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ROLE OF CONTRAST-ENHANCED CT SCAN IN THE EVALUATION OF INTRACRANIAL HAEMORRHAGE: A REVIEW

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ABSTRACT

Intracranial haemorrhage (ICH) is one of the most critical neurological emergencies, associated with significant morbidity, mortality, and long-term disability. Rapid diagnosis is essential for appropriate clinical management and improved patient outcomes. Non-contrast computed tomography (NCCT) remains the first-line imaging modality for detecting acute intracranial bleeding because of its speed, availability, and high sensitivity. However, contrast-enhanced computed tomography (CECT), particularly CT angiography (CTA), provides valuable additional information regarding the underlying cause of haemorrhage, active bleeding, vascular abnormalities, aneurysms, arteriovenous malformations (AVMs), venous thrombosis, and tumour-related haemorrhage. Recent studies demonstrate that contrast-enhanced CT significantly improves diagnostic accuracy, assists in treatment planning, predicts haematoma expansion through imaging markers such as the CTA spot sign, and contributes to better prognostic assessment. This review summarises current evidence regarding the role of contrast CT in intracranial haemorrhage, highlighting its diagnostic applications, clinical significance, advantages, limitations, and future perspectives.

KEYWORDS: Intracranial haemorrhage, Contrast CT, CT angiography, Spot sign, Neuroimaging, Stroke.

INTRODUCTION

Intracranial haemorrhage refers to bleeding within the cranial cavity and includes intracerebral haemorrhage, subarachnoid haemorrhage, subdural haemorrhage, epidural haemorrhage, and intraventricular haemorrhage. These conditions constitute neurological emergencies requiring immediate diagnosis and intervention to reduce mortality and neurological disability. Early imaging plays a fundamental role in differentiating haemorrhagic stroke from ischaemic stroke and identifying the underlying pathology.

Computed tomography has become the imaging modality of choice in emergency departments due to its rapid acquisition time, widespread availability, and excellent sensitivity for detecting acute blood. Although non-contrast CT successfully identifies the presence and location of haemorrhage, it may not always determine the underlying cause. Contrast-enhanced CT has therefore emerged as an important complementary investigation, providing vascular and structural information that directly influences patient management.

Types of Intracranial Haemorrhage

Intracranial haemorrhage is classified according to the anatomical location of bleeding.

Intracerebral haemorrhage (ICH) is the most common spontaneous haemorrhage and is usually associated with hypertension, cerebral amyloid angiopathy, vascular malformations, or anticoagulant therapy.

Subarachnoid haemorrhage (SAH) typically results from rupture of an intracranial aneurysm and presents with sudden severe headache and neck stiffness.

Subdural haemorrhage (SDH) usually occurs following trauma due to tearing of bridging veins.

Epidural haemorrhage (EDH) commonly results from arterial injury, particularly involving the middle meningeal artery.

Intraventricular haemorrhage (IVH) occurs when blood enters the ventricular system either primarily or secondary to extension of another haemorrhage.

Each subtype demonstrates characteristic CT findings that guide diagnosis and management.

Role of Non-Contrast CT

Non-contrast CT remains the gold standard initial imaging technique for suspected intracranial haemorrhage. Fresh blood appears hyperdense because of its high protein and iron content.

NCCT rapidly identifies:

- Location of haemorrhage
- Volume of bleeding
- Midline shift
- Mass effect
- Hydrocephalus
- Intraventricular extension

These findings enable rapid clinical decision-making in emergency settings. However, NCCT often cannot identify the source of bleeding or underlying vascular abnormalities.

Importance of Contrast-Enhanced CT

Contrast-enhanced CT provides detailed vascular information beyond that available on non-contrast studies.

Its principal advantages include:

- Detection of active contrast extravasation
- Identification of the CTA spot sign
- Detection of aneurysms
- Diagnosis of arteriovenous malformations
- Detection of cerebral venous sinus thrombosis
- Identification of tumour-related haemorrhage
- Evaluation of unexplained or atypical haemorrhage

The CTA spot sign has become one of the most important prognostic imaging markers. It represents active leakage of contrast into the haematoma and strongly predicts continued bleeding, haematoma expansion, neurological deterioration, and poor clinical outcome.

Contrast CT in Different Types of Haemorrhage Intracerebral Haemorrhage

Contrast CT helps identify active bleeding, underlying vascular malformations, occult tumours, and spot signs. It is particularly useful in younger patients and those with atypical lobar haemorrhage.

Subarachnoid Haemorrhage

CT angiography has become indispensable for detecting intracranial aneurysms, determining aneurysm size and location, and planning neurosurgical clipping or endovascular coiling.

Subdural and Epidural Haemorrhage

Although plain CT is generally sufficient, contrast studies are useful when vascular injury or underlying pathology is suspected.

Intraventricular Haemorrhage

Contrast-enhanced imaging assists in identifying associated vascular lesions, aneurysms, AVMs, or tumours responsible for ventricular bleeding.

Clinical Applications

Several studies have shown that contrast-enhanced CT improves patient management by:

- Predicting haematoma expansion
- Identifying patients requiring neurosurgical intervention
- Detecting surgically treatable vascular lesions
- Assisting risk stratification
- Improving diagnostic confidence
- Supporting emergency treatment planning

Early contrast-enhanced imaging allows clinicians to initiate timely interventions, reducing complications and improving outcomes.

Evidence from Recent Studies

The prospective study described in the thesis evaluated **70 patients** with intracranial haemorrhage over a six-month period. The findings demonstrated:

- Slight male predominance (55.7%)
- Highest incidence in patients aged 60–69 years
- Intracerebral haemorrhage as the commonest subtype (51.4%)
- Basal ganglia as the most frequent anatomical site (31.4%)
- Active contrast extravasation in 25.7%
- CTA spot sign in 20%
- Vascular abnormalities in 14.3%
- Aneurysms in 11.4%
- AVMs in 7.1%

These findings reinforce previous literature showing that contrast-enhanced CT substantially improves identification of active bleeding and underlying vascular pathology while supporting clinical decision-making.

Advantages of Contrast CT

Major advantages include:

- Rapid examination
- High diagnostic accuracy
- Wide availability
- Excellent vascular visualisation
- Early identification of treatable lesions
- Better surgical planning
- Improved prognostic assessment
- Reduced diagnostic uncertainty

Compared with MRI, contrast CT remains faster, more accessible, and more practical in emergency settings.

Limitations

Despite its advantages, contrast-enhanced CT has several limitations:

- Exposure to ionising radiation
- Risk of contrast-induced nephropathy
- Potential allergic reactions
- Limited soft tissue contrast compared with MRI
- Contraindicated in selected patients with severe renal impairment

MRI remains superior for chronic haemorrhage, microbleeds, cavernous malformations, and detailed tissue characterisation.

Future Perspectives

Advances in multidetector CT technology, artificial intelligence, automated haemorrhage detection, radiomics, and machine learning are expected to further improve diagnostic accuracy. Future research should focus on multicentre studies with larger sample sizes and long-term clinical follow-up to establish evidence-based guidelines for contrast-enhanced CT in intracranial haemorrhage.

CONCLUSION

Contrast-enhanced CT has become an indispensable adjunct to non-contrast CT in evaluating intracranial haemorrhage. While non-contrast CT remains the first investigation for acute

bleeding, contrast-enhanced imaging provides additional diagnostic and prognostic information that significantly influences patient management. Detection of active contrast extravasation, vascular abnormalities, aneurysms, AVMs, and the CTA spot sign enables earlier intervention and more accurate prognostic assessment. Current evidence supports the selective use of contrast-enhanced CT in patients with spontaneous, atypical, or unexplained intracranial haemorrhage. Continued advances in CT technology are expected to further strengthen its role in emergency neuroimaging.

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