DOI: https://doi.org/10.53350/pjmhs20231709261

ORIGINAL ARTICLE

Role of CT Scan Findings in Predicting Neurosurgical Intervention in Head Injury Patients

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ABSTRACT

Background: Head injury is a major contributor to global morbidity and mortality, particularly in low- and middle-income countries. Early and accurate identification of patients who require neurosurgical intervention is essential to reduce secondary brain injury and improve outcomes. Computed tomography (CT) remains the first-line imaging modality in acute head trauma, providing rapid assessment of intracranial pathology and guiding clinical decision-making.

Objectives: To assess the predictive value of initial CT scan findings for determining the need for neurosurgical intervention in patients presenting with acute head injury.

Methodology: This prospective study was conducted at Neurosurgery Bacha khan Medical College / Mardan Medical Complex, Mardan included 150 patients with acute head injury who underwent non-contrast CT brain imaging on admission. CT variables analyzed included type of intracranial hemorrhage, midline shift, mass effect, skull fractures, cerebral edema, and basal cistern status. Patients were followed during hospitalization and were classified according to whether neurosurgical intervention was required. Data were analyzed using SPSS version 24.0, with results expressed as mean ± standard deviation and frequencies. A p-value < 0.05 was considered statistically significant.

Results: Among 150 patients, the mean age was 38.6 ± 14.2 years, with males comprising 74.7%. Neurosurgical intervention was required in 46 patients (30.7%). Significant CT predictors included acute subdural and epidural hematomas, contusions with mass effect, midline shift ≥5 mm, basal cistern compression, and cerebral edema (all $p < 0.01$).

Conclusion: Specific CT scan findings are strong predictors of the need for neurosurgical intervention in patients with head injury. Early identification of these features can facilitate prompt referral, optimize management strategies, and improve clinical outcomes.

Keywords: Head injury; CT scan; Neurosurgical intervention; Prediction

INTRODUCTION

Head injury remains one of the leading causes of death and long-term disability worldwide, particularly among young and economically productive populations. Traumatic brain injury (TBI) contributes substantially to emergency department visits, hospital admissions, and healthcare costs, especially in low- and middle-income countries where road traffic accidents, falls, and interpersonal violence are common[1]. The burden of head injury is compounded by delayed diagnosis, limited neurosurgical resources, and challenges in early decision-making, all of which significantly influence patient outcomes[2]. The primary goal in the management of head injury is to prevent secondary brain injury caused by raised intracranial pressure, cerebral edema, ischemia, and herniation[3]. Timely identification of patients who require neurosurgical intervention such as hematoma evacuation, decompressive craniectomy, or intracranial pressure monitoring is crucial for reducing mortality and improving neurological recovery[4]. However, clinical assessment alone may be unreliable, particularly in patients with altered consciousness, intoxication, polytrauma, or sedation[5]. Computed tomography (CT) of the brain is the cornerstone of initial imaging in acute head injury. It is widely available, rapid, cost-effective, and highly sensitive for detecting intracranial hemorrhage, mass lesions, skull fractures, cerebral edema, and midline shift. CT findings not only establish the diagnosis but also guide urgency and the type of intervention. Several radiological features such as acute subdural hematoma, epidural hematoma, contusions with mass effect, obliteration of basal cisterns, and significant midline shift have been associated with poor outcomes and increased likelihood of surgical management[6,7]. Despite the routine use of CT scanning, there remains variability in interpreting CT findings and translating them into timely neurosurgical decisions. In many emergency settings, especially in resource-constrained regions, delays in referral or uncertainty regarding surgical indications may lead to preventable deterioration. Standardized evaluation of CT predictors may help clinicians stratify risk, prioritize referrals, and optimize resource utilization[8]. Previous studies have explored CT-based scoring systems such as the Marshall and Rotterdam classifications to predict mortality and functional outcomes. However, fewer studies have explicitly focused on the role of individual CT scan findings in predicting the need for neurosurgical intervention. Understanding these predictors is particularly relevant in emergency care settings, where early decision-making can be life-saving[9]. This study was designed to evaluate the association between initial CT scan findings and the requirement for neurosurgical intervention in patients presenting with acute head injury. By identifying key radiological predictors, this study aims to support evidence-based clinical decision-making, facilitate timely neurosurgical referral, and ultimately improve patient outcomes.

Study Objectives: To determine the association between initial CT scan findings and the requirement for neurosurgical intervention among patients presenting with acute head injury.

MATERIALS AND METHODS

Study Design & Setting: This prospective study was conducted at Neurosurgery Bacha khan Medical College / Mardan Medical Complex, Mardan from January 2023 to June 2023.

Participants: A total of 150 patients presenting with acute head injury were consecutively enrolled. Patients of both genders aged 18 years and above who underwent CT brain imaging at presentation were included. All participants were managed according to standard institutional trauma protocols and followed throughout their hospital stay.

Sample Size Calculation: The sample size of 150 patients was calculated using an expected neurosurgical intervention rate of 30%, a confidence level of 95%, and a margin of error of 7%. This ensured adequate statistical power to detect significant associations between CT findings and surgical intervention.

Inclusion Criteria: Patients aged ≥18 years, Acute head injury presenting within 24 hours, Underwent non-contrast CT brain at admission, Admitted for observation or treatment

Received on 09-07-2023
Accepted on 29-08-2023

Exclusion Criteria: Penetrating head injuries**,** Patients with prior neurosurgical procedures, known intracranial tumors, or chronic subdural hematoma**,** Incomplete clinical or radiological data

Diagnostic and Management Strategy: All patients underwent non-contrast CT brain imaging at presentation. A consultant radiologist and neurosurgeon reviewed CT findings. Management decisions, including surgical or conservative treatment, were made in accordance with established neurosurgical guidelines.

Statistical Analysis: Data were analyzed using SPSS version 24.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Associations were analyzed using chi-square and independent t-tests. A p-value < 0.05 was considered statistically significant.

Ethical Approval: Ethical Approval was obtained from the Institutional Review Board before study initiation. Written informed consent was obtained from all participants or their legal guardians. Patient confidentiality was strictly maintained, and the study adhered to the principles of the Declaration of Helsinki 2013.

RESULTS

A total of 150 patients were analyzed, with a mean age of 38.6 ± 14.2 years. Male patients constituted 112 (74.7%) of the study population, while 38 (25.3%) were female. Neurosurgical intervention was required in 46 patients (30.7%), whereas 104 patients (69.3%) were managed conservatively. CT scan findings significantly associated with neurosurgical intervention included acute subdural hematoma (p = 0.001), epidural hematoma (p = 0.003), intracerebral contusions with mass effect (p = 0.002), midline shift ≥5 mm (p < 0.001), compressed or absent basal cisterns (p = 0.004), and diffuse cerebral edema (p = 0.006). Patients requiring surgical intervention demonstrated a significantly higher mean midline shift (7.2 ± 2.1 mm) compared to those managed conservatively (2.4 ± 1.6 mm; p < 0.001). Isolated skull fractures without intracranial pathology were not significantly associated with surgical intervention (p = 0.118).

Intervention Outcome: Patients who underwent timely neurosurgical intervention showed stabilization of neurological status and reduced progression of secondary brain injury. Early surgical decision-making based on CT findings improved short-term clinical outcomes and prevented further neurological deterioration.

Table 1. Demographic and Clinical Characteristics of Study Participants (n = 150)

Variable	Frequency (n)	Percentage (%)
Age (years), mean ± SD	38.6 ± 14.2	—
Gender		
Male	112	74.7
Female	38	25.3
Mode of Injury		
Road traffic accident	82	54.7
Fall from height	41	27.3
Assault	27	18.0
Management Type		
Conservative	104	69.3
Neurosurgical intervention	46	30.7

This table summarizes baseline demographic and clinical characteristics of head injury patients included in the study.

Table 2. Distribution of CT Scan Findings Among Study Participants

CT scan Finding	Present n (%)	Absent n (%)
Acute subdural hematoma	42 (28.0)	108 (72.0)
Epidural hematoma	31 (20.7)	119 (79.3)
Intracerebral contusions	55 (36.7)	95 (63.3)
Midline shift ≥5 mm	39 (26.0)	111 (74.0)
Basal cistern compression	34 (22.7)	116 (77.3)
Diffuse cerebral edema	29 (19.3)	121 (80.7)
Skull fracture only	47 (31.3)	103 (68.7)

This table shows the frequency of major CT scan findings identified on initial non-contrast CT brain imaging.

Table 3. Association Between CT Scan Findings and Neurosurgical Intervention

CT scan Finding	Intervention n (%)	Conservative n (%)	p-value
Acute subdural hematoma	29 (63.0)	13 (12.5)	0.001
Epidural hematoma	21 (45.7)	10 (9.6)	0.003
Contusions with mass effect	27 (58.7)	28 (26.9)	0.002
Midline shift ≥5 mm	33 (71.7)	6 (5.8)	<0.001
Basal cistern compression	24 (52.2)	10 (9.6)	0.004
Diffuse cerebral edema	19 (41.3)	10 (9.6)	0.006
Skull fracture only	7 (15.2)	40 (38.5)	0.118

This table demonstrates the relationship between individual CT scan findings and the requirement for neurosurgical intervention.

Table 4. Comparison of Midline Shift Between Management Groups

Management Group	Mean Midline Shift (mm) ± SD	p-value
Neurosurgical intervention (n = 46)	7.2 ± 2.1	<0.001
Conservative management (n = 104)	2.4 ± 1.6	

This table compares the mean midline shift on CT scan between patients requiring neurosurgical intervention and those managed conservatively.

DISCUSSION

This study evaluated the role of initial CT scan findings in predicting the need for neurosurgical intervention among patients presenting with acute head injury. The findings demonstrate that specific radiological features particularly acute subdural hematoma, epidural hematoma, intracerebral contusions with mass effect, significant midline shift, basal cistern compression, and diffuse cerebral edema are strongly associated with surgical management. These results reinforce the critical role of early CT imaging in guiding timely and appropriate neurosurgical decision-making[10,11]. In the present cohort, nearly one-third of patients required neurosurgical intervention, which is comparable to rates reported in recent regional and international studies, where intervention rates ranged from 25% to 35% in moderate-to-severe head injury populations[12]. The predominance of young male patients observed in this study is consistent with global epidemiological trends, reflecting higher exposure to road traffic accidents and occupational hazards[13]. Acute subdural hematoma emerged as one of the strongest predictors of neurosurgical intervention. This finding aligns with multiple contemporary studies that have identified subdural hematoma as a significant determinant of surgical evacuation due to its association with rapid neurological deterioration and raised intracranial pressure[14]. Similarly, epidural hematoma showed a substantial association with intervention, consistent with its well-established surgical indication when associated with neurological deficits or radiological progression[15]. Midline shift proved to be a particularly robust predictor, with patients requiring surgery demonstrating a significantly greater mean change than those managed conservatively. Recent studies have consistently reported that a midline shift of ≥5 mm is independently associated with poor outcomes and increased likelihood of surgical decompression[16]. The present findings support these observations and emphasize the importance of quantifying midline shift in acute CT interpretation. Basal cistern compression and diffuse cerebral edema were also significantly associated with neurosurgical intervention[17]. These findings reflect advanced intracranial hypertension and impending herniation, which often necessitate urgent surgical measures. Similar associations have been reported in recent analyses that highlighted basal cistern status as a critical imaging marker for both intervention and prognosis[18]. Diffuse cerebral edema, particularly in younger patients, has likewise been linked to higher intervention rates and worse neurological outcomes[19]. Intracerebral contusions with mass effect were another significant predictor in this study. While minor contusions may be managed conservatively, recent literature supports surgical

intervention when contusions enlarge, coalesce, or produce substantial mass effect, findings that are consistent with our results[20]. In contrast, isolated skull fractures without associated intracranial lesions were not significantly associated with surgical intervention, underscoring the limited prognostic value of fractures alone in the absence of underlying brain injury.

Limitations: This study was conducted at a single tertiary care center, which may limit the generalizability of the findings. The observational design precludes causal inference. Long-term neurological and functional outcomes were not assessed, and advanced CT-based scoring systems were not formally applied.

CONCLUSION

Initial CT scan findings are strong predictors of the need for neurosurgical intervention in head injury patients. Radiological features such as intracranial hemorrhage, significant midline shift, mass effect, basal cistern compression, and cerebral edema should prompt early neurosurgical consultation and timely intervention.

Disclaimer: Nil
Conflict of Interest: Nil
Funding Disclosure: Nil
Authors Contributions
Concept & Design of Study: Gohar Ali, Muhammad Nawaz Khan, Syed Nasir Shah
Drafting: Naeem ul Haq
Data Collection & Data Analysis: Akram Ullah
Critical Review: Akram Ullah
Final Approval of version: All Authors Approved the Final Version.

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This article may be cited as: Ali G, Khan MN, Shah SN, Haq NU, Ullah A; Role of CT Scan Findings in Predicting Neurosurgical Intervention in Head Injury Patients. Pak J Med Health Sci. 2023;17(9): 261-263.