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ORIGINAL ARTICLE

Clinical and radiological features predicting outcome of operated acute subdural hematoma.

Syed Shayan Shah[1], Farooq Azam[2], Zahid Khan[3], Muhammad Sohaib Khan[4], Syed Jawad Ahmad[5], Muhammad Aamir[6]

ABSTRACT… Objective: To determine in hospital mortality and Identify clinical and radiological predictors of outcomes in acute subdural hematoma evacuation. **Study Design:** Prospective Observational study. **Setting:** Lady Reading Hospital, Peshawar, Pakistan. **Period:** July 2024 to June 2025. **Methods:** 116 consecutive patients aged 2–65 years undergoing surgery for traumatic ASDH. Patients requiring conservative management, expiring before surgery, or with significant comorbidities were excluded. Data on demographics, Glasgow Coma Scale (GCS) at presentation, pupillary reactivity, hematoma thickness, midline shift, and in-hospital mortality were collected. Frequencies, means/medians, chi-square/Fisher's exact tests, and multivariable logistic regression were used for analysis. **Results:** Of 116 patients, in-hospital mortality was 48.3% (56/116). Mean age was 38.4 ± 16.2 years; 78% were male. Road traffic accidents caused 62% of cases. Median GCS was 7 (IQR 5–9); 52% had non-reactive pupils at presentation. Mean hematoma thickness was 18.6 ± 6.4 mm; mean midline shift was 9.8 ± 4.7 mm. Mortality was significantly higher with GCS ≤8 (62.9% vs. 18.2%, p<0.001), non-reactive pupils (71.7% vs. 23.2%, p<0.001), hematoma thickness ≥15 mm (64.8% vs. 21.4%, p<0.001), and midline shift ≥10 mm (70.9% vs. 25.0%, p<0.001). Multivariable analysis confirmed GCS ≤8 (OR 5.42, 95% CI 2.18–13.48), non-reactive pupils (OR 6.81, 95% CI 2.76–16.79), and midline shift ≥10 mm (OR 4.17, 95% CI 1.68–10.34) as independent predictors. **Conclusion:** In-hospital mortality after surgical evacuation of traumatic ASDH was 48.3%, with low GCS, fixed pupils, and significant midline shift independently predicting poor outcome. These factors can guide prognostication and resource allocation in resource-limited settings.

Key words: Acute Subdural Hematoma, Glasgow Coma Scale, Mortality Predictors, Midline Shift, Surgical Outcome, Traumatic Brain Injury.

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INTRODUCTION

Acute subdural hematoma (ASDH) is defined as the accumulation of blood between the dura and arachnoid, most commonly traumatic in origin.[1,2] It represents 50–60% of subdural hematomas and occurs in 10–20% of head injury admissions, rising to ~60% in severe traumatic brain injury (GCS ≤8).[2,3] Road traffic accidents predominate in younger patients, while falls are common in the elderly.[4] Non-traumatic causes include anticoagulation or aneurysmal rupture.[3]

Surgical evacuation via craniotomy or decompressive craniectomy is the mainstay for ASDH with mass effect or herniation.[5] Despite advances, mortality remains high (36–79%), exceeding other traumatic intracranial hemorrhages.[6] Prognostic factors include age, admission GCS, pupillary reactivity, hematoma volume/thickness, midline shift, timing of surgery, and associated injuries.[2,7-9] Elderly patients and those with a GCS <6 have worse outcomes.[8] Concurrent injuries, especially in road traffic accidents, further elevate risk.[9] Early surgical intervention reduces secondary injuries.[10,11]

While GCS, pupillary response, and neuroimaging findings are established predictors, their relative weights and thresholds vary across studies.[12] Local data from low- and middle-income countries (LMICs), where trauma burden is high and resources are limited, are scarce. This prospective study aimed to determine in-hospital mortality and identify clinical/radiological predictors of outcome in surgically managed traumatic ASDH.

1. MBBS, Postgraduate Resident Neurosurgery, Lady Reading Hospital, Peshawar, Pakistan.
2. FCPS, Professor Neurosurgery, Lady Reading Hospital, Peshawar, Pakistan.
3. MBBS, Postgraduate Resident Neurosurgery, Lady Reading Hospital, Peshawar, Pakistan.
4. MBBS, Postgraduate Resident Neurosurgery, Lady Reading Hospital, Peshawar, Pakistan.
5. MBBS, Postgraduate Resident Neurosurgery, Lady Reading Hospital, Peshawar, Pakistan.
6. MBBS, Postgraduate Resident Neurosurgery, Lady Reading Hospital, Peshawar, Pakistan.

Correspondence Address:
Dr. Zahid Khan
Department of Neurosurgery, Lady Reading Hospital, Peshawar.
neurosurgeonzahid@yahoo.com

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METHODS

This prospective observational study was conducted in the Department of Neurosurgery, Lady Reading Hospital, Peshawar, Pakistan, a major tertiary trauma referral center after ethical approval by institutional review board (424/LRH/MTI).

Consecutive patients undergoing surgery for traumatic acute subdural hematoma from July 2024 to June 2025 were enrolled using consecutive sampling. A total of 116 patients met the inclusion criteria during the study period.

Inclusion and Exclusion Criteria

Included: Age ≥2 years, traumatic ASDH requiring surgery, both genders.
Excluded: Conservative management, pre-operative death, significant comorbidities.

Ethical approval and informed guardian consent were obtained. Demographics, mechanism of injury GCS at presentation, pupillary reactivity, CT findings (hematoma thickness, midline shift), associated injuries and in-hospital mortality were recorded prospectively.

Surgery (craniotomy ± decompressive craniectomy) was performed per standard protocol by experienced consultants.

SPSS v26 was used for analysis. For categorical variables: frequencies or percentages; for continuous variables: mean ± SD or median (IQR). Normality assessed via Shapiro-Wilk. Associations were tested using the chi-square test or Fisher's exact test. Multivariable logistic regression included significant univariate predictors ($p<0.10$). $p \leq 0.05$ was considered significant.

RESULTS

Baseline Characteristics

116 patients were enrolled (Table-I). The average age was 38.4 ± 16.2 years; 78% were male. Road traffic accidents accounted for 62%, falls for 28%, and assaults for 10%. The median GCS was 7 (IQR 5–9); 69% had a GCS of 8 or less. Non-reactive pupils were observed in 52%. The mean hematoma thickness was 18.6 ± 6.4 mm, and the mean midline shift was 9.8 ± 4.7 mm. Associated contusions were present in 42%, and pneumocephalus in 18%.

TABLE-I

Baseline demographic and clinical characteristics (n=116)

Characteristic	n (%) or Mean ± SD / Median (IQR)
Age (years)	38.4 ± 16.2
Male gender	90 (77.6%)
Mechanism: RTA	72 (62.1%)
Mechanism: Fall	32 (27.6%)
Mechanism: Assault	12 (10.3%)
GCS at presentation	7 (5–9)
GCS ≤8	80 (69.0%)
Non-reactive pupils	60 (51.7%)
Hematoma thickness (mm)	18.6 ± 6.4
Midline shift (mm)	9.8 ± 4.7
Associated contusion	49 (42.2%)
Associated pneumocephalus	21 (18.1%)

In-Hospital Mortality

Overall mortality was 48.3% (56/116). Functional outcome scales were not assessed; the outcome was limited to in-hospital mortality.

Univariate Analysis of Predictors

Mortality differed significantly by clinical and radiological factors (Table-II).

1. GCS ≤8: 62.5% vs. 19.4% ($p<0.001$)
2. Non-reactive pupils: 71.7% vs. 23.2% ($p<0.001$)
3. Hematoma thickness ≥15 mm: 64.8% vs. 21.4% ($p<0.001$)
4. Midline shift ≥10 mm: 70.9% vs. 25.0% ($p<0.001$)

Age >50 years showed a trend toward higher mortality (58.3% vs. 44.2%, $p=0.142$). Gender and mechanism were non-significant ($p>0.30$).

Multivariable Analysis

Logistic regression (including age >50, GCS ≤8, non-reactive pupils, thickness ≥15 mm, shift ≥10 mm) identified three independent predictors (Table-III):

1. GCS ≤8: OR 5.42 (95% CI 2.18–13.48, $p<0.001$)
2. Non-reactive pupils: OR 6.81 (95% CI 2.76–16.79, $p<0.001$)

3. Midline shift ≥10 mm: OR 4.17 (95% CI 1.68–10.34, p=0.002)

Age and hematoma thickness lost significance after adjustment.

TABLE-II

Univariate stratification of mortality by predictors

Predictor	Mortality n (%)	Survival n (%)	Mortality Rate (%)	P-Value
Age >50 years	21 (58.3)	15 (41.7)	58.3	0.142
Age ≤50 years	35 (44.2)	45 (55.8)	44.2	
GCS ≤8	50 (62.5)	30 (37.5)	62.5	<0.001
GCS >8	6 (19.4)	30 (80.6)	19.4	
Non-reactive pupils	43 (71.7)	17 (28.3)	71.7	<0.001
Reactive pupils	13 (23.2)	43 (76.8)	23.2	
Hematoma thickness ≥15 mm	46 (64.8)	25 (35.2)	64.8	<0.001
Hematoma thickness <15 mm	10 (21.4)	35 (78.6)	21.4	
Midline shift ≥10 mm	39 (70.9)	16 (29.1)	70.9	<0.001
Midline shift <10 mm	17 (25.0)	44 (75.0)	25.0	

FIGURE-1

Bar chart comparing mortality rates across dichotomous predictors (GCS ≤8, non-reactive pupils, thickness ≥15 mm, shift ≥10 mm).

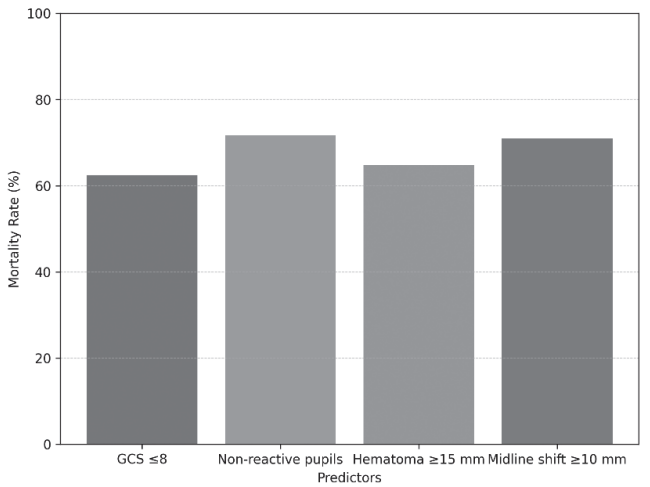

TABLE-III

Multivariable logistic regression for in-hospital mortality

Predictor	Odds Ratio (95% CI)	P-Value
Age >50 years	1.82 (0.74–4.48)	0.189
GCS ≤8	5.42 (2.18–13.48)	<0.001
Non-reactive pupils	6.81 (2.76–16.79)	<0.001
Hematoma thickness ≥15 mm	1.96 (0.71–5.41)	0.193
Midline shift ≥10 mm	4.17 (1.68–10.34)	0.002

DISCUSSION

This prospective study of 116 surgically managed traumatic acute subdural hematoma (ASDH) patients demonstrated an in-hospital mortality rate of 48.3%, which lies within the widely reported range of 36–79% for operated ASDH but remains higher than several contemporary single-center series.[12] This mortality is comparable to that reported by Yilmaz et al. (51%) and Gunjkar et al. (47–50%), while exceeding the 42% reported by Alagoz et al., despite similar distributions of admission Glasgow Coma Scale (GCS) and pupillary reactivity.[13-15] The elevated mortality in our cohort likely reflects challenges characteristic of low- and middle-income country (LMIC) settings including delayed prehospital transfer limited neurocritical care capacity, and constrained access to advanced monitoring, factors repeatedly associated with poorer ASDH outcomes.[16-18]

Admission GCS ≤8 emerged as a strong independent predictor of mortality (OR 5.42), consistent with prior studies and guideline-based evidence demonstrating an exponential increase in mortality below a GCS threshold of 9.[19-20] Karibe et al. and Huang et al. similarly identified low GCS as the most robust clinical predictor of outcome, underscoring its continued relevance despite advances in surgical technique and perioperative care.[21-22]

Pupillary non-reactivity conferred the highest risk of mortality (OR 6.81), reflecting irreversible brainstem dysfunction and raised intracranial pressure. This finding aligns with Leitgeb et al., who reported mortality rates approaching 70% in patients with bilateral fixed pupils, as well as with more recent prospective cohorts that emphasize pupillary status

as a key triage and prognostic marker.[17,23] Midline shift ≥10 mm independently predicted death (OR 4.17) reinforcing the prognostic value of radiological mass effect. Multiple studies have demonstrated that midline shift thresholds of 8-10 mm are consistently associated with poor outcomes, regardless of surgical modality.[24-25]

Hematoma thickness ≥15 mm showed significance on univariate analysis but lost independent predictive value on multivariable modeling, suggesting collinearity with midline shift and neurological severity. This observation is supported by Bartels et al. and Yuan et al., who highlighted midline shift and hematoma volume as more integrative markers of intracranial dynamics than thickness alone.[13,18]
Age >50 years demonstrated a univariate trend toward higher mortality but was not an independent predictor in this cohort. While earlier studies emphasized age-dependent vulnerability, particularly in patients older than 65 years, recent systematic reviews suggest that age may act as a surrogate for frailty, comorbidities, and physiological reserve rather than an isolated determinant of outcome.[15,23] The exclusion of major comorbidities in our study may partly explain this finding.

Road traffic accidents accounted for the majority of injuries (62%), reflecting regional trauma epidemiology and reinforcing the need for targeted injury prevention strategies.[16] Strengths of this study include its prospective design, consecutive enrollment, and multivariable analysis features still uncommon in regional ASDH literature. Limitations include its single-center nature, lack of long-term functional outcomes, absence of surgical timing data, and restriction to in-hospital mortality.

Overall, these findings reaffirm admission GCS, pupillary response, and midline shift as core prognostic indicators in traumatic ASDH. In LMIC settings, system-level interventions aimed at reducing prehospital delays, expediting neuroimaging, and ensuring timely surgical decompression may offer the greatest opportunity for improving survival.

CONCLUSION

In-hospital mortality after surgical evacuation of traumatic ASDH was 48.3%. Low GCS, fixed pupils, and significant midline shift independently predicted death, providing actionable prognostic markers in resource-limited settings.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Syed Shayan Shah:** Draft writing.
2	**Farooq Azam:** Data collection.
3	**Zahid Khan:** Drafting.
4	**Muhammad Sohaib Khan:** Data analysis.
5	**Syed Jawad Ahmad:** Data entry.
6	**Muhammad Aamir:** Critical revisions.