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A Study Of Various Types Of Brain Herniations In Patients With Extraaxial Hematomas And Its Correlation With Patient's Neurological Status

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Abstract

Background: Extra-axial hematomas (epidural, subdural, and subarachnoid) commonly result from traumatic brain injury, with acute cases being frequent in neurosurgical practice. Spontaneous extra-axial hematomas are rare. Brain herniation due to these hematomas carries significant prognostic implications. The Glasgow Coma Scale (GCS) is crucial for assessing neurological status. This study aims to correlate neurological status with extra-axial hematomas causing brain herniation.

Objectives:

- To identify and classify brain herniations in patients with extra-axial hematomas using CT/MRI.
- To correlate imaging findings with patients' neurological status.

Materials & Methods: The study involved 40 patients from the Department of Radiodiagnosis at GMC Patiala. Patients underwent non-contrast CT or MRI of the brain, which were analyzed for extra-axial hemorrhages, midline shift (MLS), and cerebral herniations. GCS scores were recorded at presentation. The correlation between imaging findings and neurological status was assessed.

Results: Subdural hematomas were the most common (77.5%), followed by subarachnoid (37.5%) and epidural hematomas (32.5%). Among the 40 patients, 26 (65%) had subfalcine herniation, 9 (22.5%) had uncal herniation, 3 (7.5%) had descending transtentorial herniation, 2 (5%) had transcalvarial herniation, and 1 (2.5%) had tonsillar herniation. The mean GCS was 10.75±3.06. The majority scored 13-15 (40%). The mean MLS was 9.57±4.81 mm. A negative correlation was found between GCS and MLS (Pearson correlation coefficient -0.3852, $p = 0.0142$).

Conclusion: Subdural hematomas are most frequently associated with brain herniation. Neurological status, as indicated by GCS, worsens with increased MLS. Descending transtentorial and tonsillar herniations are linked to the worst outcomes.

Keywords: Extraaxial hematomas, Subdural hematoma, Midline shift, Brain herniation, descending transtentorial herniation, tonsillar herniation, subfalcine herniation, transcalvarial herniation

Introduction

Intracranial hemorrhage refers to various conditions where blood accumulates outside of blood vessels within different areas of the brain. Based on its location, haemorrhages can also be divided into extra-axial and intra-axial categories.[1]

Intra-axial haemorrhage

1. Intracerebral/ intraparenchymal haemorrhage (ICH)

Extra- axial haemorrhage

2. Epidural (Extradural) haemorrhage (EDH)
3. Intralaminar dural haemorrhage
4. Subdural haemorrhage (SDH)
5. Subarachnoid haemorrhage (SAH) [1]

Motor vehicle collisions stand out as the primary cause of TBI in developing countries.[8] Extra-axial hematomas are very fatal and significantly more prevalent in TBIs connected to RTAs.[9] Extra-axial haemorrhages can arise from non- traumatic reasons such as hypertension, cerebral amyloid angiopathy, cerebral aneurysms, dural arteriovenous fistulae, mycotic aneurysm, and hemorrhagic conversion of ischemic infarction.[2]

Brain herniation is the displacement of brain tissue through the rigid dural folds (i.e., falx and tentorium) or skull openings (e.g., foramen magnum). Brain herniation can be called the "brain code" to emphasize the urgent need to promptly address these dangerous brain processes.[3] The total of the volumes of the brain, CSF, and intracranial blood is constant, according to the Monro-Kellie theory. One or both of the other components' volumes will drop in response to an increase in one of them.[4]

Brain herniation can be categorized into two broad groups: intracranial and extracranial.[5]

It is classified as follows:

Types of brain herniations:

1. **Subfalcine herniation-** It involves pushing of the cingulate gyrus against the falx cerebri.
2. **Transtenorial (uncal) herniation-** It involves squeezing the medial temporal lobe, often by a mass under and across the tentorium.
3. **Central Herniation (descending and ascending):** It occurs when the brainstem descends pathologically through the incisura, leading to Duret hemorrhages due to venous congestion and damage to small perforators.
4. **Transalar (transsphenoidal) Herniation:** In the descending subtype of transalar herniation, infarction within the middle cerebral artery area may occur due to compression in the sphenoid ridge. In ascending subtype transalar herniation, Compression of the supra-clinoid segment of the internal carotid artery against the anterior clinoid process in front (rising) transalar herniation results in infarction within the territory of anterior and middle cerebral arteries.
5. **Tonsillar herniation-** It is caused by an infratentorial mass, forcing the cerebellar tonsils through the foramen magnum.
6. **Upward herniation-** It involves compression of the brainstem by an infratentorial mass.
7. **Extracranial or transcalvarial brain herniation** refers to herniation of brain tissue external to the calvaria through a skull bone defect, which may be post- traumatic or post-surgical [6,7]

Subsequent Brain Damage and Herniation: Herniation brought on by a mass effect can result in secondary brain injuries such as haemorrhages, hydrocephalus, and infarctions.[7]

CT and MRI are the most helpful imaging modalities for diagnosing brain herniations. CT is frequently used in the emergency room to quickly detect conditions that could need surgery.[7]

Neurological Assessment:

In order to diagnose neurological problems, a neurological examination evaluates a patient's mental state, cranial nerves, motor and sensory function, coordination, and gait.[8]

One of the most commonly used classification systems is the Glasgow Coma Scale, which offers a practical way to evaluate loss of consciousness in reaction to specific stimuli. It is a crucial aspect of clinical practice and research worldwide. It evaluates neurologic functions and assigns scores between 3 and 15 according to three aspects of neurologic functions.[9]

Materials & Methods

The present study was carried out in the department of Department of Radiodiagnosis, Rajindra hospital, Government Medical College, Patiala.

Source of data: The patients were referred to Department of Radiodiagnosis from Department of emergency and Department of surgery who presented with extra axial hematomas causing brain herniations undergoing NCCT/MRI of brain.

Sample size: A minimum of 40 cases were taken up for study in order to derive a significant result and statistical analysis.

Inclusion criteria:

1. Patients with various types of brain herniations as a result of extra-axial hematomas.

Exclusion criteria:

1. Absence of midline shift or other brain herniations on CT/MRI of brain
2. Patients with intra-axial hematomas.
3. Patients not giving consent for the study

Equipment:

4. CT scan Machine (GE CT revolution EVO 3.6B MID BJG 128 SLICE)
5. MR Imaging was done with 1.5 Tesla superconductive scanner (Siemens 1.5T mangnetom AERA machine)

Methodology: The patients were subjected to non-contrast CT brain or MRI Brain study. The radiographs and scans were evaluated for extra axial hemorrhages, midline shift and cerebral herniations. The patient's Glasgow coma scale was evaluated at the time of presentation. After the CT/MRI study types brain herniations and extraaxial hemorrhage were tabulated. The findings were correlated with neurological status of the patient.

Data Acquisition: Non contrast CT brain protocol: CT images were acquired using the Siemens 128 slice. 5mm slices with 100 to 120 Kvp and 80 to 150 mAs were takenfrom the vertex upto the thoracic inlet. Reformatting of the study was done and 1mm thin slices was studied in axial, sagittal and coronal section. The CT was studied in both soft tissue and bony windows.

MRI protocol: MRI protocol followed in this study includes T1-weighted images (T1WI), T2-weighted images (T2WI), T2W-FLAIR, Gradient echo GRE sequences and Susceptibility Weighted (SWI) sequences, in addition to standard Diffusion Weighted Imaging (DWI).

Observation and Tabulation: The results of observations of individual subjects were pooled and analyzed. Statistical analysis was performed using Statistical Program for Social Sciences (SPSS) software version 20.0 Chicago, Illinois, USA.

Results

The different extra-axial hematomas in patients- Subdural hematoma (77.5%), subarachnoid hematoma (37.5%), and extradural hematoma (32.5%).

Out of 40 patients, 26 patients (65%) had Subfalcine herniation, 9 patients (22.50%) had Uncal herniation, 3 patients (7.50%) had Descending transtentorial herniation, 2 patients (5%) had Transcalvarial herniation, and 1 patient (2.5%) had Tonsillar herniation. The mean GCS was 10.75±3.06 (range 5-15). Majority of patients (40%) had Glasgow Coma Score (GCS) of 13-15, followed by 15 patients (37.50%) with GCS of 3-8 and 9 patients (22.50%) with GCS of 9-12. The mean MLS was 9.57±4.81 mm (range 3.6-21.9 mm). Majority of patients (45%) had midline shift of >5-10 mm, followed by 12 patients (32.5%) with MLS of >10-20 mm, 8 patients (20%) with ≤5 mm, and 1 patient (2.5%) with MLS >20 mm. Assessment of the relationship of midline shift with patient's neurological status showed in 15 patients with GCS (3-8), 5 patients (12.50%) had MLS (>5-10 mm), 8 patients (20%) had MLS (>10-20 mm), and 1 patient each (2.5%) had MLS (≤5 mm and >20mm). The mean MLS was 11.31±5.69 mm. In 9 patients with GCS (9-12), 6 patients (15%) had MLS (>5-10 mm), and 3 patients (7.5%) had MLS (>10-20 mm). The mean MLS was 10.09±3.51 mm. Whereas in 16 patients with GCS (13-15), 7 patients (17.5%) had MLS (≤5 mm), 7 patients (17.50%) had MLS (>5-10 mm), and 2 patients (5%) had MLS (>10-20 mm). The mean MLS was 7.37±4.11mm. The Pearson Correlation Coefficient was -0.3852 which showed negative correlation (i.e., value of GCS decreases with increase in the MLS). The correlation was statistically significant (p value 0.0142). Assessment of the relationship type of brain herniation with patient's neurological status showed in 25 patients with Subfalcine herniation, GCS (3-8) was present in 3 patients (7.5%), 7 patients (17.5%) had GCS (9-12), and 15 patients (37.5%) had GCS (13-15). The mean GCS was 12.36±2.43. In 11 patients with Uncal herniation, GCS (3-8) was present in 7 patients (17.5%), and 1 patient (2.5%) had GCS (9-12), and

GCS 13-15). The mean GCS was 8.22±1.99. Whereas in all the 3 patients with central descending transtentorial herniation, GCS was 3-8. The mean GCS was 8. Two patients with Transcalvarial herniation had GCS 7 and 11 (Mean 9±2.82). One patient with Tonsillar herniation had GCS 5.

Fig 1 NCCT coronal image of brain shows hypodense collection (Black arrow) along right cerebral convexity with hyperdense areas within it. It is causing mass effect in the form of herniation of medial part of the right temporal lobe over the edge of tentorium(blue arrow) and compression of left side of the midbrain against the tentorium. Final diagnosis: Subdural hematoma with right sided uncal herniation

Figure 2-NCCT Axial image showing a crescentric shape subdural hematoma (blue arrow) along left cerebral convexity causing mass effect in the form of subfalcine herniation (black arrow) Final diagnosis: Subdural hematoma with Sub falcine herniation.

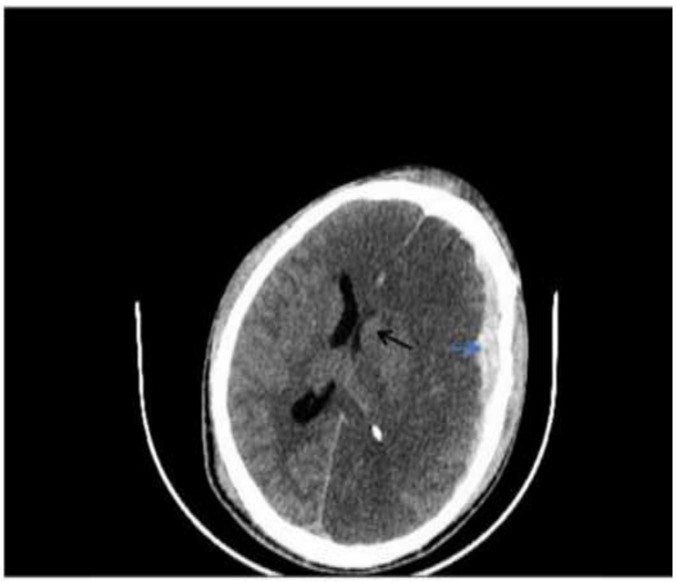
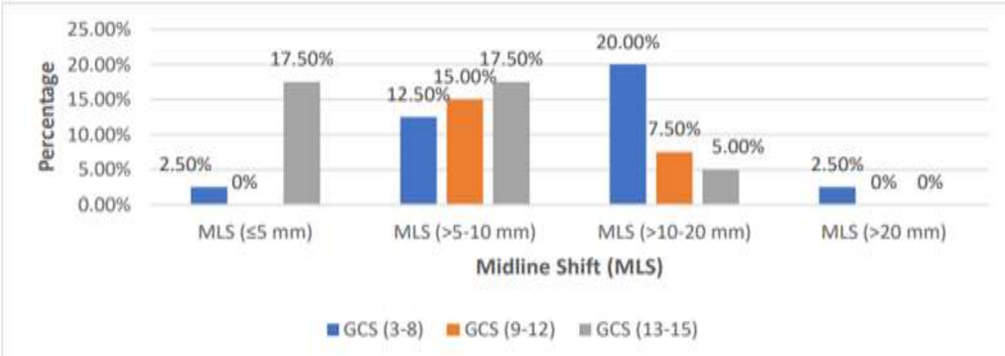


Figure 3- Relationship of midline shift with patient's neurological status



Discussion

Type of extra-axial hematomas: The different diagnoses identified in patients were- Subdural hematoma (77.5%), subarachnoid hematoma (37.5%), and extradural hematoma (32.5%). **Gurer B et al (2013)** reported that Subdural hematoma (68%), epidural hematoma (28%), and both Subdural and epidural hematoma (4%).[10]

Type of brain herniation: Out of 40 patients, 26 patients (65%) had Subfalcine herniation, 9 patients (22.50%) had Uncal herniation, 3 patients (7.50%) had Descending transtentorial herniation, 2 patients (5%) had Transcalvarial herniation, and 1 patient (2.5%) had Tonsillar herniation. **Kalita J et al (2009)** reported that out of 24 patients with intracerebral hemorrhage, cerebral herniations were present in 11 (46%) patients. Subfalcine herniation (in six) was the commonest followed by uncal (in three). Combination of subfalcine and uncal herniations was present in one and subfalcine, uncal and tonsillar herniations in another.[11] **Gurer B et al (2017)** reported that out of 108 patients, Ipsilateral uncal herniation was present in 90 patients, Bilateral uncal herniation in 15 patients, and Kernohan's herniation in 3 patients.[12]

Glasgow Coma Score: The majority of patients (40%) had Glasgow Coma Score (GCS) of 13-15, followed by 15 patients (37.50%) with GCS of 3-8 and 9 patients (22.50%) with GCS of 9-12. The mean GCS was 10.75±3.06 (range 5-15). Regarding Glasgow coma Scale Pupils Score (GCS-P), 16 patients each (40%) had GCS-P of 13-15 and 3-8, followed by 8 patients (20%) with GCS-P score of 9-12. The mean GCS- P score was 10.42±3.41 (range 5-15). **Choudhary A et al (2021)** reported that out of 56 patients with head injury, there were 31 (51.35%) patients with severe head injury (GCS score: 3–8), 17 (30.36%) patients with moderate head injury (GCS score: 9–12), and 8 (14.28%) with mild head injury (GCS score: 13–15).[13]

Midline shift (MLS): The majority of patients (45%) had midline shift of >5-10 mm, followed by 12 patients (32.5%) with MLS of >10-20 mm, 8 patients (20%) with ≤5 mm, and 1 patient (2.5%) with MLS >20 mm. The mean MLS was 9.57±4.81 mm (range 3.6- 21.9 mm). **Choudhary A et al (2021)** reported that the MLS was present in 56 cases. In 15 (26.78%) patients, the MLS was less than 5 mm, in 35 (62.50%) patients, it was 5-10 mm, and in 6 (10.71%) patients, it was>10 mm. [13]

An MLS correlates to the subsequent brain shift caused by the space- occupying effect of the hematoma. Brain shift, in turn, is a prognostic indicator of adverse neurological effects.[14]

Relationship of midline shift with patient's neurological status: In the present study, in 15 patients with GCS (3-8), 5 patients (12.50%) had MLS (>5-10 mm), 8 patients (20%) had MLS (>10-20 mm), and 1 patient each (2.5%) had MLS (≤5 mm and >20mm). The mean MLS was 11.31±5.69mm. In 9 patients with GCS (9-12), 6 patients (15%) had MLS (>5-10 mm), and 3 patients (7.5%) had MLS (>10-20 mm). The mean MLS was 10.09±3.51 mm. Whereas in 16 patients with GCS (13-15), 7 patients (17.5%) had MLS (≤5 mm), 7 patients (17.50%) had MLS (>5-10 mm), and 2 patients (5%) had MLS (>10-20 mm). The mean MLS was 7.37±4.11 mm. The Pearson Correlation Coefficient was -0.3852 which showed negative correlation (i.e., value of GCS decreases with increase in the MLS). The correlation was statistically significant (p value 0.0142). **Chaurasia et al (2021)**

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reported that out of 28 patients (18.67%) with GCS score of 3-8, 7 patients had no MLS, 2 patients had MLS <5 mm, and 19 patients had MLS ≥5 mm. Out of 57 patients (38%) with GCS score of 9-13, 43 had no MLS, 4 patients had MLS <5 mm, and 10 patients had MLS ≥5 mm. All the 65 patients (43.33%) with GCS score of 14-15 had no MLS.[15]

Relationship of type of brain herniation with patient's neurological status: In 26 patients with Subfalcine herniation, GCS (3-8) was present in 3 patients (7.5%), 8 patients (20%) had GCS (9-12), and 15 patients (37.5%) had GCS (13-15). The mean GCS was 12.30±2.39. In 11 patients with Uncal herniation, GCS (3-8) was present in 9 patients (22.5%), and 1 patient (2.5%) had GCS (9-12), and GCS 13-15). The mean GCS was 8.09±1.81. Whereas in all the 3 patients with central descending transtentorial herniation, GCS was 3-8. The mean GCS was 8.

It is important to note a few of the current study's shortcomings. The study's short timeframe and small sample size restrict the applicability of its findings to wider geographic areas. Larger-scale prospective randomised trials in the future will enable more reliable research and significantly improve the findings of the present study.

Conclusion

The present study revealed that Subdural hematomas are the most common extra axial hematomas causing brain herniations. The study concluded that the neurological status (as reflected by Glasgow coma scale score) of the patients deteriorates with increase in the level of midline shift. Descending transtentorial herniation and tonsillar herniations are associated with worst neurological status, followed by Uncal and transcranial herniation. The patients with subfalcine herniation had best neurological status.

Ethical approval and Consent

Approval was taken from the relevant ethics committee and written informed consent was taken from each patient to publish his details while maintaining confidentiality.

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