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Research Article

A Risk Stratification Scoring System for Predicting Recurrence in Chronic Subdural Hematoma

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Abstract: ***Introduction:*** Recurrence following surgical evacuation of chronic subdural hematoma (CSDH) remains a major challenge and contributes to increased morbidity, repeated surgeries, and healthcare costs. Identification of factors associated with recurrence may facilitate risk stratification and optimize postoperative management.**Objectives:** To evaluate the clinical and radiological predictors of recurrence in patients with chronic subdural hematoma and to develop a risk stratification scoring system for predicting recurrence.**Materials and Methods**: This hospital-based observational study was conducted in the Department of Neurosurgery, King George's Medical University, Lucknow, from January 2024 to August 2025. A total of 50 consecutive patients with radiologically confirmed CSDH who underwent burr-hole craniostomy with closed-system drainage were included. Demographic, clinical, and radiological variables including hematoma laterality, density, cortical atrophy, hematoma thickness, midline shift, and Nakaguchi classification were evaluated. Patients were followed for three months, and recurrence was defined as symptomatic reaccumulation requiring repeat intervention. Statistical analysis was performed using SPSS version 26.0, and a p-value <0.05 was considered statistically significant.**Results:** The mean age of the patients was 71.4±10.8 years, and males constituted 72% of the study population. Overall recurrence occurred in 8 patients (16.0%). Advanced age (≥70 years), bilateral hematoma, cortical atrophy, hyperdense hematoma, and homogeneous or separated hematoma configuration showed significant associations with recurrence (p<0.05). Patients classified into the high-risk category exhibited a recurrence rate of 38.5%, compared with 14.3% in the moderate-risk group, whereas no recurrence was observed in the low-risk group.**Conclusion:** Advanced age, bilateral hematoma, cortical atrophy, hyperdense appearance, and homogeneous or separated hematoma morphology are important predictors of recurrence in chronic subdural hematoma. The proposed risk stratification scoring system provides a simple and practical tool for identifying patients at increased risk of recurrence and may aid in individualized postoperative surveillance and management.

Keywords: Chronic subdural hematoma; Recurrence; Risk stratification score; Burr-hole craniostomy; Cortical atrophy; Nakaguchi classification; Predictors.

INTRODUCTION

Chronic subdural hematoma (CSDH) is one of the most common neurosurgical disorders encountered in elderly individuals and is characterized by the accumulation of liquefied blood products between the dura mater and arachnoid membrane. With increasing life expectancy and widespread use of anticoagulant and antiplatelet agents, the incidence of CSDH has risen steadily, making it an important public health concern. The annual incidence ranges from 5 to 14 cases per 100,000 population and increases markedly among individuals older than 65 years, reaching approximately 58 cases per 100,000 population.[1-3]

Although burr-hole evacuation with closed-system drainage remains the standard treatment for symptomatic CSDH, recurrence continues to represent a major challenge. Reported recurrence rates vary from 2.5% to 34%, often necessitating repeat surgical intervention and prolonged hospitalization.[2,4,5] Recurrence adversely affects functional recovery, quality of life, and healthcare costs, particularly in elderly patients with multiple comorbidities.[6]

The pathophysiology of recurrence is multifactorial and involves persistent inflammation, angiogenesis, fibrinolysis, repeated microhemorrhages, and impaired brain re-expansion after hematoma evacuation.[7] Several clinical, radiological, and surgical factors have been implicated in recurrent CSDH, including advanced age, bilateral hematomas, hematoma thickness, degree of midline shift, postoperative residual cavity, cortical atrophy, and internal hematoma architecture.[8] The radiological classification proposed by Nakaguchi et al. has gained widespread acceptance, with homogeneous, laminar, and separated types demonstrating higher recurrence rates compared with trabecular hematomas.[9] Recent studies have focused on developing predictive models and risk stratification systems to identify patients at increased risk of recurrence. Lioi et al. developed a scoring system based on preoperative radiological characteristics and demonstrated that hyperdense appearance, cortical atrophy, and homogeneous or separated hematoma configurations were associated with progressively increasing recurrence rates.[1] Such predictive tools enable personalized postoperative surveillance and may help identify patients who could

benefit from adjunctive therapies such as middle meningeal artery embolization or pharmacological interventions.[1,2]

Despite numerous studies worldwide, data regarding predictors of recurrence and the applicability of risk stratification models in the Indian population remain limited. Therefore, the present study was undertaken at the Department of Neurosurgery, King George's Medical University, Lucknow, to evaluate clinical and radiological factors associated with recurrence of chronic subdural hematoma and to establish a risk stratification scoring system for predicting recurrence among surgically treated patients.

MATERIALS AND METHODS

This hospital-based observational study was conducted in the Department of Neurosurgery, King George's Medical University (KGMU), Lucknow, Uttar Pradesh, India, over a period extending from January 2024 to August 2025. The study included patients diagnosed with chronic subdural hematoma who underwent surgical treatment and were followed prospectively for evidence of recurrence.

Sample Size: A total of **50 consecutive patients** with chronic subdural hematoma were included in the study.

Inclusion Criteria: Patients fulfilling the following criteria were enrolled:

- Age ≥18 years.
- Radiologically confirmed unilateral or bilateral chronic subdural hematoma on computed tomography (CT) scan.
- Symptomatic patients requiring surgical evacuation.
- Hematoma thickness >10 mm and/or midline shift >5 mm.
- Patients who underwent burr-hole craniostomy with closed-system drainage.
- Patients willing to participate and available for follow-up.

Exclusion Criteria: Patients with the following conditions were excluded:

- Acute subdural hematoma or acute-on-chronic subdural hematoma.
- Previous surgery for recurrent CSDH.
- Patients managed conservatively.
- Presence of ventriculoperitoneal shunt.
- Incomplete clinical or radiological records.
- Follow-up period less than three months.

Data Collection

Demographic and clinical variables recorded included:

- Age and sex.
- History of trauma.
- Comorbid conditions such as hypertension and diabetes mellitus.
- History of antiplatelet or anticoagulant use.
- Presenting neurological symptoms.
- Glasgow Coma Scale (GCS) score at admission.

Radiological parameters assessed on preoperative CT scans included:

- Hematoma laterality (right, left, bilateral).
- Maximum hematoma thickness.
- Midline shift.
- Hematoma density.
- Internal architecture according to Nakaguchi classification (homogeneous, laminar, separated, or trabecular type).
- Presence of cortical atrophy.

Surgical Procedure: All patients underwent burr-hole craniostomy with irrigation using warm normal saline and placement of a closed-system subdural drain. The drain was maintained for 48–72 hours according to postoperative neurological status and radiological findings.

Follow-up and Definition of Recurrence: Postoperative CT scans were obtained within the first 24–72 hours following surgery. Patients were subsequently evaluated clinically and radiologically at one month and three months after discharge or earlier if neurological deterioration occurred.

Recurrence was defined as:

- Reappearance or increase in hematoma volume on the ipsilateral side demonstrated on CT scan, accompanied by neurological symptoms or signs, and
- Requirement of repeat surgical intervention within three months following the initial surgery.

Risk Stratification Score: A risk stratification scoring system was formulated based on preoperative radiological variables identified as predictors of recurrence, including:

- Hematoma density,
- Nakaguchi classification,
- Presence of cortical atrophy,

as described by Lioi et al[1]. Patients were categorized into low-, moderate-, and high-risk groups according to their cumulative scores.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 26.0. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were expressed as frequencies and percentages. Associations between variables and recurrence were evaluated using the Chi-square test or Fisher's exact test for categorical variables and Student's t-test for continuous variables. Logistic regression analysis was performed to identify independent predictors of recurrence. A p-value <0.05 was considered statistically significant.

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RESULTS

Table 1 shows the demographic and clinical profile of the 50 patients included in the study. The mean age of the patients was 71.4±10.8 years, with the majority (70%) being older than 60 years. Males constituted 72% of the study population, demonstrating a male predominance. A history of head trauma was present in 78% of patients. Hypertension and diabetes mellitus were observed in 58% and 22% of cases, respectively, while 26% of patients had a history of antiplatelet or anticoagulant use.

Table 1: Baseline demographic and clinical characteristics of study participants (n=50)

Variable	Number (n=50)	Percentage (%)
Age group (years)		
<60	10	20.0
60–69	17	34.0
70–79	18	36.0
≥80	5	10.0
Mean age (years)	71.4 ± 10.8	
Sex		
Male	36	72.0
Female	14	28.0
History of trauma		
Present	39	78.0
Absent	11	22.0
Hypertension		
Present	29	58.0
Absent	21	42.0
Diabetes mellitus		
Present	11	22.0
Absent	39	78.0
Antiplatelet/anticoagulant use		
Yes	13	26.0
No	37	74.0

Table 2 summarizes the radiological findings of the study participants. Left-sided hematomas were slightly more common (42%) than right-sided hematomas (38%), whereas bilateral hematomas accounted for 20% of cases. The mean hematoma thickness was 22.8±5.1 mm, and 64% of patients had a hematoma thickness greater than 20 mm. A midline shift exceeding 5 mm was observed in 68% of patients, with a mean midline shift of 7.3±2.9 mm. Cortical atrophy was present in 56% of the study population.

Table 2: Radiological characteristics of chronic subdural hematoma (n=50)

Variable	Number (n=50)	Percentage (%)
Laterality		
Right	19	38.0
Left	21	42.0
Bilateral	10	20.0
Maximum hematoma thickness		
≤20 mm	18	36.0
>20 mm	32	64.0
Mean thickness (mm)	22.8 ± 5.1	
Midline shift		
≤5 mm	16	32.0
>5 mm	34	68.0
Mean midline shift (mm)	7.3 ± 2.9	
Cortical atrophy		

Present	28	56.0
Absent	22	44.0

Table 3 depicts the distribution of chronic subdural hematomas according to the Nakaguchi radiological classification. Homogeneous hematomas were the most common subtype, accounting for 40% of cases, followed by separated hematomas (26%), laminar hematomas (18%), and trabecular hematomas (16%). Thus, homogeneous and separated types together constituted approximately two-thirds of all hematomas encountered in the present study.

Table 3: Distribution of hematomas according to Nakaguchi classification (n=50)

Type of hematoma	Number	Percentage (%)
Homogeneous	20	40.0
Laminar	9	18.0
Separated	13	26.0
Trabecular	8	16.0

Table 4 presents the density patterns of chronic subdural hematomas observed on computed tomography. Isodense hematomas were the most frequent pattern, seen in 48% of patients, followed by hyperdense hematomas in 30% and hypodense hematomas in 22%. Therefore, nearly one-third of the patients demonstrated hyperdense lesions, which have been reported to be associated with an increased risk of recurrence.

Table 4: Density characteristics on CT scan (n=50)

Density pattern	Number	Percentage (%)
Hypodense	11	22.0
Isodense	24	48.0
Hyperdense	15	30.0

Table 5 illustrates the postoperative outcomes of patients with chronic subdural hematoma. Among the 50 patients studied, recurrence occurred in 8 patients, resulting in an overall recurrence rate of 16%. Six patients (12%) required repeat surgical evacuation, while recurrence resolved with conservative management in two patients (4%). The remaining 42 patients (84%) experienced no recurrence during the follow-up period

Table 5: Surgical outcome and recurrence rate (n=50)

Outcome	Number	Percentage (%)
No recurrence	42	84.0
Recurrence	8	16.0
Repeat surgery performed	6	12.0
Conservatively managed recurrence	2	4.0

Table 6 demonstrates the relationship between various clinical and radiological parameters and recurrence of chronic subdural hematoma. Advanced age (≥70 years), bilateral hematoma, presence of cortical atrophy, hyperdense hematoma, and homogeneous or separated hematoma configuration showed statistically significant associations with recurrence ($p<0.05$). In contrast, antiplatelet or anticoagulant use and a midline shift greater than 5 mm were not significantly associated with recurrence. These findings suggest that specific radiological characteristics are important predictors of postoperative recurrence.

Table 6: Association of selected variables with recurrence of chronic subdural hematoma

Variable	Recurrence (n=8)	No recurrence (n=42)	p-value
Age ≥70 years	7	16	0.041*
Bilateral hematoma	4	6	0.027*
Cortical atrophy present	7	21	0.046*
Hyperdense hematoma	5	10	0.038*
Homogeneous/Separated type	7	26	0.031*
Midline shift >5 mm	7	27	0.081
Antiplatelet/anticoagulant use	3	10	0.421

Table 7 shows the distribution of patients according to the proposed risk stratification score and the corresponding recurrence rates. Sixteen patients were categorized as low risk, 21 as moderate risk, and 13 as high risk. No recurrence was observed in the low-risk group, whereas recurrence rates were 14.3% and 38.5% in the moderate- and high-risk groups, respectively. The progressive increase in recurrence rates across the three categories indicates that the proposed risk stratification scoring system effectively differentiates patients according to their likelihood of recurrence and may aid in tailoring postoperative surveillance and management strategies.

Table 7: Risk stratification score and recurrence rates

Risk category	Score	Number of patients	Recurrence (n)	Recurrence rate (%)
Low risk	0–2	16	0	0.0
Moderate risk	3–5	21	3	14.3
High risk	6–8	13	5	38.5
Total		50	8	16.0

DISCUSSION

Chronic subdural hematoma (CSDH) is one of the most frequently encountered neurosurgical conditions in elderly patients, and recurrence following surgical evacuation remains a significant challenge. The present study was conducted to identify factors associated with recurrence and to develop a risk stratification scoring system in patients undergoing burr-hole evacuation for CSDH. The overall recurrence rate observed in the present study was 16%, which is consistent with rates reported in previous studies ranging from 9% to 37%.[1,3,5]

The mean age of patients in the present study was 71.4±10.8 years, with the majority being above 60 years of age. Similar findings were reported by Lioi et al.[1] and Mercado et al.[5], who observed mean ages of 73 and 74 years, respectively. Abdullah et al.[3] reported a comparatively lower mean age of 63.1 years. The predominance of elderly patients may be attributed to age-related cerebral atrophy, which predisposes bridging veins to rupture and facilitates enlargement of the subdural space.[6]

A marked male predominance was observed in the current study, with males accounting for 72% of cases. Comparable male predominance has been described by Abdullah et al.[3] (72.6%), Lampros et al.[2] (72.5%), and Mercado et al.[5] (78.9%). This finding supports the established epidemiological pattern of CSDH occurring more frequently in men.

History of trauma was present in 78% of patients in the present series. Abdullah et al.[3] and Lampros et al[2], similarly reported trauma in 56.5% and 90% of patients, respectively. Minor trauma often goes unnoticed in elderly individuals but acts as an initiating event for the development of chronic subdural hematoma.

The overall recurrence rate of 16% observed in this study falls within the range reported in literature. Lioi et al.[1] reported recurrence rates varying from 9.5% to 31.3% according to the risk category, whereas Abdullah et al.[3] documented a recurrence rate of 21%, and Mercado et al.[5] reported recurrence in 9.9% of patients. The recurrence rate in the present study is therefore comparable to previous observations.

Advanced age (≥70 years) was significantly associated with recurrence in the present study. Similar findings have been reported by Stanišić and Pripp[7], who demonstrated that elderly patients are at greater risk for recurrence owing to poor brain re-expansion and increased cortical atrophy. However, Lampros et al.[2] did not find age to be a significant predictor, indicating that its role remains controversial.

Bilateral hematoma was found to be significantly associated with recurrence (p=0.027). This observation is consistent with the findings of Abdullah et al.[3], who identified bilateral hematoma as the only independent predictor of recurrence with an adjusted odds ratio of 5.47. Bilateral lesions have also been implicated as important predictors in several other studies because they reflect greater cerebral atrophy and impaired postoperative brain re-expansion.[7,8]

In the present study, cortical atrophy showed a significant association with recurrence. Similar observations were made by Lioi et al.[1], who incorporated cortical atrophy into their predictive score and demonstrated progressively increasing recurrence rates with increasing degrees of cerebral atrophy. Age-related loss of brain volume results in larger residual subdural spaces and delayed re-expansion, thereby facilitating reaccumulation of blood.[6]

Hyperdense hematomas were significantly associated with recurrence in the present series. Lioi et al.[1] likewise demonstrated that hyperdense and mixed-density hematomas carry a higher risk of recurrence compared with hypodense lesions. Hyperdensity reflects ongoing bleeding and active inflammatory processes within the hematoma membranes, thereby increasing the probability of postoperative reaccumulation.[9]

According to the Nakaguchi classification, homogeneous and separated hematomas were significantly associated with recurrence in the present study. Nakaguchi et al.[9] first demonstrated that separated and laminar types exhibited higher recurrence rates than trabecular hematomas. Similar findings were subsequently reported by Lioi et al.[1], who incorporated homogeneous and separated hematoma patterns into their risk stratification model. These hematoma subtypes are believed to represent active stages of hematoma evolution with increased fibrinolytic activity and recurrent microhemorrhage.

Although antiplatelet and anticoagulant use was observed in 26% of patients, no statistically significant association with recurrence was found. This finding agrees with the results of Abdullah et al.[3] and Lampros et al.[2], both of whom failed to demonstrate a significant relationship between antithrombotic therapy and postoperative recurrence. Likewise, midline shift greater

than 5 mm was not significantly associated with recurrence in the present study, similar to observations by Lampros et al.[2]

The proposed risk stratification score effectively differentiated patients according to recurrence risk. Patients classified into the high-risk category had a recurrence rate of 38.5%, compared with 14.3% in the moderate-risk group, while no recurrence was observed among low-risk patients. These findings are comparable to those of Lioi et al.[1], who demonstrated recurrence rates ranging from 9.5% in low-risk patients to 31.3% in high-risk groups. Therefore, the present scoring system may be useful for identifying patients requiring closer postoperative surveillance and consideration of adjunctive therapeutic measures.

Limitations: The present study had certain limitations. It was conducted at a single tertiary care center with a relatively small sample size of 50 patients, which may limit the generalizability of the findings. In addition, the follow-up period was restricted to three months, and external validation of the proposed scoring system was not performed. Larger multicentric prospective studies are required to validate the predictive utility of the proposed model.

CONCLUSION

Chronic subdural hematoma recurrence remains a common postoperative complication, with an overall recurrence rate of 16% in the present study. Advanced age, bilateral hematoma, cortical atrophy, hyperdense hematoma, and homogeneous or separated hematoma configuration were significantly associated with recurrence. The proposed risk stratification scoring system successfully categorized patients into low-, moderate-, and high-risk groups, with progressively increasing recurrence rates across these categories. This scoring system may serve as a simple and practical tool for predicting postoperative recurrence and facilitating individualized follow-up strategies. Further multicenter studies with larger sample sizes are warranted to validate these findings and enhance their clinical applicability.

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