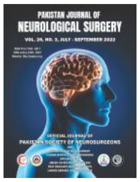

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Original Article

The Swirl Sign and Its Relationship to Patient Outcomes in Extradural Hematomas: A Retrospective Investigation

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ABSTRACT

Introduction:" Swirl sign" is a relatively uncommon sign, seen on non-contrast CT scans in patients with head trauma who develop extradural hematoma the prognostic significance of which is controversial. This research aims to evaluate the predictive significance of the swirl sign in patients with an extradural hemorrhage.

Material and Methods: It was a retrospective study and included 145 patients, with traumatic brain injury, who underwent surgical treatment at the Department of Neurosurgery Holy Family Hospital, Rawalpindi, Pakistan, between January 2022 and January 2023 and had traumatic EDH identified by computed tomography scan. Patients who did not undergo surgery or had combined or open craniocerebral injuries were eliminated. A Glasgow Outcome Scale score was used to evaluate outcomes after three months of traumatic brain injury. Mann-Whitney U test, the Chi-square test, and multivariate logistic regression were applied for descriptive and inferential analysis.

Results: A total of 145 cases were evaluated, 19 (13.1%) demonstrated the sign on a CT scan of the brain. Analysis displayed a notable association between the incidence of the swirl sign and pupillary size, preoperative Glasgow Coma Scale score, time between trauma and first CT scan, and volume of hematoma measured intraoperatively. Patients displaying the swirl sign showed an increased mortality rate (25%) compared to patients without the swirl sign (5%) and worse outcomes at 3 months.

Conclusion: The presence of the swirl sign on the CT scan had a significant association with worse outcomes. Early detection and prompt surgical evacuation are important for patients with this sign.

Keywords: Extradural hematoma; Head trauma; Swirl sign.

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INTRODUCTION

An extradural hematoma is a pathology that occurs when blood collects outside the brain and puts pressure on the brain tissue.[1,2] It's a type of brain injury that occurs when there is a bleed between the outermost layer of the meninges i.e. dura mater and the skull. It is a serious condition that requires immediate medical attention.[3,4]

An extradural hematoma is mostly post-traumatic. The bleeding can be severe and can lead to a rapid increase in pressure within the skull, which can cause the brain to be squeezed or compressed.[2]

One possible sign of an extradural hematoma is a "swirl" sign, which refers to the appearance of the hematoma on a non-contrast computed tomography (NCCT) scan. The hematoma appears as a swirling or swirling pile of blood within the skull, which may be seen as a circular or ovoid-shaped area. It has 2 components: hyperacute, which represents ongoing active intracranial bleed, and acute, which comprises surrounding hyper-attenuated clotted blood. It is caused by the accumulation of blood outside the brain, which appears as a dense area on scans.[5-8]

A headache, nausea, vomiting, dizziness, loss of consciousness, complete or partial weakness of one side of the body, seizures, speech impairment, and visual changes are some additional extradural hematoma signs and symptoms. The person may also experience confusion, difficulty speaking or understanding others, and changes in behavior. In severe cases, an extradural hematoma can cause loss of consciousness or a coma.[1-5]

Finding out the importance of the swirl sign in EDH is the aim of this study. It's critical to seek medical care as soon as you suspect an extradural hematoma. The condition is treated with surgery to remove the excess blood and relieve the pressure on the brain. If left untreated, an extradural hematoma can lead to serious complications and even death. The swirl sign is a key indicator of an extradural hematoma, a serious brain injury that requires immediate medical attention. The warning signs and symptoms of this condition should be recognized, and anyone experiencing them should seek medical attention.

MATERIALS AND METHODS:

Study Design & Settings

A retrospective study of patients was done who underwent neurosurgical management at the Department of Neurosurgery Holy Family Hospital, Rawalpindi, Pakistan, between January 2022 and January 2023 and had traumatic EDH identified by CT.

Sample Size & Technique

The WHO sample size calculator was used to determine the minimally required sample size (n = 145) as follows: confidence interval: 95%, absolute precision: 0.05. Non-probability consecutive sampling was considered.

Inclusion Criteria

The current study included trauma patients with resulting brain injury who were admitted within 4 hours of the trauma.

Exclusion Criteria

Patients with open or multiple injuries or those who already had neurological conditions were excluded from the study. On the admission CT scan, patients with a subdural hematoma and brain contusions were excluded.

Data Collection

Upon entering the emergency room, the patient's demographic information, Glasgow Coma Scale (GCS) score at admission, pupils examination, and imaging findings (non-contrast CT Scan Brain) were noted. All of the patients underwent immediate evaluations that included head plain CT scans. Patients who needed surgery for the surgical evacuation of the intracranial hematoma were then brought into the operating room. A significant craniotomy with a question mark incision was used to perform hematoma evacuation via standard craniotomy. The bone flap was replaced. The Glasgow Outcome Scale (GOS) was utilized to evaluate the following outcomes three months after the trauma: 1, death rate, 2, vegetative state, 3, severe disability, 4, some degree of disability, and 5, complete recovery. GOS scores were used to define unfavorable outcomes as 1, 2, or 3 for statistical comparison purposes, whereas favorable results were defined as GOS scores of 4 or 5.

Technically sound radiologists from the Department of Radiology reviewed every CT scan. Both the CT scan and the results from the surgery helped to confirm where the hematoma was located. The EDH swirl sign was described as a larger extradural hyperattenuating clot surrounded by a hypodense portion with a swirled appearance. In cases where the swirl sign was unclear, the neuroradiologist's report was used to determine whether it was present or not.

Data Analysis

Data were analyzed using SPSS V.25.0. The units of expression for the data were percentages (%) or means with standard deviations (SD). The descriptive and inferential analyses were performed using the Mann-Whitney U test, the Chi-square test, and multivariate logistic regression. In all analyses, the level of statistical difference was set at P values < 0.05.

RESULTS

Characteristics of the Patient

145 patients with traumatic head injuries were included in this study. The range of patients' ages was from 20 to 56 years, with a mean of 39.1 ± 10.59 years; 107 (73.7%) were male, while females were 38 (26.3%). Road traffic accidents gave rise to 126 (86.8%) of the injured patients, while falls and heavy strikes resulted in 19 (13.2%) injuries. 19 (13.1%) of the 145 patients evaluated showed the swirl sign. The average age of these patients was 42.49 ± 10.13 years, with 13 (68.4%) males and 6 (31.6%) females.

Table 1: Characteristics of patients.

Total Number of patients	145
Males	107
Females	38
Mean age	39.1+/-10.59
Mechanism of Injury	
RTA	126
Falls	19

Table 2: Clinical Results.

Swirl sign		**P-value**
Total	19	
Males	13	
Females	6	
Mean Age	42.49 +/-10.43	
Preop GCS		
3-8	13	
9-12	4	
13-15	2	
Pupils		
Bilaterally dilated	6	
Unilateral dilated	8	0.05
Normal	5	
Intra-op Hematoma volume		
In patients with a swirl sign	77.89+/-8.91	0.002
In patients without a swirl sign	55.31+/-6.86	

Imaging and Clinical Features

The swirl sign significantly correlated with the pre-operative Glasgow Coma Scale score, pupillary size, time between injury and CT scan, and volume of hematoma measured intraoperatively, according to univariate analysis. (Table 1). The gender, age, mechanism of injury, GCS score at hospitalization, position, mediastinal shift, skull cracking, or blood clot volume on CT images did not show any statistically significant correlation with the swirl sign.

The swirl sign was found in 13 of the 59 patients with a pre-operative Glasgow Coma Scale point total of 3 – 8, compared to only 2 of the 13 patients (15%) with a preoperative Glasgow Coma Scale score of 13 – 15. Before surgery, the swirl sign occurred in 31.5% (6 of 19 patients) of patients with bilateral mydriasis and 10.9% (8 of 73 patients) of those who had unilateral reflexes (P = 0.058). Only 5 (7.5%) of the 53 patients without mydriasis displayed the swirl sign. The swirl sign was seen in 21% of the 51 patients who underwent a CT scan within 2 hours of injury, compared to 14% of those who had a CT scan within 2 – 6 hours (P = 0.05). Only 3 patients (5.8%) exhibited the swirl sign among those who had a CT scan more than six hours after the injury.

The mean hematoma amount estimated by neurosurgeons during the operation was higher in patients for whom the CT scan had shown the swirl sign than in those who did not (77.89+/-8.91 vs. 55.31+/-6.86, respectively; P 0.002).

Clinical Results

Three months after the injury, CT scans showed that 61% of patients with a swirl sign and 86% of patients without one had a favorable Glasgow outcome scale (GOS > 4) (P = 0.032). Patients who exhibited the swirl sign died at a rate that was significantly higher than that of patients who did not (25 vs. 5%, respectively; P = 0.029). In total, 4 of the 19 patients who had the swirl sign and 7 of the 126 patients who did not have the swirl sign passed away from the illness. The independent prognostic factor of mortality was the presence of the swirl sign (OR = 4.71; CI of 95%: 1.41 – 14.78; P 0.04) and adverse consequence at three months (OR = 3.51; CI of 95%: 1.31-8.91; P 0.04) in multivariate logistic regression analysis.

Table 3: Follow-up at 3 months in terms of GOS and mortality.

GOS at 3 Months

	Swirl	Without Swirl	P value
> 4	61%	86%	0.032
Mortality Rate	4/19 (25%)	7/126 (5%)	0.029

Table 4a: Regression analysis.

Swirl Sign for Predicting Mortality	
Odds ratio	4.71
Confidence of interval 95%	1.41 – 14.78
P-value	0.04

Table 4b: Multivariate Logistic Regression analysis.

Unfavorable Consequences at 3 Months	
Odds ratio	3.51
Confidence of interval 95%	1.31 – 8.91
P-value	0.04

DISCUSSION

Swirl sign is active bleeding inside a hematoma on a non-enhanced CT scan brain. Radiologically, it is an area of hypo-density surrounded by hyper-attenuated clotted blood.

In our study, the extradural hematoma was more frequent in males (73.7%) than in females (26.3%). This was consistent with the study conducted by Guo et al,[5] where 73% of males were diagnosed with extradural hematoma as compared to 27% of females. The most common mechanism of injury in our study was motor vehicle accidents (86.8%). This is comparable to Guo et al. where 86% of EDH cases were the result of motor vehicle accidents. However, another study by Beniwal et al,[9] showed that motor vehicle accidents led to EDH in 67.4% of patients.

Greenberg et al,[10] demonstrated that swirl signs led to increased mortality and morbidity as it represents ongoing rapid bleeding inside an intracranial hematoma. Our study reinstated these outcomes of Greenberg et al. by reporting that the existence of a swirl sign in acute extradural hemorrhage leads to adverse outcomes and increased mortality by the end of 3 months post-surgery.

Lee et al,[11] analyzed 200 patients retrospectively and suggested that pupillary size, GCS score, and preoperative conscious level have a significant effect on the functional consequences of patients with acute extradural hemorrhage. On the other hand, Ono et al,[12] concluded that the only reliable prognostic factor in patients with severe head trauma was the GCS score. Our study showed that patients exhibiting the swirl sign had a reduced pre-operative Glasgow Coma Scale score and pupillary dilatation ahead of surgery, which was comparable to the study by Guo et al. al.[5]

Our study shows that patients who underwent CT scan within 2 hours of trauma demonstrated swirl signs more frequently as compared to those in whom CT was delayed for more than 6 hours after injury, which is relatable to Guo et al.[5] This indicates that time between injury and performance of CT is crucial in predicting the incidence of swirl sign in acute EDH.[13-15] Therefore, a CT scan should be done as soon as possible. It will help in the detection of ongoing active bleeding and close observation of the patient's neurological signs so that early surgical intervention can be done in case of rapid deterioration.

Comparable to previous studies,[15-18] the most common location of extradural hemorrhage is temporal or temporoparietal, irrespective of the presence or absence of a swirl sign. This is caused by a fracture of the pterion which results in the puncturing of middle meningeal vessels. Even though there was no significant relationship between the intraoperative volume of hematoma on CT scan and swirl sign, according to our study, patients without the swirl sign had a smaller intraoperative hematoma volume than those who did. To take prompt surgical action, et al, patients with swirl signs should undergo close neurological observation and repeated CT scans if needed.[19,20] There is a significant role of time since trauma to surgical intervention in predicting the outcomes of EDH. Our study results were consistent with Tian et al,[21] and Beniwal et al,[9] who demonstrated that the time between the occurrence of trauma and surgery was associated with higher mortality, and good outcomes were achieved in patients with early decompression. Therefore, in patients in whom surgery is indicated, it is suggested to do early surgical decompression and hemostasis.[22, 23]

There were a few limitations to our study. First, there is a possibility of a notable bias concerning data collection and choice of patients because this was a retrospective study. Second, many patients with acute extradural hematoma were excluded who did not undergo surgical intervention or had incomplete clinical data. Finally, the number of patients demonstrating swirl signs was low which limits the detection of potential outcomes due to the presence of swirl signs, clinical effects, and severity of the injury.

CONCLUSION

In patients with traumatic extradural hematoma, the presence of the swirl sign on non-contrast CT scans is significantly associated with worse outcomes, including higher mortality rates and poorer outcomes at three months post-injury.

RECOMMENDATIONS

Early identification of the swirl sign on CT scans can aid in prompt surgical intervention, which is critical in improving outcomes for these patients. Neurosurgeons and radiologists should be aware of this imaging finding, and swift evaluation and treatment should be considered in patients with this sign. Further research is needed to better understand the mechanisms underlying the prognostic significance of the swirl sign and to identify additional imaging biomarkers that may improve outcomes in patients with traumatic brain injury.

Limitations of the Study

The study was conducted at a single center, which may limit the generalizability of the results to other settings or populations. The sample size was relatively small, which may limit the statistical power of the study and increase the risk of type II errors. The study only included patients who underwent surgical treatment for traumatic EDH, which may not be representative of all patients with this type of injury. The study relied on CT scans to identify the presence of the swirl sign, which may not be sensitive enough to detect all cases. The study did not investigate other potential confounding factors, such as the presence of other traumatic injuries or comorbidities, which may have influenced the outcomes. The study did not investigate the inter-observer reliability of the swirl sign or other imaging findings, which may have introduced bias into the analysis.

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Additional Information

Disclosures: Authors report no conflict of interest.
Ethical Review Board Approval: The study was retrospective.
Human Subjects: Consent was obtained by all patients/participants in this study.
Conflicts of Interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:
Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

AUTHORS CONTRIBUTIONS

Sr.#	Author’s Full Name	Intellectual Contribution to Paper in Terms of:
1.	Muhammad Ammad-ul-Haq, Saad Javed, & Eesha yaqoob	1. Study design and methodology.
2.	Muhammad Ammad-ul-Haq, Muhammad Jazib Ijaz, Anam Ali, Sania Bhatti, & Maheen Sabah	2. Paper writing.
3.	Muhammad Ammad-ul-Haq, Muhammad Jazib Ijaz, Anam Ali, Sania Bhatti, & Maheen Sabah	3. Data collection and calculations.
4.	Eesha Yaqoob, Sania Bhatti, & Saad Javed	4. Analysis of data and interpretation of results.
5.	Muhammad Ammad-ul-Haq	5. Literature review and referencing.
6.	Muhammad Ammad-ul-Haq, & Saad Javed	6. Editing and quality insurer.