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The Radiological Diagnosis of Primary Brain Tumours

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The investigation of primary brain tumours has changed dramatically as a result of the development of Computed Tomography and Magnetic Resonance Imaging. Computed Tomography can be performed rapidly with little patient discomfort but artifacts degrade images of the posterior fossa. Magnetic Resonance Imaging of the brain is a more sensitive procedure but it is time consuming. In addition not all patients are cooperative enough and some become claustrophobic in the scanner. Patients with cardiac pacemakers, aneurysm clips or intraoccular foreign bodies cannot be examined by MRI. These new modalities allow earlier diagnosis with less risk to the patient. The impact of early diagnosis in the treatment of malignant tumours is not clear, but in the case of benign tumours it will reduce the morbidity from operation.

Historical Overview

The imaging of primary brain tumours was reported not long after the discovery of X-rays in 1895. At a meeting of the Society for Psychiatry and Nervous Diseases in Berlin on November 13, 1899, Oppenheim [cited by Bull and Fishgold, 1967] described the abnormal deepening and expansion of the sella in a patient with a pituitary tumour. In the same year Church (1899) described calcification of a cerebellar tumour.

Walter Dandy (1918) pioneered ventriculography and encephalography in the diagnosis of brain tumours and in 1927, Egas Moniz (1927) described "Arterial Encephalography" (arteriography) as an additional technique. In a remarkable paper Oldendorf (1961) described a procedure for imaging a series of nails embedded in a plastic block that some years later would lead to the development of Computed Tomography by Hounsfield in 1973. Ambrose (1973) described the clinical application in the same year.

Damadian (1971) and Lauterbur (1973) suggested the possibility of using Magnetic Resonance Imaging in humans, and Damadian, Goldsmith, and Minkoff (1977) as well as Hinshaw, Bottomley, and Holland (1977), and

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Mansfield, Pykett, Morris, and Coupland (1978) published images of the human body. The first large series of brain tumours investigated with Magnetic Resonance Imaging was reported by Bydder et al. in 1982.

The diagnosis of primary brain tumours has changed dramatically in the last few years with the development of Computed Tomography (C.T.) and Magnetic Resonance Imaging (MRI). Angiography still plays a vital role in both diagnosis and preoperative embolization. Encephalography and ventriculography have been replaced by MRI and its exquisite anatomical detail. The advantages of MRI are the ability to obtain images in the axial, coronal and sagittal planes. This is of particular value in posterior fossa tumours where bone artifact often degrades the images of computed tomography. Supratentorial tumours are demonstrated well by both C.T. and MRI. In practical terms, it is easier and quicker to obtain a C.T. scan; on the other hand, it requires the injection of contrast material. MRI takes longer and some patients become very claustrophobic in the scanner and cannot tolerate the examination. Patients with aneurysm clips, pacemakers or metallic ocular foreign bodies cannot be examined by MRI.

Supratentorial Tumours

Gliomas. Intrinsic tumours may be demonstrated equally well with C.T. or MRI. On the other hand, MRI has greater sensitivity and allows for superior anatomical demonstration due to the ability to image in coronal and saggital planes (see Figure 1a and 1b). The distinction between tumour and surrounding edema may be difficult to ascertain. Distinctions between tumour and other disease processes may also not be possible.

Meningiomas. Often result in hyperostosis and occasionally in lytic defects on skull roentgenograms. On C.T., they frequently show increased density and florid enhancement after contrast. Their proximity to the dura and their extracerebral location may be defined by C.T. Angiography is frequently required to demonstrate the blood supply and for consideration of preoperative embolization. Meningiomas around the sella may mimic other tumours (see Figure 2a and 2b). The tissue characteristics of meningiomas on MRI may resemble that of normal brain and Cerebral Spinal Fluid (CSF) so that without contrast agents such as gadolinium, a meningioma may escape diagnosis. In the posterior fossa, meningioma may be difficult to distinguish from acoustic neuroma. Intraventricular meningiomas are rare and most commonly occur in the lateral ventricle. Intraventricular meningiomas may be difficult to differentiate from ependymoma even after angiography.

Pituitary Tumours

Microadenoma. Small (under 10mm) hormone secreting tumours (prolactin, ACTH or growth hormone) may be demonstrated by C.T. or MRI.

The tumours are usually too small to cause significant changes in the sella on skull roentgenograms.

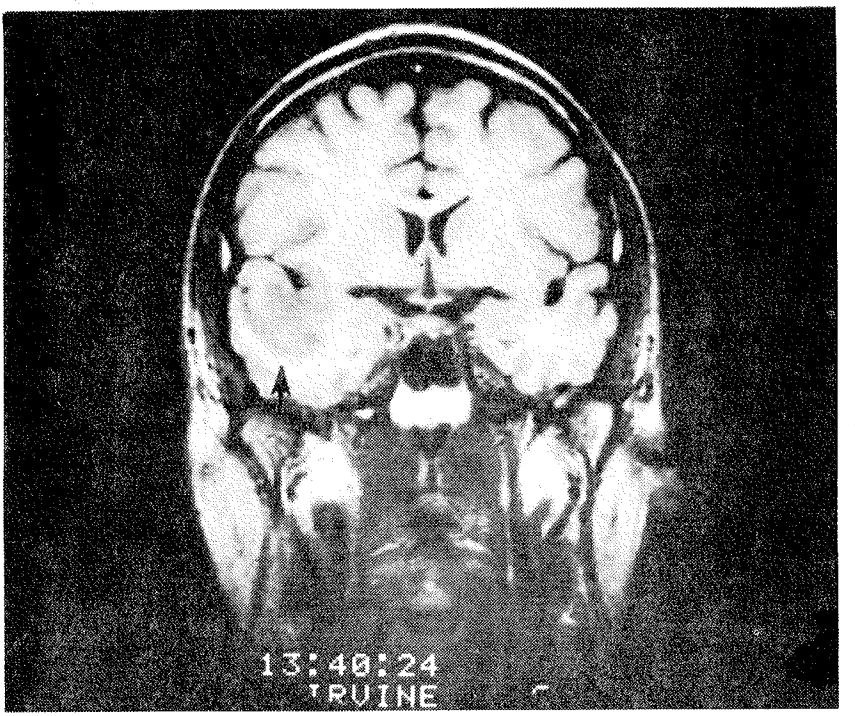

Figure 1a: Temporal Lobe Glioma. Coronal MR image shows low intensity area (grey) in superior aspect of temporal lobe (arrow). The temporal lobe is expanded.

The findings on C.T. and MRI are very similar. A low density lesion is seen in the pituitary on contrast enhanced C.T. and a low signal intensity nodule is seen on MRI. The pituitary may be enlarged and the hypophyseal stalk displaced. C.T. with contrast infusion and a bolus with direct coronal images is preferred to axial images with coronal and sagittal reconstruction. Patients often find this position in the scanner very uncomfortable and teeth fillings may degrade the image.

MRI imaging is performed without contrast and the patient is comfortably supine. However, not all MRI scanners allow for the thin enough sections (1.5mm) that may be necessary.

Macroadenoma. Pituitary tumours larger than 10mm enlarge the sella and roentgenograms demonstrate diagnostic changes. Patients consult physicians and optometrists with complaints of loss of vision and their failure to take an x-

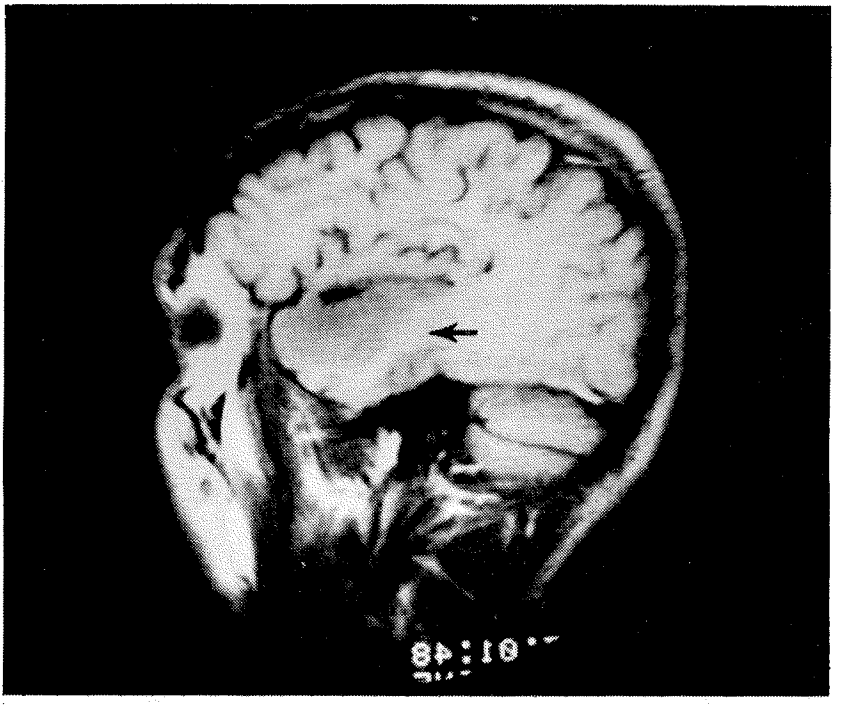

Figure 1b: Temporal Lobe Glioma. Sagittal MR image shows low intensity area involving superior temporal gyrus and anterior temporal lobe.

ray of the skull may delay treatment and result in permanent loss of vision for some patients. Tumours may be demonstrated equally well on C.T. or MRI but their appearance is very similar to other tumours. Craniopharyngiomas, optic chiasm gliomas, meningiomas and aneurysms all have similar characteristics on contrast C.T. Skull roentgenograms and angiography may be required. In general MR images demonstrate exquisite anatomy but are not reliable indicators of histology. Aneurysms, however, unless they are thrombosed, show characteristic low intensity on MR due to a flow void as in other vessels.

Craniopharyngiomas. Craniopharyngiomas frequently show calcification on skull roentgenograms, occurring in approximately 80% of patients under the age of 16 and approximately 55% overall. The calcification is usually suprasellar but may be intrasellar. The calcification may be curvilinear or amorphous. Curvilinear calcifications should raise suspicion of possible aneurysms. Pituitary tumours seldom calcify (about 1%) and the calcifications may be in the capsule of the tumour (curvilinear) or the end result of a hemorrhage (amorphous).

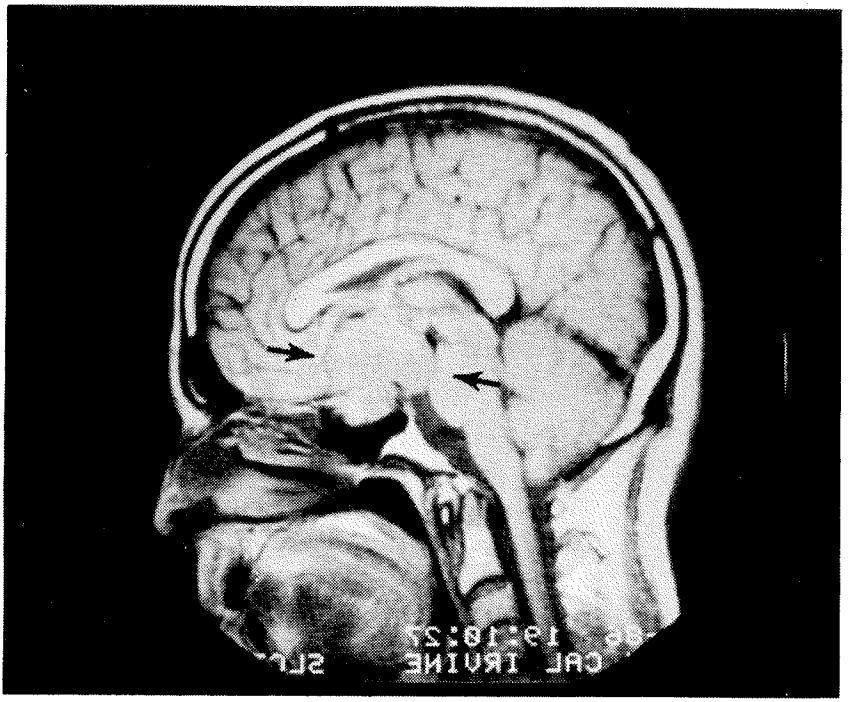

Figure 2a: Intrasellar and Suprasellar Meningioma. Sagittal MR image demonstrates intrasellar and suprasellar tumour (arrows).

On C.T. there may be evidence of calcification and/or cyst formation and after contrast there may be florid enhancement of the solid portions of a partially cystic tumour. The MRI characteristics vary according to the amount of cholesterol in the cystic portion of the tumour. This results in high intensity, a finding that may be mimicked by haemorrhage.

Optic chiasm and hypothalamic gliomas. Optic chiasm gliomas with involvement of the optic nerves will enlarge the optic canal on roentgenogram and C.T. Hypothalamic gliomas may show calcifications but in many cases cause no radiological abnormality. C.T. appearances may resemble those of other tumours but MRI may demonstrate involvement of the hypothalamus, thalamus and midbrain, suggesting the presence of an intrinsic tumour. The distinction from extracerebral masses is important as the surgical approach is different. The distinction may require skull roentgenogram, C.T., MRI and angiography. Extracerebral masses are usually well demarcated on MRI.

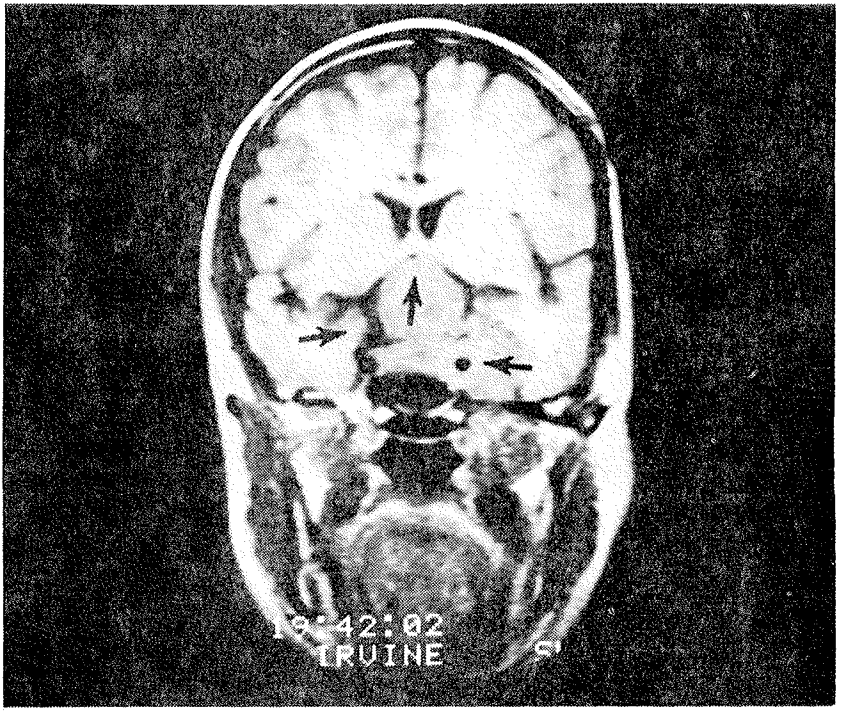

Figure 2b: Intrasellar and Suprasellar Meningioma. Coronal MR image demonstrates intrasellar and suprasellar tumour. The suprasellar extension has obliterated the anterior third ventricle (vertical arrow). The supracavernous internal carotid artery (left arrow) is displaced laterally and the anterior cerebral arteries are displaced upward (vertical arrow). The cavernous internal carotid artery shows lateral displacement (left arrow).

Third Ventricle Tumours

Anterior third ventricle. Colloid cyst is probably the most common third ventricular mass (see Figure 3). It is strategically located at the foramen of Monro where it may lead to obstruction of the lateral ventricles. C.T. commonly demonstrates a rounded mass of increased density although isodense or hypodense cysts may occur. Occasionally the cyst may be an incidental finding causing neither hydrocephalus or intermittent obstruction. MRI also demonstrates a high intensity mass. Craniopharyngiomas may occur within the third ventricle and the findings on MRI and C.T. are the same as when they occur in their normal suprasellar location. An uncommon tumour is the xanthogranuloma which resembles a colloid cyst on C.T. and MRI but usually contains an area of calcification. Hypothalamic and thalamic gliomas may be identified on C.T. or MRI but the latter may demonstrate infiltration of the thalamus and midbrain better than C.T.

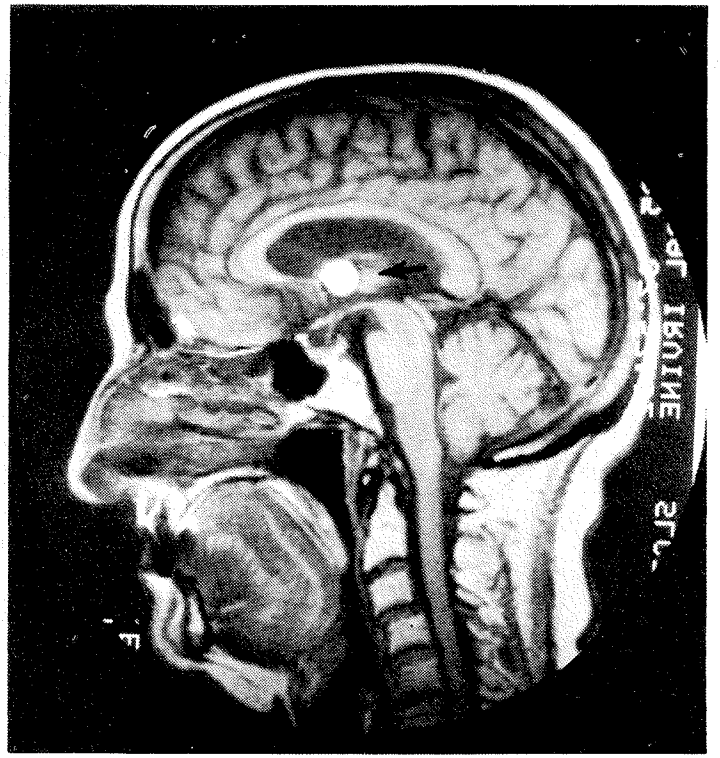

Figure 3: Colloid cyst of third ventricle. Sagittal MR image shows cyst as a high intensity (white) lesion due to the protein content.

Posterior third ventricle. In the posterior aspect of the third ventricle, Pineal tumours (pinealocytomas, pinealoblastomas, germinomas and teratomas) occur as well as gliomas that originate in the tectum of the midbrain. C.T. and MRI both demonstrate these tumours. MRI is superior in showing the anatomy but in many cases the distinction of pineal tumours from gliomas and even meningiomas may be difficult to make. Angiography will identify meningiomas by their meningeal blood supply, particularly the meningohypophyseal trunk. Pineal tumours frequently show diffuse calcification whereas calcification in midbrain gliomas is rare. Ependymal cysts within the third ventricle and arachnoid cysts in the cisterna vena magna are easily recognized on C.T. and MRI.

Posterior Fossa Tumours

Although C.T. may demonstrate posterior fossa tumours adequately, bone artifact frequently degrades the image. In addition, the ability of MRI to

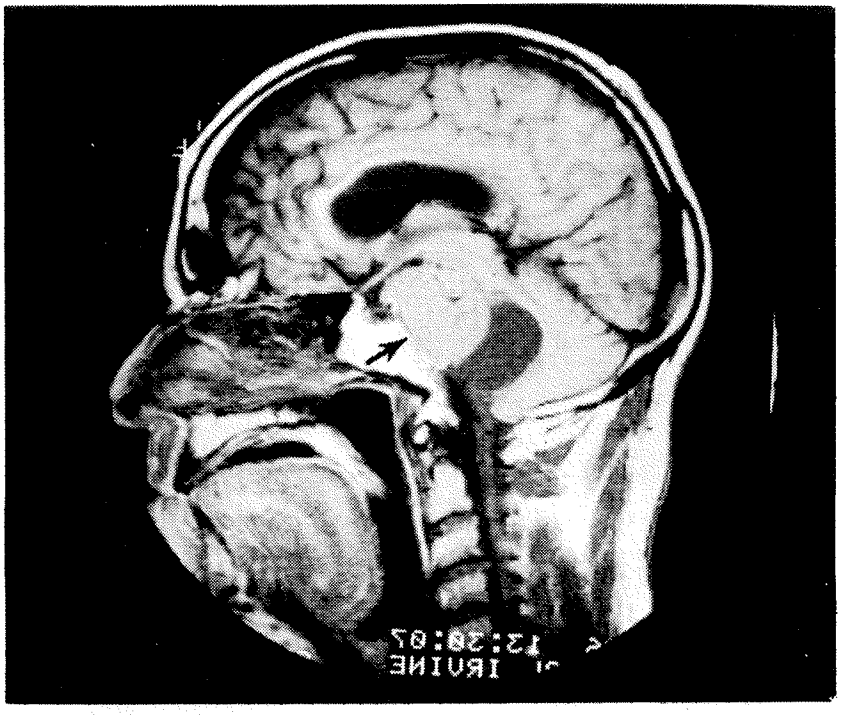

Figure 4a: Clivus Meningioma. Sagittal MR image shows tumour (arrow) and associated arachnoid cyst.

generate images in the coronal and sagittal planes frequently results in a superior anatomical demonstration of tumours (see Figure 4a and 4b). Acoustic neuroma, meningioma, pontine, midbrain, cerebellar and fourth ventricle tumours are particularly well displayed on MRI. Cerebellar haemangioblastomas may be suspected on account of their vascularity.

Acoustic neuroma. Acoustic neuromas may show enlargement of the internal auditory canal on roentgenograms and C.T. Large tumours may be demonstrated on C.T. or MRI. Intracanalicular tumours may be demonstrated on contrast enhanced C.T. or may require the introduction of a small amount of air into the cerebellopontine angle for diagnosis. MRI is also capable of demonstrating intracanalicular tumours but not all scanners allow thin enough sections, so small tumours may escape diagnosis. The distinction of acoustic neuroma from meningioma rests on the fact that an acoustic neuroma is centered on the internal auditory canal whereas a meningioma is frequently eccentric–being either partially in front or behind the meatus. Angiography may be necessary for diagnosis and possible pre-operative embolization.

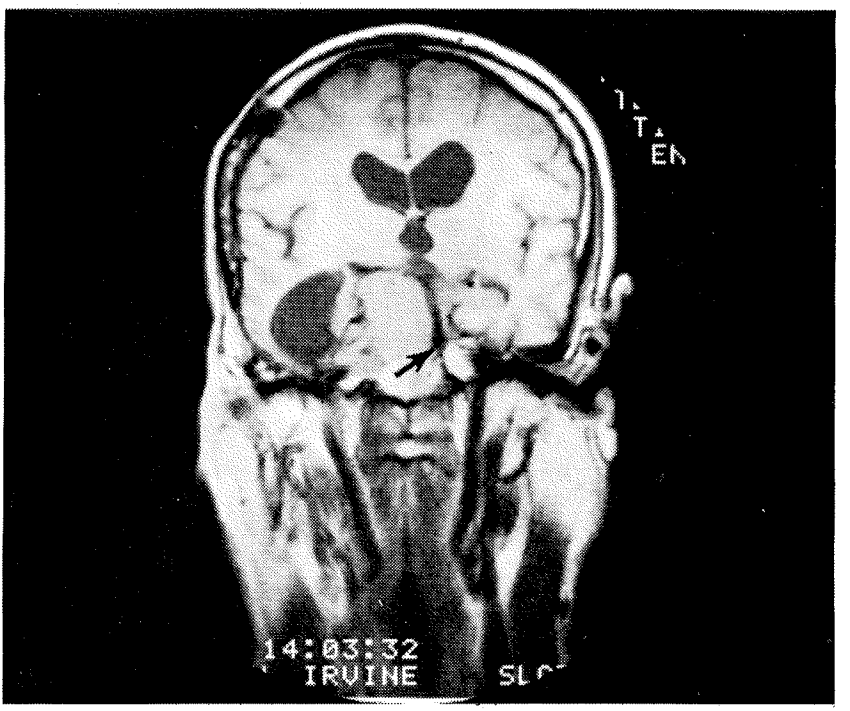

Figure 4b: Clivus Meningioma. Coronal MR image shows tumour displacing basilar artery (arrow).

Pontine and midbrain tumours. Pontine tumours are usually hypodense on C.T. and may show variable enhancement. Occasionally pontine tumours will present acutely with hemorrhage into the tumour. Anatomical demonstration is superior on MRI but, both C.T. and MRI may be needed to confirm the presence of a cyst within the tumour (see Figure 5, 6a and 6b). Cryptic malformations commonly occur in the midbrain, pons or medulla. MRI will usually permit diagnosis on account of their characteristic appearance as a mixture of high and low intensity.

Fourth ventricle tumours. Fourth ventricle tumours cause hydrocephalus early. Ependymoma may show stippled calcification on skull roentgenogram and/or C.T. Papillomas of the choroid plexus and medulloblastoma usually do not calcify. Epidermoids commonly are low density on C.T. and of high intensity on MRI. However, on occasion an epidermoid may be hyperdense on C.T. Fourth ventricle masses may be seen well on C.T. but their anatomical demonstration is better on MRI (see Figure 7).

Cerebellar tumours. Cerebellar tumours may be cystic or solid.

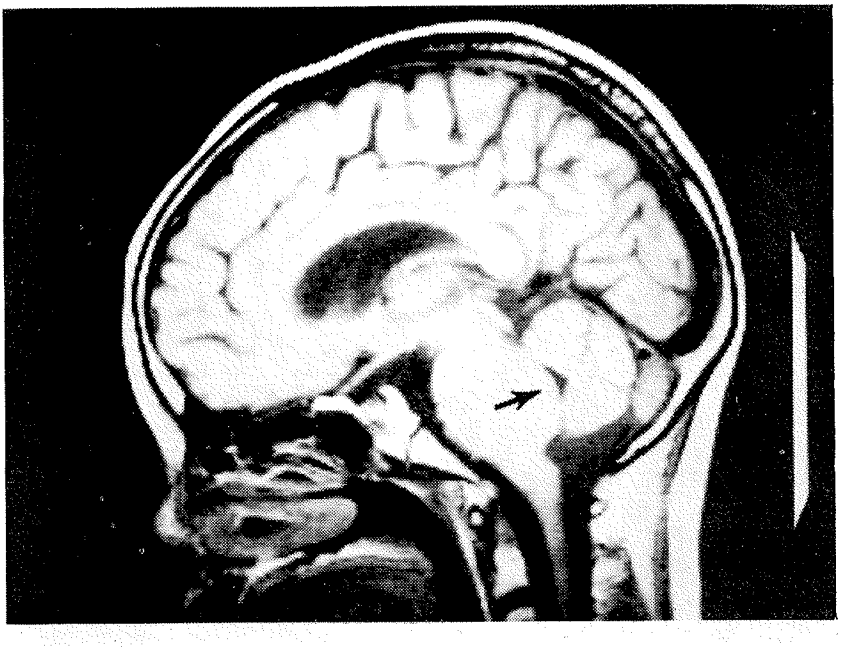

Figure 5: Pontine Glioma. Sagittal MR image shows expanded pons displaying the fourth ventricle (arrow).

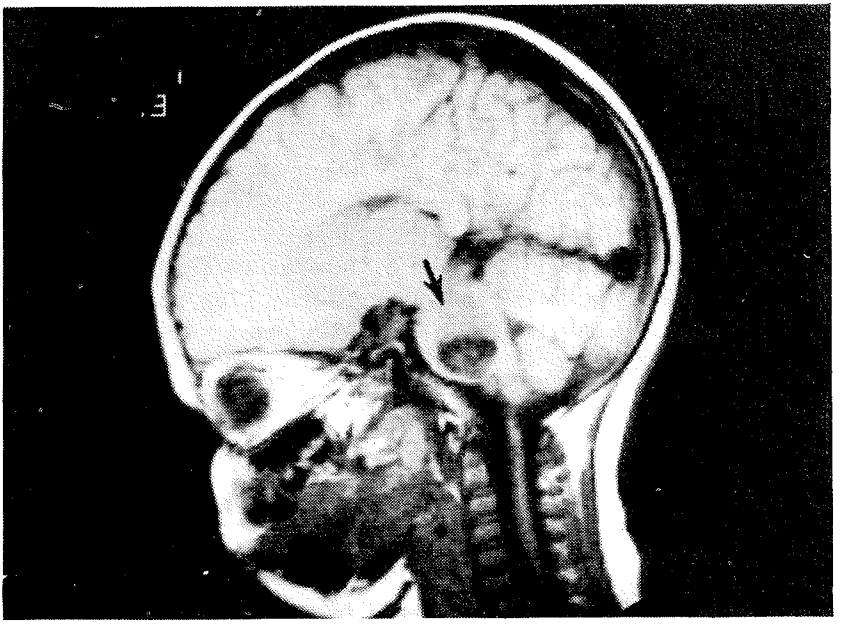

Figure 6a: Partially Cystic Pontine Glioma. Sagittal MR image shows expanded pons with cystic portion (arrow).

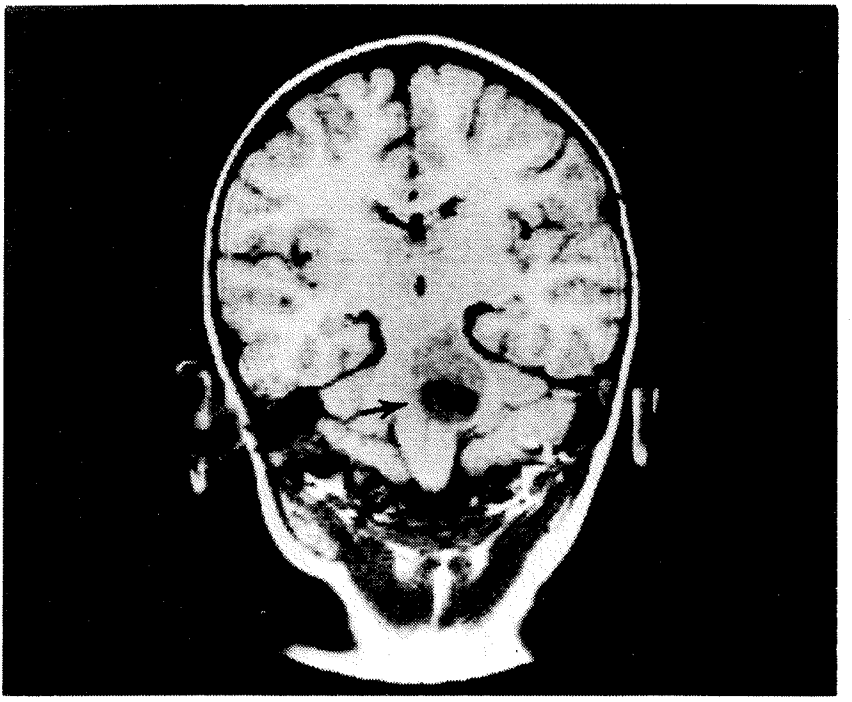

Figure 6b: Partially Cystic Pontine Glioma. Coronal MR image shows asymmetrically expanded pons with cystic component (arrow).

Astrocytoma and haemangioblastoma frequently are associated with a cyst (see Figure 8). Haemangioblastomas enhance dramatically on C.T. and increased vascularity may be recognized on MRI. Hydrocephalus is frequently present and there is displacement of the fourth venticle. MRI demonstration is superior to that of C.T.

Conclusion

Computed Tomography and Magnetic Resonance Imaging have had a dramatic impact on the diagnosis of primary brain tumours. The advantages of computed tomography are that it can be performed very rapidly whereas MRI is time consuming. Patient cooperation is vital and some cannot tolerate being in the MRI scanner. On the other hand, MRI allows imaging in the axial, sagittal and coronal planes and is a more sensitive modality.

Magnetic Resonance Imaging is rapidly becoming the procedure of choice supplemented by computed tomography and angiography when indicated. As in all medicine there are potential pitfalls to this approach and further experience and knowledge are necessary.

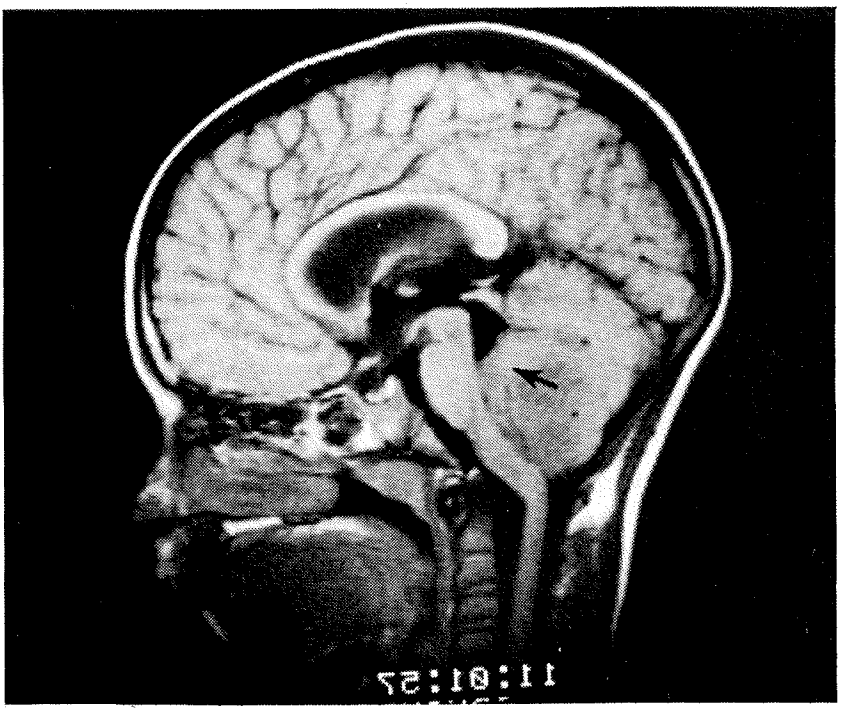

Figure 7: Medulloblastoma. Sagittal image shows tumour arising from the inferior vermis and fourth ventricle (arrow).

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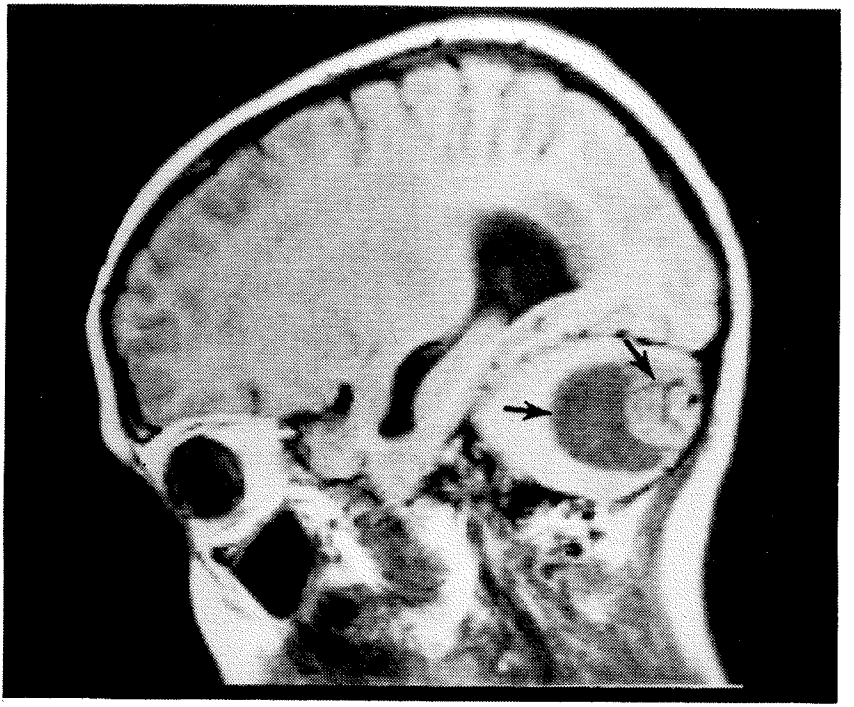

Figure 8: Cerebellar Cystic Haemangioblastoma. Sagittal MR image shows cyst (left arrow) and solid tumour (right arrow), the black serpentine tubes are blood vessels.

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