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Visualisation of stereotatic radiolesions by nuclear magnetic resonance

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SUMMARY The ability to visualise stereotactic brain lesions produced by irradiation from the stereotactic Gamma Unit at the Karolinska Hospital was investigated. A patient who had undergone bilateral stereotactic gamma capsulotomy in two stages was examined by the nuclear magnetic resonance imaging technique, which demonstrated that the stereotactic lesions in the internal capsule could be visualised in the immediate postoperative period. This gives stereotactic radiosurgery a reliable anatomical basis and facilitates the planning and follow-up studies in this type of cerebral surgery.

Stereotactic radiosurgery is an effective method for non-invasive section of cerebral pathways (for a review, see Leksell 1982).[1] The brain lesions obtained by gamma irradiation from the stereotactic ^{60}Co-unit are precise and well circumscribed. Anatomical verification, however, is rarely possible and a satisfactory method for postoperative visualisation of the brain lesions would be an important advance. The unique physical properties of the nuclear magnetic resonance (NMR) imaging method, might offer a solution to this problem. A patient who had undergone bilateral stereotactic gamma capsulotomy[2] was examined by this technique at the Philips Research Laboratories in Eindhoven.

Case report

The patient was a 29-year-old factory worker suffering from permanent severe anxiety and fear of flushing in the presence of other people (erythrophobia), with secondary alcohol abuse. During the past four years his condition deteriorated steadily, with increasing anxiety, insomnia, headache and indigestion. Psychotherapy and neuropharmacological treatment had failed and there was an imminent danger of suicide.

Operation

Stereotactic radiosurgery was performed in two stages.

Anterior gamma capsulotomy, right side (9 December 1983).

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The procedure was performed according to the principles described previously.[1,3] The target coordinates were determined from the CT images.[4] A collimator helmet with 8 mm apertures was used and an absorbed dose of 100 Gy was administered in a single treatment to the centre of the target area in the most anterior part of the internal capsule. The time of irradiation was 100 min. The operation was performed as an out-patient procedure and the patient left the hospital on the same day.

Anterior gamma capsulotomy, left side (9 January 1984). The procedure was carried out in exactly the same way as the first stage, but the dose of radiation was 120 Gy and the treatment time 120 min.

On the following day the patient was examined in Eindhoven, since at the present time no NMR imaging unit is available in Sweden.

NMR examination

The investigation was made with a standard Philips Gyroscan S5, 24 hours after the last operation. A magnetic field strength of 0·5 Tesla and a standard Rf head coil with an inner diameter of 30 cm was used. The imaging was performed with a spin-echo pulse sequence, with repetition time 1 s and echo-time 50 ms.

Three scans, spaced 4 mm apart, were made in the transaxial plane. In the uppermost scan two symmetric lesions could be observed exactly at the precalculated site in the anterior part of the internal capsule (fig). In this image the 24-hour-old lesion appeared to be of approximately the same size as the one made one month earlier.

During the interval between the two operations the patient's symptoms were practically unchanged. His psychiatric condition will be followed up later and is not reported here.

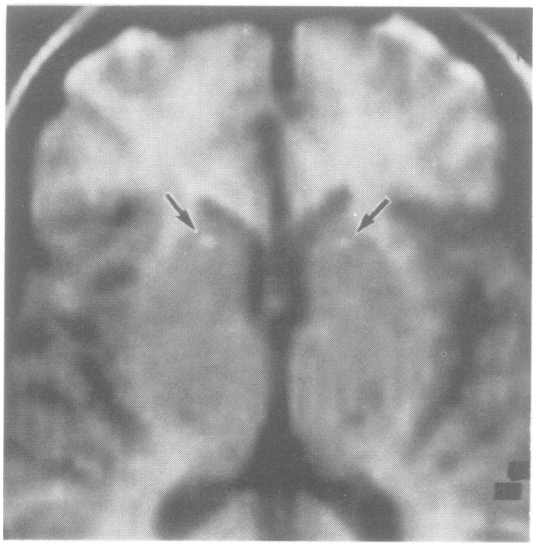

Fig. *NMR image in the transaxial plane recorded with a Philips Gyroscan S5 using a spin-echo pulse sequence (repetition time 1 s, echo-time 50 ms). Two symmetric lesions are observed at the precalculated site in the anterior part of the internal capsule.*

Comment

This is, to our knowledge, the first time the effects of ionizing radiation on the brain have been visualised early after the irradiation. The implications for stereotactic neurosurgery are important. Since this technique was first tried in a similar case,[5] using x-rays, anatomical studies of the brain lesions have only been possible in a small group of patients after gamma thalamotomy for cancer pain.[6] Now it seems possible to verify the lesion, and check its correct placement, in the early postoperative period and to follow its further development. The NMR studies may also facilitate the determination of the optimal dose level for various intracranial target structures. In irradiation of grey matter, as in thalamotomy, no lesions have been obtained with these narrow beams below a dose of radiation of about 140 Gy, and then only after a relatively long latent period. In the present case a lower dose was administered and so far the exact nature of the NMR findings is unknown. Presumably the white substance in the internal capsule is more radiosensitive than the thalamus, and it might be possible to achieve a selective destruction of cerebral fibre tracts without injury to surrounding grey matter. The possibility of visualising radiation injury to the cerebral tissue in this way may also be of importance in the stereotactic treatment of vascular malformations and some deep-seated tumours.

One interesting example is the small acoustic tumours[7] which are now routinely treated here by stereotactic radiosurgery.[8,9]

NMR-imaging appears to be a valuable tool for clarifying some of the still unsolved problems connected with the use of the gamma unit and will make stereotactic radiosurgery still safer and more effective.

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