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Radiation Necrosis of the Brain. Neuroradiological Considerations with Computed Tomography

J. Brismar*, G. H. Roberson and K. R. Davis

Section of Neuroradiology, Department of Diagnostic Radiology, Massachusetts General Hospital, Boston, Mass, USA

Summary. In cases with radiation necrosis of the brain, conventional neuroradiological examinations usually demonstrate only an avascular mass lesion impossible to differentiate from intracerebral tumor or hemorrhage. Computed tomography, performed in addition to angiography in three cases, consistently demonstrated the radiation necrosis as a low density area exhibiting enhancement following infusion of contrast medium. The importance of recognizing radiation necrosis as a differential diagnosis to brain neoplasm is emphasized.

Key words: Radiation necrosis, Computed tomography.

Recurrent symptoms after radiation treatment of intracranial disorders, though usually due to recurrence of the original lesion, are sometimes caused by radiation necrosis. Radiation necrosis may affect not only tissue adjacent to the original tumor but also, depending on the dose distribution in the brain, appear in tissue well separated from the original lesion and may also occur as a complication to the treatment of extracerebral disorders. Radiation necrosis has thus been observed following irradiation of scalp lesions [1, 2], following radiotherapy for tumors of the paranasal sinuses and nasopharynx [3, 4] as well as for pituitary disorders [5, 6, 7, 8] and also in the occipital lobes following irradiation of tumors in the posterior fossa [9]. These cases often present difficult diagnostic problems, especially as symptoms and signs of radiation necrosis may develop after an interval of several years following radiotherapy. Three patients illustrating these diagnostic problems have been examined recently, and all have been subject to both cerebral angiography and computed tomography (CT scanning). One of the patients was also examined with radionuclide brain scan.

The aim of the present report is to use these cases as a basis for a discussion concerning the neuroradiological diagnosis of radiation necrosis with special reference to the role of computed tomography.

Methods

The angiographic examinations were performed with 1.6 times whole head magnification technique. An EMI scanner with the 160 × 160 matrix was used for computed tomography; additional scans following drip infusion of meglumine diatrizoate (300 ml containing 42.3 g iodine) were obtained in all cases.

Case Reports

Case 1

A 65 year old woman presented with confusion one year after operation and postoperative cobalt therapy for a pituitary adenoma. A ventriculoatrial shunt had been inserted 6 months prior to admission. A CT scan two months before admission demonstrated only postoperative changes. A repeat scan on admission disclosed decreased attenuation bilaterally in the temporal areas, more pronounced on the right side (Fig. 1 a, b). A rim of elevated absorption values was seen in the right temporal region after the infusion of contrast medium (Fig. 1 c, d). The lateral ventricles were small and the midline was shifted to the left. Right and left

* On leave from the Section of Neuroradiology, Department of Diagnostic Radiology, University Hospital, S-22185 Lund, Sweden (reprint address).

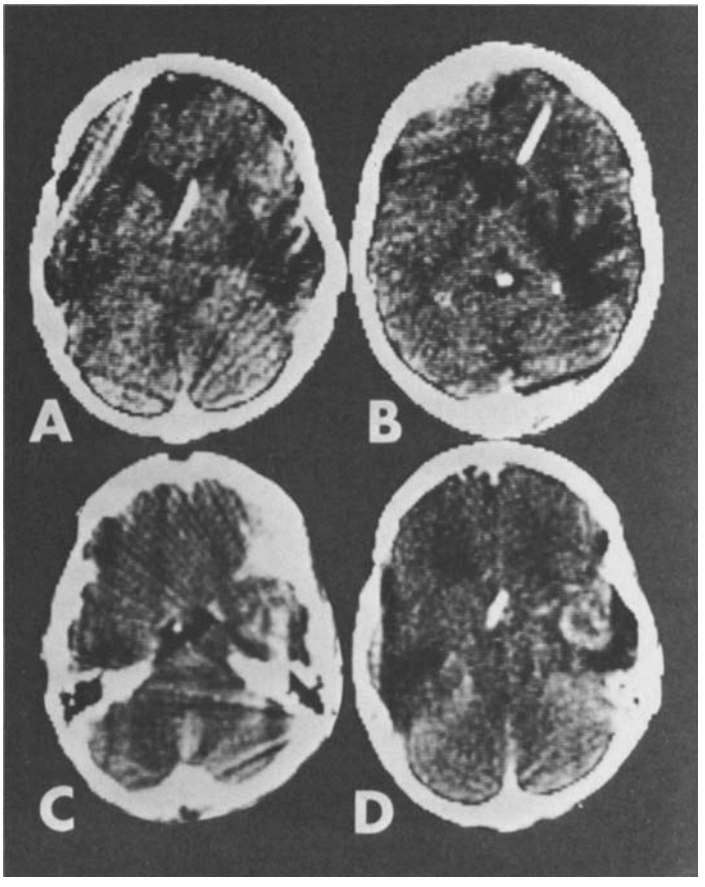


Fig. 1. Case 1, CT scan. a, b) Contiguous 13 mm sections before infusion of contrast medium demonstrate bilateral low absorption in the temporal lobe areas. c, d) After infusion of contrast medium irregular contrast enhancement is evident on the right. Right temporal lobectomy confirmed the diagnosis of radiation necrosis

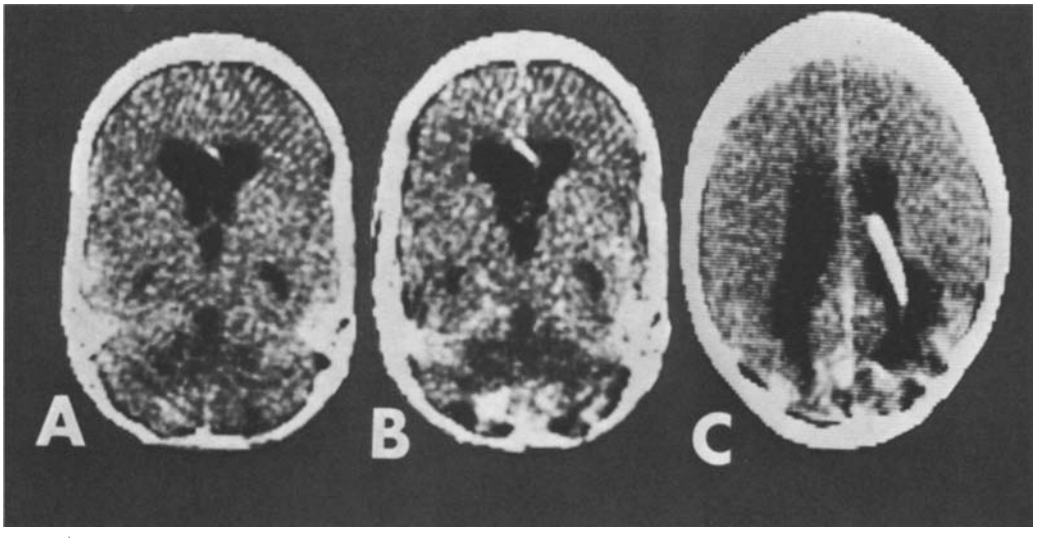
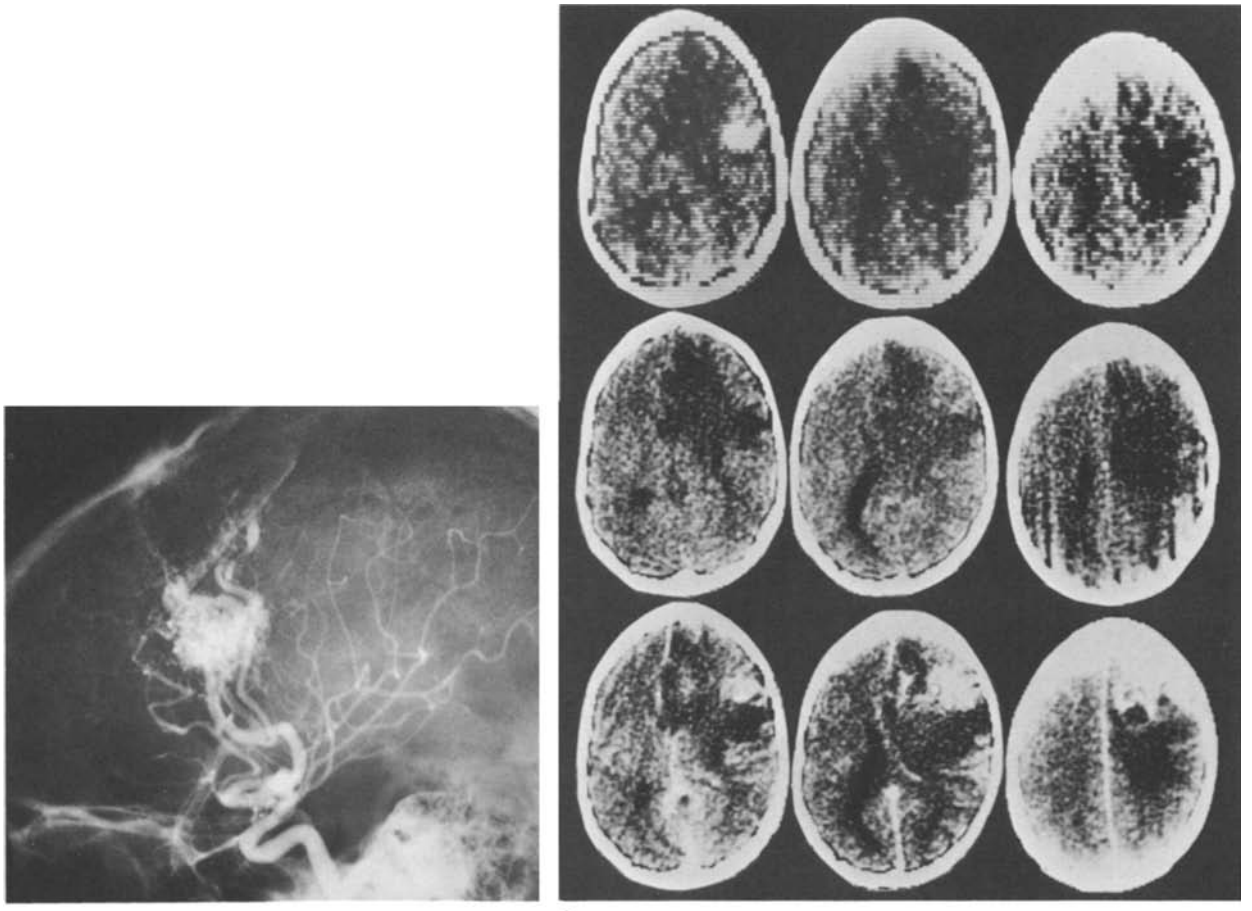


Fig. 2. Case 2. Plain CT scan demonstrates bilateral low density areas in the posterior fossa (a) and in the occipital lobes. Following infusion of contrast medium these areas (b, c) exhibit irregular contrast enhancement, interpreted as indicating radiation necrosis



a b

Fig. 3. Case 3. a) Right carotid angiography demonstrates an arteriovenous malformation and a large suprasylvian mass effect. b, upper row) Plain CT scans disclose a small hematoma with a large surrounding low absorption lesion. b, middle row). Plain CT scans 1.5 years later demonstrate a slightly larger low density lesion without evidence of hematoma on the right. The low density area seems to surround an anterolateral area of slightly increased absorption value, probably at least partly corresponding to the malformation. b, lower row) Following infusion of contrast medium irregular contrast enhancement is seen in a much larger area than possibly accounted for by the malformation which, on angiography, had decreased in size

carotid angiography disclosed a definite right and a questionable left avascular temporal mass lesion with a shift of the internal cerebral veins 5 mm to the left. Surgical exploration of the right temporal lobe disclosed an intratemporal tumor of hard and rubbery consistency, and an anterior temporal lobectomy was performed. The diagnosis of radiation necrosis was not established until the microscopic examination of permanent sections from the surgical specimen was compleded.

Case 2

A 35 year old woman was subjected to neuroradiological evaluation 9 years after postoperative irradiation of the posterior fossa following partial removal of a fourth ventricular subependymal astrocytoma because of slowly progressive visual field defects and attacks of distorted vision. Vertebral and bilateral internal carotid angiography disclosed a slight mass effect with possible hypervascularity in the posterior fossa as well as stretching, slight dislocation and slow circulation of terminal occipital branches of the right posterior cerebral artery.

Radionuclide brain scan with 99m Tc disclosed areas of increased activity interpreted as postoperative changes. A CT scan performed in temporal sequence to angiography and radionuclide scan, was of limited value because of scanning artefacts from intracranial metallic clips. A repeat CT scan one year later disclosed findings of a low absorption abnormality in the posterior superior aspect of the posterior fossa (Fig. 2a) as well as areas of decreased attenuation values in both occipital lobes. Following infusion of contrast medium all these low density areas showed

irregular contrast enhancement (Fig. 2b, c). No pathological verification is available in this case.

Case 3

A 16 year old girl was referred for neuroradiological evaluation one year after proton irradiation (4,000 r) of a right posterior frontal arteriovenous malformation, because of clinical signs of a recent frontal hemorrhage. Carotid angiography (Fig. 3a) demonstrated a reduction in size of the malformation since the angiogram prior to irradiation but also disclosed an interval development of a sizable right suprasylvian mass effect, interpreted as most likely representing a hematoma. CT scanning (Fig. 3b, upper row) confirmed the angiographic mass effect; the hematoma however, was found to be small and surrounded by a much larger volume of diminished absorption abnormality. The patient received supplementary proton beam irradiation (900 r).

She was again referred for neuroradiological examination 19 months later because of a 6 month history of loss of strength and dexterity of the left arm and leg as well as daily headache. A repeat plain CT scan (Fig. 3b, middle row) no longer demonstrated any evidence of hematoma. The low density area had an irregular but quite sharp demarcation and anterolaterally was enclosing an area of slightly increased absorption values. Following infusion of contrast medium (Fig. 3b, lower row), pronounced irregular enhancement was seen not only corresponding to the malformation (as seen on angiography), but in a much larger area. Right internal carotid angiography, in fact, demonstrated that the malformation had further decreased in size, confirmed the mass effect and also disclosed arterial spasm. At operation the brain in the right posterior frontal region was of an unusually firm consistency with areas of necrosis and thrombosed vessels. The malformation was resected. Fragments from the surrounding tissue were studied microscopically and were found to be consistent with radiation necrosis.

Discussion

In all three cases there were difficulties in establishing the clinical diagnosis. In the first patient a postoperative basal arachnoiditis had previously necessitated the installation of a ventriculoatrial shunt and the symptoms were initially interpreted to be caused by shunt dysfunction. CT scanning, as well as angiography, strongly suggest the diagnosis of radiation necrosis by excluding hydrocephalus and demonstrating bilateral temporal lobe abnormalities.

In the second patient the combination of postoperative neurological changes, symptoms possibly caused by recurrent tumor, and visual problems related to the occipital regions, added confusion to the clinical picture. The angiographic findings of a unilateral occipital mass lesion was initially interpreted as indicative of supratentorial tumor growth. The demonstration of discrete bilateral occipital lesions on CT scanning strongly supports the diagnosis of radiation necrosis, especially as the tentorium was left intact at the previous operation. Dose reconstruction revealed, that the irradiation therapy had created high-dose areas ("hot spots") in the occipital lobes.

In the third patient the clinical picture, preceding the second proton irradiation treatment, was that of an intracranial hemorrhage. The angiographic studies were consistent with a large intracerebral hematoma. CT scanning (80×80 matrix), however, disclosed that the hematoma was of limited size and the mass effect was caused primarily by a large low density lesion involving major parts of the frontal and parietal lobes on the right side. With our present experience, this low density area probably indicates the presence of a radiation necrosis already at that time; the findings were, however, interpreted as intracrebral hemorrhage in combination with infarction and a second proton beam treatment given. The repeat CT scanning 19 months later, with the combination of the new 160×160 matrix, supplementary contrast enhanced scans and larger personal experience, made the diagnosis of radiation necrosis more evident.

In all our cases the angiographic findings were those of a mass lesion without specific diagnostic characteristics. This is consistent with the experiences of previous investigators, whether using angiography [3, 7] or pneumoencephalography [6, 10]. The clinical picture may also be consistent with an infiltrating glioma, so a correct preoperative diagnosis has not always been obtainable [3, 7]. Since on inspection and palpation "neural parenchyma has the appearance of being replaced by an ill-defined, firm space occupying mass that mimics a diffusely infiltrating glioma" [11] even the postoperative diagnosis may be entirely dependent on microscopic examination.

According to the scanty information available, radionuclide brain scanning has sometimes proven informative by demonstrating increased activity in the region of radiation necrosis [3, 7]. Only one of our patients (Case 2) was subjected to such scanning; the findings were interpreted as consistent with postoperative changes, but may have represented activity in the areas of radiation necrosis.

Computed tomography offers entirely new diagnostic capabilities. This technique not only permits a confirmation or exclusion of possible differential diagnoses such as ventricular dilatation or intracerebral

hemorrhage, but also enables us to visualize the necrotic brain tissue *per se*. The findings on CT scanning were similar in all three cases. Before infusion of contrast medium the region of radiation necrosis presented as a low density area. Following infusion of contrast medium irregular enhancement was seen in all patients. Similar changes may also appear in conjunction with malignant gliomas. It may thus be almost impossible to differentiate, following radiotherapy, between recurrence of a malignant intracerebral tumor and radiation necrosis.

In order to avoid misinterpretation in patients who have received irradiation to the head, the clinical information is of utmost importance. Not only must the physician be aware of radiation necrosis as a possible differential diagnosis to brain tumor in such cases, but he must also have sufficient clinical information available to suggest this possibility. The diagnosis might then be supported by the relation of the intracerebral abnormality to the portals of entry of previous irradiation or to high-dose areas, ("hot spots") produced by that irradiation.

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Jan Brismar, M. D.
Section of Neuroradiology
Department of Diagnostic Radiology
University Hospital
S-221 85 Lund, Sweden