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Galen (130-201 A.D.):
Hisstory's Most Enduring Medic
(Refer to page 116-117)

Editorial

Neuroimaging in Acute Stroke

N Venketasubramanian, F Hui

Stroke is Singapore's third leading cause of death, a major cause of adult disability and rising hospital admissions. Clinical trials particularly in the last decade have yielded potentially more effective stroke treatments[1]. None of these advances would have been possible without matching progress in the field of neuroimaging.

Brain imaging serves the following purposes when performed in the patient suspected to have had a stroke[2]:

1. rule out differential diagnoses – neoplasm, abscess, etc
2. distinguish haemorrhage from infarction – clinical scores have at best 70% accuracy
3. indicate the vascular territory involved – basilar artery penetrators, anterior cerebral artery, etc
4. demonstrate the vascular lesion – hyperdense middle cerebral artery sign due to fresh thrombus, intramural blood due to dissection, etc
5. suggest mechanism of stroke – multiple large artery territory infarcts suggest cardioembolism, predominantly inter-hemispheric blood suggests a ruptured anterior communicating artery aneurysm, etc
6. detect complications – "malignant" cerebral oedema, haemorrhagic transformation, etc
7. assess the results of interventions – haematoma evacuation, extraventricular drainage for acute hydrocephalus, etc
8. uncover previous or "silent" strokes

Early neuroimaging would allow the appropriate treatment to be given in a timely manner. The Ministry of Health's Clinical Practice Guidelines for the management of acute stroke recommend that brain scans be performed as soon as possible, preferably within 24 hours of patient contact.

Non-contrast Computed Tomography (CT) is widely used as the first imaging modality as it is quick, widely available, and relatively inexpensive. However, it may fail to detect small lesions, or lesions in the lower brainstem (due to beam-hardening artifacts). Magnetic Resonance Imaging (MRI) is more accurate, but takes longer to perform than CT, more costly, less likely to be available on a 24-hour basis, and has a number of contraindications.

CT and MR are able to show non-invasively the location of disease, such as a stenosed middle cerebral artery or an occluded internal carotid artery by CT or MR angiography. Catheter digital subtraction angiography remains the "gold standard". Information on cerebral vasculature is also obtainable inexpensively and non-invasively by extracranial and transcranial ultrasonography.

While hemorrhage is detected in almost 100% of cases, particularly by CT, infarct changes may not be visible in the early hours following

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an ischemic stroke, or by routine MRI. The trained eye may notice early ischemic changes such as sulcal effacement, loss of grey-white differentiation in the cortex or in the deep nuclei, and loss of the insular ribbon. Fortunately, advances in MRI with diffusion-weighted imaging (DWI) have now made the early positive diagnosis of ischemic stroke possible[3].

DWI relies on the phenomenon of reduced Brownian movement of water molecules during cytotoxic oedema due to ischemia. Areas with severe ischemia appear as bright signals within minutes of stroke, even while the conventional T2-weighted MRI image (T2WI) is relatively normal. These areas are believed to represent regions that are so severely damaged that they are likely to die. The increased signal persists for 10 to 14 days. Thus DWI now makes it possible to "rule in" an acute ischemic stroke. New strokes can also be differentiated from older ones that are more than two weeks old. The "stroke MRI" may include T2WI and DWI axial images and an MR angiogram, and takes only 20 minutes to perform. False positives may occur – tumours, multiple sclerosis plaques, etc may exhibit T2 shine-through; this is overcome by reviewing the apparent diffusion coefficient (ADC) maps – only ischemia causes reduced ADC.

The paper by Chan *et al* that appears in this issue of the SMJ[4] reports the experience of DWI in a busy clinical radiology unit of a large teaching hospital in Singapore. The rapid subminute isotropic DWI technique was highly sensitive to acute ischemic lesions, and was superior to T2WI. The lesion was more conspicuous on DWI especially among patients imaged within 12 hours of stroke onset. This would suggest that DWI would be extremely useful for the positive diagnosis of ischemic stroke, particularly if the CT or T2 weighted MRI scan is normal, or fails to show a lesion that explains the patient's clinical syndrome.

Reversal of early DWI abnormalities does not mean that the ischemic tissue has returned to a normal state. Thus caution is warranted when relying solely on DWI for assessment of ischemic damage[5]. The volume of the DWI has been shown to have prognostic value – the larger the volume, the worse the outcome. The best predictor of stroke recovery may be the combined measurement of the NIH stroke scale, time between stroke onset and DWI scan, and the volume of ischemic brain tissue on DWI[6].

Interruption of blood flow results in a core of dead tissue, surrounded by a rim hypoperfused "ischemic penumbra", with blood flows of 12 to 22 ml/100 g brain tissue/min, comprising a range of cells in various stages of function/dysfunction[7]. Over the succeeding hours, the cells in the ischemic penumbra are likely to succumb and die if blood flow is not rapidly restored. This region of cerebral hypoperfusion may be visualised by single photon emission computed tomography (SPECT), CT perfusion studies, or by perfusion-weighted imaging (PWI) on MRI. Only Xenon-CT perfusion provides quantitative data. The area defined by subtracting the DWI high signal region from the hypoperfused area seen on PWI, the area of "diffusion-perfusion mismatch", is believed to represent the ischemic penumbra, now the target of emergent rescue therapies[8].

Other advances in MR neuroimaging include MR spectroscopy (MRS) and MR diffusion tensor imaging (DTI)[9]. Multivoxel MRS allows the determination of ischemic tissue based on the buildup of lactate and loss of choline and creatine in these regions. DTI allows the tracking of fibre tracts, and may show subtle abnormalities

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in stroke. However these advances still lag far behind positron emission tomography (PET). PET is able to quantitatively demonstrate the range of cerebral responses to ischemia - increased cerebral blood volume, reduced blood flow, increased oxygen extraction, reduced metabolism of glucose and oxygen. Cerebrovascular reserve may be assessed by SPECT, CT perfusion or ultrasonography, using carbon dioxide or acetazolamide challenges.

These new techniques have not yet entered routine clinical practice. Until then, the clinician should continue to maximise the use of currently available technology to assist him in the management of his patient with acute stroke. SMJ

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