Diagnostic Imaging Pathways - Stroke

Population Covered By The Guidance

This pathway provides guidance on the imaging of adult patients following a suspected cerebrovascular accident (stroke).

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Quick User Guide

Move the mouse cursor over the PINK text boxes inside the flow chart to bring up a pop up box with salient points.
Clicking on the PINK text box will bring up the full text.
The relative radiation level (RRL) of each imaging investigation is displayed in the pop up box.

SYMBOL	RRL	EFFECTIVE DOSE RANGE
	None	0
	Minimal	< 1 millisieverts
	Low	1-5 mSv
	Medium	5-10 mSv
	High	>10 mSv

Pathway Diagram

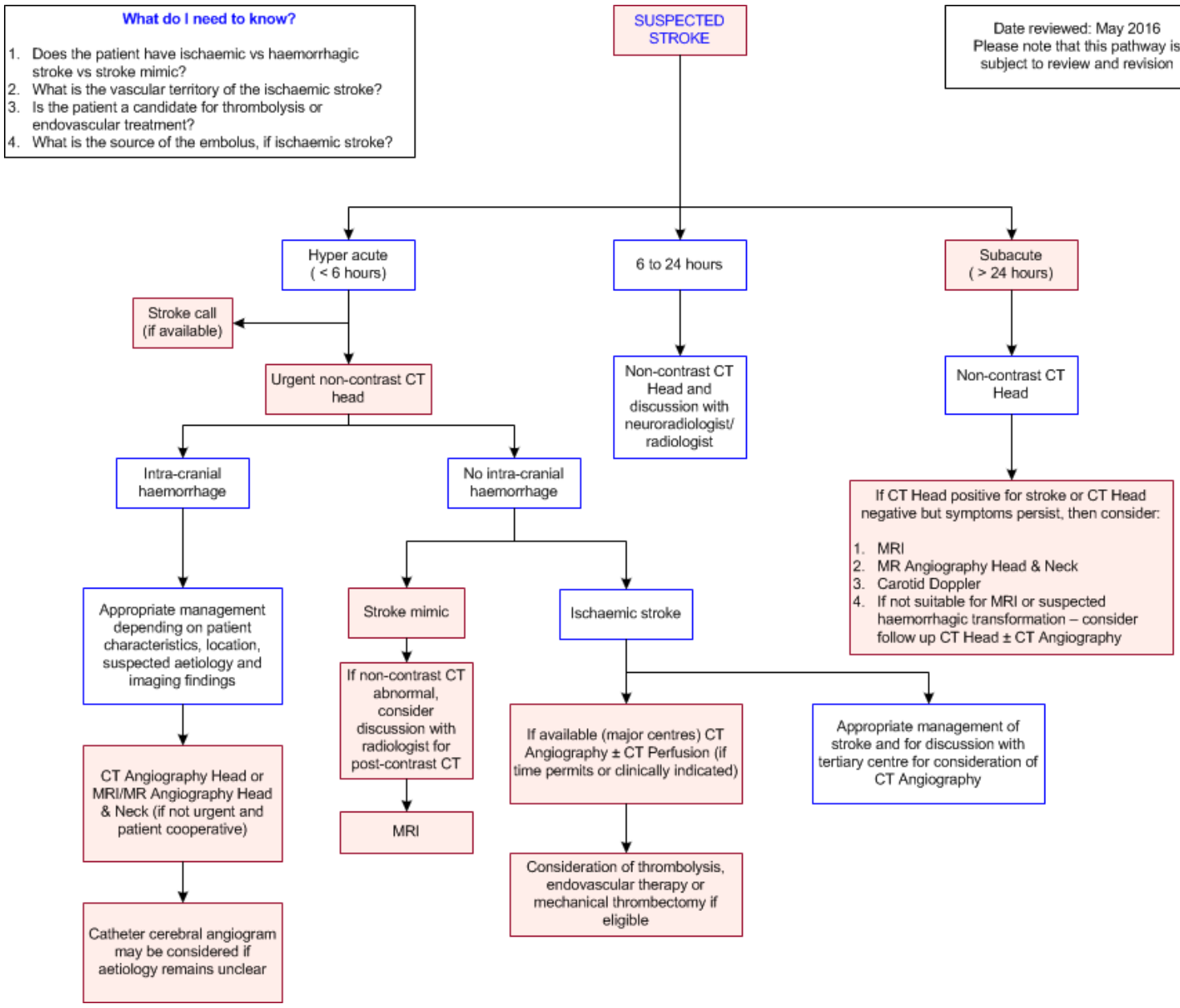
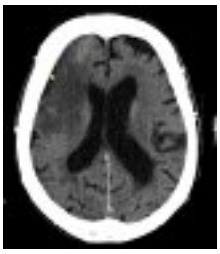


Image Gallery

Note: These images open in a new page

1a



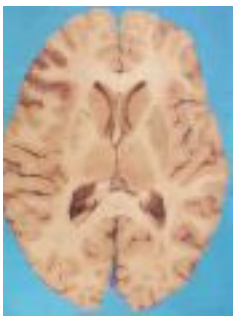
Ischaemic Stroke

Image 1a (Computed Tomography): Acute ischaemic stroke in the right middle cerebral artery territory (arrow).

1b

Ischaemic Stroke

Image 1b : Post-mortem specimen (of a different patient) showing embolic



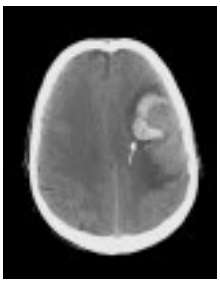
infarct in the region of right middle cerebral artery.

2

Ischaemic Stroke

Image 2 (Computed Tomography): Acute ischaemic stroke in the right posterior inferior cerebellar artery territory (arrow) with compression of the fourth ventricle.

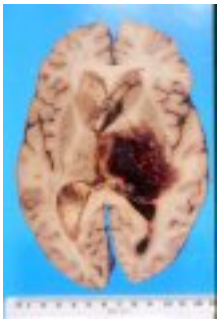
3



Haemorrhagic Stroke

Image 3 (Computed Tomography): Acute intracranial haemorrhage secondary to a ruptured left arteriovenous malformation (AVM).

4



Haemorrhagic Stroke

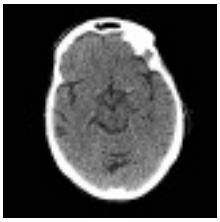
Image 4 : Post-mortem specimen showing a hypertensive intracerebral haemorrhage in the region of the left thalamus and extending into the lateral ventricles.

5

Old Cystic Infarct

Image 5 : Post-mortem specimen showing an old cystic infarct in the left middle cerebral artery territory. Old infarcts appear as cystic spaces of varying size, depending on the size of the artery occluded (an old infarct undergoes liquefactive necrosis and may become a fluid-filled cyst).

6



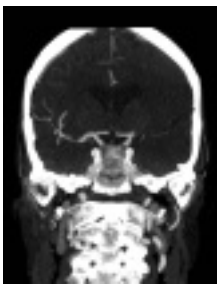
Dense MCA Sign

Image 6: Non-contrast CT head demonstrates dense M1 segment of middle cerebral artery (MCA) [arrow] on the left side. Dense MCA reflects a thrombus causing occlusion of left M1 segment of MCA.

7

Occluded left M1 MCA

Image 7: CT Angiogram of head and neck demonstrates occlusion of M1 segment of left middle cerebral artery secondary to thrombus.



8a

Occluded left M1 MCA

Image 8a: Catheter Cerebral Angiogram (Digital Subtraction Angiogram) demonstrates no blood flow through occluded left M1 middle cerebral artery prior to mechanical thrombectomy.

8b

Recanalisation of left MCA

Image 8b: Catheter Cerebral Angiogram in same patient as image 8a demonstrating recanalization of left MCA and restoration of blood flow after mechanical thrombectomy.

Teaching Points

- Imaging in the setting of suspected stroke serves a number of purposes
    - To distinguish between haemorrhagic and ischaemic stroke
    - To determine vascular territory of stroke and location and extent of intravascular clot
    - To determine presence and extent of ischaemic core and penumbra
    - To determine aetiology of the stroke
    - To identify alternative causes of clinical symptoms
- A non-contrast CT is the initial imaging modality of choice in suspected stroke. The main value of CT in the acute setting is to exclude haemorrhage or tumour
- Further imaging is dictated by the clinical situation and includes CTA (CT Angiogram) +/- CTP (CT Perfusion) depending on resources and expertise available. CTA/CTP should can be performed while recombinant tissue plasminogen activator (rtPA) is being prepared and should not delay the administration of recombinant tissue plasminogen activator
- For patients who are outside the time window for acute reperfusion therapies [> 4.5 hours at sites where only IV recombinant tissue plasminogen activator (rtPA) is being considered; > 8hours at sites where endovascular therapy is considered] and for patients with Transient Ischaemic Attack (TIA) , emphasis is on secondary prevention and their imaging work-up should be focused on vascular imaging (MRA or Carotid Doppler or CTA) to assess carotid arteries as a possible source of emboli with secondary prevention in mind. If MRA is obtained, DWI, T1, T2 sequences should be performed as well at the same time

Computed Tomography

- A non-contrast CT is the initial imaging modality of choice for the patient with suspected stroke and should be done as soon as possible (24hrs at the latest)
- CT in the setting of suspected stroke serves a number of purposes

    - To distinguish between haemorrhagic and ischaemic stroke
    - To determine vascular territory of stroke and location and extent of intravascular clot
    - To determine presence and extent of “ischaemic core” and “penumbra”
    - To determine aetiology of the stroke
    - To identify the alternative causes of clinical symptoms
- A normal CT does not exclude a stroke
    - In as little as 31% of CT scans, early changes within 3 hours of ischaemic stroke are visible 1
    - The early CT signs of stroke may be subtle and difficult to detect even for experienced clinicians 2, 3
    - Approximately 90% of patients with a large cortical infarct will have visible changes on CT by 48 hours 4
- Signs of infarction include 5-7, 8
    - Parenchymal hypodensity
    - Loss of grey/white differentiation
    - Effacement of cortical sulci
    - Local mass effect
    - Loss of the insular ribbon
    - Obscuration of the lentiform nucleus
    - Hyperdense middle or other cerebral artery
- Advantages
    - Widely available and less expensive than MRI
    - Excellent sensitivity for detecting acute haemorrhage 9
- Disadvantages
    - Less sensitive than DWI for the detection of acute ischaemia within first 12 hours 9
    - Ionizing radiation – this may be of significance in younger patients

Contrast Enhanced CT Head (CECT)

- CECT Head is the first line investigation when a stroke mimic is suspected to the cause of a clinical stroke-like presentation
- Useful to rule out following conditions
    - Arteriovenous malformation (AVM)
    - Intracranial abscess
    - Intracranial tumours
- No added advantage to non-contrast enhanced CT Head in ischaemic stroke
- Advantages:
    - Widely available
    - Less expensive than MRI
    - Can be used for patients not suitable for MRI
- Disadvantages:
    - Ionising radiation – this may be of significance in younger patients
    - Less sensitive than MRI
    - Not suitable for patients allergic to iodine based contrast and in renal impairment

Magnetic Resonance Imaging

- MRI involves static magnetic field and non-ionizing radiation to acquire diagnostic images

- MRI is ideal for soft tissue imaging like Brain and Spine
- Advantages:
    - Does not involve ionising radiation
    - Superior soft tissue contrast and hence better yield than CT
- Disadvantages:
    - Limited availability
    - Longer acquisition time
    - Not suitable for patients with metal implants or foreign body

Computed Tomography Angiography (CTA)

- Non-invasive imaging modality for demonstrating vascular anatomy, with greater than 90% sensitivity for depiction of cerebral aneurysms greater than 3mm in size 10
- Is a fast, thin section examination that utilises a time-optimised bolus of intravenous contrast to opacify blood vessels
- With modern multi-slice CT scanners, the region from the common carotid arteries up to the circle of Willis can be covered in less than 20 seconds 11
- The sensitivity and specificity of CTA for trunk occlusions of the circle of Willis has varied from 83-100% and 99-100% respectively in comparison to digital subtraction angiography 12-16
- Although CTA may be performed to identify the level of the occlusion, it is not a prerequisite to IV thrombolysis according to current national guidelines 17
- If the patient is eligible for thrombolysis therapy, acquisition of CT Angiography or CT Perfusion should not delay the administration of IV recombinant tissue plasminogen activator 18-20
- CTA is essential for planning of Mechanical Thrombectomy; and anatomical variations, arterial loops and angulated origins of arteries can be identified and also provides the information on the ability to deliver the treatment to the target for Endovascular Therapy 21-24

Computed Tomography Perfusion (CTP) 25-28

- Useful for evaluation of tissue viability i.e. ischaemic core vs penumbra
- CTP can be performed on any standard helical CT Scanner with a bolus tracking technique in which a contrast agent is injected rapidly (5-7 cc/sec) into a peripheral vein and images of brain are acquired repeatedly as contrast agent passes through brain. Images are then converted to contrast agent concentration versus time curves 20
- Perfusion CT examination is a valuable tool in the early evaluation of acute stroke patients and in the selection of the therapeutic strategy 29
- Good correlation was shown in a study between areas of abnormality detected on the CT perfusion studies and the volumes of abnormality found on the corresponding MR perfusion images 30

Magnetic Resonance Angiography (MRA)

- Traditional non-enhanced MRA (Time of Flight MRA) is a non-invasive procedure utilising flow-related enhancement. Contrast-enhanced MRA (CE MRA) is a relatively new form of imaging involving a time-optimised bolus of gadolinium-based intravenous contrast to define the vasculature 31, 32
- The sensitivity and specificity for MRA in the detection of intracranial artery stenosis and occlusions has varied between 85%-100% and 91%-97% respectively in comparison to digital subtraction angiography 33-35

- Overall sensitivity for detection of cerebral aneurysms > 3mm is greater than 90%, which is similar to CTA 36, 37
- The use of MRA in combination with MRI + DWI for determining the vascular territory of ischaemic stroke has a sensitivity of 89%-100%, and positive predictive value of 95%-100% 38
- Limitations include: 39
    - MR scanners are not widely available
    - Overestimates the degree of arterial stenosis especially in high grade narrowing
    - Difficulties in depiction of distal and small vessels which is exacerbated in older patients
    - Limited sensitivity for the detection of small cerebral aneurysms (< 3mm)

Catheter Cerebral Angiogram

- Digital Subtraction Angiography, the most widely used method of conventional catheter-based angiography, remains the gold standard for evaluating the cerebral vessels with regard to determining the degree of arterial stenosis and the presence of dissection, vasculopathy, vasculitis or occult lesion such as vascular malformation 40
- Provides information about collateral circulation and perfusion
- Rarely performed in acute setting due to availability of non-invasive modalities such as CTA and MRA
- Involves risk of stroke (0.14 to 1 percent) and TIA (0.4 to 3 percent) 41, 42

Carotid Doppler Ultrasound

- Recommended for all patients with carotid artery territory symptoms (e.g. amaurosis fugax, dysphasia) who would potentially be candidates for carotid re-vascularisation
- Screening modality of choice for the study of vessels involved in causing symptoms of transient ischaemic attacks 43, 44
- ~87% sensitivity and ~75% specificity in identifying severe internal carotid artery stenosis 44, 45
- In some centres, Doppler ultrasonography is viewed as a screening test and patients with > 50% stenosis in the ipsilateral carotid artery with symptomatic disease are referred for further imaging in the form of MRA or CTA
- Advantages: non-invasive, relatively inexpensive and widely available
- Disadvantages
    - More "operator dependant" compared to other imaging modalities
    - Difficult to distinguish between 'trickle flow' seen in severe stenosis, and complete occlusion

Endovascular Treatment / Mechanical Thrombectomy

- Mechanical treatments include the use of catheters to retrieve a thromboembolus that is occluding a cerebral artery
- Endovascular therapy has shown better outcomes as compared to IV thrombolysis alone when administered within 8 hours from ictus (some studies support up to 12 hours from ictus). 22, 46 Mechanical thrombectomy is best for large proximal intracranial occlusion such as M1 or proximal M2 segment occlusions
- Mechanical thrombolytic devices can remove a clot in a matter of minutes, whereas pharmaceutical thrombolytics, even those delivered intra-arterially, may take as long as 2 hours to dissolve a thrombus 47, 48

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Date of literature search: May 2016

The search methodology is available on request. Email

References are graded from Level I to V according to the Oxford Centre for Evidence-Based Medicine, Levels of Evidence. Download the document

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