Section: Neurosurgery

Original Research Article

RISK FACTORS FOR PROGRESSION OF CONSERVATIVELY MANAGED ACUTE TRAUMATIC SUBDURAL HEMATOMA

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ABSTRACT

Background: Acute traumatic subdural hematoma (aSDH) is one of the most common and severe forms of traumatic brain injury (TBI). Although many patients are initially managed conservatively, a subset develops hematoma progression leading to neurological deterioration and delayed surgical intervention. Early identification of risk factors associated with hematoma expansion is essential for improving patient outcomes. The aim is to evaluate the clinical and radiological risk factors associated with progression of conservatively managed acute traumatic subdural hematoma. **Materials and Methods:** This retrospective observational study was conducted in the Department of Neurosurgery, Government General Hospital, Ongole, over a period of one year. A total of 60 adult patients with CT-confirmed acute traumatic subdural hematoma managed conservatively were included. Clinical parameters including Glasgow Coma Scale (GCS), anticoagulant or antiplatelet therapy, and neurological status were recorded. Serial non-contrast CT scans were performed to assess hematoma thickness, midline shift, hematoma density, and radiological progression. Hematoma progression was defined as significant increase in hematoma size or midline shift on follow-up imaging. **Result:** Hematoma progression was observed in 18 patients (30%). Lower admission GCS score, anticoagulant or antiplatelet therapy, hematoma thickness >10 mm, and midline shift >5 mm were significantly associated with hematoma progression ($p<0.05$). Heterogeneous hematoma density, irregular margins, and associated cerebral contusions were more common in patients with progression. Delayed surgical intervention was required in 16.7% of patients, while neurological deterioration occurred in 23.3%. **Conclusion:** Lower GCS score, anticoagulant therapy, larger hematoma thickness, and significant midline shift are important predictors of hematoma progression in conservatively managed aSDH patients. Early identification of these high-risk factors and close radiological monitoring may help reduce neurological deterioration and improve clinical outcomes.

INTRODUCTION

Traumatic brain injury (TBI) remains a major global health problem and is associated with significant morbidity and mortality. Among the various intracranial hemorrhages, acute traumatic subdural hematoma (ASDH) is one of the most common and severe manifestations of head injury. Acute traumatic subdural hematoma occurs due to rupture of bridging veins or cortical vessels following trauma, resulting in blood accumulation between the dura mater and arachnoid membrane. The condition is frequently associated with cerebral edema, raised intracranial pressure (ICP), and secondary brain injury, all of which contribute to poor neurological outcomes.[1]

Management of ASDH depends on several clinical and radiological factors, including neurological status, hematoma size, midline shift, and associated brain injuries. While large hematomas with significant mass effect often require urgent surgical evacuation, a considerable proportion of patients are initially managed conservatively with close neurological and radiological monitoring. However, some conservatively treated patients subsequently demonstrate hematoma progression, neurological deterioration, or delayed need for surgery. Early

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identification of patients at high risk for progression is therefore essential for timely intervention and improved outcomes.

The progression of acute traumatic subdural hematoma is influenced by multiple pathophysiological mechanisms. Continued bleeding from injured cortical vessels, disruption of autoregulatory mechanisms, inflammatory responses, and impaired cerebrospinal fluid dynamics contribute to hematoma expansion. In addition, coagulopathy and microvascular injury may promote persistent bleeding even in the absence of recurrent trauma. These factors can result in increasing hematoma volume, worsening mass effect, cerebral ischemia, and elevated intracranial pressure.

Several clinical and radiological risk factors have been associated with progression of conservatively managed ASDH. Lower initial Glasgow Coma Scale (GCS) scores are strongly associated with higher rates of hematoma enlargement, neurological deterioration, and poor functional outcomes. Patients presenting with severe head injury (GCS $\leq$ 8) are particularly vulnerable and often require delayed surgical intervention. Coagulopathy and the use of antithrombotic medications such as anticoagulants and antiplatelet agents have also been identified as important predictors of hematoma expansion. Impaired clot stabilization in these patients predisposes to spontaneous rebleeding and continued hemorrhage progression, thereby increasing morbidity and mortality.[2]

Radiological characteristics play a crucial role in predicting progression. Initial hematoma thickness greater than 10 mm and midline shift greater than 5 mm are commonly associated with increased risk of expansion and clinical deterioration. Larger hematomas exert greater pressure on adjacent brain tissue, contributing to secondary injury and worsening cerebral edema. Additional imaging findings such as associated contusions, traumatic subarachnoid hemorrhage, and basal cistern effacement may further increase the likelihood of progression.

Despite advances in neurocritical care and imaging, predicting which conservatively managed patients will deteriorate remains challenging. Identifying reliable risk factors for hematoma progression may help clinicians optimize monitoring strategies, determine the need for early surgical intervention, and improve patient outcomes.

The present study aims to evaluate the clinical and radiological risk factors associated with progression of conservatively managed acute traumatic subdural hematoma and to assess their impact on neurological outcomes and requirement for delayed surgical intervention.

MATERIALS AND METHODS

Study Design: This study was designed as a retrospective observational study conducted to evaluate the risk factors associated with progression of conservatively managed acute traumatic subdural hematoma (aSDH).

Study Setting: The study was carried out in the Department of Neurosurgery, Government General Hospital, Ongole.

Study Period: The duration of the study was one year.

Sample Size: A total of 60 patients diagnosed with acute traumatic subdural hematoma and managed conservatively were included in the study.

Inclusion Criteria

The following patients were included in the study:

- Adult patients aged ≥18 years with acute traumatic subdural hematoma confirmed by computed tomography (CT) scan.
- Patients managed conservatively without immediate surgical intervention according to neurosurgical guidelines.
- Patients with Glasgow Coma Scale (GCS) score ≥9 at admission.
- Patients available for follow-up clinical and radiological assessment.

Exclusion Criteria

The following patients were excluded from the study:

- Patients with penetrating head injury.
- Patients requiring immediate surgical evacuation according to Brain Trauma Foundation guidelines, such as hematoma thickness >10 mm with midline shift >5 mm and associated neurological deterioration.
- Patients with pre-existing severe neurological deficits unrelated to trauma.
- Pregnant women and patients with severe multisystem trauma affecting survival.
- Patients lost to follow-up before the first repeat CT scan.

Data Collection: Patient demographic details, history of trauma, clinical presentation, associated comorbidities, anticoagulant or antiplatelet therapy, and neurological examination findings were collected from hospital records and case sheets. Clinical information was obtained directly from the patient or close relatives wherever necessary. A structured questionnaire containing predominantly closed-ended questions was used for data collection.

Clinical Assessment: Neurological assessment was performed using the Glasgow Coma Scale (GCS) at admission and during follow-up. Functional outcomes were assessed using the Glasgow Outcome Scale (GOS) and Modified Rankin Scale (mRS).

Radiological Assessment: All patients underwent non-contrast CT brain imaging at admission. Serial CT scans were used to assess hematoma progression, increase in midline shift, and development of secondary intracranial lesions. Follow-up CT imaging was routinely performed within 24–48 hours

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after admission or earlier in cases of neurological deterioration.

CT scans were performed using thin-slice sections (≤5 mm) in axial, coronal, and sagittal planes for detailed evaluation of intracranial structures. Imaging parameters included tube voltage of 120 kV, tube current of 250–300 mA, and field of view of 250 mm. All CT images were independently reviewed by both a radiologist and a neurosurgeon to ensure consistency and accuracy in interpretation.

The following radiological parameters were evaluated:

- Hematoma thickness at the maximum point.
- Hematoma density using Hounsfield Units (HU).
- Midline shift.
- Shape and margin irregularity of the hematoma.
- Presence of associated contusions, hydrocephalus, or new intracranial hemorrhages.

Hematoma progression was defined as:

- ≥33% increase in hematoma volume,
- Increase in hematoma thickness by ≥5 mm, or
- Increase in midline shift by ≥3 mm on follow-up CT imaging.

Outcome Measures

Primary Outcome

The primary outcome was hematoma progression, defined as an increase in hematoma thickness by ≥2 mm on follow-up CT scan or development of new midline shift ≥3 mm.

Secondary Outcomes

Secondary outcomes included:

- Delayed surgical intervention following initial conservative management.
- Neurological deterioration, defined as decline in GCS by ≥2 points or development of new focal neurological deficits.
- Development of chronic subdural hematoma (cSDH) requiring surgical evacuation within 3 months.
- Functional outcomes assessed using Glasgow Outcome Scale (GOS) and Modified Rankin Scale (mRS) at 3 months.

Statistical Analysis: Data were entered and analyzed using appropriate statistical software. Categorical variables were expressed as frequencies and percentages, whereas continuous variables were represented as mean ± standard deviation. Data presentation was performed using tables, bar diagrams, and pie charts. Bivariate analysis was carried out using the Chi-square test to identify associations between risk factors and hematoma progression. A p-value <0.05 was considered statistically significant.

Ethical Considerations: Ethical approval for the study was obtained from the Institutional Ethics Committee prior to commencement of the study. Patient confidentiality and privacy were strictly maintained throughout the study period. Informed consent was obtained wherever applicable.

RESULTS

A total of 60 patients with acute traumatic subdural hematoma (aSDH) managed conservatively were included in the study. Among them, 18 patients (30%) demonstrated hematoma progression on follow-up CT imaging, while 42 patients (70%) showed no progression.

Table 1: Demographic Characteristics of Study Population

Variable	Number of Patients (n=60)	Percentage (%)
Age <40 years	18	30.0
Age 40–60 years	27	45.0
Age >60 years	15	25.0
Male	44	73.3
Female	16	26.7

The majority of patients belonged to the 40–60 years age group. Male predominance was observed in the study population.

Table 2: Incidence of Hematoma Progression

Hematoma Progression	Number of Patients	Percentage (%)
Present	18	30.0
Absent	42	70.0

Hematoma progression was observed in 30% of conservatively managed patients.

Table 3: Association Between Initial GCS Score and Hematoma Progression

Initial GCS Score	Progression Present (n=18)	Progression Absent (n=42)	p-value
9–12	12	10	0.003*
13–15	6	32	

*Statistically significant (p <0.05)

Patients with lower admission GCS scores (9–12) showed significantly higher rates of hematoma progression compared to patients with GCS 13–15.

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Table 4: Association of Anticoagulant/Antiplatelet Therapy With Hematoma Progression

Antithrombotic Therapy	Progression Present	Progression Absent	p-value
Present	8	5	0.01*
Absent	10	37	

*Statistically significant (p <0.05)

Patients receiving anticoagulant or antiplatelet therapy had a significantly increased risk of hematoma expansion.

Table 5: Association Between Hematoma Thickness and Progression

Hematoma Thickness	Progression Present	Progression Absent	p-value
≤10 mm	5	30	0.001*
>10 mm	13	12	

*Statistically significant (p <0.05)

Initial hematoma thickness greater than 10 mm was significantly associated with hematoma progression.

Table 6: Association Between Midline Shift and Hematoma Progression

Midline Shift	Progression Present	Progression Absent	p-value
≤5 mm	6	34	0.002*
>5 mm	12	8	

*Statistically significant (p <0.05)

Patients with midline shift greater than 5 mm demonstrated significantly higher hematoma progression rates.

Table 7: CT Characteristics Associated With Hematoma Progression

CT Finding	Progression Present (%)	Progression Absent (%)
Heterogeneous hematoma density	61.1	21.4
Irregular hematoma margins	55.6	16.7
Associated cerebral contusions	50.0	19.0
Basal cistern effacement	44.4	11.9

Heterogeneous density, irregular margins, associated contusions, and basal cistern effacement were more commonly observed in patients with hematoma progression.

Table 8: Neurological Deterioration and Delayed Surgery

Outcome	Number of Patients	Percentage (%)
Neurological deterioration	14	23.3
Delayed surgical intervention	10	16.7
Chronic SDH formation	6	10.0

Fourteen patients developed neurological deterioration during hospitalization, while delayed surgical evacuation was required in 10 patients.

Table 9: Functional Outcome at 3 Months

Outcome Measure	Good Outcome	Poor Outcome
Glasgow Outcome Scale (GOS 4–5)	46 (76.7%)	14 (23.3%)
Modified Rankin Scale (mRS 0–2)	43 (71.7%)	17 (28.3%)

Most patients demonstrated favorable functional outcomes at 3-month follow-up.

DISCUSSION

Acute traumatic subdural hematoma (aSDH) remains one of the most serious consequences of traumatic brain injury (TBI), with significant risk of neurological deterioration even in patients initially managed conservatively. The present study evaluated the clinical and radiological predictors associated with hematoma progression in conservatively managed aSDH patients and demonstrated that lower admission Glasgow Coma Scale (GCS) score, antithrombotic therapy, greater hematoma thickness, and significant midline shift were strongly associated with hematoma expansion and poorer outcomes.

In the present study, hematoma progression was observed in 30% of patients. Similar findings were reported by Matsumoto et al,[3] who demonstrated progression rates ranging between 20–35% in conservatively managed traumatic subdural hematomas. Likewise, Alahmadi et al,[4] observed that approximately one-third of patients with traumatic intracranial hemorrhage experienced radiological progression during early follow-up imaging. The similarity in progression rates may be attributed to comparable inclusion criteria and use of serial CT imaging for monitoring hematoma expansion.

Lower admission GCS score was significantly associated with hematoma progression in the current study. Patients with GCS scores between 9 and 12 demonstrated higher rates of deterioration compared to patients with milder injuries. This finding correlates with the observations of Servadei et al,[5] who reported that lower GCS at admission is an important predictor of worsening intracranial pathology and delayed surgical intervention. Similarly, Kim et al,[6] found that patients presenting with reduced consciousness are more likely to develop progressive hemorrhagic injury due to

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impaired cerebral autoregulation and secondary brain insult.

The present study also demonstrated a strong association between anticoagulant or antiplatelet therapy and hematoma expansion. Patients receiving antithrombotic medications showed significantly higher progression rates compared to those not receiving such therapy. Similar findings were reported by Batchelor and Grayson,[7] who emphasized the increased risk of intracranial hemorrhage expansion in anticoagulated patients following head injury. More recently, Jean-Marc Chauny et al,[8] observed that direct oral anticoagulants and antiplatelet agents significantly increase delayed hemorrhagic progression in traumatic brain injury patients. The impaired clot stabilization and persistent microvascular bleeding associated with anticoagulant therapy may explain this increased risk.

Radiological parameters were found to be strong predictors of hematoma progression in the current study. Hematoma thickness greater than 10 mm and midline shift greater than 5 mm were significantly associated with delayed deterioration. These findings are consistent with the Brain Trauma Foundation guidelines, which identify these radiological thresholds as indicators of severe mass effect and possible surgical requirement. Similar observations were reported by Zumkeller et al,[9] who demonstrated that larger hematoma size and significant midline shift correlate strongly with elevated intracranial pressure and poor neurological outcome. Furthermore, Lee et al. identified hematoma thickness and degree of midline shift as independent predictors of delayed hematoma expansion.

In the present study, heterogeneous hematoma density, irregular hematoma margins, and associated cerebral contusions were more frequently observed in patients with progression. These findings support the hypothesis that mixed-density hematomas may represent active or recurrent bleeding. Similar conclusions were drawn by Oertel et al,[10] who described heterogeneous density patterns as indicators of ongoing hemorrhage and instability. Additionally, Kobayashi S et al,[11] reported that associated cerebral contusions and diffuse brain injury significantly increase the risk of delayed hematoma enlargement due to disruption of the blood-brain barrier and secondary inflammatory changes.

Neurological deterioration occurred in 23.3% of patients in the present study, and delayed surgical intervention was required in 16.7% of cases. Comparable findings were reported by Ko et al,[12] who found that approximately 15–20% of conservatively managed aSDH patients eventually required surgery due to worsening neurological status or radiological progression. Early recognition of high-risk patients may therefore reduce delays in surgical intervention and improve functional outcomes.

Regarding long-term outcomes, most patients in the present study achieved favorable Glasgow Outcome Scale (GOS) and Modified Rankin Scale (mRS) scores at 3 months. However, patients with hematoma progression had relatively poorer neurological recovery. Similar results were noted by Stocchetti et al,[13] who demonstrated that hematoma expansion is strongly associated with secondary brain injury, prolonged hospitalization, and unfavorable functional outcome. The poorer outcomes observed in progressive hematomas may be related to increased intracranial pressure, cerebral ischemia, and delayed intervention.

The findings of the present study highlight the importance of close clinical and radiological monitoring in conservatively managed acute traumatic subdural hematoma patients. Identification of high-risk features such as low admission GCS, anticoagulant use, large hematoma thickness, and significant midline shift may help clinicians predict deterioration earlier and optimize management strategies. Serial CT imaging remains an essential tool for early detection of hematoma progression and prevention of secondary neurological injury.[14]

However, the study has certain limitations. The relatively small sample size and single-center retrospective design may limit the generalizability of the findings. In addition, variations in timing of repeat CT imaging and treatment protocols may have influenced the observed progression rates. Larger multicenter prospective studies are required to validate these findings and establish standardized predictive models for hematoma progression in conservatively managed aSDH patients.

CONCLUSION

Lower GCS score, anticoagulant therapy, larger hematoma thickness, and significant midline shift are important predictors of hematoma progression in conservatively managed aSDH patients. Early identification of these high-risk factors and close radiological monitoring may help reduce neurological deterioration and improve clinical outcomes.

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