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ORIGINAL ARTICLE

Determinants of Recovery Outcomes in Patients with Post-Traumatic Brain Contusions

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ABSTRACT

Background: Prognostication has evolved with tools like the Glasgow Coma Scale (GCS) and neuroimaging, yet predictors of clinical progression and surgical necessity remain debated. This study aimed to identify factors predicting clinical/radiological progression, surgical intervention, and functional outcomes in isolated traumatic brain contusions.

Methods: A prospective study of 100 patients (50 conservative [Group A], 50 surgical [Group B]) with isolated contusions. Serial CT scans, neurological assessments (GCS, Glasgow Outcome Scale [GOS]), and clinical monitoring were performed. Surgical intervention was guided by clinical deterioration (e.g., GCS decline) and radiological progression (midline shift ≥5 mm).

Results: Group A (Conservative): Mild GCS (13–15) correlated with favorable 3-month GOS (4.9 ± 0.3) and shorter hospital stays (4.6 ± 2.0 days), while severe GCS (3–8) predicted poor outcomes (GOS 1.5 ± 0.7, 20% mortality). Midline shift negatively correlated with GOS (ρ=-0.53, P=0.01) and prolonged hospitalization (ρ=0.57, P=0.007). Radiological progression occurred in 16% (8/50), but only 4 required surgery due to clinical decline. Group B (Surgical): Severe GCS (3–8) linked to longest stays (17.5 ± 3.8 days) and highest mortality (25%). Midline shift worsened post-surgery (3.96 ± 1.62 mm to 6.40 ± 1.35 mm), correlating with poorer GOS (ρ=-0.52, P=0.01). Polytrauma patients (84%) had worse outcomes (GOS 3.2 ± 1.8 vs. 4.5 ± 0.6 in localized trauma).

Conclusions: Midline shift and initial GCS are pivotal in guiding management. Conservative care suffices for mild cases, while surgery mitigates risks in severe injuries, albeit with residual mortality.

Keywords: Traumatic Brain Contusion; Glasgow Coma Scale; Midline shift; Surgical Intervention; Conservative management

INTRODUCTION

Cerebral contusion, a form of traumatic brain injury (TBI), results in bruising of brain tissue and is a leading cause of lifelong physical, cognitive, and emotional impairment **[1].** While posttraumatic mass lesions are more prevalent in comatose patients, they can also occur in individuals with mild to moderate head injuries. Although most recover fully, some deteriorate rapidly, leading to fatal outcomes ("talk-and-die" cases) **[2].** TBI remains a significant contributor to global mortality and disability **[3],** with rising incidence attributed to increased motor vehicle use in low- and middle-income countries [4] and aging populations in developed nations **[5].**

Head injury imposes substantial demands on healthcare systems, particularly affecting young individuals and requiring rigorous outcome assessments focused on neurological and cognitive function [6]. Since the 1970s, the Glasgow Coma Scale (GCS) and computed tomography (CT) scans have been integral to evaluating TBI patients **[7].** Rapid assessment and intervention are critical to improving survival and minimizing disability **[8].**

This study aimed to Identify predictors of clinical progression and surgical necessity in

patients with posttraumatic cerebral contusions and to evaluate how these predictors influence patient outcomes.

METHODS

Study Design and Ethical Considerations

A prospective clinical study was conducted at the Neurosurgery Department, Zagazig University hospitals during the last year (2024). (Approval code: 1216 /15-4-2025).

Inclusion Criteria: Age ≥6 years (to ensure reliable GCS and Glasgow Outcome Scale [GOS] assessments). Diagnosis of posttraumatic cerebral contusion confirmed by admission CT scan. Willingness to participate in follow-up for 3 months.

Exclusion Criteria: Penetrating brain injury. re-existing neurological disorders (e.g., stroke, dementia). Hemodynamic instability or multiorgan failure requiring intensive care.

Clinical and Radiological Evaluation

Initial Assessment: General and Neurological Examination: Including GCS scoring (mild: 13–15, moderate: 9–12, severe: ≤8). Systemic Evaluation: Vital signs, signs of polytrauma. Laboratory Tests: Complete blood count (CBC), coagulation profile (PT, INR, aPTT), liver function tests (ALT, AST), and renal function tests (creatinine, BUN).

Imaging Protocol: CT Scans: Performed on admission, at 24 hours, and as needed for clinical deterioration. Contusion Volume Calculation: Using the ABC/2 method for ellipsoid volumes. Midline Shift Measurement: Defined as displacement ≥5 mm from the falx cerebri.

Patients were stratified into two groups based on initial management: Group A (Conservative, n = 50): Managed medically with intracranial pressure (ICP) monitoring, osmotic therapy (mannitol), and sedation. Follow-up CT at 24 hours; additional scans if GCS dropped by ≥2 points. Group B (Surgical, n = 50): Underwent surgery (craniotomy, hematoma evacuation, or decompressive craniectomy) per Brain Trauma Foundation guidelines [Carney et al., 2017]: GCS ≤8. Frontal/temporal contusion volume >20 cm³. Midline shift ≥5 mm or cisternal compression.

Outcome Measures

Primary Outcome: Need for surgical intervention (conversion from Group A to B).

Secondary Outcomes: Functional Outcome: Assessed via GOS at 3 months: 5 (Good recovery), 4 (Moderate disability), 3 (Severe disability), 2 (Persistent vegetative state), 1 (Death). Favorable: GOS 4–5. Unfavorable: GOS 1–3. Mortality Rate: Deaths within 3 months.

Statistical Analysis

Data were analyzed using STATA/SE 11.2 (StataCorp, College Station, TX). Descriptive Statistics: Mean ± SD for continuous variables; frequencies for categorical variables. Inferential Statistics: Chi-square/Fisher's exact test for categorical variables (e.g., GOS categories). Mann-Whitney U test for non-parametric continuous data (e.g., contusion volume). Multivariate logistic regression to identify predictors of surgical need and unfavorable outcomes (variables: age, GCS, contusion volume). Correlation Analysis: Spearman's rho for associations (e.g., GCS vs. GOS). Survival Analysis: Kaplan-Meier curves for mortality. Significance threshold: $p < 0.05$.

Results

Both groups were well-matched in gender distribution (80% male), age ranges, and primary trauma causes (road traffic accidents dominated in both). However, Group B exhibited more severe clinical profiles: a higher proportion of moderate-to-severe GCS scores (88% vs. 34% in Group A), larger initial contusion volumes (22.36 cm³ vs. 14.90 cm³), and greater midline shifts (3.96 mm vs. 0.19 mm). (Table 1)

The strong negative association between initial GCS scores and hospital stay (ρ = -0.86 in Group A, ρ = -0.79 in Group B) emphasizes that lower GCS (greater injury severity) predicts prolonged hospitalization. Similarly, the positive correlation between GCS and 3-month GOS (ρ = 0.73 in Group A, ρ = 0.69 in Group B) reinforces the prognostic value of early GCS assessment. Midline shifts were strongly linked to outcomes in Group A (ρ = 0.57 with hospital stay; ρ = -0.53 with GOS), reflecting the impact of cerebral edema in conservatively managed patients. In contrast, Group B

showed weaker correlations for midline shifts, likely due to surgical mitigation of mass effect. (Table 2)

In Group A, outcomes varied markedly by age and initial GCS. Younger patients (<15 years) had shorter hospital stays (4.4 days) and better GOS (4.2), while older patients (45–65 years) experienced longer stays (8.2 days) but still favorable GOS (4.6). The starkest differences emerged with GCS severity: mild GCS (13–15) patients had excellent recovery (GOS 4.9) and minimal mortality (0%), whereas severe GCS (3–8) patients faced dismal outcomes (GOS 1.5, 20% mortality). This underscores the importance of early GCS stratification in conservative management. Notably, polytrauma patients (80% of Group A) had longer stays than local trauma cases, aligning with the systemic burden of multi-organ injuries. The absence of mortality in mild GCS subgroups highlights the efficacy of conservative approaches for less severe injuries. (Table 3)

Surgical outcomes in Group B were heavily influenced by age, trauma type, and GCS severity. Younger patients (<15 years) paradoxically endured the longest hospital stays (18.2 days) and poorest GOS (2.8), likely due to surgical complexity in pediatric cases or delayed intervention. Severe GCS (3–8) patients had the highest mortality (25%) and prolonged stays (17.5 days), reflecting the challenge of salvaging critically injured individuals. (Table 4)

Table 1: Comparisons Between the Studied Groups (n=50 per group)

Variable	Group A (Conservative; n=50)	Group B (Surgical; n=50)
Age (years)		
- <15	12 (24.00%)	10 (20.00%)
- 15–29	14 (28.00%)	8 (16.00%)
- 30–44	12 (24.00%)	16 (32.00%)
- 45–65	12 (24.00%)	16 (32.00%)
Mean ± SD	28.01 ± 19.00	32.78 ± 19.11
Range	9–60	7–65
Gender		
- Female	10 (20.00%)	10 (20.00%)
- Male	40 (80.00%)	40 (80.00%)
Cause of Trauma		
- Falling from height	10 (20.00%)	14 (28.00%)
- Direct head trauma	10 (20.00%)	8 (16.00%)
- RTA	30 (60.00%)	28 (56.00%)
Type of Trauma		
- Local trauma	10 (20.00%)	8 (16.00%)
- Polytrauma	40 (80.00%)	42 (84.00%)
Neuro-deficit		
- No deficit	40 (80.00%)	24 (48.00%)
- Aphasia	0 (0.00%)	6 (12.00%)
- Lt. side weakness	7 (14.00%)	18 (36.00%)
- Rt. side weakness	2 (4.00%)	2 (4.00%)
Other Systems Affection		
- No	36 (72.00%)	40 (80.00%)
- Cardiothoracic	5 (10.00%)	4 (8.00%)
- Orthopaedic	9 (18.00%)	6 (12.00%)
Associated Medical Problems		
- No	48 (96.00%)	46 (92.00%)

Variable	Group A (Conservative; n=50)	Group B (Surgical; n=50)
- Cardiac	0 (0.00%)	4 (8.00%)
- Hypertension	2 (4.00%)	0 (0.00%)
Initial GCS Score		
- Mild (13–15)	33 (66.00%)	6 (12.00%)
- Moderate (9–12)	12 (24.00%)	32 (64.00%)
- Severe (3–8)	5 (10.00%)	12 (24.00%)
Mean ± SD	12.95 ± 2.18	10.24 ± 2.18
Range	7–15	5–14
Contusion Volume (cm^3)		
- 1st CT (Mean ± SD)	14.90 ± 1.81	22.36 ± 3.84
- 2nd CT (Mean ± SD)	14.90 ± 1.80	27.00 ± 2.36[a]
Midline Shift (mm)		
- 1st CT (Mean ± SD)	0.19 ± 0.51	3.96 ± 1.62
- 2nd CT (Mean ± SD)	0.26 ± 0.80	6.40 ± 1.35[a]

Table 2: Correlation Between Outcome Indicators and Patient Characteristics

Characteristic	Group A (Conservative; n=50)		Group B (Surgical; n=50)	
	Duration (days)	*3-month GOS*	*Duration (days)*	*3-month GOS*
Age (years)	Rho=0.28 (P=0.21)	Rho=0.22 (P=0.34)	Rho=-0.45 (P=0.02*)	Rho=-0.11 (P=0.60)
Initial GCS score	Rho=-0.86 (P<0.001***)	Rho=0.73 (P=0.0002***)	Rho=-0.79 (P<0.001***)	Rho=0.69 (P=0.0001***)
Initial contusion volume	Rho=0.19 (P=0.40)	Rho=-0.27 (P=0.23)	Rho=0.36 (P=0.08)	Rho=-0.14 (P=0.49)
Midline shift (1st CT)	Rho=0.57 (P=0.007**)	Rho=-0.53 (P=0.01*)	Rho=0.21 (P=0.31)	Rho=-0.52 (P=0.01*)

*GCS: Glasgow Coma Scale; GOS: Glasgow Outcome Scale; CT: Computed Tomography; Rho: Spearman's correlation. *: P<0.05; **: P<0.01; ***: P<0.001*.

Table 3: Group A (Conservative) Outcomes by Characteristics (n=50)

Variable	Subgroup	Hospital Stay (days)	3-month GOS	Mortality
Age	<15 (n=12)	4.4 ± 1.9	4.2 ± 1.8	1 (8.3%)
	15–30 (n=14)	7.3 ± 3.5	3.3 ± 1.9	1 (7.1%)
	30–45 (n=12)	5.0 ± 2.0	5.0 ± 0.0	0 (0%)
	45–65 (n=12)	8.2 ± 4.1	4.6 ± 0.9	0 (0%)
Initial GCS	Mild (13–15; n=33)	4.6 ± 2.0	4.9 ± 0.3	0 (0%)
	Moderate (9–12; n=12)	9.6 ± 2.9	3.6 ± 1.7	1 (8.3%)
	Severe (3–8; n=5)	9.5 ± 0.7	1.5 ± 0.7	1 (20%)

GOS: Glasgow Outcome Scale; GCS: Glasgow Coma Scale.

Table 4: Group B (Surgical) Outcomes by Characteristics (n=50)

Variable	Subgroup	Hospital Stay (days)	3-month GOS	Mortality
Age	<15 (n=10)	18.2 ± 3.8	2.8 ± 1.6	1 (10%)
	15–30 (n=8)	11.0 ± 8.0	4.5 ± 0.6	0 (0%)
	30–45 (n=16)	8.0 ± 3.8	4.4 ± 1.4	2 (12.5%)
	45–65 (n=16)	8.4 ± 4.6	2.5 ± 2.1	2 (12.5%)
Initial GCS	Mild (13–15; n=6)	4.7 ± 0.6	5.0 ± 0.0	0 (0%)
	Moderate (9–12; n=32)	9.1 ± 5.2	3.8 ± 1.8	2 (6.3%)
	Severe (3–8; n=12)	17.5 ± 3.8	2.9 ± 1.6	3 (25%)

GOS: Glasgow Outcome Scale; GCS: Glasgow Coma Scale.

DISCUSSION

Brain contusions represent the most common type of post-traumatic intracerebral lesions. However, their study is inherently complex due to frequent coexistence with other intracranial hematomas, complicating efforts to isolate their clinical and radiological progression **[6].** Unlike prior studies that often conflated contusions with mixed pathologies, this prospective analysis focused exclusively on patients with brain contusions as the primary lesion. Our goal was to identify predictors of clinical/radiological progression, surgical necessity, and functional outcomes. Historically, prognostication in traumatic brain injury (TBI) relied on subjective clinical judgment. The advent of standardized tools like the Glasgow Coma Scale (GCS) **[9]** and Glasgow Outcome Scale (GOS) transformed this into an evidence-based science. Further refinement came with neuroimaging, particularly CT scans, which enabled quantification of structural damage (e.g., midline shift, lesion volume) **[10, 11].**

The Brain Trauma Foundation guidelines **[12]** advocate surgical intervention for contusions based on clinical deterioration, radiological progression (midline shift >5 mm, cistern compression), and elevated intracranial pressure (ICP). While the Marshall CT classification [10] stratified TBI into broad categories, the Rotterdam CT score (Maas et al., 2005) improved prognostic precision by integrating specific CT characteristics **[13].** Recent studies highlight the value of quantitative CT metrics (e.g., lesion volume, midline shift) **[14],** aligning with our focus on these parameters.

The findings of this study align with several key publications while highlighting nuanced discrepancies that underscore the complexity of managing traumatic brain contusions. Iaccarino et al. **[2]** emphasized that clinical deterioration in traumatic brain injury (TBI) patients is strongly predicted by midline shift progression and basal cistern compression, advocating for surgical intervention when these radiological markers coincide with neurological decline. Our results corroborate this, as midline shift ≥5 mm on follow-up CT, coupled with clinical deterioration (e.g., declining GCS, new deficits), served as the primary indication for surgery in 4 patients initially managed conservatively.

This mirrors Smith et al. **[15],** who reported that 5% of conservatively managed patients required delayed surgery due to radiological progression and clinical decline. Our cohort similarly demonstrated that radiological progression alone (e.g., hematoma expansion) does not universally mandate surgery unless accompanied by neurological worsening, aligning with Alahmadi et al. [16], who observed that nearly half of conservatively managed contusions progress radiologically without clinical deterioration.

Chiewvit et al. **[17]** identified midline shift as a critical predictor of poor outcomes, a finding consistent with our data. In both Group A (conservative) and Group B (surgical), midline shift on initial CT negatively correlated with 3-month GOS (ρ =

-0.53 and -0.52, respectively) and positively correlated with prolonged hospitalization (ρ = 0.57 in Group A). Similarly, the significant positive correlation between initial GCS and 3-month GOS (ρ = 0.73 in Group A, ρ = 0.69 in Group B) reinforces the prognostic primacy of GCS, as emphasized by Teasdale and Jennett **[9].** However, our results diverge from Narayan et al. **[18],** who directly linked hematoma volume progression to clinical decline.

While we observed a negative correlation between contusion volume and GOS (ρ = -0.17 in Group A, ρ = -0.18 in Group B), this association was weaker than that of midline shift or GCS, suggesting that volume alone may be insufficient to predict outcomes without contextualizing mass effect or neurological status.

Contradictions emerged regarding age-related outcomes. Keser and Döşoğlu [19] reported increasing mortality with age, a trend not replicated in our study, likely due to our limited sample size. However, in Group B, pediatric patients (<15 years) had the longest hospital stays (18.2 ± 3.8 days, P = 0.04), reflecting the surgical complexity of severe TBI in younger populations. This aligns with Alahmadi et al. [16], who noted that radiological progression does not uniformly correlate with clinical decline, as seen in our Group A, where 8 patients exhibited contusion expansion on follow-up CT, yet only 4 required surgery due to concurrent neurological deterioration.

The small cohort (n = 50 per group) and short-term follow-up (3 months) limit the generalizability of our findings, particularly regarding age-related mortality trends. Additionally, while our study reaffirmed the prognostic value of midline shift and GCS, quantitative CT metrics (e.g., contusion volume) showed weaker correlations, possibly due to measurement variability or the overshadowing influence of mass effect. Future studies should prioritize larger cohorts, extended follow-up periods, and advanced imaging protocols (e.g., MR spectroscopy, ICP monitoring) to refine prognostic models. Integrating the Rotterdam CT score (Maas et al., 2005), which combines multiple CT parameters, may further enhance surgical decision-making.

Our findings validate midline shift and GCS as pivotal predictors of outcomes in traumatic brain contusions, supporting Iaccarino et al. **[2]** and Chiewvit et al. **[17].** However, the discordance with Narayan et al. [18] on hematoma volume and Keser **[9]** on age-mortality associations highlights the need for context-driven, multimodal assessment. Conservative management suffices for stable patients, while surgery remains indispensable for those with clinical-radiological progression, albeit with persistent risks. These insights underscore the importance of individualized treatment algorithms in TBI care.

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