# IMAGING IN STROKE

Dr. Sunithi Elizabeth Mani, Assoc. Professor, Department of Radiology, CMC, Vellore.

The window period for thrombolysis for stroke is very short and hence early, definitive diagnosis is an essential component of management. Radiological imaging for detection of stroke and description of the arterial territory involved plays a vital role in this regard both for diagnosis and therapy.

## Aims of imaging in acute stroke:

### 1. Exclusion of hematoma

Exclusion of hematoma is important as this is a contraindication for thrombolytic therapy.

### 2. Differentiate between infarcted tissue and penumbra

Identification of the penumbra (area of risk for infarction, which is not already infracted) is necessary. This area is the target for reperfusion therapy.

### 3. Identify stenosis or occlusion of major extra- and intracranial arteries.

The detection of stenosis or occlusion of the artery helps in deciding whether endovascular intervention is feasible or not.

Apart from these, imaging helps in identifying brain swelling and mass effect which may require medical or neurosurgical intervention.

The imaging modalities used in acute stroke patients are CT, MRI and Doppler studies.

## Role of CT in Stroke Imaging

CT is the quickest, cheapest and most easily accessible imaging modality. It is the first imaging done for these patients. It has the highest sensitivity for detecting intracranial hemorrhage. With helical and multislice CT, even slight movement of the patient does not seriously compromise detail on the scan as repeat imaging of specific areas can be done without delay.

Hemorrhage is most readily picked up by a CT when compared to MRI. A hematoma is seen as an area of hyperdensity (bright) within the brain parenchyma. An infarct on the other hand is usually seen as an area of hypodensity (dark). Fig 1 shows a hematoma in the putaminal region on the right side surrounded by oedema.

Fig. 1: Right putaminal hemorrhage

Fig. 2: Right middle cerebral artery territory infarct with brain swelling

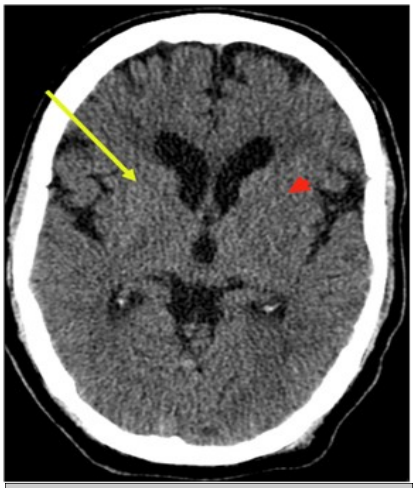

Fig. 3: Yellow arrow points to normal lentiform nucleus visualization, This is obscured on the other side.

## SUBTLE SIGNS ON CT

CT may be appear to be normal in about 30% of patients with stroke but careful examination will prove otherwise. Some of the subtle signs of an infarct which can be missed are:

**1. Obscured lentiform nucleus sign:** The lentiform nucleus and the adjacent internal capsule are usually well demarcated. In an infarct involving this region, the entire region appears uniformly dark or grey. (Fig.3)

**2. Loss of sulcation:** The sulci on the cerebral surface are less evident on the side of an infarct due to cerebral oedema. (Fig. 4)

**3. Hyperdense vessel sign:** A thrombus in a vessel may be seen as a bright line in the CT (Fig.5). This indicates that the thrombus has occurred in the last 90 minutes. This sign has a high specificity (100%) but only moderate sensitivity (30%) in diagnosing a stroke. Loss of grey-white differentiation along with a hyperdense vessel increases the sensitivity. Hyperdense vessel sign is indicative of a large vessel occlusion and therefore predicts a poor stroke outcome (positive predictive value of 91%).

**4. Insular ribbon sign:** The loss of the normal grey-white interface of the insular cortex is known as the 'Insular ribbon' sign. The insula is supplied by the distal branches of the MCA and is susceptible to ischemia.

### Advantages of CT

1. It is cheap and quick.
2. Less vulnerable to motion artefacts.
3. Very sensitive in detecting hemorrhage.

### Disadvantages of CT

1. Not very sensitive in detection of very early or hyperacute infarcts.
2. Small infarcts may be missed.
3. Exposure to ionizing radiation

## CT ANGIOGRAPHY AND CT PERFUSION STUDIES

CT perfusion study can be done to assess the blood flow patterns in the brain which helps in early detection of ischemia, areas of poor perfusion and whether there is occlusion or stenosis of a vessel . Contrast is injected intravenously during the CT and a series of images are taken over a period of time. Coloured images indicate regions ofpoor perfusion which is the penumbra and pa-

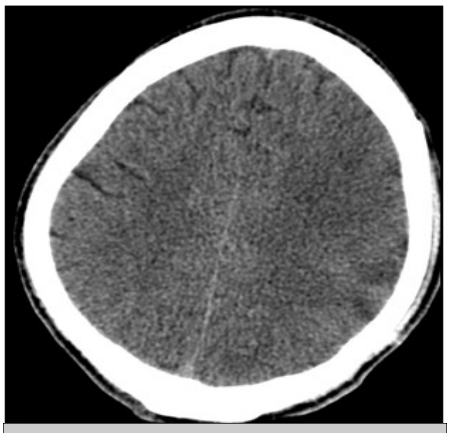

Fig. 4: shows an infarct on the left side—note the loss of grey-white differentiation and loss of sulci suggestive of oedema in the left cerebral hemisphere.

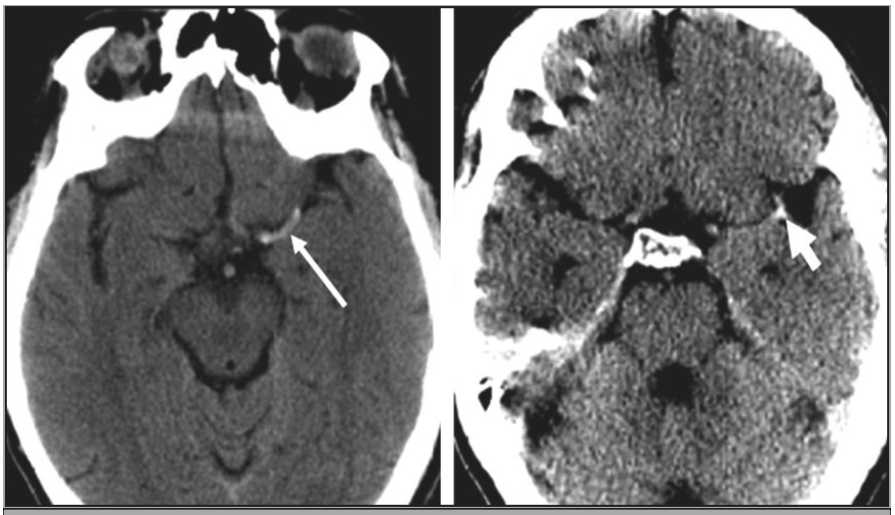

Fig. 5: White arrow points to hyperdensity in the left middle cerebral artery (patient had right sided weakness) indicating thrombus within. This


Fig. 5: CT series showing progression of right middle cerebellar stroke over time: A: 3 hours, B: 16 hours, C: 24 hours, D: After decompressive craniectomy

tients with these findings will benefit from thrombolysis.

## Role of MRI

T1 and T2 weighted imaging have a relatively poor sensitivity in detecting ischemia. The introduction of Diffusion Weighted Imaging (DWI) however has revolutionized the imaging of acute stroke patients both for diagnosis and management.

**DWI images have a much higher sensitivity and specificity than CT in detection of an acute infarct** and also an infarct can be detected within minutes after it has occurred. (Fig.6)

DWI images indicate completely infracted tissue or tissue that cannot be salvaged. Infarcted tissue is bright on the DWI and dark on the ADC.

### Concept of diffusion perfusion mismatch

The area of diffusion restriction (bright in DWI and dark in ADC) indicates non salvageable tissue. On MR Perfusion, the tissue having poor perfusion is identified and this indicates tissue at risk of infarction. Hence, the difference between these areas shows the area that is potentially salvageable by thrombolysis therapy. (Fig.7)

| | |
|---|---|
|  | Restricted diffusion (grey) << perfusion deficit (black) – good prognosis |
|  | Restricted diffusion = perfusion deficit – poor prognosis |
|  | Restricted diffusion >> perfusion deficit – subacute infarct/ reperfusion |

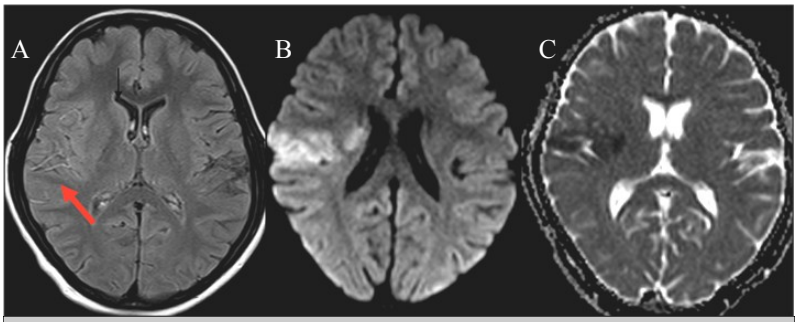


Fig 6.A- FLAIR images showing slow flow in right MCA branches in the sylvian fissure (arrow). Fig 6.B. DWI imaging showing wedge shaped infarct and Fig 6.C: ADC image showing hypointensity in the same region.

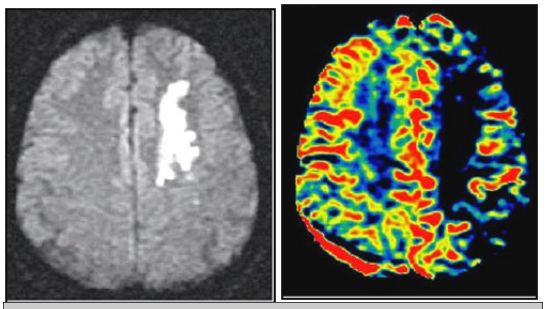

Fig.7: DWI image showing infarct and perfusion deficit on MR Perfusion image. There is a mismatch between the two and hence there is potentially salvageable tissue.

## MR Angiography (MRA)

MRA can be done along with the MRI to guide the therapeutic decision. Intracranial MRA with nonenhanced TOF techniques has a sensitivity ranging from 60% to 85% for stenoses and from 80% to 90% for occlusions compared with CTA or DSA.

### Advantages of MRI

1. DWI imaging is more sensitive and specific in detecting an acute and hyperacute infarct.
2. DWI imaging can detect an infarct within minutes of its occurrence and is useful if a stroke is suspected clinically but the CT appears normal.
3. DWI and MR perfusion imaging (diffusion-perfusion mismatch) can identify patients who can benefit from thrombolytic therapy.
4. Small and deep-seated infarcts are detected better than CT.
5. No exposure to ionizing radiation.

### Disadvantages of MRI

1. MRI is more expensive compared to a CT.
2. It is more time consuming.
3. Movement artefacts can impair the quality of the image and interpretation.
4. It is less sensitive than a CT in detection of hemorrhage.

## Role of Doppler

Transcranial Doppler (TCD) ultrasonography can be used to evaluate occlusion in intracranial vessels but their accuracy is much lesser than that of CT and MRI. TCD is useful for sonothrombolysis which may be used as an adjunct to intravenous thrombolysis.

Carotid Doppler is to be done in patients with transient ischemic attack within a week to identify carotid artery plaques which can be surgically excised if found to be significant.

**References:**

1. "Parenchyma,Pipes,Perfusion,Penumbra" (4P's) Srinivasan et al. RadioGraphics 2006; 26:S75–S95
2. Tomandel et al. RadioGraphics 2003; 23:565–592
3. Heindenreich et al. Acta Radiol. 2008 Jun;49(5):550-7

### Conclusions

- TIME FOR DIAGNOSIS IS SHORT
- CT is the best choice for first imaging. It is more sensitive in detecting hemorrhage.
- DWI is good for detecting a hyperacute infarct and to detect non-salvagable tissue.
- CT Perfusion and MR perfusion imaging can detect tissue at risk for progression to infarct.

**********

### CMC wins SKOCH and BMJ Awards

CMC's initiatives in the fields of innovation, inclusion and information received national recognition at the SKOCH Foundation Awards. Skoch Group is a Gurgaon based think tank dealing with socio-economic issues with a focus on inclusive growth since 1997. **Skoch Group has instituted India's highest independent civilian honours in the field of governance, finance, technology, economics and social sector.**

CMC was conferred 9 awards in the top Platinum category. These included:

**Social Inclusion:** (1) RUHSA, and (2) Tribal Health Initiative in Jawadhi Hills. **Digital Inclusion:** (3) CHRIS Card, (4) Clinical Workstation - The CMC Model, (5) E-learning-The CMC Way, and (6) GIS in Community Care. **Smart Governance:** (7) Integrated Curriculum in Bio-Ethics, (8) Distance Education in India's Medical Education Needs, and (9) HR Strategies in CMC.

***BMJ* Award:** The Tribal Health Initiative of the CMC, Vellore in the Jawadhi Hills was awarded the BMJ Award for excellence in Primary Health Care in Challenging Circumstances. Conferred by The BMJ, one of the world's leading medical journals, the award reflects CMC's mission to improve patient outcomes and showcase the very best healthcare.