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# Identifying Criteria for Surgical Management of Traumatic Supratentorial Intraparenchymal Lesions: A Retrospective Study

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## Abstract

*Background:* Traumatic supratentorial Intraparenchymal hemorrhages (IPH) may require urgent surgical intervention, but evidence-based criteria remain debated. This study analyzes predictors of postoperative outcomes.

*Aim of Study:* To analyze surgical outcomes and predictors of prognosis in patients with traumatic supratentorial intraparenchymal hemorrhages managed surgically, with emphasis on hematoma volume, admission Glasgow Coma Scale (GCS), and outcome correlations.

*Patients and Methods:* A retrospective observational study of 40 traumatic intraparenchymal hemorrhage and Contusion patients (2022–2024) undergoing surgical intervention at Cairo University Hospitals. Primary outcomes: Mortality and Glasgow Outcome Scale (GOS) at 3 months. Statistical analysis included *t*-tests and Pearson's correlation.

*Results:* Mortality was 10% (all GCS ≤8; $p<0.001$). Hematoma volume >50cm$^3$ correlated with higher mortality ($p=0.13$). Favorable outcomes (GOS 4–5) occurred in 60% at discharge, improving to 88% at 3 months.

*Conclusion:* Admission GCS is the strongest predictor of survival. Surgery is justified for hematomas >20cm$^3$ with mass effect, aligning with current guidelines.

***Key Words:*** *Traumatic brain injury – Intraparenchymal hemorrhage – GCS, Hematoma volume – Craniotomy – Decompressive craniectomy – Surgical outcome – Prognosis.*

## Introduction

**TRAUMATIC** brain injury (TBI) continues to be a major cause ofmorbidity and mortality worldwide, particularly among young adults, and often results in intracranial hemorrhagic lesions that require urgent neurosurgical intervention **[1]**. Among these, supratentorial intraparenchymal hemorrhages also referred to as traumatic intracerebral hemorrhages or contusions are particularly common in severe TBI, occurring in over 40% of such cases and being associated with worse outcomes **[2]** Unlike extradural or acute subdural hematomas, where surgical indications are well defined, the optimal management of traumatic intraparenchymal hemorrhages remains controversial. Current neurosurgical guidelines recommend surgical evacuation for frontal or temporal contusions >20cm$^3$ with mass effect (especially in patients with GCS 6–8) or for any hemorrhagic lesion >50cm$^3$ **[3]** but these thresholds are largely based on retrospective evidence and expert opinion **[2]**. Studies show that larger hemorrhage volumes correlate with worse neurological outcomes **[4]** supporting the rationale for decompressive surgery, yet high-quality prospective data remain limited. Randomized trial STITCH (Trauma) did not demonstrate aclinically meaningful improvement infunctional outcome with early surgery, although it showed a trend toward benefit and significantly reduced mortality **[5]**.

Surgical decision-making is typically guided by hematoma volume, midline shift, signs of raised intracranial pressure, and the patient's neurological status, frequently evaluated using the Glasgow Coma Scale (GCS) **[3]**.

However, the management of borderline cases with moderate contusions remains debated **[2]**, and the operative thresholds are especially uncertain in resource-limited settings. In developing countries, decision-making often relies on local experience, available infrastructure, and evolving institutional protocols **[6]**. Continuous local auditing and out-

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come analysis are therefore essential to inform and refine context-specific guidelines **[7]**. In light of these challenges, we conducted a retrospective analysis of 40 surgically treated TBI patients with supratentorial intraparenchymal hematomas and contusions to evaluate the relationship between key variables age, GCS, and hematoma volume and clinical outcomes. We hypothesized that lower GCS and larger hemorrhage volumes would be linked to worse outcomes, thus justifying early surgical intervention, while patient age may play a more modest role. Our findings are discussed within the framework of current literature on surgical thresholds for TBI-related hemorrhagic lesions.

*Aim of the work:*

The aim of this study is to recognize key clinical and radiological criteria associated with favorable surgical outcomes in patients with traumatic supratentorial intraparenchymal hematomas. Specifically, we assess the predictive value of hematoma volume and admission GCS on surgical outcomes, determine mortality rates, and evaluate functional outcomes at discharge and follow-up in a consecutive cohort managed surgically at a tertiary neurosurgical center.

## Patients and Methods

*Ethics approval:* "Approved by Cairo University Faculty of medicine IRB N-289-2024").

*Study design and setting:* Retrospective observational approach was utilized in this study, which was conducted at the Department of Neurosurgery, Cairo University Hospitals, from January 2022 to December 2024".

*Patient selection:*

This study included 40 patients with traumatic supratentorial intraparenchymal hemorrhages and contusions who underwent surgical intervention at our institution. Inclusion criteria:

- Patients of all age groups and both sexes
- Radiologically confirmed supratentorial intraparenchymal hemorrhage
- Hematoma volume >20cm$^3$ accompanied by:

  o Significant mass effect, defined as midline shift >5mm and/or cisternal effacement on CT imaging, and/or

  o Neurological deterioration was defined as a drop of ≥1 point in the Glasgow Coma Scale (GCS) from baseline (while maintaining a GCS >4), accompanied by clinical signs of lesion-related worsening such as pupillary asymmetry, new motor deficits, or radiological evidence of mass effect.

- Any hematoma volume ≥50cm$^3$ regardless of other features.
- Patients who underwent craniotomy or decompressive craniectomy with hematoma evacuation.

*Exclusion criteria included:*

- Infratentorial hemorrhages.
- Penetrating cranial injuries.
- Coexisting major extracranial trauma.
- Spontaneous intraparenchymal hemorrhages, particularly those involving deep structures such as the basal ganglia
- Hemorrhages secondary to vascular etiologies, including ruptured aneurysms or arteriovenous malformations (AVMs).

*Data collection:*

Retrospective data collection utilized medical records, operative notes, and radiological imaging. Collected variables included:

- Demographics: Age, sex.
- Clinical: Mechanism of injury, admission GCS.
- Radiological: Hematoma location and volume (calculated via the ABC/2 method), presence of midline shift or basal cistern compression.
- Surgical intervention: Type of surgery (craniotomy or decompressive craniectomy).
- Patient outcomes were evaluated based on three parameters: In-hospital mortality, neurological status at discharge, and clinical outcome at 3-month follow-up. Discharge and follow-up status were evaluated via the Glasgow Outcome Scale (GOS) **[8]**.

A favorable outcome was defined as a GOS score of 4 or 5, indicating the patient was functionally independent. An unfavorable outcome included GOS scores of 1 to 3, corresponding to death, vegetative state, or severe disability, respectively. Table (1).

Table (1): The Glasgow Outcome Scale (GOS) **[8]**.

| (GOS) Score | Description | Interpretation |
|---|---|---|
| 5 | Good Recovery | - Resumption of normal life despite minor deficits |
| 4 | Moderate Disability | - Independent with physical or mental disability |
| 3 | Severe Disability | - Conscious but disabled; dependent on others for daily support |
| 2 | Vegetative State | - No awareness of environment or self |
| 1 | Death | - Patient did not survive |

*Statistical analysis:*

The analysis included descriptive statistics for all variables; categorical variables were evaluated using the chi-square or Fisher's exact test. Continuous variables were compared using independent *t*-tests. Correlation between continuous variables was determined using Pearson's method, with a significance threshold set at $p<0.05$. All analyses were conducted using Microsoft Excel and "Python v3.8 with SciPy for *t*-tests".

## Results

*Patient demographics and clinical presentation:*

A total of 40 patients with traumatic supratentorial intraparenchymal hemorrhages were included in this study. The mean age was 24.3±15.6 years (range: 0.3–58 years), with a male predominance (75%). All patients presented with either moderate or severe traumatic brain injury (TBI). The mean admission Glasgow Coma Scale (GCS) score was 7.9±2.3, with 25% (n = 10) presenting with moderate TBI (GCS 9–12) and 75% (n = 30) with severe TBI (GCS ≤8).

*Radiological findings:*

All patients had supratentorial intraparenchymal hemorrhages confirmed by CT. The mean hematoma volume was 43.8±9.5cm$^3$ (range: 25–65cm$^3$). Fig. (1) Approximately one-third of patients (33%) had hematomas >50cm$^3$. Signs of raised intracranial pressure (e.g., midline shift, basal cistern compression) were present in the majority of cases.

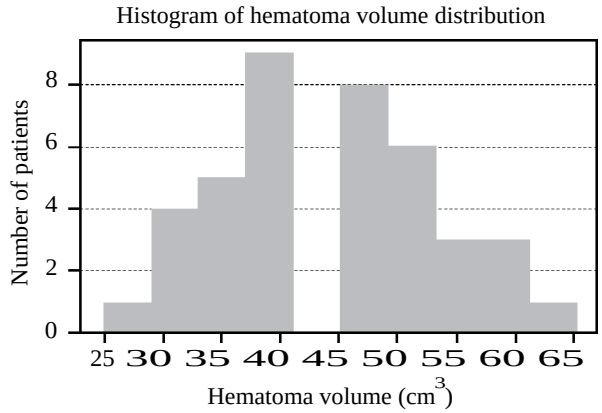


Fig. (1): Histogram of hematoma volume distribution.

Surgical management:

*All patients (100%) underwent surgical evacuation:*

- Craniotomy and evacuation: 32 patients (80%).
- Decompressive craniectomy and evacuation: 8 patients (20%).

*In-hospital outcomes:*

- Survival to discharge: 36 patients (90%).
- In-hospital mortality: Mortality occurred exclusively in severe TBI (GCS ≤8; 4/30, 13.3% vs. 0% for moderate TBI; $p<0.001$).
- Favorable outcome at discharge (GOS: Good recovery or moderate disability): 24 patients (60%)
- Unfavorable outcome (severe disability or vegetative state): 12 patients (30%).

Follow-up outcomes:

*At 3-month follow-up:*

- Good recovery (GOS 5): 16 patients (44% of survivors).
- Improved with deficit (GOS 4): 16 patients (44%).
- Improved with complication (GOS 3): 4 patients (11%).
- Neurological improvement was observed in 100% of survivors compared to their discharge condition. Table (2).

Table (2): Summary of Patient Characteristics, Management, and Outcomes.

| | |
|---|---|
| Patients (n) | 40 |
| Age in years | The mean age was 24.3±15.6 years (range: 0.3–58 years) |
| Sex male to female | Male predominance (75%) |
| *Mechanism of trauma:* | |
| RTA | 55% |
| Falling | 25% |
| Blow | 20% |
| Mean admission Glasgow Coma Scale (GCS) | 7.9±2.3, with 25% (n = 10) presenting with moderate TBI (GCS 9–12) and 75% (n = 30) with severe TBI (GCS ≤8) |
| Hematoma Volume (cm$^3$) | Mean hematoma volume was 43.8±9.5 cm$^3$ (range: 25–65 cm |
| *Surgery Type:* | |
| - Craniotomy and evacuation | : 32 patients (80%) |
| - Decompressive Craniectomy Evacuation | : 8 patients (20%) |
| In-Hospital Outcomes | • Survival to discharge: 36 patients (90%)<br>• In-hospital mortality: 4 patients 10% |
| Discharge | Favorable outcome at discharge (GOS: Good recovery or moderate disability): 24 patients (60%) |
| At 3-month follow-up of survivors: | • Unfavorable outcome (severe disability or vegetative state): 12 patients (30%)<br>• Good recovery: 16 patients (44% of survivors)<br>• Improved with deficit: 16 patients (44%)<br>• Improved with complication: 4 patients (11%) |

*Statistical associations:*

- GCS and mortality: Mortality was observed exclusively in patients with a GCS score of 6, showing a statistically significant association (*t*-test, $p<0.001$). Fig. (2).
- Hematoma volume and mortality: Mean hematoma volume was significantly larger in non-survivors (58.2cm$^3$) than survivors (42.1cm$^3$), although a correlation was observed, it lacked statistical significance ($p=0.13$). All fatalities occurred in patients with volumes >40cm$^3$, with most exceeding 50cm$^3$.
- Gender and outcome: Mortality occurred only in males (4/30), however, the relationship did not show statistical significance ($p=0.22$).
- Age and outcome: No significant difference in mean age between survivors and non-survivors ($p=0.51$).
- Correlation between hematoma volume and GCS: No significant correlation ($r=+0.024$, $p=0.88$).

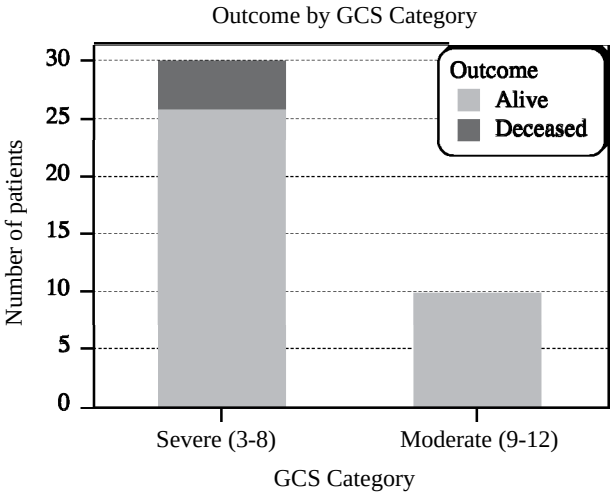


Fig. (2): Bar chart of outcome by GCS category.

## *Discussion*

This retrospective study evaluated surgical outcomes in 40 patients with traumatic supratentorial intraparenchymal hemorrhages (IPH) managed exclusively with surgical evacuation. All patients underwent either conventional craniotomy (80%) or decompressive craniectomy with evacuation (20%), reflecting the institutional preference for aggressive surgical intervention in cases of large or space-occupying hematomas.

Our 90% survival rate aligns with Mendelow et al. [5]. (STITCH-Trauma), though their cohort had higher mean hematoma volumes (55cm$^3$ vs. our 43.8cm$^3$)

*Key findings in context:*

*Age and Survival:* Our study had a relatively young mean age (24.3 years), which likely contributed to the high overall survival rate (90%). This is consistent with prior literature showing improved recovery potential in younger TBI patients due to greater neuroplasticity and fewer comorbidities [9]. Most patients presented with severe TBI (75%), yet a significant proportion still achieved favorable functional outcomes at follow-up, highlighting the potential benefit of timely surgical evacuation.

*Hematoma Volume and Outcomes:* Hematoma volume was a critical factor in clinical decision-making. The mean volume was 43.8cm$^3$,was lower than in STITCH-Trauma (55cm$^3$) [5], all fatalities occurred in patients with volumes >50cm$^3$. While this association did not reach statistical significance in our dataset ($p=0.13$), it aligns with Brain Trauma Foundation (BTF) guidelines which recommend surgical evacuation for lesions >50cm$^3$ or those causing mass effect [3].

*GCS as a Prognostic Tool:* All non-survivors presented with GCS=6, underscoring its predictive value. Moderate TBI patients (GCS 9–12) universally survived,Our findings are in line with recent literature, including the CENTER-TBI and TRACK-TBI studies, which support surgery for moderate-to-severe TBI with large hematomas [4,10].

In particular, moderate TBI patients in our study all survived, and many had good outcomes, supporting a more aggressive surgical stance in this "gray zone" of neurotrauma.

*Limitations:*

Despite these encouraging results, our study has limitations. The retrospective design limits causal inference, and all patients were managed surgically, preventing comparison with conservative treatment. Additionally, while short-term outcomes were generally favorable, long-term follow-up was limited, and some deficits persisted at 3 months.

Nevertheless, this study contributes to the growing body of evidence advocating for early surgical intervention in large traumatic Intra Intraparenchymal Hemorrhage, especially in young or moderate TBI patients who are not moribund at presentation. Future prospective studies with randomized designs and larger sample sizes are essential to refine surgical indications and optimize patient outcomes.

*Conclusion:*

Surgical evacuation remains a cornerstone in the management of traumatic supratentorial intra-

parenchymal hemorrhages, particularly in patients with large hematomas and deteriorating neurological status. Admission GCS is the strongest mortality predictor. In our series of 40 surgically treated patients, timely intervention was associated with a high survival rate and favorable outcomes, especially among younger patients and those with moderate TBI.

*Conflicts of Interest:*

No potential conflicts of interest were disclosed by the authors concerning this research.

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# تحديد معايير التدخل الجراحى للنزف داخل نسيج المخ فوق الخيمة الناتج عن الصدمات: دراسة استعادية


مقدمة: يُعد النزف داخل نسيج المخ فى الفصوص الدماغية العليا الناتج عن الإصابات الرضحية (TBI) من الحالات التي قد تتطلب تدخلاً جراحياً عاجلاً، إلا أن المعايير المستندة إلى الأدلة لاتخاذ القرار الجراحى لا تزال محل جدل. تهدف هذه الدراسة إلى تحليل العوامل المتنبئة بالنتائج بعد التدخل الجراحى.

الهدف: تحليل نتائج التدخل الجراحى والعوامل المتوقعة للإنذار لدى مرضى النزف داخل نسيج المخ الناتج عن إصابات رضحية، مع التركيز بشكل خاص على حجم النزف الدموى، مقياس جلاسكو عند استقبال المريض، وارتباطها بالنتائج.

الطرق: دراسة استعادية شملت ٤٠ مريضًا مصابًا بنزف أو كدمة داخل نسيج المخ (٢٠٢٢-٢٠٢٤) خضعوا لتدخل جراحي في مستشفيات جامعة القاهرة. شملت النتائج الأساسية: معدل الوفيات ومقياس جلاسكو للنتائج الوظيفية (GOS) بعد ٣ أشهر. تم استخدام اختبارات t وتحليل بيرسون الإحصائى.

النتائج: بلغت نسبة الوفيات ١٠٪ (جميعهم كانت درجات الوعى بمقياس جلاسكو اقل من او =٨؛ $p$<٠,٠٠١). وارتبط حجم النزف الدموى اكثر من٥٠ سم$^3$ بارتفاع معدل الوفيات ($p$=٠,١٣). لوحظت نتائج جيدة بمقياس جلاسكو للنتائج الوظيفية (GOS ٤-٥) لدى ٦٠٪ عند الخروج، تحسنت لتصل إلى ٨٨٪ بعد ٣ أشهر.

الخلاصة: يُعد مقياس جلاسكو عند القبول أقوى مؤشر على البقاء على قيد الحياة. التدخل الجراحى مبرر فى الحالات التى يتجاوز فيها حجم الورم الدموى ٢٠ سم$^3$ مع وجود تأثير كتلى، بما يتماشى مع الإرشادات الحالية.