OR: 3.22, 95% CI: 1.55 - 6.68, p=0.02). Intraventricular hemorrhage showed an increased risk, but it was not statistically significant (OR: 2.09, 95% CI: 0.73 - 6.01, p=0.16). Petechial hemorrhage had a non-significant association with adverse outcomes (OR: 1.77, 95% CI: 0.55 - 5.69, p=0.33). Epidural hematoma (EDH) did not show a significant risk increase (OR: 1.48, 95% CI: 0.58 - 3.77, p=0.41). Midline shift was strongly associated with adverse outcomes (OR: 9.31, 95% CI: 2.63 - 32.93, p<0.001), and basal cisterns effacement also showed a significant association (OR: 3.72, 95% CI: 1.27 - 10.85, p=0.01). [Table 5]

Table 1: Demographic and Clinical Characteristics of the Study Population

Characteristic	Total (n=150)	Disability (n=73)	Good Recovery (n=77)	p-value
	Frequency (%)/ mean ± SD			
Age (years)	35.8 ± 15.2	38.2 ± 14.9	33.6 ± 15.3	0.12
Sex				
Male	98 (65.3)	45 (61.6)	53 (68.8)	0.34
Female	52 (34.7)	28 (38.4)	24 (31.2)	0.34
Mode of Injury				
RTA Pedestrian	18 (12.0)	9 (12.3)	9 (11.7)	0.9
RTA Two-wheeler	76 (50.7)	39 (53.4)	37 (48.1)	0.54
RTA Four-wheeler	9 (6.0)	5 (6.8)	4 (5.2)	0.67
Self-fall	34 (22.7)	14 (19.2)	20 (26.0)	0.31
Assault	13 (8.7)	6 (8.2)	7 (9.1)	0.83
Admission GCS Score				
13	32 (21.3)	18 (24.7)	14 (18.2)	0.33
14	47 (31.3)	23 (31.5)	24 (31.2)	0.97
15	71 (47.3)	32 (43.8)	39 (50.6)	0.41
Clinical Symptoms				
Headache	88 (58.7)	42 (57.5)	46 (59.7)	0.76
Vomiting	48 (32.0)	30 (41.1)	18 (23.4)	0.019
Loss of Consciousness (minutes)	5.1 ± 2.7	6.2 ± 2.3	4.1 ± 2.8	<0.001
Cerebellar Signs (Present)	19 (12.7)	14 (19.2)	5 (6.5)	0.015
History of Seizures (Post-trauma)	11 (7.3)	8 (11.0)	3 (3.9)	0.08
Focal Neurological Deficit	41 (27.3)	30 (41.1)	11 (14.3)	<0.001
ENT Bleed	22 (14.7)	15 (20.5)	7 (9.1)	0.048
External Skull/Face Injury	33 (22.0)	18 (24.7)	15 (19.5)	0.45

Table 2: CT Findings in the Study Population

CT Finding	Total (n=150)	Disability (n=73)	Good Recovery (n=77)	p-value
	Frequency (%)			
Contusion	65 (43.3)	45 (61.6)	20 (26.0)	<0.001
Subarachnoid Hemorrhage (SAH)	56 (37.3)	35 (47.9)	21 (27.3)	0.009

Subdural Hematoma (SDH)	47 (31.3)	32 (43.8)	15 (19.5)	0.001
Intraventricular Hemorrhage	17 (11.3)	11 (15.1)	6 (7.8)	0.14
Petechial Hemorrhage	13 (8.7)	8 (11.0)	5 (6.5)	0.35
Epidural Hematoma (EDH)	21 (14.0)	12 (16.4)	9 (11.7)	0.37
Midline Shift	23 (15.3)	20 (27.4)	3 (3.9)	<0.001
Basal Cisterns Effacement	20 (13.3)	15 (20.5)	5 (6.5)	0.015

Table 3: Location of Hematoma and Hemorrhage in the Study Population

Location	Total (n=150)	Disability (n=73)	Good Recovery (n=77)	p-value
	Frequency (%)			
Contusion				
Frontal	25 (16.7)	18 (24.7)	7 (9.1)	0.006
Temporal	20 (13.3)	15 (20.5)	5 (6.5)	0.015
Parietal	15 (10.0)	10 (13.7)	5 (6.5)	0.13
Occipital	5 (3.3)	2 (2.7)	3 (3.9)	0.67
Subarachnoid Hemorrhage (SAH)				
Frontal	20 (13.3)	12 (16.4)	8 (10.4)	0.28
Temporal	15 (10.0)	10 (13.7)	5 (6.5)	0.13
Parietal	12 (8.0)	7 (9.6)	5 (6.5)	0.47
Occipital	9 (6.0)	6 (8.2)	3 (3.9)	0.32
Subdural Hematoma (SDH)				
Frontal	15 (10.0)	11 (15.1)	4 (5.2)	0.04
Temporal	12 (8.0)	8 (11.0)	4 (5.2)	0.24
Parietal	10 (6.7)	6 (8.2)	4 (5.2)	0.53
Occipital	10 (6.7)	7 (9.6)	3 (3.9)	0.18
Epidural Hematoma (EDH)				
Frontal	7 (4.7)	5 (6.8)	2 (2.6)	0.28
Temporal	6 (4.0)	4 (5.5)	2 (2.6)	0.42
Parietal	5 (3.3)	3 (4.1)	2 (2.6)	0.67
Occipital	3 (2.0)	1 (1.4)	2 (2.6)	0.57

Table 4: Management and Follow-Up Outcomes in the Study Population

Variable	Total (n=150)	Disability (n=73)	Good Recovery (n=77)	p-value
	Frequency (%)/ mean ± SD			
Medical Management	118 (78.7)	52 (71.2)	66 (85.7)	0.03
Surgical Management	32 (21.3)	21 (28.8)	11 (14.3)	0.02
Duration of Hospital Stay (days)	12.7 ± 7.2	16.5 ± 8.0	9.1 ± 4.0	<0.001
Mortality	1 (0.7)	1 (1.3)	0 (0)	<0.001
GOS-E Score				
At 1 week	4.5 ± 1.2	3.2 ± 1.1	5.7 ± 0.8	<0.001
At 1 month	5.1 ± 1.5	3.8 ± 1.4	6.3 ± 0.9	<0.001
At 3 months	5.6 ± 1.6	4.1 ± 1.5	6.8 ± 0.8	<0.001
At 6 months	6.0 ± 1.8	4.5 ± 1.7	7.2 ± 0.9	<0.001

Table 5: Association between CT Findings and Disability in the Study Population

CT Finding	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Contusion	4.58	2.28 - 9.17	<0.001
Subarachnoid Hemorrhage	2.45	1.24 - 4.81	0.03
Subdural Hematoma	3.22	1.55 - 6.68	0.02
Intraventricular Hemorrhage	2.09	0.73 - 6.01	0.16
Petechial Hemorrhage	1.77	0.55 - 5.69	0.33
Epidural Hematoma	1.48	0.58-3.77	0.41
Midline Shift	9.31	2.63 - 32.93	<0.001
Basal Cisterns (Effacement)	3.72	1.27 - 10.85	0.01

DISCUSSION

Our study evaluated a cohort of 150 mTBI patients, of which 73 experienced adverse outcomes (disability) and 77 had good recovery, and similar outcomes were observed in the studies by Theadom et al., Levin et al., and Sakkas et al.[13,14,15] Age and sex distribution were comparable between the groups, with a mean age of 35.8 ± 15.2 years and a male predominance (65.3%), and a similar trend was observed in the studies by Levin et al., and Sakkas et al.[14,15] The disability group had a longer average duration of loss of consciousness (6.2 ± 2.3 minutes vs. 4.1 ± 2.8 minutes, p<0.001) and a higher incidence of vomiting (41.1% vs. 23.4%, p=0.019), cerebellar signs (19.2% vs. 6.5%, p=0.015), focal neurological deficits (41.1% vs. 14.3%, p<0.001), and ENT bleed (20.5% vs. 9.1%, p=0.048). The disability group had a significantly longer hospital stay (16.5 ± 8.0 days vs. 9.1 ± 4.0 days, p<0.001). The clinical findings and duration of hospital stay of present study were coherent with the studies by Weber et al., and Howe et al.[16,17]

Contusions were found to be significantly associated with disability, with an odds ratio (OR) of 4.58 (95% CI: 2.28 - 9.17, p<0.001). This finding aligns with previous studies which have shown that

cerebral contusions are a critical indicator of brain injury severity. For instance, Isokuortti et al., reported that contusions, particularly when multiple or large, significantly correlate with poor functional outcomes and increased mortality.[18] The high odds ratio in our study suggests that patients with contusions are more than four times as likely to experience disability or death, highlighting the need for intensive monitoring and potentially more aggressive interventions in these patients.[19]

SAH was also significantly associated with disability (OR: 2.45, 95% CI: 1.24 - 4.81, p=0.03). The presence of SAH can indicate severe trauma and increased intracranial pressure, contributing to poorer outcomes. Similar associations have been reported in other studies by Yuh et al., and Riemann et al.[20,21] A study by Yuh et al., demonstrated that SAH is an independent predictor of poor neurological outcomes in TBI patients.[20] The increased risk associated with SAH in our study reinforces the necessity for prompt diagnosis and management to mitigate the risk of adverse outcomes.[21]

SDH showed a strong association with disability (OR: 3.22, 95% CI: 1.55 - 6.68, p=0.02). This finding is consistent with literature suggesting that SDH is a critical determinant of prognosis in TBI.[22,23,24] According to a study by Magnussone et al., SDH is linked with higher morbidity and mortality rates, particularly in older adults.[22] The pathophysiology of SDH, which involves significant brain tissue damage and potential for rebleeding, may explain its strong association with poor outcomes in our study population.[23,24]

The presence of a midline shift was the most significant predictor of disability (OR: 9.31, 95% CI: 2.63 - 32.93, p<0.001). Midline shift indicates severe intracranial pressure and mass effect, often necessitating surgical intervention. Our findings are supported by previous research, such as that by Shetty et al., which showed that a midline shift greater than 5 mm is associated with a significantly higher risk of poor neurological outcomes.[25] The pronounced odds ratio in our study emphasizes the critical nature of this finding and the urgent need for surgical evaluation.

Effacement of the basal cisterns was another significant predictor of disability (OR: 3.72, 95% CI: 1.27 - 10.85, p=0.01). This finding correlates with increased intracranial pressure and the potential for brainstem compression, both of which are associated with poor prognoses. A study by Laalo et al., similarly identified basal cisterns effacement as a key predictor of mortality in TBI patients, reinforcing our findings.[26]

The location of the injuries also played a role in the prognosis. Frontal and temporal contusions were significantly more frequent in the disability group (24.7% vs. 9.1%, p=0.006 for frontal; 20.5% vs. 6.5%, p=0.015 for temporal). Similar trends were observed for subdural hematomas in the frontal region (15.1% vs. 5.2%, p=0.04).

Clinical Implications

The significant associations identified in this study highlight the need for comprehensive initial CT evaluations in patients with mild TBI. Identifying high-risk patients based on CT findings can inform clinical decision-making, guiding the need for more intensive monitoring, early surgical intervention, and tailored rehabilitation strategies. For example, patients with a midline shift or significant contusions may benefit from early neurosurgical consultations and close intracranial pressure monitoring.[27,28]

Limitations and Future Directions

This study has several limitations. The single-center design may limit the generalizability of our findings. Additionally, the follow-up period was limited to six months, which may not capture long-term outcomes. Future multicenter studies with longer follow-up periods are necessary to validate our findings and explore the prognostic value of CT findings in different populations. Moreover, integrating CT findings with clinical parameters and advanced imaging techniques such as MRI could provide a more comprehensive prognostic model for TBI patients.

CONCLUSION

In conclusion, specific CT findings, including contusions, SAH, SDH, midline shift, and basal cisterns effacement, are significant predictors of disability in patients with mild TBI. These findings emphasize the importance of detailed initial CT evaluations in guiding clinical management and improving patient outcomes. Future research should focus on validating these findings in larger, multicenter cohorts and integrating advanced imaging modalities to enhance prognostic accuracy.

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