Radiation-induced cerebral injury: a longitudinal MR study

Y. Chan[1], S. Leung[2], A. King[1], P. Lee[3], A. Ching[3]

[1]Diagnostic Radiology and Organ Imaging, Chinese University of Hong Kong, Shatin, Hong Kong, [2]Clinical Oncology, Chinese University of Hong Kong, Shatin, Hong Kong, [3]Diagnostic Radiology and Organ Imaging, Prince of Wales Hospital, Shatin, Hong Kong

BACKGROUND and OBJECTIVES

Late delayed radiation (RT)-induced injury of the brain is one of the most serious complications of radiation therapy for brain tumors and tumors at the skull base [1]. Studies of late RT-induced injury of the brain in patients irradiated for brain tumor is confounded by the presence of tumor and the unreliable differentiation between recurrent tumor and radiation-induced changes. Long term studies are hampered by the poor prognosis in these patients. The natural long term course of RT-induced cerebral injury therefore has not been adequately studied. Temporal lobe injury is a well-recognized late complication of RT of nasopharyngeal carcinoma. It represents a model of radiation injury to the native brain as the brain abnormalities were solely accounted for by RT. MRI has revealed the complex imaging features inherent in the disease [2]. The objective of the present study was to employ serial MR imaging to study the natural course of late RT-induced injury of the temporal lobes.

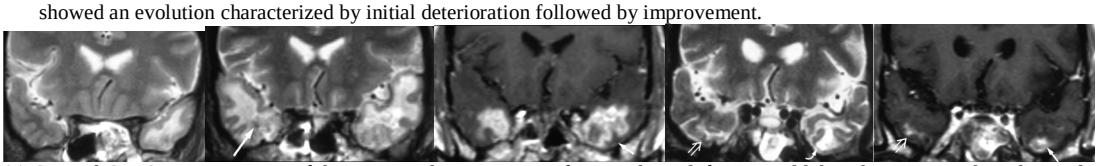
MATERIALS AND METHODS

Serial MRI examinations of patients with RT-induced temporal lobe injury were with the following inclusion criteria: (i) history of nasopharygneal carcinoma treated by RT; (ii) serial monitoring with MRI with coronal gradient and spin-echo (GraSE) T2-weighted, axial pre-contrast enhanced T1-weighted and coronal post contrast-enhanced T1-weighted imaging for at least two years; (iii) at least three MRIs performed; and (iv) no history of steroid treatment. Severity of lesion was assessed from changes in the extent of white matter lesion; necrosis and accentuation of mass effect. Four evolution groups were classified: static, progressive improvement, progressive deterioration, waxing and waning. In consecutive examinations showing deterioration, the occurrence of cystic transformation or enlargement, increase in blood-brain barrier (BBB) disruption as shown by increase in contrast enhancement, and increase in blood breakdown products as evidenced by markedly hypointense foci on GraSE images, were evaluated.

RESULTS

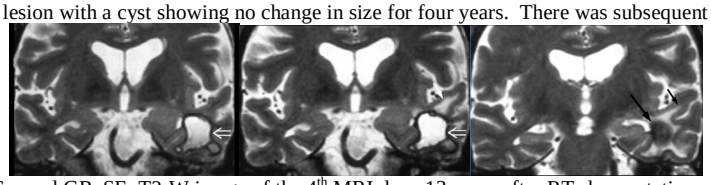
Twenty-seven patients aged 35-75 years satisfied the study criteria. Serial studies spanned 2.1- 5.7 years with 3-7 MR examinations performed in each patient. The interval from RT to the first MRI was 2.1-12.7 years (median 4 years) and that to the last MRI was 5.5-18 years (median 9.5 years). Of 50 temporal lobes with lesions, 10 remained static, 14 improved progressively, 12 deteriorated progressively, 14 waxed and waned. Twenty-six lobes had evidence of deterioration. Increase in the extent of contrast-enhancement (P=0.0002) and deposition of blood breakdown products (P=0.0004), but not cystic transformation, were significantly associated with deterioration (Figs 1 and 2). Deteriorating episodes associated with increase only in blood breakdown products occurred at a significantly longer interval (median 9.8 years, P=0.01) from RT compared to those associated with an increase in contrast enhancement only (median 5.3 years).

Fig. 1. MR images (a to e displayed from left to right) obtained in a 52-year-old man who underwent radiation therapy 2.1 years ago. Both right and left temporal lobes showed an evolution characterized by initial deterioration followed by improvement.



(a) Coronal GRaSE T2-W image of the 1st MRI done 2.1 years after RT shows left temporal lobe white matter edema but no lesion in the right lobe;
(b) Coronal GRaSE T2-W image of the 3rd MRI done 3.3 years after RT shows bilateral temporal lobe swelling with hyperintense white matter edema.
(c) Gadolinium-enhanced T1-W image shows marked increase in extent of contrast-enhancement bilaterally (arrows);
(d) Coronal GRaSE T2-W image of the 4th MRI done 5.8 years after RT shows decrease in white matter lesion and swelling in both temporal lobes compared with fig. 1c. A small cyst is beginning to form in the left temporal lobe (curved arrow);
(e) Gadolinium-enhanced T1-W image shows decrease in extent of contrast enhancement bilaterally (arrows), as compared with fig. 1c.

Fig. 2. MR images (a to c displayed from left to right) obtained in a 60-year-old man who underwent radiation therapy 9 years ago. The patient had static left temporal lobe lesion with a cyst showing no change in size for four years. There was subsequent deterioration due to increase in blood breakdown products.



(a) Coronal GRaSE T2-W image of the 4th MRI done 13 years after RT shows static cyst size (open arrow);
(b) Coronal GRaSE T2-W image of the 5th MRI done 14.5 years after RT shows unchanged cyst size (open arrow) but there is evidence of deterioration as shown by increase in vasogenic edema extending to the superior temporal gyrus (arrow);
(c) more posterior section shows vasogenic edema (arrow) and markedly hypointense focus (long black arrow) in keeping with increase in blood breakdown products.

DISCUSSION

In the current study, of 26 lobes with deteriorating episodes on consecutive MRI, 13 (50%) had evidence of increase in disruption of BBB. The findings suggest that an increase in BBB disruption is an important but not universal factor in the deterioration of RT-induced injury. BBB disruption as seen in these deteriorating cases tended to occur earlier after RT compared to those cases related to increase in blood breakdown products. There was also significant association between increase in blood breakdown products and deterioration, with a longer interval from RT compared to those associated with increase in extent of BBB disruption only. Emergence or enlargement of cyst was not significantly associated with deterioration. Cyst formation may represent the chronic or late stage accumulation of fluid subsequent to body homeostasis in clearing tissue necrosis.

CONCLUSION

The natural course of late radiation-induced injury in the temporal lobes could follow variable patterns. Temporal lobes that deteriorated in their course were frequently and significantly associated with increase in BBB disruption and blood breakdown product deposition, with the latter tending to occur more delayed than the former.

REFERENCES

1. Sheline GE, Wara WM, Smith VS. Int J Radiat Oncol Biol Phys 1980;6:1215. 2. Chan YL, Leung SF, King AD, et al. Radiology 1999;213:800.