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Original Research Article

Distribution and Computed Tomography Characteristics of Subdural and Epidural Hematomas in Adult Patients with Head Trauma: A Prospective Observational Study

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ABSTRACT:

Introduction: Traumatic subdural hematoma (SDH) and epidural hematoma (EDH) are major extra-axial hemorrhages requiring prompt detection. Non-contrast computed tomography (NCCT) is the primary imaging modality, and hematoma thickness and midline shift are key measures of mass effect. This study assessed the distribution and CT characteristics of traumatic SDH, EDH, and combined SDH/EDH in adults with head trauma. **Methods**: This prospective observational study was conducted in the Department of Radiodiagnosis and Medical Imaging at a tertiary care center in Nepal from November 2025 to May 2026. Adult patients aged ≥18 years with traumatic SDH, EDH, or combined SDH/EDH on NCCT were consecutively enrolled. Hematoma category, maximum hematoma thickness, and midline shift were recorded. Data were analyzed using PSPP 2.1.1. The Kruskal–Wallis test, chi-square test, and Spearman's rank correlation were used, with $p < 0.05$ considered significant. **Results**: A total of 150 patients were included (mean age, 50.81 ± 17.92 years; 74.00% male). SDH was the most frequent category, followed by EDH and combined SDH/EDH. EDH had the greatest mean maximum thickness, and the difference among categories was significant ($H = 18.43$, $p < 0.001$). Midline shift occurred in 45 (30.00%) patients and did not differ significantly across categories ($p = 0.13$). No significant correlation was found between maximum hematoma thickness and midline-shift magnitude ($\rho = 0.02$, $p = 0.88$). **Conclusions**: SDH was the predominant extra-axial hematoma, while EDH had the greatest thickness. Thickness and midline shift appear to provide complementary rather than interchangeable information. NCCT remains essential for characterizing these lesions.

Keywords: Computed tomography; Epidural hematoma; Head trauma; Midline shift; Subdural hematoma.

INTRODUCTION:

Traumatic brain injury (TBI) is a major cause of death and disability worldwide and is a major public health problem. Rapid identification of intracranial hemorrhage is essential because traumatic intracranial lesions may progress rapidly and require immediate neurosurgical intervention.[1] Non-contrast computed tomography (NCCT) is the primary imaging examination for patients with suspected clinically significant TBI because it is rapid, widely available, and highly effective for detecting acute intracranial hemorrhage, skull fractures, and mass effect. Current clinical guidance recommends NCCT as the principal initial imaging investigation when clinically significant TBI is suspected.[2]

Subdural hematoma (SDH) and epidural

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hematoma (EDH) are major types of traumatic extra-axial hemorrhage.[3,4] Acute SDH most commonly results from tearing of the bridging veins and typically appears on CT as a crescent-shaped extra-axial collection. EDH is commonly associated with injury to the meningeal arteries or other vessels and characteristically appears as a biconvex or lentiform extra-axial collection.[5,6] Hematoma thickness and midline shift are important CT measures of mass effect in these lesions.[7] In acute SDH, hematoma thickness greater than 10 mm or midline shift greater than five mm are radiological criteria considered in surgical decision-making, along with clinical status and other factors.[7,8] Previous studies have also shown that these measurements may have prognostic value in acute traumatic SDH.[8,9] However, data on the distribution and CT characteristics of these hematomas in our setting are limited. The present study assessed the distribution and CT measurements of traumatic SDH, EDH, and combined SDH/EDH in adults with head trauma.

METHODS:

This prospective observational study was conducted in the Department of Radiodiagnosis and Medical Imaging at Universal College of Medical Sciences and Teaching Hospital (UCMS-TH), Bhairahawa, Nepal, from November 2025 to May 2026. Ethical approval was obtained from the Institutional Review Committee of UCMS-TH (Ref. No. UCMS/IRC/164/25). Written informed consent was obtained from the legal guardian of each patient. Patient confidentiality was maintained, and data were analyzed anonymously without patient identifiers.

Adult patients aged ≥18 years with traumatic subdural hematoma (SDH), epidural hematoma (EDH), or combined SDH and EDH diagnosed on non-contrast computed tomography (NCCT) of the brain were consecutively enrolled. Patients with incomplete imaging data were excluded.

The sample size was calculated using the formula $n = Z^2p(1-p)/d^2$, with Z = 1.96 for a 95% confidence level, p = 42.1% (based on the proportion of extra-axial hematomas reported in a previous study from a similar population),[10] and d = 8% margin of error. An 8% margin of error was chosen pragmatically to ensure a feasible sample size within the study period and resources available at a single tertiary care center, while maintaining adequate precision for the primary descriptive objectives. The calculated sample size was 146.3, and 150 participants were included in the study.

NCCT brain examinations were performed using a GE 128-slice Revolution Maxima CT scanner with five mm axial sections. The images were reviewed independently by two radiologists to determine the hematoma category, SDH thickness, EDH thickness, maximum hematoma thickness, and midline shift; discrepancies were resolved by consensus. Maximum hematoma thickness was defined as the greatest perpendicular distance between the inner and outer margins of the hematoma on the axial CT slice showing the greatest thickness. In isolated SDH or EDH, the maximum thickness of the respective hematoma was recorded. In combined SDH and EDH, the thickness of each hematoma was measured separately, and the larger measurement was recorded as the maximum hematoma thickness for analysis. Midline shift was measured at the level of the septum pellucidum as the perpendicular distance between the anatomical midline and the displaced septum pellucidum. The presence, magnitude (mm), and direction of midline shift were recorded.

Data were analyzed using PSPP 2.1.1. Continuous variables were summarized as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The chi-square test was used to assess associations between hematoma category and categorical variables, while the Kruskal–Wallis test was used to compare maximum hematoma thickness among the three hematoma categories. Spearman's rank correlation was used to assess the relationship between maximum hematoma thickness and midline-shift magnitude among patients with measurable midline shift. A p-value <0.05 was considered statistically significant.

RESULTS:

A total of 150 adult patients with traumatic SDH, EDH, or combined SDH and EDH were included in the study. The mean age was 50.81 ± 17.92 years, ranging from 18 to 80 years. There were 111 (74.00%) males and 39 (26.00%) females, giving a male-to-female ratio of 2.85:1 (**Table 1**).

SDH was the most frequent hematoma category, followed by EDH and combined SDH and EDH. The mean age and sex distribution did not differ significantly among the three categories (**Table 2**).

EDH had the greatest mean maximum hematoma thickness, followed by SDH and combined SDH and EDH. The difference in maximum hematoma thickness among the three

Table 1. *Demographic characteristics of the study population (n = 150)*

Characteristic		n	%
Sex	Male	111	74.00
	Female	39	26.00
Age group (years)	18–29	20	13.33
	30–39	27	18.00
	40–49	24	16.00
	50–59	22	14.67
	60–69	29	19.33
	70–80	28	18.67

Table 2. *Demographic distribution according to hematoma category*

Hematoma category	n	%	Age, mean ± SD (years)	Male, n (%)	Female, n (%)
SDH	101	67.33	51.15 ± 17.60	79 (78.22)	22 (21.78)
EDH	28	18.67	47.25 ± 17.52	19 (67.86)	9 (32.14)
Combined SDH and EDH	21	14.00	53.90 ± 20.01	13 (61.90)	8 (38.10)
Test statistic			H = 2.00	χ^2=3.08 (df = 2)	
p-value			0.37	0.21	

SDH—subdural hematoma; EDH—epidural hematoma; H—Kruskal–Wallis test statistic; χ^2—chi-square test statistic; df—degrees of freedom.

Table 3. *Maximum hematoma thickness according to hematoma category*

Hematoma category	n (%)	Mean ± SD (mm)	Range (mm)
SDH	101(67.33)	14.96 ± 5.90	4.90–24.80
EDH	28 (18.67)	22.55 ± 9.67	5.40–39.50
Combined SDH and EDH	21 (14.00)	13.39 ± 3.33	8.30–18.70
H*		18.43	
p-value		<0.001	

**H—Kruskal–Wallis test statistic*

Table 4. *Midline-shift findings according to hematoma category*

Hematoma category	n (%)	MLS present, n (%)	MLS absent, n (%)	MLS when present, mean ± SD (mm)
SDH	101 (67.33)	26 (25.74)	75 (74.26)	9.60 ± 3.33
EDH	28 (18.67)	9 (32.14)	19 (67.86)	10.30 ± 4.71
Combined SDH and EDH	21 (14.00)	10 (47.62)	11 (52.38)	9.88 ± 3.81
χ^2		4.04 (df = 2)		
p-value		0.13		

MLS—midline shift

groups was statistically significant (H = 18.43, $p < 0.001$) (**Table 3**). Post-hoc pairwise comparisons showed that EDH thickness was significantly greater than both SDH and combined SDH/EDH ($p < 0.05$ for both), while SDH and combined SDH/EDH did not differ significantly.

Midline shift was present in 26 (25.74%) patients with SDH, 9 (32.14%) with EDH, and 10 (47.62%) with combined SDH and EDH. The occurrence of midline shift did not differ significantly across the three hematoma categories ($\chi^2 = 4.04$, df = 2, p = 0.13). No significant correlation was observed between maximum hematoma thickness and midline-shift magnitude in the 45 patients with measurable midline shift (Spearman's $\rho = 0.02$, p = 0.88) (**Table 4**).

DISCUSSION:

This study evaluated the distribution and CT measurements of traumatic subdural hematoma (SDH) and epidural hematoma (EDH) in 150 adults with head trauma. SDH was the most frequent hematoma category, followed by EDH and combined SDH and EDH. The predominance of SDH is consistent with previous studies reporting SDH as a common traumatic extra-axial hemorrhage.[5,11,12] The male predominance observed in the present study is also consistent with the higher occurrence of traumatic brain injury among males reported by Maas et al.1 and Aromatario et al.[11]

The epidural hematoma group had the greatest mean maximum thickness, and the overall difference among the three categories was statistically significant (H = 18.43, $p < 0.001$) (**Table 3**). This finding may partly reflect differences in the anatomical configuration of the lesions. Epidural hematomas are commonly biconvex or lentiform and may accumulate between the skull and dura, whereas subdural hematomas spread along the cerebral surface in a crescentic configuration. These different patterns may influence the maximum perpendicular thickness measured on axial CT.[3,4] Similar findings have been reported in previous studies, where EDH demonstrated greater thickness than SDH on CT, although SDH was associated with greater midline shift.[13,14]

Midline shift was present in 45 (30.00%) patients and occurred across all hematoma categories, most frequently in combined SDH and EDH, although the difference among categories was not statistically significant ($\chi^2 = 4.04$, df = 2, $p = 0.13$) (**Table 4**). These findings indicate that midline shift should be considered an important CT marker of mass effect regardless of hematoma category. The relatively small numbers of patients in the EDH and combined groups may have limited the statistical power to detect differences among hematoma categories. Among patients with midline shift, the mean magnitude was similar across categories (9.60 ± 3.33 mm in SDH, 10.30 ± 4.71 mm in EDH, and 9.88 ± 3.81 mm in combined hematomas).

In the present study, no significant correlation was observed between maximum hematoma thickness and midline-shift magnitude among the 45 patients with measurable midline shift (Spearman's $\rho = 0.02$, $p = 0.88$). This finding suggests that, within this study population, greater hematoma thickness was not associated with greater midline shift. Midline shift may be influenced by other factors, including hematoma location, cerebral edema, associated contusions, hydrocephalus, and age-related cerebral atrophy, which were not specifically evaluated in this study.

The relationship between hematoma thickness and midline shift may itself carry prognostic significance. A recent study demonstrated that a mismatch between midline shift and hematoma thickness, the Zumkeller Index, was an independent predictor of mortality in patients with acute subdural hematoma.[15] It suggested that the difference between these two measurements provides information beyond either value alone. Previous work has identified specific thresholds at which hematoma thickness and midline shift become prognostically significant. For example, a hematoma thickness of approximately 17 mm and midline shift of 15 mm were associated with 50% survival in patients with acute subdural hematoma.[16] These findings further support the notion that thickness and midline shift contribute independent and complementary prognostic information.

Taken together, these observations indicate that hematoma thickness and midline shift should be regarded as complementary rather than interchangeable CT parameters. Current recommendations for traumatic SDH and EDH incorporate imaging findings together with neurological status and other clinical factors when considering surgical management.[3,4] The measurements reported in this study should be interpreted within the broader clinical and radiological context rather than as isolated indicators of management or prognosis.

Beyond individual measurements, composite CT features, including the presence of subarachnoid blood and the overall appearance of the scan, have been shown to independently predict survival after head injury.[9] This adds prognostic value beyond clinical variables such as age, Glasgow Coma Score, and pupil reaction.

This study has several limitations. It was conducted at a single center with a relatively modest sample size, which may limit the generalizability of the findings. The margin of error was set at 8.00% rather than the conventional 5.00%, primarily due to resource and time constraints at a single tertiary care center; this may have limited the precision of our estimates. Because only patients with traumatic SDH and/or EDH were included, the study cannot estimate the incidence or prevalence of these lesions among all patients presenting with head trauma. Clinical severity, treatment, and patient outcomes were not assessed. Other potentially relevant CT findings, including hematoma volume, skull fractures, cerebral contusions, traumatic subarachnoid hemorrhage, cerebral edema, and basal cistern status, were also not evaluated. In addition, interobserver variability and measurement reproducibility were not assessed. As an observational study, no causal inferences can be drawn. These limitations should be considered when interpreting the absence of a significant relationship between hematoma thickness and midline shift.

Future research should address several gaps identified in this study. Multicenter prospective studies with larger sample sizes are needed to confirm these findings and improve generalizability. Such studies should incorporate volumetric assessment of hematomas, which may correlate better with mass effect and clinical outcomes than linear thickness measurements alone. The inclusion of clinical severity scores (e.g., Glasgow Coma Scale), neurological outcomes, and surgical decision-making data would help establish the prognostic value of CT measurements. Also, future studies should evaluate the role of associated intracranial injuries such as cerebral contusions, traumatic subarachnoid hemorrhage, and cerebral edema, and their influence in midline shift and clinical outcomes.

Interobserver reproducibility of CT measurements should also be assessed to ensure consistency across raters. Finally, longitudinal follow-up studies are warranted to determine whether hematoma thickness and midline shift at presentation predict long-term functional outcomes in patients with traumatic extra-axial hemorrhage.

CONCLUSIONS:

Traumatic subdural hematoma was the predominant extra-axial hematoma in this adult cohort, while epidural hematoma had the greatest mean maximum hematoma thickness. Midline shift was observed across all hematoma categories and was most frequent in patients with combined subdural and epidural hematomas, but this difference was not statistically significant. No significant correlation was observed between maximum hematoma thickness and the magnitude of midline shift. These findings suggest that hematoma category, thickness, and midline shift provide complementary radiological information in the assessment of traumatic extra-axial hemorrhage. Further multicenter studies incorporating hematoma volume, clinical severity, associated intracranial injuries, treatment, and clinical outcomes are warranted to establish the clinical significance and prognostic value of these CT measurements.

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