CT IMAGING IN ACUTE STROKE

Neuroimaging plays an essential role in acute stroke assessment by providing critical information to allow the accurate triage of patients, hastening clinical decision-making for treatment.

Non-contrast CT imaging, (also known as un-enhanced CT imaging), CT perfusion imaging and CT angiography have become the central component of diagnosis for stroke in acute stroke service departments, due to their relative speed of implementation and availability. Although MRI offers more sensitivity, especially with regard to early parenchymal changes, its clinical application is often limited by problems in accessing MRI in a timely manner in many centres. Our summary article provides an overview of CT scanning techniques and their use in ischemic stroke, the most prevalent form of stroke, accounting for almost 90% of cases.

The Four P's: Goals of acute stroke imaging

Parenchyma	Assess early signs of cerebral ischemia, rule out haemorrhage
Pipes	Assess extracranial circulation (carotid and vertebral arteries of the neck) and intracranial circulation for evidence of intravascular thrombus or artherosclerotic occlusion
Perfusion	Assess cerebral perfusion by analysing cerebral blood volume (CBV), cerebral blood flow (CBF), mean transit time (MTT) and time to peak (TTP) of contrast agent
Penumbra	Assess tissue at risk of dying if ischemia continues without recanalization and reperfusion

Table 1: The Four P's: Goals of acute stroke imaging. Source reference [1]

Non-contrast CT imaging in ischemic stroke

Non-contrast CT is a quick and reliable imaging method that is readily available in most stroke centres.

Several factors are known to influence accurate detection of cerebral ischemia by this method, these include brain territory, the experience and interpretation of the examining neuroradiologist and critically, the time of the scan from the onset of stroke symptoms. The key aims of initial emergency non-contrast CT scans comprise [2]:

1. Exclude intracranial haemorrhage, which would contraindicate thrombolysis
2. Identify early features of infarction
3. Rule out non-stroke processes, like tumour and other intracranial pathologies that can mimic stroke.

Un-enhanced CT imaging can also detect a unilateral hyperdense vessel sign. This is the result of an acute thrombus in an intracranial vessel and is also referred to as hyperdense MCA sign, when the middle cerebral artery is involved.

Additionally, a common sign of focal cerebral ischemia is an obscured lentiform nucleus appearing hypoattenuated due to cytotoxic edema [3]. Another feature is referred to as the insular ribbon sign, where ischemic damage in the insular cortex results in local hypodensity and a loss of grey-white matter definition [3].

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Quantitation of ischemia in stroke:

Several stroke scales have been widely used in the management of stroke patients. The National Institutes of Health Stroke Score, (NIHSS), involves a clinician evaluating neurological function by asking the patient to carry out individual tasks [4]. There are 11 different test categories, covering left and right motor function and left and right cortical function. Performance is recorded against each and more points are awarded with the decrease in the patient's ability to undertake the task. The higher the score (42 being the maximum), the more ischemic damage is usually seen to have occurred.

The Alberta Stroke Program Early CT Score (ASPECTS) was put forward in 2001 [5] and has since been accepted as a robust means of quantitative assessment using a topographic 10-point scoring system [3]. In the same way that the NIHSS scale grades the clinical severity of the stroke, ASPECTS puts a metric to the patient's brain vitality, thereby also making patients comparable. The MCA territory is divided into ten regions and a point deducted for every area involved. Therefore, a score of 10 is normal and a score of 0 indicates diffuse ischemic involvement. Studies suggest that a high ASPECTS score (>7) can be indicative of a favourable long-term outcome and the effectiveness of thrombolytic treatment [6]. Recent clinical trials have also shown that mechanical endovascular thrombectomy did not benefit stroke patients with an ASPECTS score of 4 or less [7]. The ASPECTS system has now also been automated by software known as e-ASPECTS that has shown to eliminate inter-examiner variability in interpretation [8].

Other less commonly used stroke scales include: Canadian Neurological Scale, Mathew Stroke Scale, Orgogozo Stroke Scale, Scandinavian Stroke Scale, thrombolysis in cerebral infarction (TICI)[+]

CT perfusion in stroke

CT perfusion used in conjunction with CT angiography (CTA) is a crucial tool in ischemic stroke diagnosis. It offers some advantages over non-enhanced CT, including the ability to readily identify ischemic regions of the brain that can be saved from damage by thrombolysis or mechanical clot retrieval treatment. It requires the intravenous bolus injection of an iodinated contrast material. The salvageable area, referred to as the **penumbra**, can be distinguished from infarcted areas or those irreversibly fated to infarct regardless of intervention, known as the **infarct core**. Patients with a small core and a large penumbra are most likely to benefit from reperfusion therapies.

A number of perfusion parameters, including mean transit time (MTT), cerebral blood flow (CBF) and cerebral blood volume (CBV) are key to scan interpretation. Outlined below are the normal MTT, CBF and CBV in grey and white matter and the anticipated changes in these values seen in the penumbra and infarct core in ischemic stroke [9]:

	Normal		Ischemic Stroke	
	Grey Matter	White Matter	Penumbra	Core
Mean transit time (MTT/Secs)	4	4.8	Increase	Increase
Cerebral blood flow (CBF/ml/g/min)	60/100	25/100	Moderate decrease	Marked decrease
Cerebral blood volume (CBV/ ml/g)	4/100	2/100	Normal/ Moderate decrease	Marked decrease

Table 2: CT perfusion in stroke: Radiographic Features. Source reference [9]

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CT Angiography

CT angiography is used to examine the intracranial and extracranial circulation in acute stroke and helps to guide appropriate therapy. It requires the use of a time-optimised bolus injection as a contrast material for visualising vessels. It typically uses helical acquisition of volume data for definition from the aortic arc, all the way up to the arterial circle of Willis. The technique is key for identifying thrombi within intracranial vessels, directing intra-arterial thrombolysis or clot retrieval treatment. Additionally, evaluation of the circulation in the carotid and vertebral arteries in the neck can help establish stroke aetiology, for example atherosclerosis, and offer insights into the potential limitations for endovascular treatment. [10, 11]

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