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Metabolic alterations in the peritumoral brain in cases of meningiomas: ^{1}H-MRS study

Mikhail F. Chernov [a,b,d,*], Kotaro Nakaya [d], Hidetoshi Kasuya [a,c,d], Koichi Kato [d], Yuko Ono [e], Shigetoshi Yoshida [e], Ryoichi Nakamura [a,b], Takashi Suzuki [b], Yoshihiro Muragaki [b,d], Hiroshi Iseki [a,b,d], Osami Kubo [d], Tomokatsu Hori [d], Kintomo Takakura [a,b,d]

[a] International Research and Educational Institute for Integrated Medical Sciences (IREIIMS), Tokyo Women's Medical University, 8-1 Kawada-cho, Shinjuku-ku, Tokyo 162-8666, Japan
[b] Faculty of Advanced Techno-Surgery, Institute of Advanced Biomedical Engineering and Science, Tokyo Women's Medical University, 8-1 Kawada-cho, Shinjuku-ku, Tokyo 162-8666, Japan
[c] Department of Neurosurgery, Medical Center East, Tokyo Women's Medical University, 2-1-10 Nishiogu, Arakawa-ku, Tokyo 116-8567, Japan
[d] Department of Neurosurgery, Neurological Institute, Tokyo Women's Medical University, 8-1 Kawada-cho, Shinjuku-ku, Tokyo 162-8666, Japan
[e] Department of Neuroradiology, Neurological Institute, Tokyo Women's Medical University, 8-1 Kawada-cho, Shinjuku-ku, Tokyo 162-8666, Japan

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ABSTRACT

The objective of the present study was metabolic characterization of the peritumoral brain in the vicinity of meningiomas using proton magnetic resonance spectroscopy (^{1}H-MRS). Data of long-echo (TR: 2000 ms, TE: 136 ms) single-voxel spectroscopic investigations were obtained during preoperative examination of 81 patients (19 men and 62 women; mean age, 56.5 years). Twenty-seven neoplasms were disclosed incidentally. Moderate-to-severe peritumoral edema was presented in 20 cases. Invasive growth of the tumor was macroscopically identified during surgery in 35 cases. Analyzed metabolites included N-acetylaspartate (NAA), choline-containing compounds (Cho), mobile lipids (Lip) and lactate (Lac). Compared to distant normal-appearing white matter ^{1}H-MRS of the brain in the vicinity of meningiomas disclosed statistically significant decrease of NAA content ($P=0.0019$). Investigated metabolic parameters depended on the presence of invasive tumor growth and prominent peritumoral edema, as well as on the size of the neoplasm, its location, and the patient's age. More severe ^{1}H-MRS-detected peritumoral metabolic abnormalities associated with invasive growth of meningioma might be used for its prediction. The presence of meningioma-related neurological symptoms was mainly determined by the size of the tumor, while might be also associated with lower normalized NAA/Cho ratio and more frequent presence of a Lip peak in the peritumoral brain. In conclusion, decrease of NAA content constitutes the most prominent ^{1}H-MRS-detected brain abnormality in the vicinity of intracranial meningiomas. Peritumoral spectroscopic alterations are determined by a variety of factors, can be predictive for invasive tumor growth and may correspond to presented neurological symptoms.

1. Introduction

During the growth of intracranial meningiomas, the surrounding brain may be affected by compression, invasion, secretion of metabolically active substances, formation of edema and cysts, and development of hypoperfusion with or without ischemia. The influence of these factors results in certain peritumoral functional and histopathological abnormalities, which lead to appearance of the local neurological symptoms. At present, metabolic alterations in the vicinity of brain tumors can be effectively and non-invasively evaluated with proton magnetic resonance spectroscopy (^{1}H-MRS). However, this has been done infrequently in cases of meningiomas. In a limited number of patients Domingo et al. [1] identified decrease of N-acetylaspartate (NAA) content and the presence of lactate (Lac) in the areas of peritumoral edema. Other reported series [2–6] were too small and usually the data were analyzed within the mixed cohort of histologically different tumors. The objectives of the present study were detailed ^{1}H-MRS-based characterization of the neuronal tissue in the vicinity of intracranial meningiomas with identification of factors associated with severity of metabolic alterations, and investigation of possible interrelationships between spectroscopic parameters of the peritumoral brain and histopathological characteristics of the tumor as well as presented neurological symptoms.

2. Materials and methods

One hundred intracranial meningiomas were investigated with single-voxel ^{1}H-MRS during routine clinical examination before

* Corresponding author. International Research and Educational Institute for Integrated Medical Sciences (IREIIMS), Tokyo Women's Medical University, 8-1 Kawada-cho, Shinjuku-ku, Tokyo 162-8666, Japan. Tel.: +81 3 3353 8111x39989; fax: +81 3 5312 1844.
E-mail address: m_chernov@yahoo.com (M.F. Chernov).

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Table 1
Modified grading of the perilesional brain edema.

Grade	Characteristic
0 (absent)	Absence of edema
I (mild)	Extension of edema not more than 2 cm from the margin of the lesion
II (moderate)	Extension of edema beyond 2 cm from the margin of the lesion up to one half of the cerebral (or cerebellar) hemisphere
III (severe)	Extension of edema to more than 1/2 of the cerebral (or cerebellar) hemisphere

From Chernov et al. [7].

surgical management in Tokyo Women's Medical University. These data represent a subject of a separate study. Informed consent was obtained from each patient at the time of metabolic imaging. In 88 of these cases spectroscopic examination of the peritumoral brain was done as well. After exclusion of 7 cases with recurrent neoplasm 81 ^{1}H-MRS investigations were left and constituted the clinical basis of the present study. All data were collected prospectively in the constantly maintained computer database.

2.1. Clinical data

There were 19 men and 62 women; mean age was 56.5 ± 12.9 years (median, 58 years). In 27 patients the tumor was disclosed incidentally and was either asymptomatic or was accompanied only by non-specific symptoms. In 9 patients epileptic seizures were marked at least once during the history of the disease, and in 5 of them it was the only neurological sign. Twenty-eight meningiomas were located on the skull base, 15 were convexital, 33 — parasagittal, 3 — intraventricular, and 2 — tentorial. The largest diameter of the neoplasm varied from 1 to 8 cm (mean, 4.0 ± 1.5 cm; median, 4.0 cm). According to CT and MRI 60 meningiomas were either round or oval in shape, whereas 21 neoplasms were irregular. Based on T_2-weighted MRI, associated peritumoral brain edema was graded according to previously proposed criteria (Table 1) [7] as mild (24 cases), moderate (16 cases), and severe (4 cases); in 37 cases the peritumoral edema was absent. Histopathological diagnosis of the tumor was established according to World Health Organization (WHO) criteria [8]. Sixty-nine meningiomas were assigned WHO grade I, 10 — WHO grade II, and 2 — WHO grade III. The MIB-1 staining index varied from 0% to 27.3% (mean, 2.8 ± 4.3%; median, 1.3%). In 35 cases more or less prominent pial or brain invasion by the tumor was

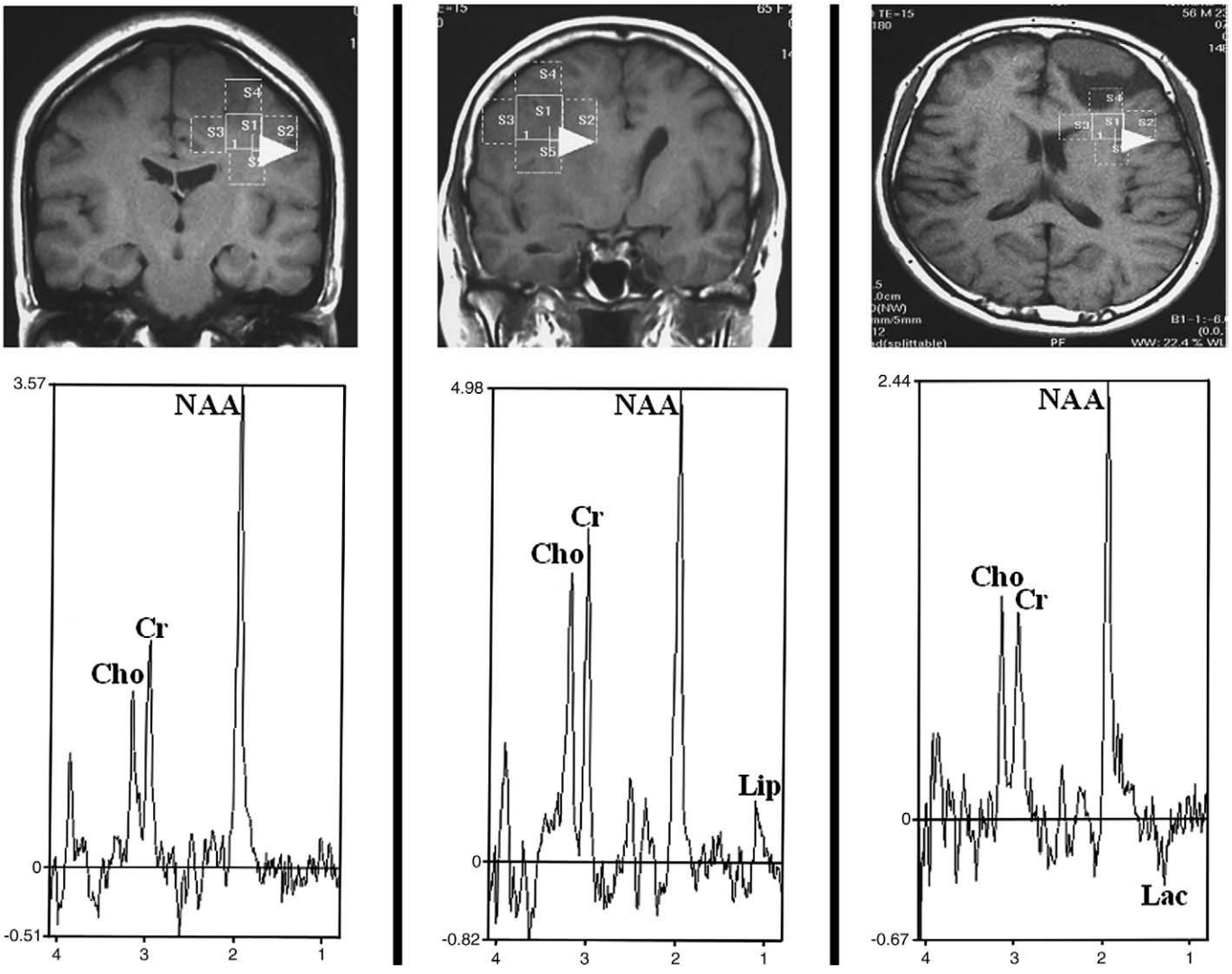

Fig. 1. Examples of the ^{1}H-MR spectra of the peritumoral brain in cases of intracranial meningiomas: without identifiable Lip and Lac peaks (*left*) and with the presence of Lip (*center*) and Lac (*right*) peaks. Marked: S1, volume of interest; S2–S5, projections of the water suppression pulses; *arrowhead*, phase encoding direction. Cho, choline-containing compounds; Cr, creatine; NAA, N-acetylaspartate; Lip, mobile lipids; Lac, lactate.