RECENT ADVANCES IN 5 RADIOLOGY

Edited by T. Lodge and R. E. Steiner

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PREFACE

This, the first issue under joint editorship of *Recent Advances in Radiology*, embraces a rather wider field than previous editions. It has been thought advisable to include references to isotope and ultrasound techniques, in order to indicate their growing applications in the modern diagnostic field. Many of the chapters are clinical in nature but others, e.g. that on metabolic bone disease, attempt to bring modern biochemical and pharmacological research into line with radiological expression of generalised disease.

The editors would like to have included some reference to computerised axial tomography of the brain, but it is felt at the time of going to press that this exciting new method, though established as a technique, has not yet been fully evaluated in a clinical context.

A good deal of interest has been shown in recent years in the hazards, not only of radiation, but also of the contrast media used in modern radiology, and with this in mind, Chapter 19 deals with the metabolism as well as the risks and methods of treatment of these compounds. In one or two chapters room has been made for speculation based on correlation of radiological with morbid anatomical disease and at least one new contrast method is introduced in this volume.

The editors would like to thank the various contributors and the publishers for a good deal of patient work in producing this volume. They are also grateful to the honorary editors of the *Irish Journal of Medical Science*, *Thorax* and the *British Journal of Radiology* for permission to reproduce Figures 9, 10 & 11, and 13 respectively in Chapter 10. Figure 3 in Chapter 15 is reproduced by permission of the editor, *Annales de Radiologie*.

1975

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CONTENTS

Chapter 1

NEURORADIOLOGY

N. A. Lewtas

ISOTOPE IMAGING

Brain scanning is now widely employed in the investigation of intracranial disease. Being safe and without discomfort, it is a suitable outpatient screening procedure. As the radiation dose involved is small, the examination is repeatable as well as harmless. The overall diagnostic accuracy is 80–85 per cent. The clinical distinction between neoplastic and vascular disease is often difficult in elderly patients. Either condition may present with a sudden or gradual onset, or with the same symptoms, e.g. epilepsy. Serial scanning may show resolution of a lesion in vascular disease, or progression with a tumour, when this change is not evident clinically.

The isotope most commonly used is 99m. Technetium as pertechnetate. An intravenous dose of about 10 millicuries (mCi), results in whole body radiation dose of 0·18 rad. A vulnerable organ is the large bowel, which receives a dose of 2 rad (Wagner, 1968), which, however, can be reduced by the prior administration of perchlorate, which diminishes the uptake of pertechnetate and also reduces a potentially confusing uptake in the choroid plexus. $^{99}Tc^{m}$ as pertechnetate is cheap, and has a short half-life of 6 hours. It gives a pure gamma ray emission of suitable energy, 140 keV.

The isotope accumulates in the extracellular space (McCready, 1967) and the normal brain shows no uptake, the blood-brain barrier being intact. Isotope accumulates in the anatomical blood pool, i.e. the vascular structures of the face, scalp, temporalis muscle, dural sinuses and superficial cerebral veins. When the blood-brain barrier is breached by disease, the isotope diffuses into the extracellular space at the site of the lesion. Positive, though non-specific scans are thus recorded at the sites of tumours, arteriovenous malformations, subdural and intracerebral haematomas, trauma, cholesteatomas and infarcts. Positive scans are also registered at the site of burr holes, needle biopsies and craniotomies. Uptake varies with the vascularity of a lesion. It is maximal in cases of malignant tumour, meningioma, abscess or acute haemorrhagic infarct. Scans may show infiltrating or multiple lesions causing no brain displacement. Lesions in the parasellar area or posterior fossa are often obscured by normal uptake in the sinuses. Scans may be negative in cystic lesions, or intrinsic tumours of low grade malignancy.

Positive scans may be given by lesions of 2 cm diameter and over, depending on the degree of uptake, site and scanning speed. Uptake of isotope also depends on the vascularity of the lesion, metabolic activity, or areas of necrosis. Using a standard rectilinear scanner, the time needed for each projection is about 20 minutes, and the whole examination takes about 1½ hours. Alignment is made with reference to the nasion, inion and external auditory meatus. Marryat and Bull (1964) have described a method of orientation by superimposing a half-exposed radiograph on the scan.

Burrows (1969) has reported on the use of radioindium, DTPA $^{113}In^{m}$ for brain scanning which can be stored for immediate use in emergency cases. The scans, however, are less accurate than those made with $^{99}Tc^{m}$. Radioindium has higher γ energy (392 keV). Radioindium scans cannot be repeated, owing to the short half-life of 1·65 hours, in comparison to the 6-hour half-life of $^{99}Tc^{m}$.

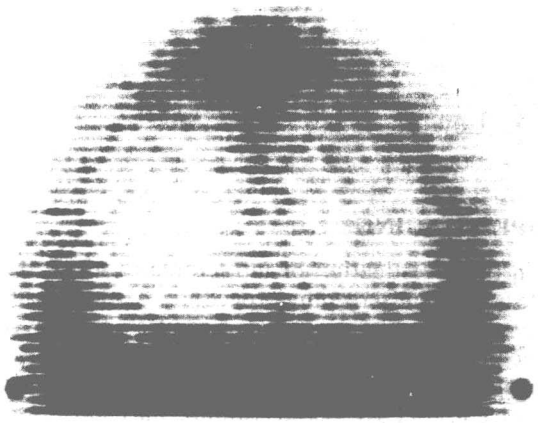


FIG. 1.1. Normal anterior scan. Midline uptake in the superior sagittal sinus.

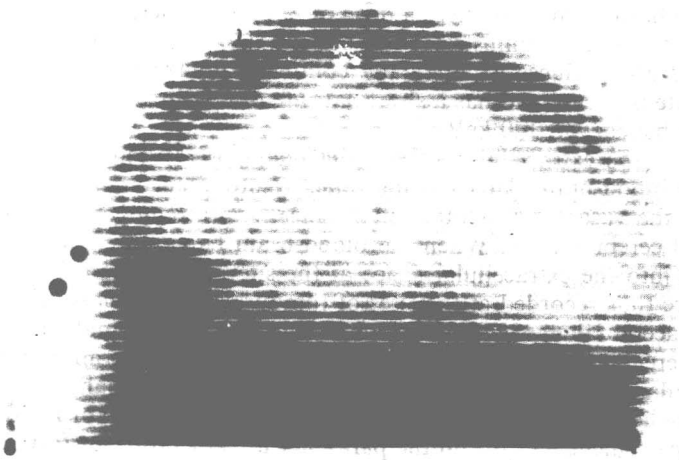


FIG. 1.2. Normal lateral scan. Basal uptake projected over suprasellar area is in middle cerebral vessels.

Equipment

Two main types of apparatus are in current use for brain scanning. The basic instrument is usually a rectilinear scanner. This consists of a sodium iodide crystal of 3 or 5 inch diameter, with a multiple-hole focusing collimator. Moved by a motor, it systematically traverses the organ under examination. The newer scintillation camera is a static imaging device and does not move. It consists of a larger (about 12 inch) sodium iodide detector

crystal with numerous parallel photomultiplier tubes. The examination time of a camera unit is about one-tenth that of a rectilinear scanner, which helps to overcome difficulties of patient movement. Since it is unfocused, the camera unit is more accurate in recording superficial and extracerebral rather than deep lesions. Contrast enhancement is possible with a scanner, but background suppression is not possible with a camera, unless a multiple channel analyser is used (Pederson and Haase, 1970; van Eck and Penning, 1970).

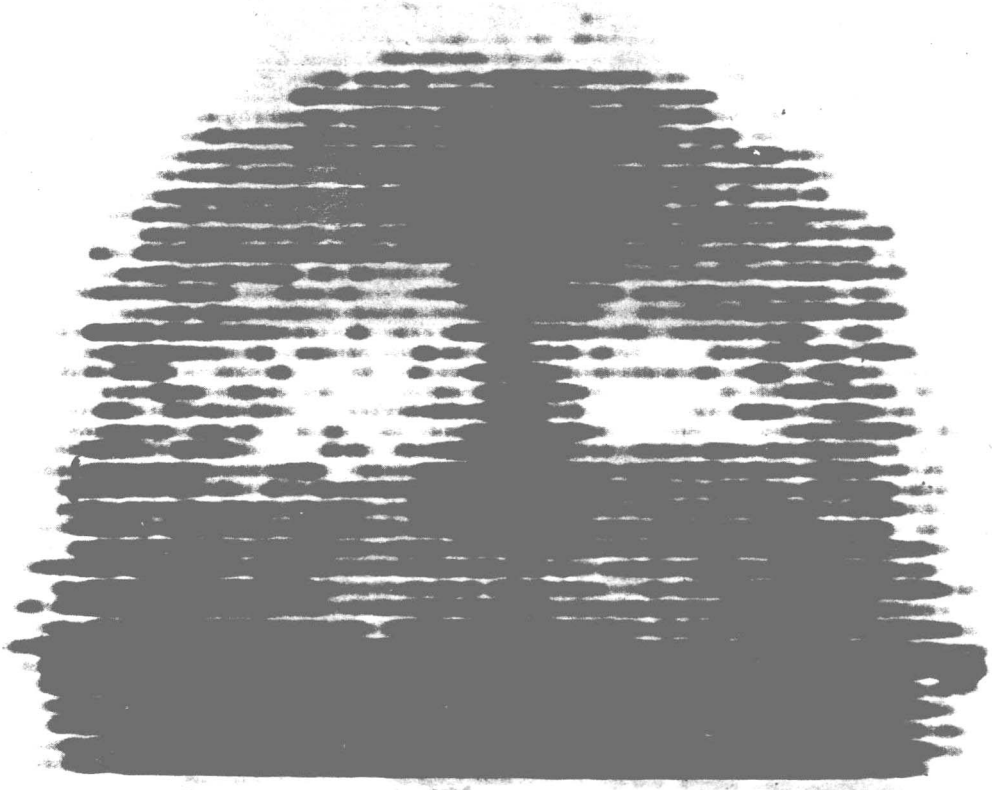


FIG. 1.3. Normal posterior scan.

Normal appearances

The usual focal length of the collimator in a rectilinear scanner is 3–5 inches, and structures in this plane will be seen best. The uptake recorded thus partly depends on the depth of its source, a fact which must be remembered particularly in anterior and posterior scans.

In the technical assessment of scans, consideration must be given to the contrast and position, and any movement of the patient. The contrast setting should give a clear distinction between normal brain and the anatomical blood pools. Position is checked from the anatomical reference points—nasion, inion and external auditory meatus. Any movement of the patient during the scan should be noted by the recording technician. This is usually seen from the reference points, and the scan repeated if necessary. Sedation is necessary for some patients.

Anterior scan (Fig. 1.1)

Isotope concentration is registered in the mouth, pharynx, nasal mucosa and frontal

FIG. 1.4. Right frontal burr hole. (a) Anterior scan. (b) Right lateral scan.

sinuses. The cavernous sinuses are seen in the midline. The superficial cortical veins may produce some asymmetry on either side of the midline. The anterior scan will show lesions in the frontal lobes, tip of the temporal lobe and caudate nucleus.

Lateral scan (Fig. 1.2)

The superior sagittal sinus clearly outlines the upper surface of the cerebral hemispheres. This sinus appears larger and of higher uptake as it runs posteriorly, collecting tributaries progressively from the superficial veins of the hemispheres. Posteriorly, the torcula and transverse sinuses are outlined, below which lie the clear areas of the cerebellar hemispheres. Both right and left lateral scans are made, and uptake is slightly higher on the side scanned first, owing to decay in activity.

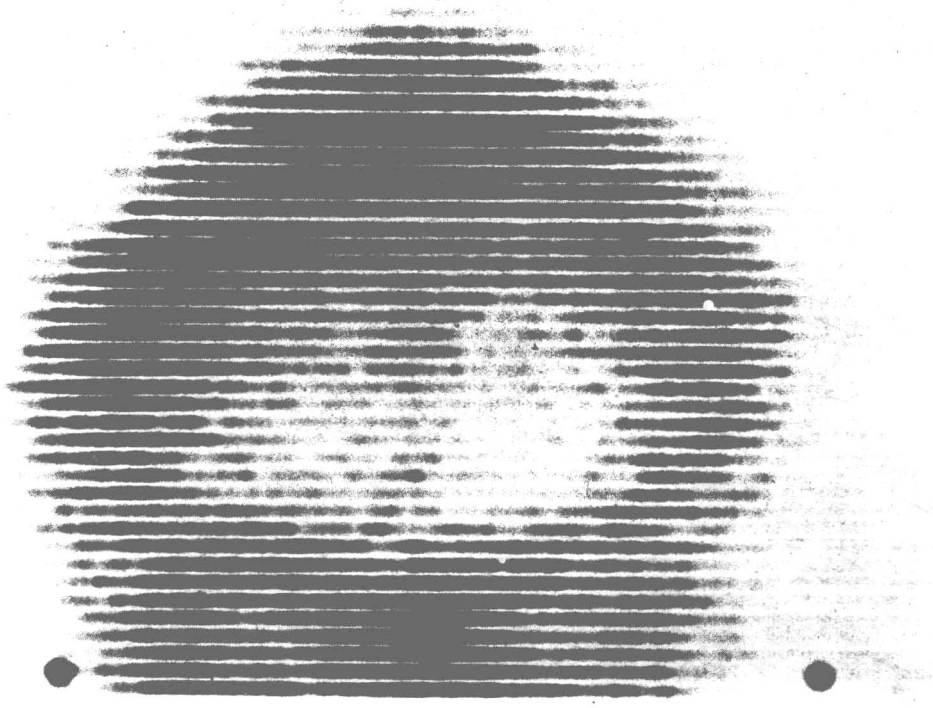


FIG. 1.5. Paget's disease. Anterior scan. Diffuse uptake in enlarged vascular diploe.

Heavy uptake is seen in the skull base, due to activity in the mucous membrane of the sinuses, the face, nasal cavity, mouth, oropharynx and parotid. Occasionally, the pituitary fossa may be seen as a small, clear area of low uptake.

Posterior scan (Fig. 1.3)

The posterior scan is made with the head well flexed in the reversed half-axial (Towne) position, to avoid the high uptake in the nuchal muscles. The sagittal and transverse sinuses should be clearly shown, with the clear areas of the cerebellar fossae below. There is often some anatomical asymmetry of the transverse sinuses, the right being more commonly dominant.

Skull lesions

Lesions of both scalp and skull vault may show areas of abnormal isotope uptake on brain scans. Interpretation thus requires adequate information about both history and plain skull radiography.

Contusions, lacerations and other lesions of the scalp may all show areas of increased uptake. Recent burr holes in the skull show positive areas of uptake (Fig. 1.4), and a bone flap may show increased uptake for up to 12 months after craniotomy.

Non-specific positive scans may be given by many different bone lesions of the skull. These include fracture, osteomyelitis, Paget's disease (Fig. 1.5), fibrous dysplasia and bone metastases. Rarely, the latter may give a positive scan in the presence of a normal radiograph. Their location may be confirmed if necessary by a repeat scan, using strontium $^{87}Sr^{m}$, a calcium analogue.

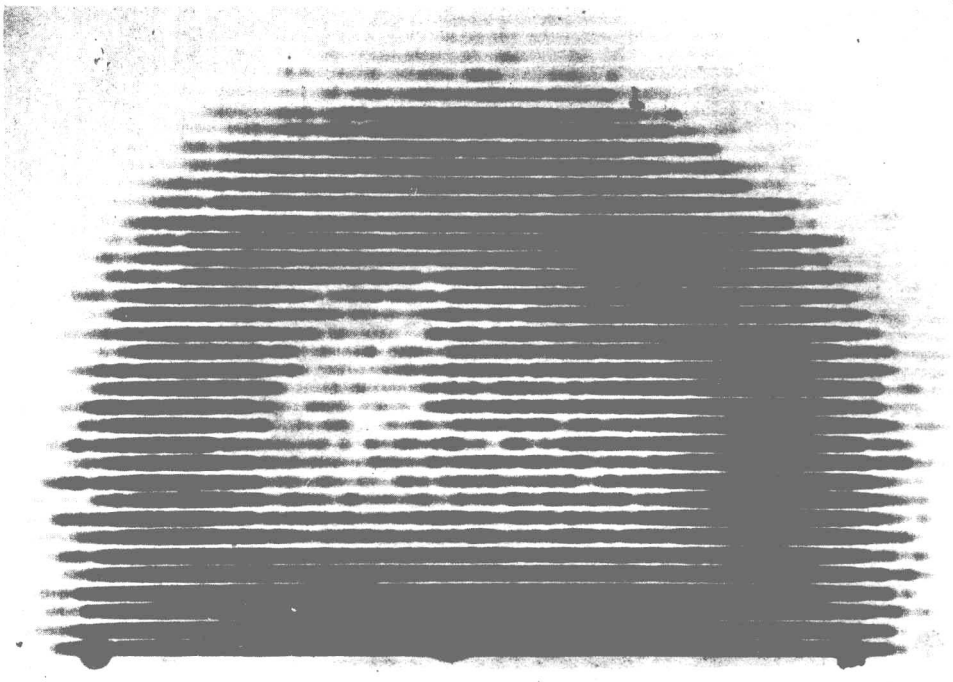


FIG. 1.6. Left subdural haematoma. Anterior scan.

Traumatic and inflammatory lesions

Subdural and extradural haematomas show increased uptake on the surface of the brain (Fig. 1.6). This uptake is usually crescentic in anterior and posterior scans. Lateral scans sometimes appear normal. The scan may be negative initially, becoming positive later, as the lesion becomes encapsulated by vascular granulation tissue. Differential diagnosis includes meningioma and Paget's disease, both of which may give crescentic areas of increased surface uptake.

Brain contusions may show increased intracerebral uptake; the scan usually reverts to normal in about 6 to 10 weeks.

Increased uptake is seen in brain abscesses. This increases with duration and encapsulation. If not excised, progress of resolution with antibiotics may be followed on serial scans.

Meningitis may show symmetrical increase in surface uptake, which may be particularly evident in the Sylvian fissures (DeLand and Wagner, 1969).

Tumours

The majority of brain tumours show an increased uptake of isotope. This is greater in

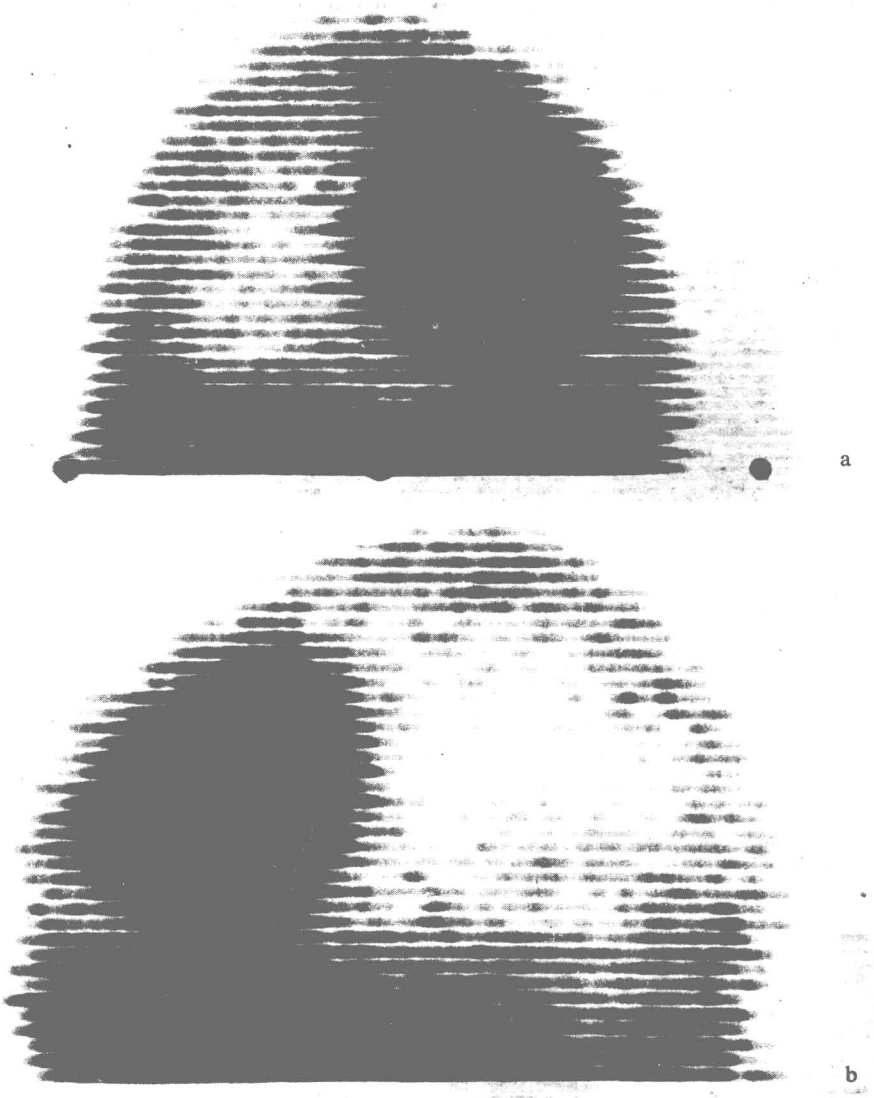


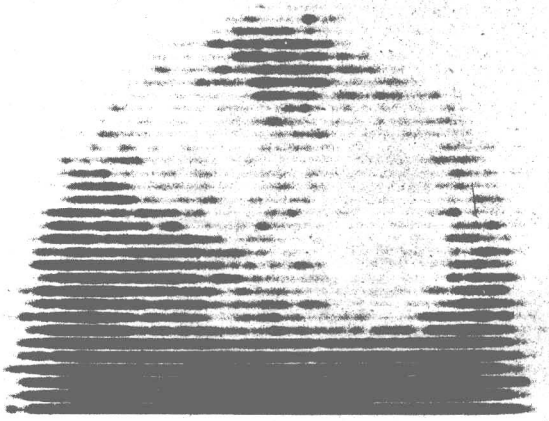
FIG. 1.7. Meningioma. (a) Anterior scan. (b) Lateral scan.

vascular than avascular tumours. In the differential diagnosis between tumour and vascular disease, both the anatomical distribution of isotope and the history are of importance. Brain scans are most accurate in the diagnosis of meningioma, glioma and metastasis, in

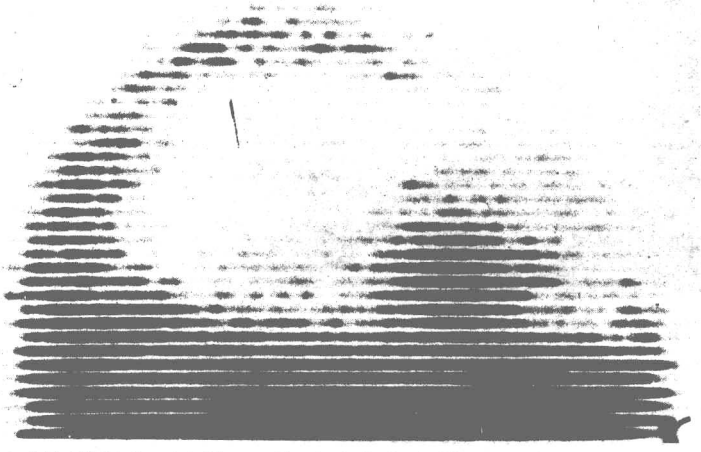
that order. The character of uptake in different types of tumours and its relation to brain anatomy have been evaluated by Bull (1966), and Takahashi *et al.* (1966).

Meningioma

These tumours are revealed as areas of high uptake, of uniform density, with well-defined margins. (Fig. 1.7) Plain radiography may show erosion or hyperostosis or increased vascular marking in the affected area. Anatomically, these lesions are extracerebral and usually occur in characteristic situations, e.g. falx, sphenoid wing, convexity, etc.



a



b

FIG. 1.8. Right frontal glioma. Intrinsic lesion of irregular uptake. (a) Anterior scan. (b) Right lateral scan.

Glioma

These intrinsic tumours present very variable appearances on brain scans. In a very low-grade infiltrating astrocytoma, the scan may be normal. Malignant gliomas show large, irregular areas of high uptake, and all variants between these two extremes are seen (Fig. 1.8). These lesions do not normally correspond to the anatomical vascular distribution, which may sometimes help in the distinction from infarction. Uptake in the area of the corpus callosum, especially if bilateral, may distinguish a glioma from a falx meningioma. The latter would lie anterior, superior or posterior to the corpus callosum. Areas of low uptake within an obvious lesion may be due to cyst formation.

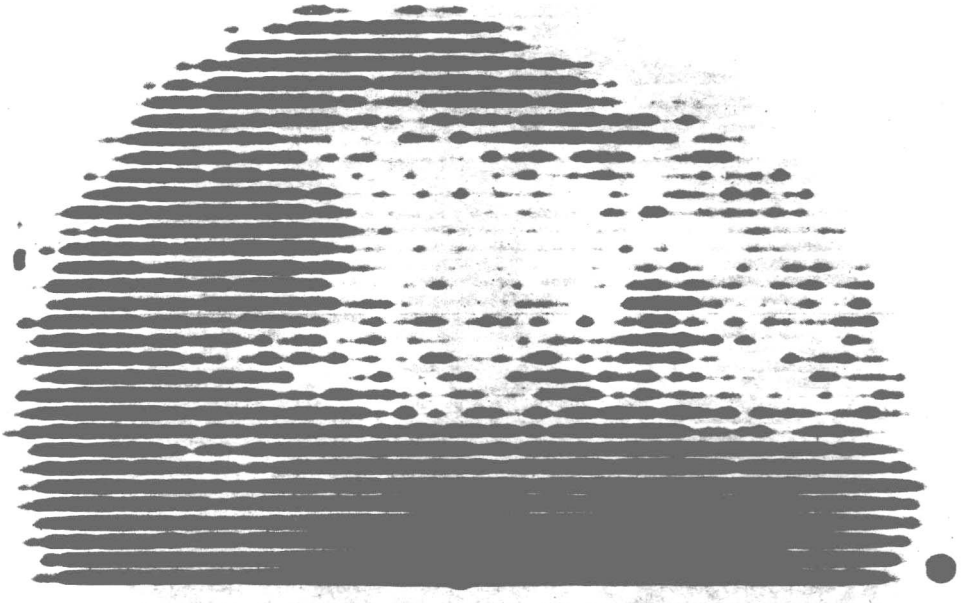


FIG. 1.9. Metastatic deposits in frontal and parieto-occipital areas.

Metastases

Secondary deposits show no characteristic features, although they are often revealed as multiple lesions which are small and of low uptake (Fig. 1.9). There may or may not be evidence of a primary tumour elsewhere in the body. The distinction of metastases from multiple small infarcts is sometimes difficult (Wagner, 1968).

Of other supratentorial tumours, pituitary adenomas and craniopharyngiomas may give positive scans, but in these cases, radiology is usually more definitive.

Posterior fossa scans

In scanning the posterior fossa, adequate flexion of the head is important. Large acoustic neuromas show high uptake in the pontine angle, and may be recognised on both posterior and lateral scans (Fig. 1.10). Midline tumours with positive uptake include medulloblastomas and cystic astrocytomas of the cerebellar vermis, as well as pontine gliomas. All these tumours are especially common in children.

In general, false negative scans are largely due to: (1) low count rate—poor absorption or small dose; (2) benign lesions, in which the blood supply and metabolism are the same as normal brain; (3) small lesions and (4) unfavourable sites—deep or midline, or near the venous sinuses, e.g. thalamus, pons or pontine angle.

Camera studies

In recent years, with the introduction of the gamma camera, more rapid scanning has become possible. Efsing, Cronquist and Hughes (1972) have reported on the time sequence

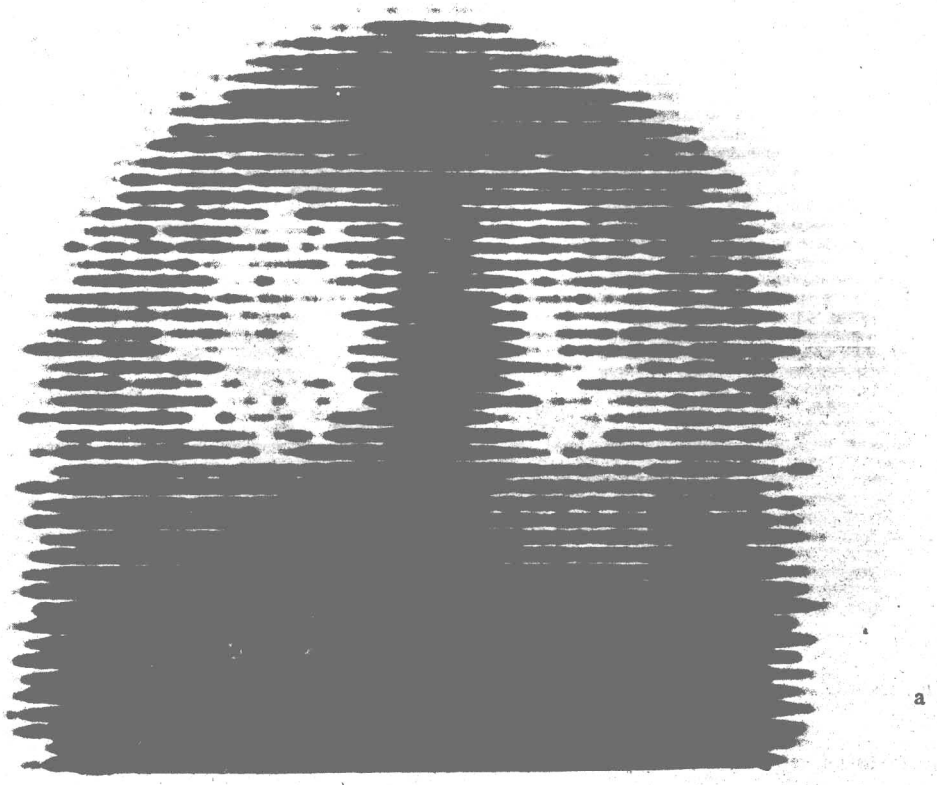


FIG. 1.10(a). Left acoustic neuroma. Posterior scan.

of uptake, using this equipment. In the diagnosis of tumours, records were made 2, 4, 10 and 30 minutes after isotope injection. Uptake was seen earlier in gliomas than astrocytomas and metastases, and was also seen earlier in meningiomas than astrocytomas. The overall diagnostic accuracy was 84 per cent, compared with 95 per cent in combined neuroradiological procedures. The camera unit, being designed for surface scanning, was liable to miss midline tumours. Diminished activity in the centre of a tumour suggests cystic degeneration. In differential diagnosis, gamma scintigraphy with sodium selenite 75 showed higher uptake in gliomas than meningiomas (Nordman and Rekonen, 1970).