The effect of steroid on thallium-201 uptake by malignant gliomas

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Abstract. In order to assess the effect of steroid on thallium-201 uptake by glioma, ^{201}Tl single-photon emission tomography was performed before and after steroid administration in four patients with recurrent malignant glioma. After steroid administration the ^{201}Tl index, expressed as the ratio of ^{201}Tl uptake in the tumour to that in the contralateral cerebral hemisphere, was 0.77±0.11 of the value before steroid (mean±SD: $P<0.05$ by paired t test). The ^{201}Tl index has been used as a possible indicator for the differentiation of malignant gliomas from relatively benign tumours or radiation necrosis. The present results indicate that the effect of steroid has to be taken into account when semi-quantitative analysis, e.g. by means of the ^{201}Tl index, is used in patients with brain tumours.

Key words: Thallium-201 – Single-photon emission tomography – Steroid – Glioma – Blood-brain barrier

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Introduction

Thallium-201 has been used for malignancy grading of glioma [1, 2] and differentiation of recurrent glioma from radiation changes [3, 4]. The ^{201}Tl index, usually expressed has the ratio of ^{201}Tl uptake in the tumour to that in the contralateral cerebral hemisphere, has been used for semi-quantitative analysis. ^{201}Tl uptake by brain tumours is related to changes in the permeability of the blood-brain barrier, the regional blood flow, and the Na^+, K^+-ATPase pump [5]. Steroid, which is often used as an anti-oedema drug in patients with brain tumour, is known to change the blood-brain barrier permeability of various substances and has a good possibility of affecting ^{201}Tl uptake by brain tumours. In order to assess the effect of steroid on ^{201}Tl uptake by glioma, we performed ^{201}Tl single-photon emission tomography (SPET) before and after steroid treatment in four patients with recurrent malignant glioma.

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Materials and methods

Patient population. Four patients with recurrent supratentorial malignant glioma were studied, two women and two men. Histological diagnosis just prior to the study was anaplastic astrocytoma in two and glioblastoma multiforme in two. All patients had initially received at least 40 Gy external beam radiotherapy and some form of chemotherapy. None of the patients took steroid for at least 2 weeks before "pre-steroid" ^{201}Tl-SPET, and were then given dexamethasone (Merck Sharp & Dohme, 4 mg/day, intravenously) for at least 1 week before "post-steroid" ^{201}Tl-SPET. Intervals between the pre-steroid and post-steroid SPET studies were 7, 8, 16 and 21 days.

^{201}Tl-SPET. The patients were intravenously injected with 111 MBq (3 mCi) of ^{201}Tl chloride (Nihon Medi-Physics Co., Ltd., Nishinomiya, Japan) and data acquisition was started from 5 min after ^{201}Tl injection and continued for 30 min using a three-head rotating gamma camera (GCA 9300A, Toshiba, Tokyo, Japan) with a high-resolution fan beam collimator. A 64×64 matrix with Butterworth filter was used and images were constructed in the transverse plane to facilitate comparison with magnetic resonance (MR) images. Regions of interest were chosen in the tumour and corresponding contralateral cerebral cortex using MR images taken shortly before the SPET studies as a guide. The ^{201}Tl index was calculated (ratio of average counts/pixel in the tumour site to that in the contralateral cerebral hemisphere) and the post-steroid ^{201}Tl index and the pre-steroid ^{201}Tl index for each patient were compared.

Results

The pre-steroid ^{201}Tl index was 5.98±1.49 and the post-steroid ^{201}Tl index, 4.65±1.63 (mean±SD). The post-steroid ^{201}Tl index was lower than the pre-steroid ^{201}Tl index in every case (Fig. 1), and the reduction of ^{201}Tl index by steroid was statistically significant ($P<0.05$,

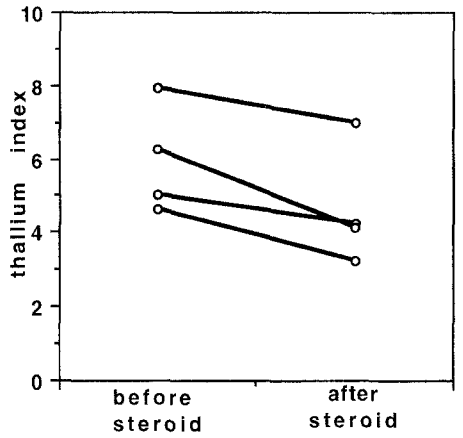

Fig. 1. The effect of steroid (dexamethasone 4 mg/day) on the ^{201}Tl index (tumour/contralateral cerebral cortex) of recurrent malignant gliomas. The index was significantly reduced by steroid administration ($P<0.05$)

paired t test). Ratios of the post-steroid to the pre-steroid ^{201}Tl index were 0.66–0.88 (mean±SD: 0.77±0.11).

Discussion

A variety of imaging modalities have been examined for their ability to accurately predict the prognosis of patients with gliomas. Although positron emission tomography with fluorine-18 fluorodeoxyglucose [6] or carbon-11 methyl-L-methionine [7] has been shown to correlate with the malignancy grade of gliomas, it cannot be widely used because of its limited availability. Computed tomography and MR imaging are widely distributed, but their reliability in grading glioma is questionable. ^{201}Tl-SPET has recently become available as a routine brain tumour imaging technique. Several methods have been proposed for semi-quantitative analysis and used to draw threshold lines between low-grade and high-grade gliomas [1, 2], between recurrent glioma and radiation changes [3, 4] or between tumours of short-term survivors and of relatively long-term survivors [8]. These methods include the ^{201}Tl index, as in the present study [1, 2, 4], the tumour-to-cardiac ^{201}Tl uptake ratio [8], and the tumour-to-scalp ^{201}Tl uptake ratio [3]. However, the effect of background medication such as steroid therapy on ^{201}Tl index has not yet been fully discussed. Because steroid is known to be a potent anti-oedema agent and is frequently used in the patients with brain tumours [9], we examined the effect of a regular dose of dexamethasone on the ^{201}Tl index.

We observed that dexamethasone, at a dose of 4 mg/day, decreased the ^{201}Tl index of gliomas by 12%–34%. Since the comparison was made between the pair of studies in each patient performed within quite a short period during which no other treatments were given, the change in ^{201}Tl index is attributable to the effect of dexamethasone on the blood-to-brain and/or blood-to-tumour transport of ^{201}Tl rather than to the changes in size and/or viability of the tumours. A recent study showed that the ^{201}Tl index is also affected by the timing of data acquisition and the malignancy of tumours [10]. These observations suggest that studies using semi-quantitative ^{201}Tl uptake index require careful planning and execution.

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