The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 4, Issue 5, 2026

CORRELATION BETWEEN HYPERTENSION SEVERITY AND INTRACRANIAL HEMORRHAGE PATTERNS ON EMERGENCY BRAIN CT

Hina Tariq[1], Fatima Raza[*2], Mr. Ali Noman[3], Arif Hussain[4], Adeeba Dilawar[5], Ahmad Raza[6], Khushbakht[7], Nasir Abbas[8]

[1]*Student, Bachelor of Medical Imaging Technology, Pakistan*
[*2]*MSDU, Lecturer, Superior University Lahore, Faculty of Allied Health Sciences, Pakistan*
[3]*MSMIT, Lecturer, Superior University Lahore, Faculty of Allied Health Sciences, Pakistan*
[4,5,6,7]*Student, Bachelor of Medical Imaging Technology, Pakistan*
[8]*Student, Bachelor of Medical Imaging Technology, Pakistan*

[*2]fatimaraza@superior.edu.pk

DOI: https://doi.org/10.5281/zenodo.20234088

Keywords
Hypertension severity, Intracranial hemorrhage, Emergency brain CT, Hematoma volume, ICH score.

Article History
Received: 17 March 2026
Accepted: 27 April 2026
Published: 16 May 2026

Corresponding Author: *
Fatima Raza

Abstract

Background: *Hypertension is a major modifiable risk factor for spontaneous intracranial hemorrhage and is associated with significant morbidity and mortality. The severity of hypertension influences cerebrovascular integrity and may determine the pattern, extent, and clinical outcome of intracranial hemorrhage. Emergency non-contrast brain computed tomography (CT) is the primary imaging modality for the rapid diagnosis and assessment of hemorrhagic stroke. However, limited local data are available correlating hypertension severity with intracranial hemorrhage patterns on emergency CT imaging.*

Objective: *To evaluate the correlation between hypertension severity and intracranial hemorrhage patterns on emergency brain CT and to assess the impact of radiological characteristics on immediate clinical outcomes.*

Methodology: *This cross-sectional study was conducted on hypertensive patients presenting with acute neurological symptoms who underwent emergency non-contrast brain CT. A total of 153 patients were included after excluding cases with incomplete clinical or imaging data. Hypertension severity was classified according to American Heart Association guidelines. CT scans were analyzed for hemorrhage type, anatomical location, hematoma volume, laterality, and associated complications. CT-based severity scores, including ICH score, Graeb score, and Modified Fisher score, were calculated. Statistical analysis was performed to assess associations between hypertension severity, imaging findings, and in-hospital outcomes.*

Results: *Spontaneous intracerebral hemorrhage was the most common hemorrhage type (77.1%). The basal ganglia (45.8%) and thalamus (22.0%) were the most frequently involved sites. Patients presenting with hypertensive crisis demonstrated significantly larger hematoma volumes and higher ICH scores compared to those with stage I or II hypertension ($p < 0.05$). Severe radiological features such as intraventricular extension, cerebral edema, and midline shift were more common in patients with severe hypertension. In-hospital mortality was 19%, with hematoma volume >60 mL, ICH score ≥3, and hypertensive crisis identified as significant predictors of mortality.*

Conclusion: *Hypertension severity has a significant association with intracranial hemorrhage patterns, radiological severity, and short-term clinical outcomes. Severe hypertension is linked to larger hemorrhage volumes, higher CT severity scores, and increased mortality. Emergency brain CT plays a crucial role in early diagnosis, severity assessment, and prognostication. Early blood pressure control and prompt imaging evaluation are essential to improve outcomes in hypertensive patients presenting with intracranial hemorrhage.*

INTRODUCTION

Hypertension remains the most significant modifiable risk factor contributing to stroke related morbidity and mortality worldwide, exerting a considerable burden on emergency healthcare systems and radiology services.[1] Among the various complications of uncontrolled blood pressure, intracranial hemorrhage (ICH) represents one of the most devastating neurological emergencies, associated with high mortality rates and long-term disability.[2] Strong epidemiological evidence indicates that hypertension is responsible for approximately 70–85% of spontaneous intracranial hemorrhage cases, highlighting a large but potentially preventable patient population.[3]

Intracranial hemorrhage occurs when a cerebral blood vessel ruptures, resulting in bleeding within the brain parenchyma or surrounding intracranial compartments.[4] Based on anatomical location, ICH is broadly classified into intraparenchymal hemorrhage, intraventricular hemorrhage, subarachnoid hemorrhage, subdural hemorrhage, and epidural hemorrhage.[5] Among these, intraparenchymal hemorrhage particularly involving deep brain structures such as the basal ganglia, thalamus, pons, and cerebellum is most strongly associated with chronic hypertension. This is primarily due to long-standing microvascular damage affecting small penetrating arteries, leading to vessel wall degeneration and eventual rupture.[6]

The severity of hypertension plays a crucial role not only in the occurrence but also in the pattern, location, and extent of intracranial hemorrhage.[7] Chronic and poorly controlled hypertension leads to progressive vascular changes, including lipohyalinosis and microaneurysm formation, which predispose vessels to rupture under increased hemodynamic stress.[8] Higher levels of blood pressure are frequently associated with larger hematoma volumes, increased likelihood of hematoma expansion, and more complex hemorrhage patterns, including multi-compartment involvement.[9] In particular, severe hypertension is strongly linked to intraventricular extension, mass effect, and midline shift radiological features that are known to correlate with poor clinical outcomes.[10]

Emergency non-contrast computed tomography (NCCT) of the brain is the gold-standard imaging modality for the rapid assessment of suspected intracranial hemorrhage.[11] Its widespread availability, rapid acquisition time, and high sensitivity for detecting acute blood make it indispensable in emergency settings. On NCCT, acute hemorrhage appears as a hyperdense lesion, allowing accurate identification of hemorrhage type, anatomical distribution, and associated complications such as ventricular involvement, hydrocephalus, and brain herniation. Importantly, CT imaging also enables quantification of hemorrhage severity through parameters such as hematoma volume, shape irregularity, and degree of mass effect.[12]

Radiological assessment plays a pivotal role in guiding clinical management and predicting patient outcomes. Various CT-based scoring systems, including the ICH Score, Graeb Score, and Modified Fisher Scale, are widely used to quantify hemorrhage severity and assist in prognostic stratification. These scoring systems incorporate imaging findings such as hemorrhage volume, location, intraventricular extension, and level of consciousness, providing valuable insight into disease severity and expected clinical progression.[13]

In low- and middle-income countries such as Pakistan, the burden of hypertension is particularly alarming, with a significant proportion of the population remaining undiagnosed or inadequately treated.[14] Poor blood pressure control, delayed presentation to healthcare facilities, and limited access to advanced neuroimaging further exacerbate the risk of severe intracranial hemorrhage.[15] Emergency departments in such settings frequently encounter hypertensive patients presenting with acute neurological deficits, where timely CT imaging is critical for diagnosis, triage, and treatment planning. Despite the well-established association between hypertension and intracranial hemorrhage, there remains a lack of comprehensive local data examining the relationship between the severity of hypertension and specific hemorrhage patterns on emergency brain CT.[16] Most existing studies focus primarily on the presence or absence of hypertension, without adequately stratifying patients based on blood pressure levels or correlating these levels with radiological findings. This gap in knowledge limits the ability to perform precise risk stratification and may hinder optimal clinical decision-making in emergency settings.[17]

Subarachnoid hemorrhage (SAH) is characterized by bleeding into the subarachnoid space between the arachnoid and pia mater. Although rupture of intracranial aneurysms remains the most common cause, hypertension plays a significant contributory role by increasing vascular wall stress, thereby facilitating aneurysm formation and rupture.[18] Clinically, SAH often presents with sudden onset of severe headache, altered level of consciousness, and focal neurological deficits, with severity influenced by the extent of bleeding.[19]

Subdural hemorrhage (SDH) involves the accumulation of blood between the dura matter and arachnoid membrane and is most associated with traumatic injury. However, in hypertensive individuals, particularly the elderly, elevated blood pressure may exacerbate bleeding due to increased fragility of bridging veins.[20] Similarly, epidural hemorrhage (EDH), which occurs between the skull and dura mater, is typically traumatic in origin but remains an essential differential diagnosis on emergency brain CT because of its rapid progression and life-threatening potential. Although SDH and EDH are not directly caused by hypertension, elevated blood pressure may influence hemorrhage severity and clinical outcome.[21]

The clinical presentation of intracranial hemorrhage varies depending on hemorrhage type, anatomical location, and volume of bleeding. Common manifestations include sudden headaches, vomiting, altered consciousness, focal neurological deficits, seizures, and, in severe cases, coma.[22] Importantly, the severity of clinical symptoms often correlates with radiological features such as hematoma size, location, and associated mass effect. From a prognostic standpoint, radiological characteristics observed on emergency brain CT are critical determinants of patient outcomes.[23] Hemorrhage location significantly influences prognosis, with deep-seated and brainstem hemorrhages associated with higher mortality and poorer functional outcomes. Hematoma volume is a well-established predictor of mortality, as larger hemorrhages contribute to increased intracranial pressure and compression of adjacent brain structures. Furthermore, hemorrhage extension, particularly intraventricular involvement or multi-compartment bleeding is strongly associated with neurological deterioration and adverse clinical outcomes.[24]

In Pakistan, hypertensive intracranial hemorrhage represents a major contributor to acute neurological disability, compounded by poor blood pressure control, delayed healthcare access, and limited availability of specialized neurosurgical services.[25] Despite the high disease burden, there is a lack of comprehensive local data evaluating the distribution and CT characteristics of hemorrhage patterns in relation to hypertension severity. This gap in imaging-based epidemiological evidence limits effective emergency triage, resource allocation, and targeted prevention strategies.[26] Emergency brain imaging, particularly non-contrast computed tomography (NCCT), plays a pivotal role in the rapid diagnosis and management of intracranial hemorrhage.[27] NCCT is the first-line imaging modality in patients presenting with acute neurological symptoms due to its speed, accessibility, and high sensitivity for detecting acute blood. It enables immediate visualization of hemorrhage without the need for contrast administration, making it especially suitable for unstable patients in emergency settings.[28]

On NCCT, acute intracranial hemorrhage appears as a hyperdense area, allowing accurate identification of hemorrhage type, anatomical location, and extent.[29] CT imaging facilitates differentiation between intraparenchymal, intraventricular, subarachnoid, subdural, and epidural hemorrhages is an essential step in guiding clinical management and determining prognosis. In addition to detection, CT provides quantitative and qualitative assessment of hemorrhage severity, including hematoma volume, shape, mass effect, ventricular involvement, and midline shift.[30] These radiological parameters are integral to clinical decision-making, as they help determine the need for urgent neurosurgical intervention, intensive care monitoring, or conservative treatment. In hypertensive patients, CT findings also reflect the underlying vascular pathology and severity of disease, thereby serving as an important tool for risk stratification and outcome prediction.[31]

Hypertension is strongly associated with distinct patterns of intracranial hemorrhage, and the severity of elevated blood pressure plays a key role in determining hemorrhage characteristics. Chronic hypertension leads to progressive degeneration of small penetrating arteries, particularly those supplying deep brain structures.[32] Consequently, hypertensive hemorrhages most commonly occur in regions such as the basal ganglia, thalamus, pons, and cerebellum. Among these, the basal ganglia are the most frequently affected site due to their supply by small perforating arteries that are highly susceptible to hypertensive damage. Similarly, thalamic hemorrhages arise from involvement of penetrating branches of the posterior circulation. In cases of severe or poorly controlled hypertension, hemorrhages may also involve the pons and cerebellum, where even small increases in hematoma size can result in significant neurological compromise due to the presence of critical neural pathways.[33]

Importantly, the severity of hypertension not only influences hemorrhage location but also affects hematoma size, expansion rate, and complexity. Higher blood pressure levels are associated with larger hematoma volumes and increased risk of hematoma expansion, reflecting ongoing vascular rupture under elevated hemodynamic stress.[34] Severe hypertension is also linked to multi-compartment hemorrhage, particularly intraventricular extension, which is a well-recognized marker of poor prognosis due to its association with hydrocephalus and raised intracranial pressure.[35]

Rationale of Study

Despite the established relationship between hypertension and intracranial hemorrhage, there remains a significant gap in systematically correlating graded hypertension severity with specific hemorrhage patterns and CT imaging features. Most existing studies focus primarily on the presence of hypertension rather than its severity, limiting the ability to perform detailed risk stratification. Therefore, this study aims to evaluate the correlation between hypertension severity and intracranial hemorrhage patterns on emergency non-contrast brain CT. By analyzing hemorrhage types, anatomical distribution, and imaging severity features in relation to blood pressure levels, this research seeks to provide clinically relevant insights that may enhance emergency decision-making, improve prognostic assessment, and support evidence-based stroke management in resource-limited healthcare settings.

AIMS AND OBJECTIVES

To determine the distribution and CT characteristics of intracranial hemorrhage types among hypertensive individuals presenting with acute neurological symptoms in the emergency setting.

METHODOLOGY

A descriptive cross-sectional study with a sample size of 165 subjects,[36], based on a 95% confidence level, was designed and conducted at Lahore Care Hospital over a four-month period. The study population comprised patients with hypertension, aged ≥18 years, and with acute neurologic symptoms who were subjected to NCCT brain scanning. These patients were selected using non-probability convenient sampling while excluding trauma, those with past history of intracranial surgery, tumors, vascular abnormalities, and poor image quality. Multi-slice CT was performed in line with the standard NCCT procedure involving patient positioning and axial scanning with optimal scan parameters. A data sheet was used to collect relevant patient data including age, sex, signs, and hypertension status through prospective and retrospective sampling from ER and radiology records. For consistency and accuracy, the CT images were interpreted by qualified radiologists. Data analysis was done in SPSS v.26 where quantitative variables were presented as mean ± SD or median and categorical variables as frequency and percentage. Patient confidentiality was strictly observed and any correlation among variables was analyzed using Chi-square, Fisher's Exact test, t-test, or ANOVA as needed.

RESULTS

Participant Recruitment & Data Completeness

A total of 165 hypertensive patients presenting with acute neurological symptoms were enrolled. After excluding 12 cases for incomplete imaging or missing clinical data, 153 patients were included in the final analysis.

Demographics: Table 1. Demographics of Study Participants (n = 153)

The demographic distribution shows that the majority of patients were older adults. Most participants (76.5%) were aged 50 years or above, with a mean age of 65.3 ± 12.1 years, reflecting the higher prevalence of intracranial hemorrhage in elderly hypertensive populations. Males constituted a larger proportion of the study population (60.1%) compared to females (39.9%), indicating a male predominance in hypertensive intracranial hemorrhage presentations.

Table 1: Demographics of Study Participants (n = 153)

Variable	n (%)
Age (years)	
30–49	22 (14.4)
50–64	58 (37.9)
65–79	59 (38.6)
≥ 80	14 (9.1)
Mean ± SD (Range)	65.3 ± 12.1 (31–92)
Sex	
Male	92 (60.1)
Female	61 (39.9)

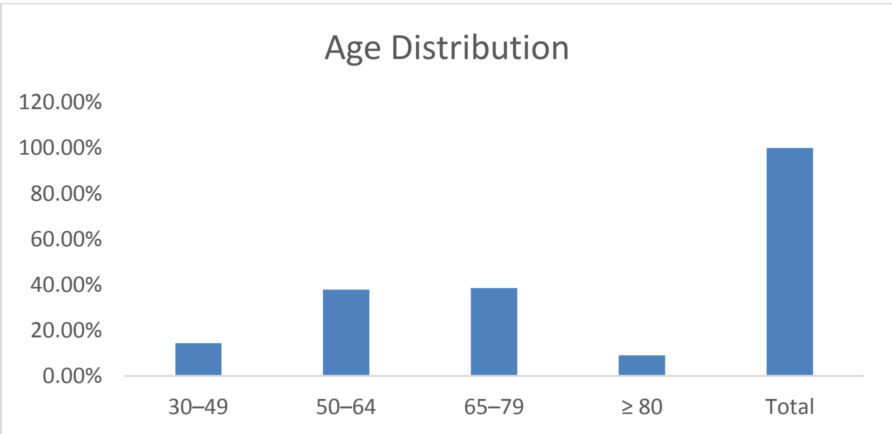

Figure 1: Age Distribution

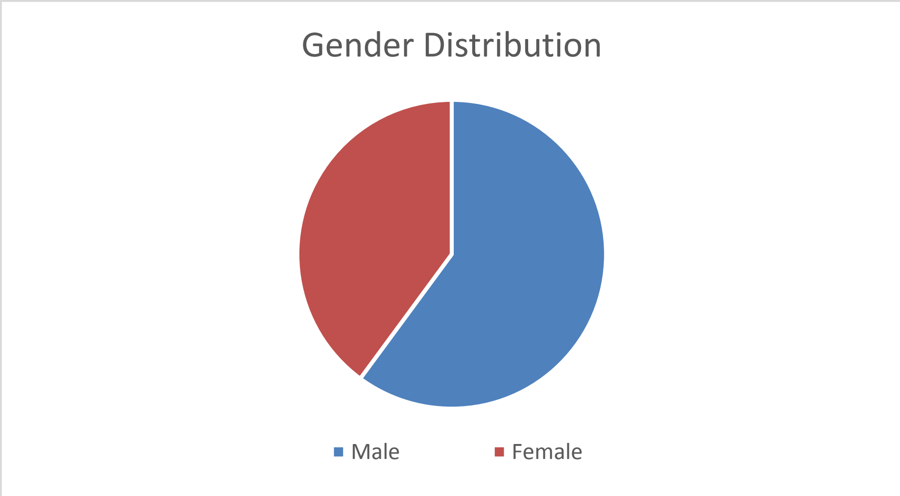

Figure 2: Gender Distribution

Clinical Profile

Table 2. Hypertension Severity & Comorbidities

More than half of the patients (51.0%) had stage II hypertension, while one-quarter (25.5%) presented with a hypertensive crisis, highlighting poor blood pressure control among the study population. Nearly 71% of patients had hypertension for more than five years, emphasizing the role of long-standing hypertension in the development of cerebrovascular complications.

Table 2: Hypertension Severity & Comorbidities

Parameter	n (%)
Hypertension Stage (AHA)	
Stage I (SBP 130–139 / DBP 80–89)	36 (23.5)
Stage II (≥140/90)	78 (51.0)
Hypertensive Crisis (≥180/120)	39 (25.5)
Duration of HTN (years)	
<5	44 (28.8)
5–10	68 (44.4)
>10	41 (26.8)

CT Imaging Findings

Table 3. Intracranial Hemorrhage Types (n = 153)

Spontaneous intracerebral hemorrhage was the most common hemorrhage type, accounting for 77.1% of cases. Subarachnoid hemorrhage and intraventricular hemorrhage were less frequent. Mixed hemorrhagic patterns were observed in a small proportion of patients, suggesting severe vascular pathology and advanced disease.

Table 3: Intracranial Hemorrhage Types (n = 153)

ICH Type	n (%)
Spontaneous Intracerebral Hemorrhage (sICH)	118 (77.1)
Subarachnoid Hemorrhage (SAH)	19 (12.4)
Intraventricular Hemorrhage (IVH)	9 (5.9)
Mixed (ICH + IVH / SAH)	7 (4.6)

Hemorrhage Location

Table 4. Anatomical Location of ICH (n = 118)

Among patients with intracerebral hemorrhage, the basal ganglia were the most frequently affected site (45.8%), followed by the thalamus (22.0%). These deep brain structures are supplied by small penetrating arteries that are particularly vulnerable to hypertensive damage. Cerebellar and pontine hemorrhages were also observed, while lobar hemorrhages were relatively uncommon.

Table 4: Anatomical Location of ICH (n = 118)

Location	n (%)
Basal Ganglia	54 (45.8)
Thalamus	26 (22.0)
Cerebellum	18 (15.3)
Pons	12 (10.2)
Lobar	8 (6.8)

Hemorrhage Volume & Symmetry

Table 5. CT Characteristics

Most patients had hematoma volumes below 60 mL; however, nearly one-fifth (19.6%) presented with large hematomas exceeding 60 mL, which are associated with worse clinical outcomes. Hemorrhages were slightly more common on the left side, although right-sided and bilateral hemorrhages were also observed.

Table 5: Characteristics of CT

Feature	n (%)
Hematoma Volume	
< 30 mL	71 (45.5)
30–60 mL	52 (34.0)
> 60 mL	30 (19.6)
Laterality	
Left	74 (48.4)
Right	64 (41.8)
Bilateral	15 (9.8)

Severe Radiologic Features

Table 6. Complications on CT

A substantial proportion of patients exhibited severe radiological features. Cerebral edema was the most frequent complication (35.3%), followed by midline shift greater than 5 mm (30.7%). Intraventricular extension was present in over one-quarter of cases, indicating severe hemorrhage and increased risk of poor outcomes.

Table 6: Complications on CT

Complication	n (%)
Intraventricular Extension	42 (27.5)
Hydrocephalus	18 (11.8)
Midline Shift > 5 mm	47 (30.7)
Cerebral Edema	54 (35.3)

Severity Scoring

Table 7. Severity Scores Distribution

The median ICH score of 2 suggests moderate disease severity among the study population. The Graeb and Modified Fisher scores further indicate a significant burden of ventricular and subarachnoid blood, reinforcing the seriousness of hemorrhagic presentations in hypertensive patients.

Table 7: Severity Scores Distribution

Score	Median (IQR)
ICH Score	2 (1–3)
Graeb Score	4 (2–7)
Modified Fisher Score	3 (2–4)

Outcome Measures

Table 8. Immediate Emergency Outcomes

Nearly two-thirds of patients required ICU admission, reflecting the critical nature of their condition. Intubation was necessary in over one-fifth of patients. The in-hospital mortality rate was 19%, underscoring the high fatality associated with hypertensive intracranial hemorrhage.

Table 8: Immediate Emergency Outcomes

Outcome	n (%)
Referred to ICU	98 (64.1)
Intubation Required	34 (22.2)
In-hospital Mortality	29 (19.0)

Inferential Analysis

Table 9: Hypertension Severity vs. Hemorrhage Volume

A statistically significant association was observed between hypertension severity and hematoma volume (p = 0.033). Patients presenting with hypertensive crisis were more likely to have large-volume hemorrhages (>60 mL), highlighting the impact of severe blood pressure elevation on bleeding extent.

Table 9: Hypertension Severity vs. Hemorrhage Volume

Group	>60 mL	≤60 mL	p-value
Stage I/II	18 (11.8%)	96 (62.7%)	
Crisis	12 (7.8%)	27 (17.6%)	0.033*

Table 10. Hypertension Severity vs. Severity Scores

Patients with hypertensive crisis had significantly higher mean ICH scores compared to those with stage I or II hypertension (p = 0.004), indicating more severe radiological and clinical presentations in patients with extreme blood pressure elevations.

Table 10: Hypertension Severity vs. Severity Scores

Group	Mean ICH Score ± SD	p-value
Stage I/II	1.9 ± 1.1	0.004
Crisis	2.7 ± 1.3	0.004

Table 11. Significant Predictors for Severe Outcome (In-hospital Mortality)

Multivariate analysis identified ICH score ≥3, hematoma volume >60 mL, and hypertensive crisis as significant predictors of mortality. Large hematoma volume emerged as the strongest predictor, emphasizing its prognostic importance.

Table 11: Significant Predictors for Severe Outcome

Predictor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
ICH Score ≥3	3.8	(1.6–8.9)	0.002
Hematoma Volume >60 mL	4.5	(1.9–10.8)	< 0.001
Hypertensive Crisis	2.2	(1.1–4.6)	0.028

DISCUSSION

The present study was designed to evaluate the correlation between hypertension severity and intracranial hemorrhage patterns on emergency brain CT and to assess how radiological characteristics influence immediate clinical outcomes. The findings provide valuable insight into the role of uncontrolled hypertension in determining hemorrhage type, location, volume, and prognosis, particularly within an emergency care setting.

The study population consisted predominantly of older adults, with a mean age of 65.3 years, reflecting the established association between increasing age and the risk of intracranial hemorrhage. Age-related vascular changes, including arterial stiffness and reduced vascular elasticity, compound the damaging effects of long-standing hypertension, making elderly individuals more susceptible to cerebral vessel rupture. Similar age distributions have been reported in previous studies examining hypertensive intracerebral hemorrhage, where the highest incidence was observed in patients older than 60 years [18].

Male predominance observed in this study is consistent with earlier research indicating that men are at a higher risk of hemorrhagic stroke than women. This difference has been attributed to variations in hormonal protection, lifestyle factors, and a higher prevalence of poorly controlled hypertension among males [31]. These findings reinforce the need for targeted preventive strategies in high-risk demographic groups.A significant proportion of patients in this study had stage II hypertension or presented with hypertensive crisis, highlighting inadequate blood pressure control in the study population. Moreover, more than two-thirds of patients had hypertension for over five years, supporting the role of chronic vascular damage in the pathogenesis of intracranial hemorrhage. Previous studies have demonstrated that prolonged hypertension leads to progressive degeneration of small cerebral arteries through lipohyalinosis and fibrinoid necrosis, ultimately predisposing vessels to rupture [41].

Patients presenting with hypertensive crisis showed more severe radiological findings, supporting earlier evidence that acute extreme elevations in blood pressure can overwhelm cerebral autoregulatory mechanisms and precipitate extensive bleeding [55]. These findings underscore the importance of early detection and aggressive management of severe hypertension to reduce cerebrovascular complications.

Spontaneous intracerebral hemorrhage was the most common hemorrhage type observed in this study, accounting for over three-quarters of cases. This aligns with global literature identifying hypertension as the leading cause of non-traumatic intracerebral hemorrhage [6]. The basal ganglia and thalamus were the most frequently involved sites, which is consistent with the vulnerability of small penetrating arteries supplying these deep brain structures. Multiple studies have reported similar location patterns, attributing them to the anatomical and physiological characteristics of lenticulostriate and thalami perforating arteries, which are particularly susceptible to hypertensive damage [37]. The relatively lower frequency of lobar hemorrhage in this study further supports hypertension as the primary etiological factor, as lobar hemorrhages are more commonly associated with cerebral amyloid angiopathy.

One of the most important findings of this study is the statistically significant association between hypertension severity and hematoma volume. Patients presenting with hypertensive crisis were more likely to develop large-volume hemorrhages (>60 mL), which are known to be strongly associated with poor clinical outcomes. Prior studies have demonstrated that larger hematoma volumes result in increased intracranial pressure, reduced cerebral perfusion, and higher mortality rates [29]. The high prevalence of severe radiological features such as intraventricular extension, cerebral edema, and midline shift further reflects the aggressive nature of hemorrhage in patients with severe hypertension. Intraventricular extension, in particular, has been consistently identified as an independent predictor of mortality due to its association with acute hydrocephalus and raised intracranial pressure [10].The use of standardized CT-based severity scoring systems in this study adds strength to the findings. Patients with hypertensive crisis demonstrated significantly higher ICH scores compared to those with lower hypertension stages, indicating more severe disease at presentation. The ICH score has been widely validated as a reliable predictor of short-term mortality and functional outcome in patients with intracerebral hemorrhage [31]. Similarly, elevated Graeb and Modified Fisher scores observed in this study reflect a higher burden of ventricular and subarachnoid blood, which has been linked to worse neurological outcomes in previous research [16]. These findings emphasize the value of incorporating CT severity scores into routine emergency assessment protocols.

The in-hospital mortality rate observed in this study is comparable to rates reported in both regional and international studies of hypertensive intracranial hemorrhage [56]. Multivariate analysis identified ICH score ≥3, hematoma volume >60 mL, and hypertensive crisis as significant predictors of mortality. These results are consistent with established prognostic models and highlight the cumulative effect of radiological severity and blood pressure extremes on patient survival [54]The high rate of ICU admission and need for intubation further underscores the critical nature of hypertensive intracranial hemorrhage and the substantial burden it places on emergency and critical care services.

The findings of this study emphasize the central role of emergency brain CT in identifying hemorrhage patterns associated with hypertension severity. Early recognition of high-risk radiological features can assist clinicians in triaging patients, initiating timely interventions, and counseling families regarding prognosis. Furthermore, the demonstrated association between blood pressure severity and hemorrhage characteristics reinforces the need for strict blood pressure monitoring and control, particularly in patients with known long-standing hypertension.

CONCLUSION

This study concludes that the severity of hypertension has a significant and measurable impact on intracranial hemorrhage patterns and outcomes as demonstrated on emergency brain CT. Patients with severe hypertension, particularly those presenting with hypertensive crisis, exhibited larger hematoma volumes, higher CT severity scores, and a greater frequency of radiological complications such as intraventricular extension, cerebral edema, and midline shift. These imaging findings were strongly associated with adverse immediate clinical outcomes, including increased need for intensive care and higher in-hospital mortality. The predominance of deep intracerebral hemorrhages involving the basal ganglia and thalamus supports the established pathophysiological link between chronic hypertension and small vessel disease. The study also highlights the prognostic value of CT-based scoring systems, as higher ICH and Graeb scores were found to be significant predictors of mortality. Overall, emergency brain CT proved to be an essential tool not only for diagnosing intracranial hemorrhage but also for assessing disease severity and guiding early clinical decision-making.The findings emphasize the critical importance of early detection, strict blood pressure control, and prompt radiological evaluation in hypertensive patients presenting with acute neurological symptoms. Understanding the relationship between hypertension severity and hemorrhage patterns can contribute to improved risk stratification, better management strategies, and ultimately improved patient outcomes.

Limitation

Single-**center study design**, which may limit the generalizability of the findings to other populations and healthcare settings.

Short-**term outcome assessment**, as long-term functional and neurological outcomes were not evaluated.

Blood **pressure classification based on admission readings only**, which may not reflect long-term blood pressure control.
Potential **confounding factors**, such as antihypertensive medication adherence and lifestyle factors, were not assessed.
Relatively **limited sample size**, which may reduce the power to detect associations in certain subgroups.

Recommendations

Early and aggressive blood pressure control should be emphasized to reduce the risk and severity of intracranial hemorrhage.
Routine use of CT-based severity scoring systems is recommended in emergency departments for early risk stratification and prognostic assessment.
Multicenter studies with larger sample sizes should be conducted to improve the generalizability of results.
Long-term follow-up studies are recommended to evaluate functional recovery and quality of life after hypertensive intracranial hemorrhage.
Public health initiatives and patient education programs should focus on hypertension awareness, regular monitoring, and treatment compliance to prevent severe cerebrovascular complications.

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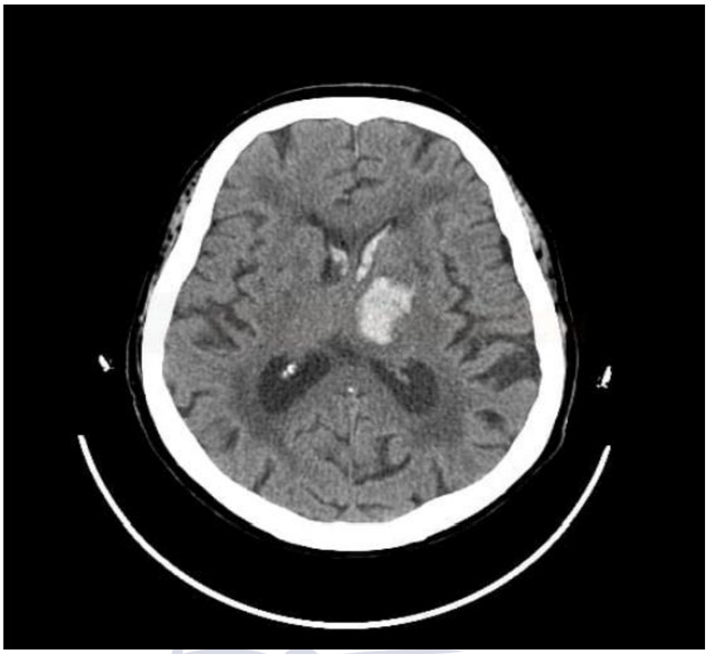
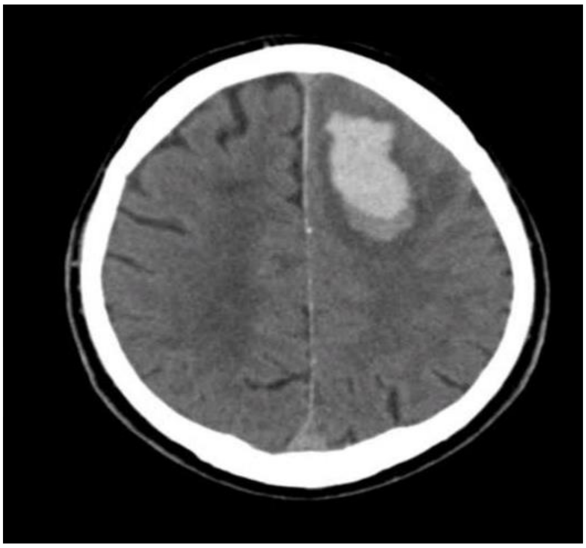
APPENDICES



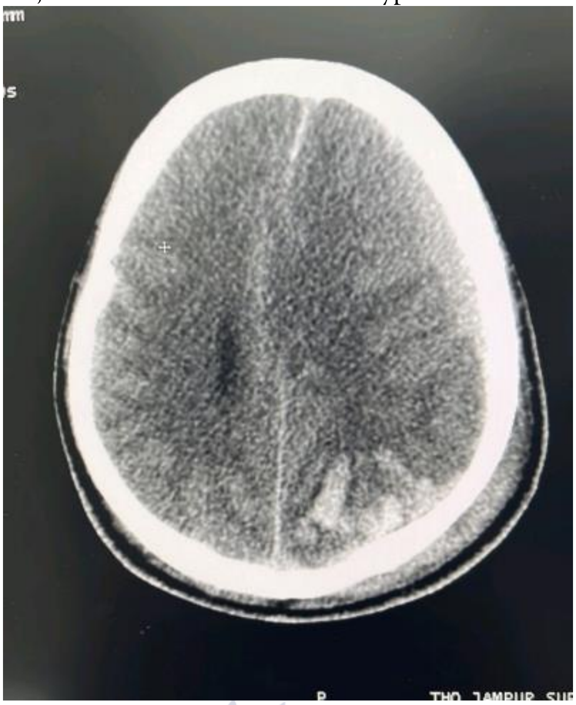
Case no 01

Axial non-contrast CT brain scan demonstrating a focal hyperdense intraparenchymal hematoma in the left basal ganglia region.The findings are consistent with an acute hypertensive intracerebral hemorrhage (ICH), meeting the study's inclusion criteria for emergency neuroimaging.



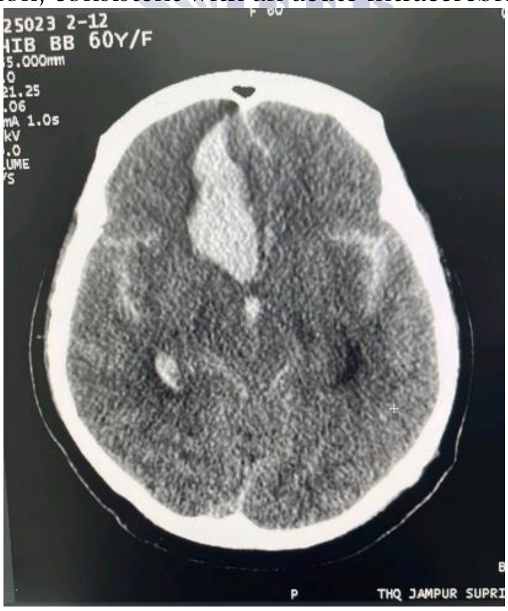
Case no 02

Axial non-contrast CT brain scan revealing a large, well-defined hyperdense intraparenchymal hematoma located in the left frontal lobe. The lesion is associated with surrounding perifocal edema and mild mass effect, consistent with an acute hypertensive intracerebral hemorrhage



Case no 03

Axial non-contrast CT brain of a 65-year-old male patient demonstrating a hyperdense area in the left parieto-occipital region, consistent with an acute intracerebral hemorrhage.



Case no 04

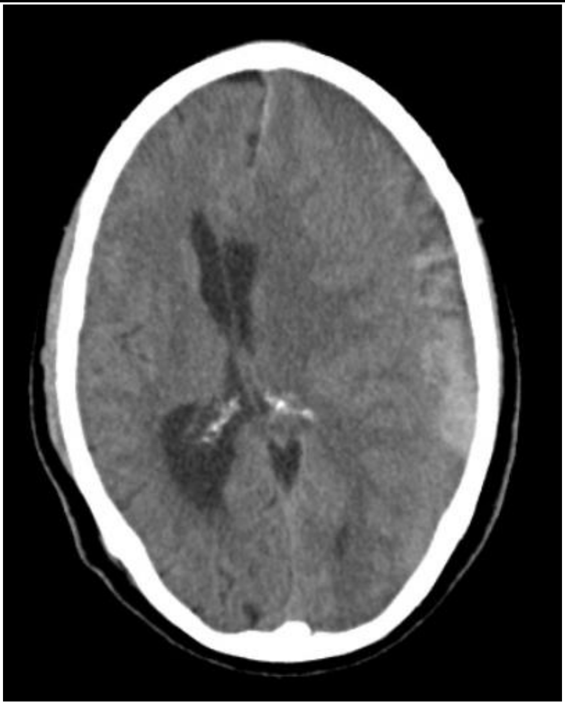
Axial non-contrast CT brain of a 60-year-old female patient showing a large acute intraparenchymal hemorrhage in the frontal lobe with evidence of intraventricular extension.

Case no 05

Axial non-contrast CT brain of a 55-year-old female patient revealing a focal hyperdense lesion in the right thalamic/basal ganglia region, typical of a hypertensive intracerebral hemorrhage.

Case no 06

Minimal subdural hematoma in right frontal region



Case no 07

Left subdural subacute hematoma involving frontoparietotemporal with effacement of left cerebral sulci & left lateral ventricle along with midline shift towards right side (as described above) Impression:

Case no 08

Subacute subdural hematoma in left frontoparietal region with mass effect and midline shift as described above Impression: