Section C

The central nervous system

CNS haemorrhage
Subarachnoid haemorrhage
Cerebral infarction
Brain atrophy
Ring enhancing lesions
MRI of the pituitary
Multiple sclerosis
Cerebrovascular disease

The patient presented confused after falling on his head. On examination there were right-sided neurological signs present.

Fig. C1 Section of a computed tomographic (CT) scan of the brain. A high attenuation abnormal area is seen in the subdural space on the left side. This is compressing the normal left cerebral hemisphere and is causing a mass effect such that there is compression of the left lateral ventricle and a shift of the midline to the right. These are the features of an acute subdural haematoma.

CNS haemorrhage

Head injuries are a common clinical problem especially in casualty departments. The investigation of choice in patients with neurological signs is a CT scan. Although skull X-rays may show a fracture, they do not provide information about the brain parenchyma. In addition, there may be quite significant brain pathology in the absence of fractures on the skull radiograph.

The following may be seen following trauma:

Extra-dural haemorrhage

- often due to ruptured middle meningeal artery
- CT scan shows a high attenuation (white) mass (fresh blood) peripherally around the brain adjacent to the cranial vault. The inner margin is often convex. Requires urgent neurological drainage

Subdural haemorrhage

- may present following a fall (often in alcoholics) with fluctuating consciousness. CT scan shows areas of crescentic peripheral high attenuation (white) with a concave inner border
- midline shift may be seen to the opposite side of haemorrhage
- mass effect may compress ventricles
- if subdural > 2 weeks old, the blood may be hypodense (grey)

Intra-cerebral haemorrhage

- focal area of increased attenuation (white) fresh blood
- may cause mass effect with midline shift
- blood may extend into the ventricles

Also seen in haemorrhage due to

- hypertensive bleed (haemorrhagic stroke)
- drugs, e.g. warfarin (over anticoagulation)
- thrombocytopaenia
- ruptured aneurysm

Cerebral contusion

- high attenuation areas in the brain are accompanied by brain swelling
- may be multi-focal
- haemorrhage may be present in areas of contusion
- due to shearing of white matter tracts, cerebral swelling may cause compression of ventricles and effacement of sulci

Fig. C2 CT scan showing low attenuation fluid collection around the right cerebral hemisphere. Fluid collection is in the right subdural space and it is causing a minimal amount of mass effect. The appearances are those of a chronic right subdural haematoma. The right lateral ventricle is not clearly seen.

Fig. C3 Section of a CT scan showing a very large right-sided intra-cerebral haematoma. The blood is fresh because the attenuation is white. Fresh bleeding causes a mass effect with a midline shift to the left side, away from the lesion. In addition, as seen, there is high attenuation (white) area in the lateral ventricles. This is due to the fact that there has been intra-ventricular haemorrhage.

Fig. C4 CT scan of the brain. There is an abnormal area of isodense attenuation seen in the left subdural space. This area is not white (i.e. it is not fresh blood). It is not of low attenuation either (i.e. it is not chronic). This density is almost similar to that of normal brain tissue. This is due to the fact that this haemorrhage is perhaps ~1 week old and is passing through the phase where the blood goes from appearing bright white to dark on the scan. These subdurals are easy to miss. Look very carefully for the mass effect. One can see that there is no left lateral ventricle clearly seen. In addition, one can see that the sulci are not clearly seen on the left side because there is a subdural collection at this site that is compressing the normal brain tissue.

Fig. C5 CT scan of the brain. Note the soft tissue abnormality outside the left occipital bone. This is a soft tissue haematoma in the superficial tissues of the skull at the back. The patient has been attacked and hit on the back of the head. There are patchy areas of increased attenuation (white) seen diagonally in the right frontal lobe that represent areas of contusion and haemorrhage at this site. This is called a contra-coup injury.

Subarachnoid haemorrhage

The patient presented with a sudden onset of headache.

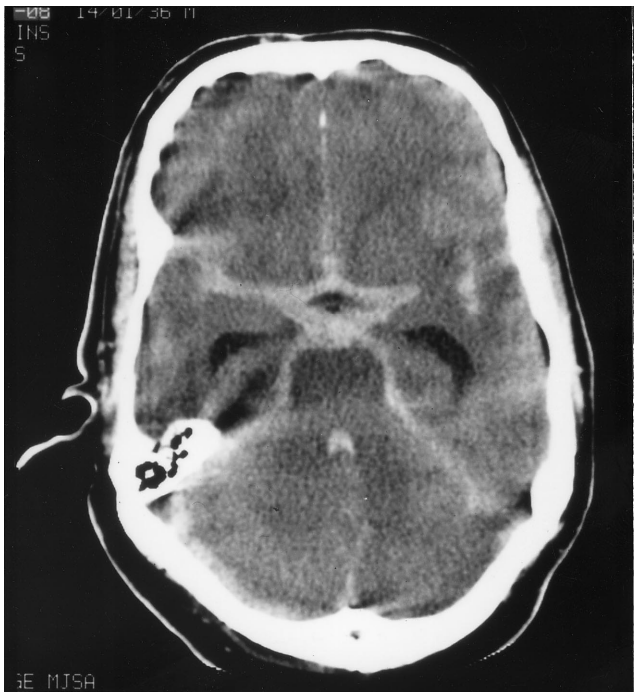


Fig. C6 CT scan of the brain and this section shows a marked high attenuation material in the cisterns of the brain and in the subarachnoid spaces. These are the appearances of a large subarachnoid haemorrhage.

Causes of subarachnoid haemorrhage

- Rupture of intra-cerebral aneurysm
- Arterio-venous malformation

Complications of subarachnoid

- Re-bleed
- Hydrocephalus (communicating)

Further tests

- Lumbar puncture
- Cerebral angiogram

Cerebral infarction

Fig. C7 CT scan of the brain showing a section at the level of the thalamus. There is a generalized atrophy noted. In addition, a low attenuation area is in the left side of the brain involving the left basal ganglia. This low attenuation region is not causing any significant mass effect. The appearances are those of an infarction of the left basal ganglia.

Fig. C8 CT section of the brain showing marked low attenuation in the left hemisphere with sparing of the left frontal lobe and left occipital lobe. These are the appearances of massive infarction of the left side of the brain due to an occlusion involving the left middle cerebral artery.

Fig. C9 CT scan of the brain at the level of the occipital loes showing a low attenuation (dark) area in the left occipital lobe. This is due to an infarct involving the left posterior cerebral artery.

Cerebral infarction

Cerebral infarction is due to an impaired circulation of the brain. A thrombus or an embolus causes it (often from the carotid vessels). The clinical presentation is that of a stroke.

Investigations

- CT scan – used to identify an infarct and to rule out a haemorrhage as the cause of a stroke. In the early stages (first 24 h) the scan may be normal in an infarct
  - early signs include loss of grey–white matter interface
  - a reduced density is noted in the brain, and the area involved usually corresponds to the arterial supply affected (e.g. anterior, middle or posterior cerebral artery territories)
  - luxury perfusion may be present
  - oedema and swelling in the early stages with mass effect
  - infarcts may be haemorrhagic
  - old infarcts show areas of low attenuation
- MRI scan
  - shows an area of increased signal on a T2-weighted image of the site of the infarct
  - posterior fossa and brain stem infarcts are better seen using MRI
- Carotid ultrasound – allows visualization of the common carotid and internal carotid arteries to look for plaque (soft or calcific) and narrowing of the vessels

Brain atrophy

Brain atrophy is due to the irreversible loss of brain tissue. Atrophy of the brain occurs with ageing and in elderly patients it is common to see the loss of brain tissue.

Radiological signs on CT/MRI

- Increased cerebro-spinal fluid (CSF) space with widening of the sulci
- Prominent ventricles
- Prominent basal cisterns and temporal horns of lateral ventricles
- In Alzheimer's disease there may be cerebellar sparing

Causes of atrophy

- Ageing
- Alzheimer's disease
- AIDS
- Trauma – long-term sequelae
- Congenital diseases of the brain
- Alcohol abuse (chronic)
- Radiotherapy
- Degenerative diseases

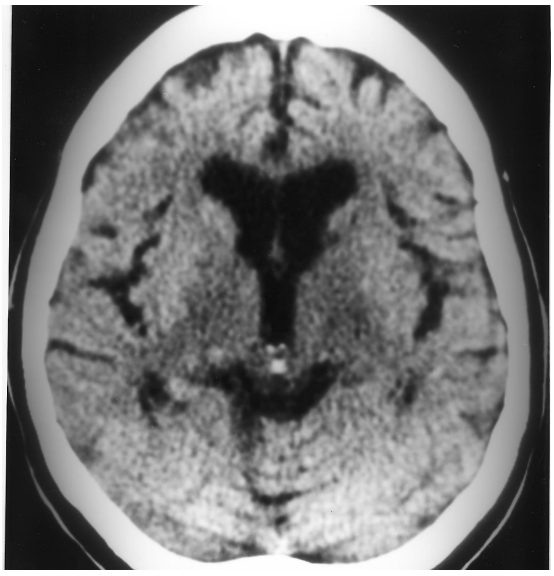


Fig. C10 CT scan of the brain showing features of atrophy. These include the prominent sulci and slightly dilated ventricles present in an atrophic brain.

This patient presented with a history of confusion following treatment of bronchial carcinoma.

Fig. C11 MRI scan of a section of the brain showing multiple ring enhancing regions in the brain. Some are associated with oedema (dark grey area). This scan has been performed with intravenous contrast to demonstrate the ring enhancement of metastatic disease.

Ring enhancing lesions

Ring enhancing lesions identified on a MRI or CT scan are due to:

- Metastases
- Cerebral abscesses
- Primary brain tumour

On a CT scan the lesions may be associated with cerebral oedema identified by areas of lower density around the lesion. On an MRI scan, oedema appears as bright signal on T2-weighted images. The swelling may cause compression of the ventricles and midline shift.

Common primary tumours that metastasize to the brain

- Lung
- Breast
- Colon

Common abscesses

- Toxoplasma in patients with AIDS
- *Staphylococcus* due to:
  - blood-borne infection, e.g. endocarditis
  - direct from mastoiditis, sinusitis
- Tuberculosis

Fig. C12 Section of a brain scan in a patient with AIDS. It has been performed with intravenous contrast showing a ring enhancing abscess, which in patients with AIDS is usually due to toxoplasmosis. The dark area around the abscess is due to oedema in the frontal lobe. A repeat scan following treatment showed improvement in the abscess.

The patient presented with bi-temporal haemionopia.

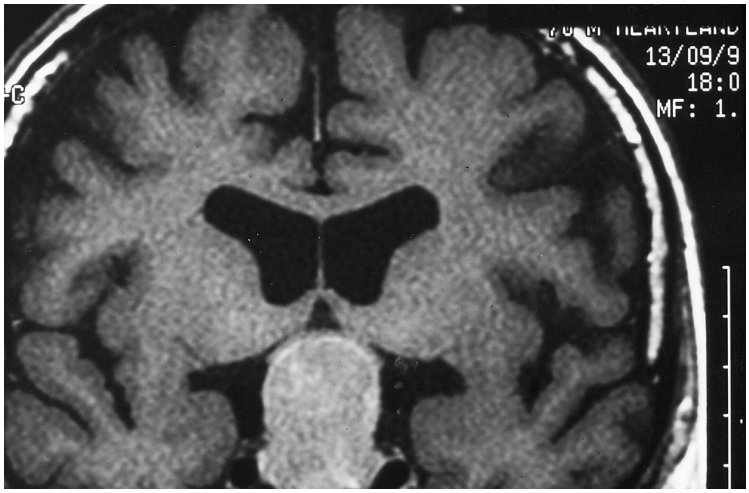


Fig. C13 Coronal section of a MRI study of the brain performed through the pituitary gland. A large mass is seen arising from the pituitary fossa. This is a mass arising from the pituitary gland and is, in fact, compressing on the optic chiasm. The mass is not involving the cavernous sinuses. It is not infiltrating into the temporal lobes. The appearances are those of an enlarging pituitary tumour involving the optic chiasm.

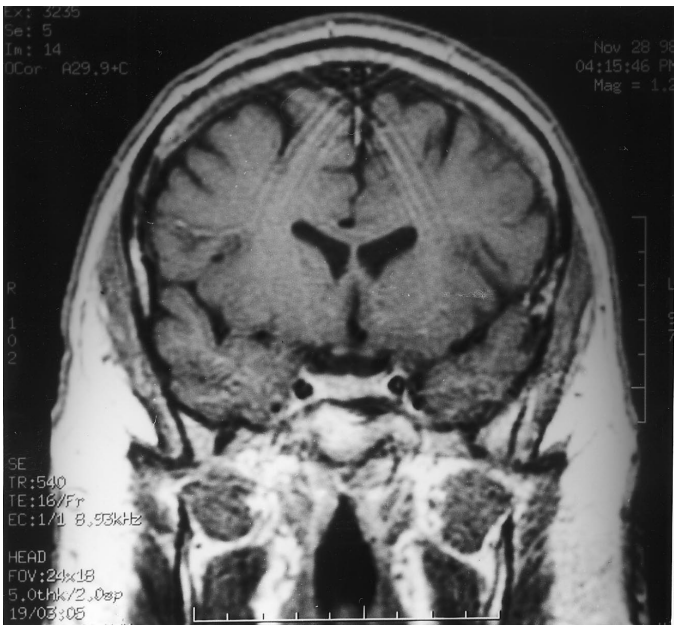


Fig. C14 Coronal section through a normal pituitary gland.

MRI of the pituitary

MRI is the radiological investigation of choice for patients with suspected pituitary tumours. Tumours may be either:

- Micro-adenomas (< 1 cm)
- Macro-adenomas (>1 cm)
- When the tumour enlarges it grows out of the pituitary fossa
- Tumour may grow upwards and compress the optic chiasm (bi-temporal hemianopia)
- May be lateral spread into the cavernous sinuses (carotid artery and cranial nerve involvement)
- May be downward growth into the sphenoidal sinus

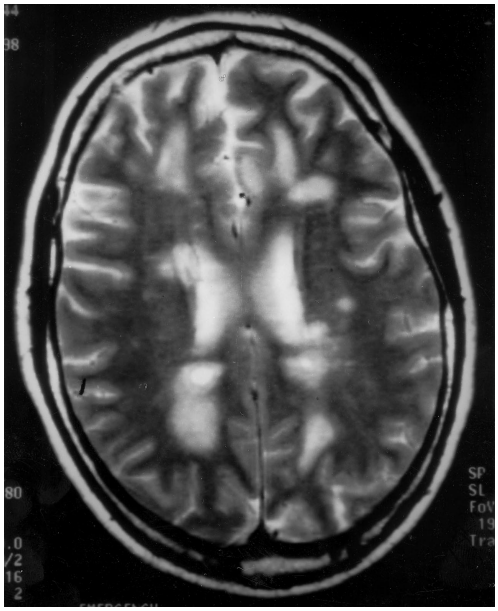
Pituitary tumours

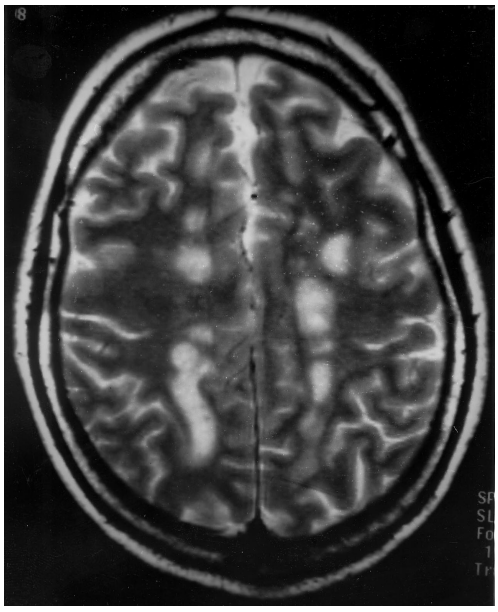
- Secretory
- Prolactinomas (35%)
- Acromegaly (growth hormone) (25%)
- Cushings' (5%)
- Non-secretory (20%)

Differential diagnosis of pituitary tumours

- Craniopharyngioma
- Aneurysm
- Supra-sellar meningioma

A 25-year-old patient presented with a history of visual disturbances and pins and needles on two separate occasions.





Figs. C15 (top) and 16 (bottom) Axial sections of an MRI study of the brain. This is in fact a T2-weighted sequence (the CSF and the ventricle appear white). There are areas of increased signal (white) in the white matter of the brain. These have the appearances of plaques of de-myelination and in someone of this age group a diagnosis of multiple sclerosis would be considered. In elderly patients these areas of increased signal (hyperintensities) are quite commonly seen and are often due to vascular changes in an elderly brain.

Multiple sclerosis

Multiple sclerosis is a disease predominantly of the young adult characterized by plaques of de-myelination in the brain and spinal cord. Relapse and remission characterize it, although it may show progression to chronic disability in a number of cases. Imaging has revolutionized the diagnosis of this disease although a detailed history and examination are of paramount importance, as imaging is not always specific.

CT findings

- Low attenuation areas in white matter
- Atrophy
- CT is **not** the first line imaging investigation of choice

MRI findings

- First-line imaging investigation
- Multiple high signal areas are seen in the brain on T2-weighted images
- High signal areas < 2 cm
- High signal areas have smooth margins, are ovoid and are often peri-ventricular in location
- High signal areas may be present in the spinal cord or optic nerves
- Active plaques may enhance with contrast
- The most sensitive MRI sequence for detecting lesions is the fluid attenuated inversion recovery (FLAIR) sequence

Differential diagnosis of white matter intensities on MRI

- Age-related changes
- Ischaemic changes
- Vasculitis
- HIV dementia

The patient presented with transient ischaemic attacks and underwent the following test.

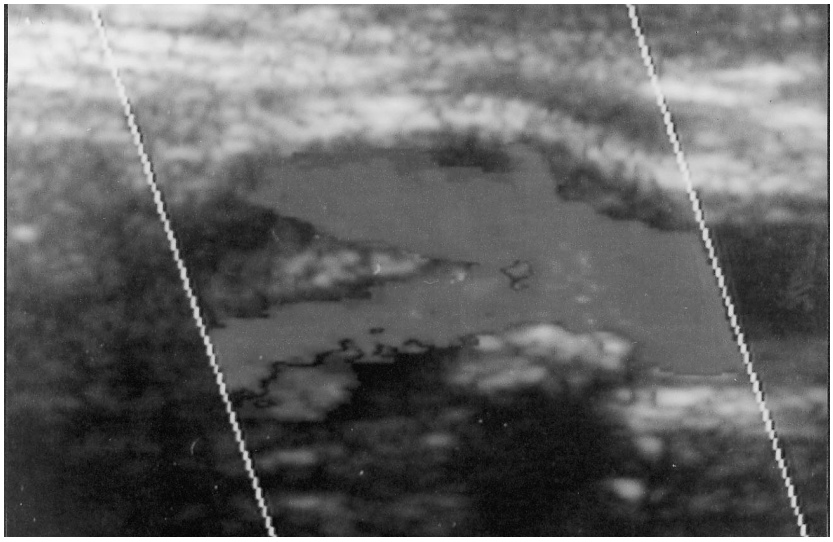


Fig. C17 Doppler investigation of the carotid artery. The section shows a calcified plaque at the origin of the internal carotid artery that appears to be causing some narrowing of the internal carotid artery. The plaque is causing some shadowing. This is the feature of a calcified plaque. The appearances are those of a plaque causing some narrowing of the internal carotid artery. Both the carotid bulb and the common carotid artery appear normal.

Cerebrovascular disease

Cerebrovascular disease is a major cause of morbidity and mortality in the Western world. Investigation of the carotid arteries may be helpful in identifying plaques and narrowing in the carotid bifurcation.

Until recently, investigation of the carotid bifurcation required invasive carotid angiography. Today, however, the first line investigation is a non-invasive carotid Doppler ultrasound investigation. Doppler ultrasound involves three steps:

- Inspection of the carotid vessels in a longitudinal plane on standard grey-scale images
- Colour Doppler to outline the stenoses
- Spectral Doppler to measure velocities of blood flow in vessels to enable quantification of stenoses

Doppler ultrasound can demonstrate

- Narrowing
- Plaques
- Intimal thickening

Other radiological tests

- Magnetic resonance angiography
  - can identify the carotid bifurcation
  - stenoses overestimated
- Invasive carotid angiography – allows angioplasty of certain lesions (risk of stroke)