Interstitial Irradiation of Inoperable Brain Stem Tumors

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Introduction

The long-term prognosis of patients with malignant brain stem and midbrain tumors must be regarded as unfavorable. Mean survival rates of 5–15 months have been reported [1]. Several studies show a correlation between prognosis and localization or histology. Most tumors in the cranial pons and in the midbrain are well differentiated astrocytomas, whereas tumors caudal to the pons and in the medulla are usually more malignant [1]. Treatment of these tumors must not be considered curative, its purpose being to increase survival time and improve life quality.

These goals may be attained by:

1. percutaneous irradiation combined with chemotherapy
2. interstitial irradiation in the form of permanent and temporary implantation of isotopes and so-called afterloading. We have lately applied the technique fractionated afterloading to the treatment of inoperable brain gliomas (Oppel et al. 1985 [4]).
   Interstitial irradiation makes it possible to attain a much higher radiation dose than percutaneous irradiation thus improving therapeutic efficiency.

During the past 5 years, 17 patients (6–73 years of age) – 6 with tumors of the brain stem and 11 with tumors of the midbrain – were submitted to interstitial irradiation by permanent implantation of ^{192}Ir seeds. The procedure of fractionated afterloading was applied in two patients.

Method

The dose required for interstitial irradiation was calculated according to the tumor volume and the configuration as determined by angiography, computerized tomography (CT) and magnetic resonance tomography (MR). The marginal tumor dose was limited to 6000–8000 rad in the brain stem and to 8000–10000 rad in the midbrain. Tumor biopsy and isotope implantation were performed by conventional stereotactic technique using an adapted biopsy forceps and an implantation catheter. In order to ensure the diagnosis and verify the exact target determination, 4–6 tumor biopsies were taken and evaluated immediately. The material thus obtained was sufficient to establish diagnosis in all cases.

Depending on the location, extent and shape of the tumor, the needle-path must be chosen so as to permit alignment within the tumor (Fig. 1). While, as a rule, ac-

M. Samii (ed.), *Surgery in and around the Brain Stem and the Third Ventricle*

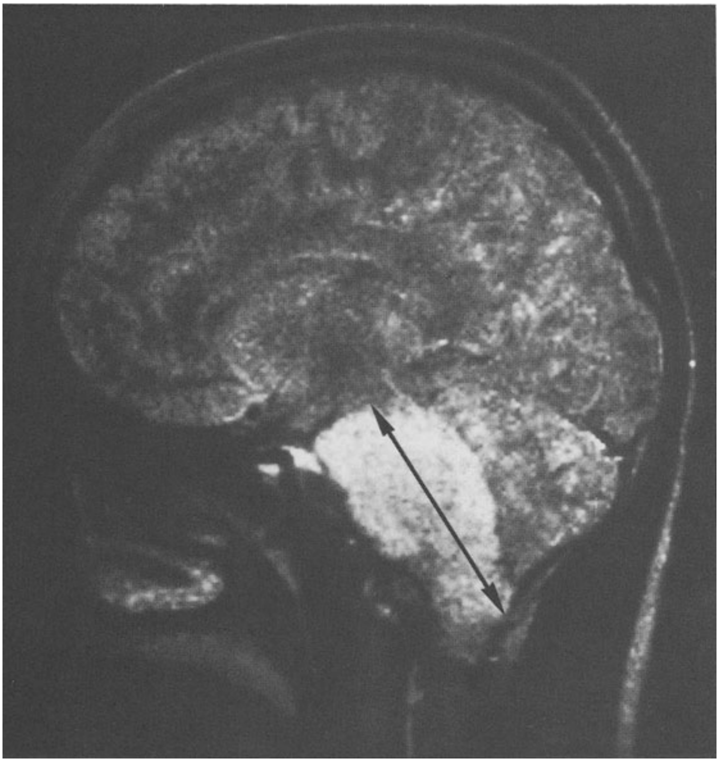

Fig. 1. Magnetic resonance picture of a brain stem tumor (astrocytoma II). Tumor localization and spreading is largely cranio-caudal. Accordingly, ^{192}Ir must be implanted in the longitudinal axis of the tumor. A transcerebellar access would not allow such an alignment of the seeds

cess to the midbrain does not present any problem, access to the brain stem may be hampered by the tentorium, the vessels in the pineal region, or the petrous bone. Since brain stem tumors are partly supra- and infratentorial in location, direct (easier) infratentorial access does not permit optimal seed positioning. For this reason, we have chosen the frontal access through the tentorial notch. As shown in Figs. 2 and 3, the implantation catheter passes between the corpus callosum and the internal capsule and through the thalamus and tentorial notch without affecting the pineal vessels. In order to eliminate the radiation problems caused by temporary interstitial irradiation, we have recently devised a technique for fractionated afterloading by modification of a technique used in the field of gynecology [5].

Our method consists of inserting a catheter (outer diameter: 3 mm) through the longitudinal access of the tumor, the target for the catheter tip being the midpoint of the distal tumor margin. The first step consists of making a burrhole into the calvarium (diameter: 8 mm) and in cutting a winding into the walls of this burrhole. This winding serves for the firm fixation of a screw bolt through which the catheter is inserted, and to which it is fixed. The skin is closed over the bolt, the catheter opening surpassing the skin surface by 2 mm (Figs. 4, 5). The patient can move unrestricted with this implanted catheter, the distal tip of which is closed. The radia-

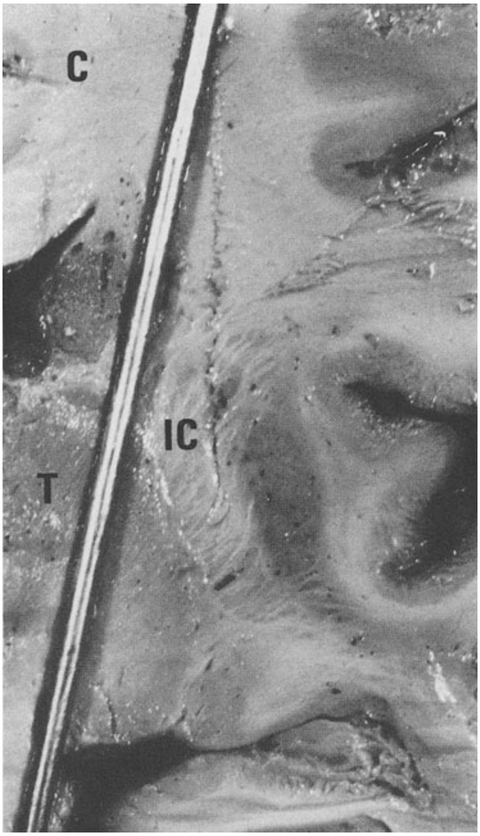

Fig. 2. Anatomic specimen. The stereotactically inserted implantation catheter passes between the corpus callosum (*C*) and the internal capsule (*IC*) transthalamically (*T*) down to the tentorial notch. (Material kindly provided by Prof. J. Lang, Würzburg)

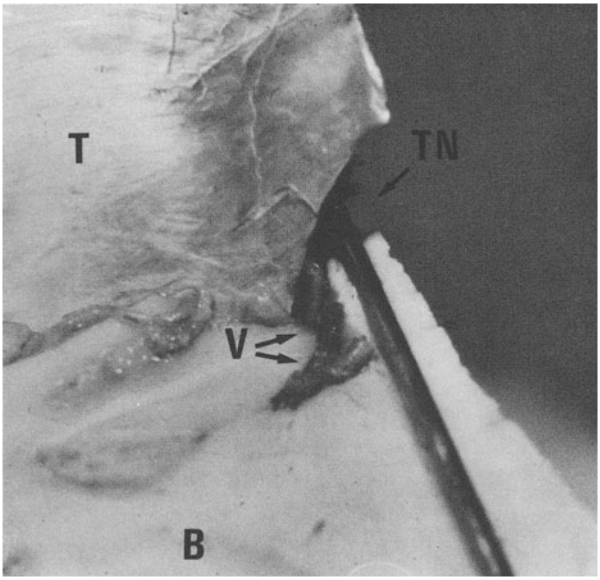

Fig. 3. Anatomic specimen. The implantation catheter passes through the tentorial notch (*TN*) without affecting the vessels of the pineal region (*V*). *T* = tentorium, *B* = brain. (Material kindly provided by Prof. J. Lang, Würzburg)

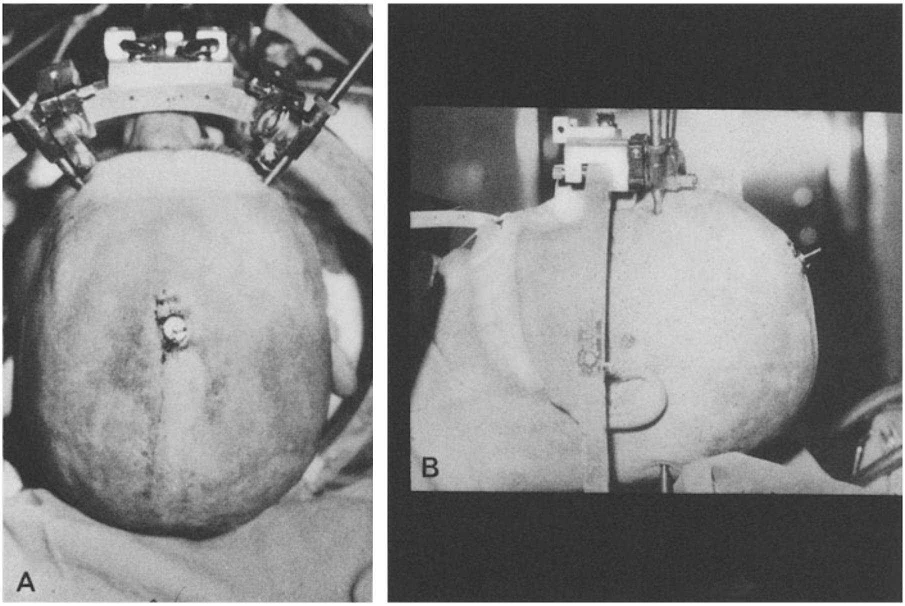

Fig. 4. A Patient fixed in the stereotactic ring. Skin closure is performed after insertion and fixation of the catheter in the screw bolt. **B** Lateral view showing the protruding catheter for later introduction of the radiation source

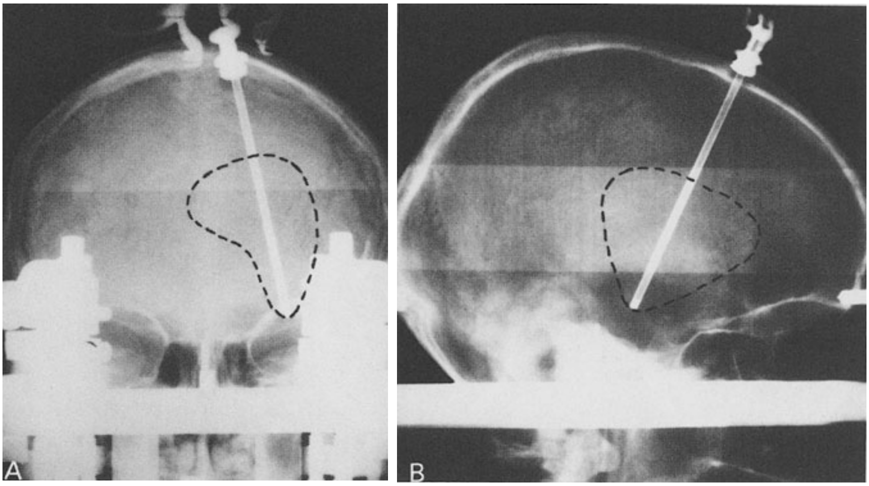

Fig. 5 A, B. X-rays showing the indwelling catheter for intermittent afterloading (with tumor contour). **A** a.p., **B** lateral view

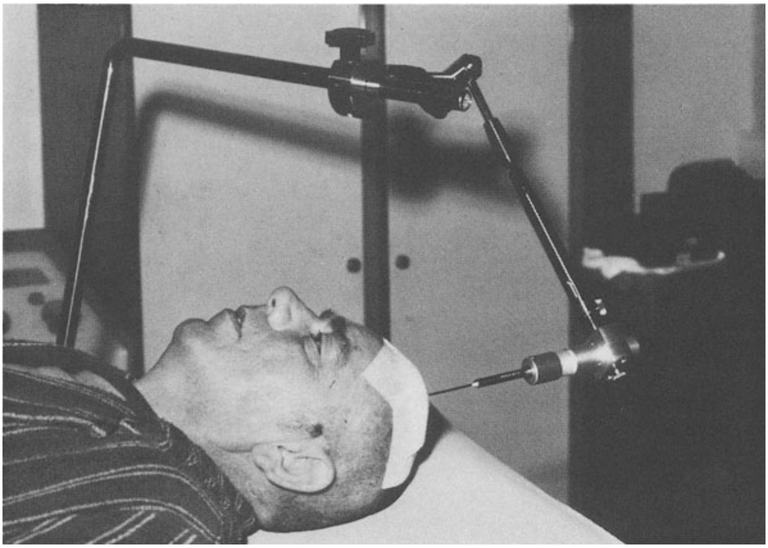

Fig. 6. Patient in the radiation chamber after introduction of the radiation source

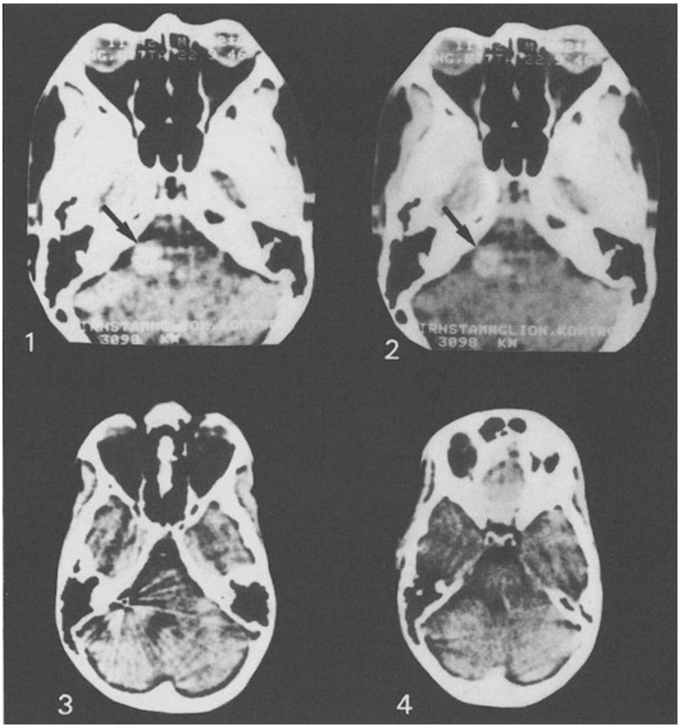

Fig. 7. CT of a pons glioma before (*1, 2, arrows*) and six months after (*3, 4*) interstitial ^{192}Ir irradiation. In the late follow-up, the tumor is no longer visible and the basal cisterns are fully open

tion source has the form of a trocar and is driven into the catheter by remote control once a day for 3–4 minutes (Fig. 6). The required radiation dose, adjusted to the tumor volume, is achieved in up to 10 sessions. After conclusion of radiotherapy, the catheter and thread bolt can be easily removed under local anesthesia. In addition, percutaneous irradiation may be performed after an interval of 3 weeks. In this way, the total radiation dose applied can be significantly increased.

Tables 1–3. Histologic diagnosis, maximal tumor spread, radiation activity and survival time of the dead (*N*) and the still living patients (*S*)

Table 1. Basal ganglia

Pat. no.	Age (years)	Sex	Pathology	Diameter max (mm)	Activity (mCi)	Survivors (S) Non-survivors (N)	Survival time
1. H. D.	57	M	Oligodendro-astrocytoma II	50	4.6	S	2 months
2. D. Z.	46	M	Oligodendroglioma II	40	4.0	N	7 months
3. G. H.	33	M	Astrocytoma II–III	40	1.6	S	8 months
4. G. L.	26	M	Astrocytoma	40	2.0	S	8 months
5. B. B.	45	F	Astrocytoma II–III	40	1.6	N	4 months

Table 2. Thalamus

Pat. no.	Age (years)	Sex	Pathology	Diameter max (mm)	Activity (mCi)	Survivors (S) Non-survivors (N)	Survival time
1. H. Sch.	54	F	Astrocytoma	35	3.4	N	4 days
2. G. L.	67	F	Astrocytoma I	40	1.5	S	3 months
3. A. K.	30	F	Astrocytoma II	30	1.6	S	16 months
4. H. G.	22	M	Astrocytoma I	40	3.0	S	8 months
5. B. H.	26	F	Oligodendro-Astrocytoma III	50	3.2	S	6 months
6. H. D.	35	F	Astrocytoma	40	3.1	S	16 months

Table 2. Brain stem

Pat. no.	Age (years)	Sex	Pathology	Diameter max (mm)	Activity (mCi)	Survivors (S) Non-survivors (N)	Survival time
1. J. Z.	32	M	Astrocytoma I	45	4.2	S	8 months
2. G. S.	70	M	Metastatic Ca.	30	1.3	S	10 days
3. F. B.	59	M	Astrocytoma II	50	5.5	N	5 days
4. H. G.	40	M	Astrocytoma III	40	2.1	N	8 months
5. N. H.	5	M	Oligodendroglioma II	60	3.3	S	4 months
6. R. Y.	37	F	Astrocytoma II	40	2.1	S	23 months

Results

Various degrees of neurologic improvement were achieved in all patients with permanent implantation of ^{192}Ir, in few cases (Fig. 7, Tables 1–3), computerized tomography gave the impression of complete tumor remission for periods up to 2 years. In other cases, tumor growth could not be checked (Tables 1–3). Age, sex, tumor size, marginal tumor dose and survival rates are shown in Tables 1–3. The results must be considered individually and are probably to a large extent dependent on the histology. No complications occurred.

Discussion

At present, interstitial irradiation through permanent ^{192}Ir implantation must be regarded as the most effective therapeutic possibility for treating inoperable tumors of the brain stem, the thalamus and the basal ganglia [2, 3]. Stereotactic technique permits optimal positioning of the seeds and allows bioptic diagnosis. Only tumors of low malignancy can be considered for this therapy, since the radiation effect must correspond to the tumor proliferation. In contrast, rapidly growing tumors can only

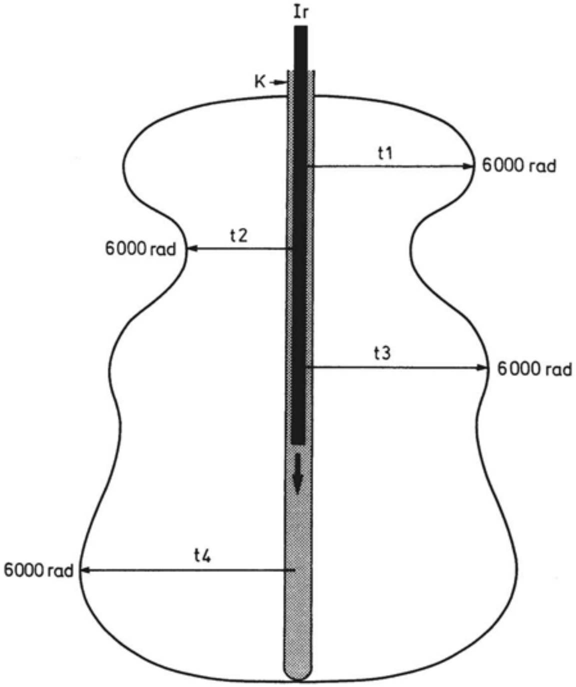

Fig. 8. Schematic representation of a tumor with irregular contours. A catheter (*K*) has been introduced through the longitudinal axis of the tumor for interstitial irradiation by fractionated afterloading. The radiation source (*Ir*) remains (*arrow*) at each point of the tumor for the individual length of time (*t 1–4*) required, the purpose being to attain a marginal tumor dose of 6000 rad through different durations of exposure

be treated and checked in their growth by a short-term high radiation dose. The technique of afterloading seems particularly suitable for this purpose, since high radiation dose can be applied without exposure of family members and nursing personnel. A further advantage is the adjustment of the radiation dose to the tumor contours (Fig. 8), the CT technique now permitting 3-dimensional tumor depiction and thus volumetry. Whenever adequate irradiation of peripheral tumor regions poses difficulties, association of interstitial and percutaneous irradiation may be useful.

Our results (Tables 1–3) show a better response to permanent interstitial ^{192}Ir irradiation in gliomas of low malignancy. This is in agreement with the findings of others [2, 3]. It must be emphasized that initially all patients experience a neurologic improvement. In patients surviving for a long time, the quality of life is markedly improved to completely normal. Patients in whom interstitial irradiation fails to stop tumor growth usually only survive for a short period of time. These patients, as a rule, die of cardiovascular complications. So far, we have not seen complications such as hemorrhages or radiolesions in the surrounding tissue. Local brain edema, the extent of which may vary, can be treated by dexamethasone. Interstitial irradiation of inoperable brain tumors in the brain stem and around the 3rd ventricle can be carried out effectively and without danger in cases of glioma of low malignancy. The new technique of fractionated afterloading seems promising for tumors of higher malignancy. However, conclusive results are not available yet.

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