Proton-decoupled 31P magnetic resonance spectroscopy of intra-cranial tumors

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INTRODUCTION

Phosphorous (^{31}P) magnetic resonance spectroscopy (MRS) is a non-invasive technique capable of providing *in vivo* metabolite formation in high-energy phosphates and membrane phospholipids. In brain tumors, one of the most important criteria for malignancy is their proliferative activity, which is accompanied by synthesis of cell and organelle membranes. The elevation of phosphomonoesters (PME) in brain tumors *in vivo* has been summarised by Negendank [1]. On proton-decoupled ^{31}P MRS, the phospholipid metabolites phosphocholine (PC), glycerol-phosphocholine (GPC), phosphoethanolamine (PE) and glycerol-phosphoethanolamine (GPE) can be resolved [2]. The objectives of this study were to employ proton-decoupled ^{31}P magnetic resonance spectroscopic imaging (^{31}P MRSI) to study the characteristics of high-energy phosphate and membrane phospholipids in different intracranial tumors.

MATERIALS AND METHODS

The study was an observational study in patients with intracranial tumor with the following inclusion criteria: (i) at least one dimension of the tumor had to be greater than or equal to 3 cm; (ii) tumour in the selected 3x3x3 cm^3 voxel on ^{31}P MRSI should occupy more than 50% of the volume of the voxel studied. Both untreated and recurrent tumors were included. In vivo 2D localized ^{31}P MRSI was performed in a 1.5 T MR imager (Gyroscan ACS-NT, Philips, Best, the Netherlands) using a ^{31}P trasmit/receive quadrature birdcage head coil. MRSI spectra were be acquired using TR 2250 ms, FOV 240 mm, matrix 8x8, slice thickness 30 mm, NEX 16, 1024 samples and acquisition time of 32 min. The volume of each voxel was 27 cm^3. ^{1}H-decoupling was implemented using a WALTZ 8 modulation achieved by continuous wave applied during the readout time and nuclear Overhauser enhancement (NOE) was applied outside the readout time with a mixing time of 1500 ms.

Spectra from the tumor and the contralateral brain were selected and analyzed in the time domain using VARPRO implemented within the MRUI [3] software package. In each selected tumor voxel and the contralateral normal voxel, the pH, phosphocreatine (PCr) /inorganic phosphate (Pi), PME/phosphodiester (PDE), PME/total phosphate (Ptotal) and PDE/Ptotal, PC/GPC and PE/GPE ratios were measured. Paired two-tailed T-test (with a significant level at $P < 0.05$) was applied within each tumor group.

RESULTS

Eight low-grade (grade I or II) gliomas, 18 high-grade gliomas and 12 meningiomas were studied. Respectively in each tumor group, the average diameter of tumors were 4.3 cm, 4.4 cm and 4.7 cm, and the average percentage of tumor in the voxel selected were 83%, 70% and 70%. In the high-grade gliomas, tumor pH (mean 7.1) was significantly more alkaline than in normal contralateral tissues (mean 7.02) but the pH of low-grade gliomas or meningiomas was not significantly different from normal tissue (Table 1). In energy metabolites, PCr/Pi was significantly lower in meningiomas (mean 2.31) compared to contralateral normal tissue (mean 4.57), whereas no significant difference was found in gliomas. In membrane phospholipids, PDE/Ptotal was significantly lower and PME/PDE significantly elevated in all tumor types compared to normal tissue. PME/Ptotal was elevated in high-grade glioma in which there was significant elevation of PCho/GPC (Table 1).

Table 1. Metabolite profiles in different tumor groups

	PH	PCr/Pi	PME/PDE	PME/Ptotal	PDE/Ptotal	PC/GPC	PE/GPE
Low-grade glioma (n=8)	7.01 ± 0.06	3.8 ± 1.3	*1.21 ± 0.35	0.13 ± 0.02	*0.11 ± 0.02	0.66 ± 0.41	2.67 ± 1.76
High-grade glioma (n=18)	**7.1 ± 0.08	3.3 ± 1.53	**1.08 ± 0.33	**0.13 ± 0.02	**0.12 ± 0.03	*0.65 ± 0.31	#2.54 ± 2.21
Meningioma (n=12)	7.08 ± 0.05	**2.31 ± 1.05	*1.45 ± 0.6	0.14 ± 0.04	*0.17 ± 0.1	0.86 ± 0.47	2.5 ± 1.5

*P < 0.05, **P < 0.01, #P = 0.07, T-test, tumor voxel compared with contralateral normal voxel.

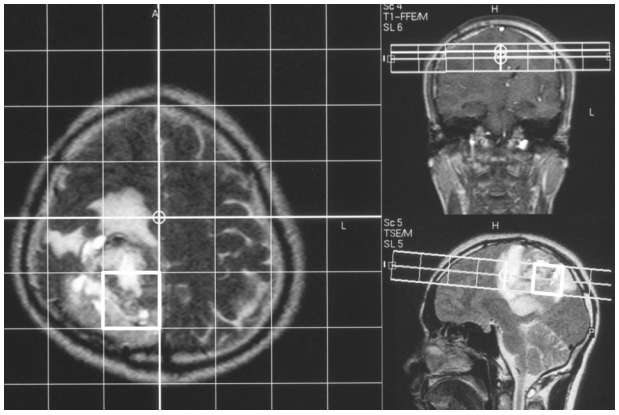

Fig.1

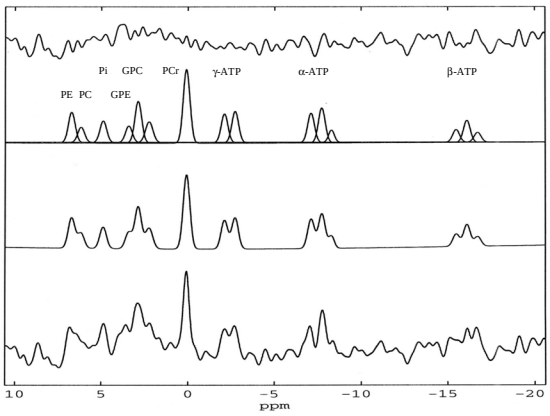

Fig. 2 – Spectra of tumor from voxel shown by the white box in Fig. 1 of a patient with glioblastoma multiforme.

DISCUSSION

The present study confirmed the low PCr level in meningiomas, the low PDE in gliomas and meningiomas and the alkaline pH in glioblastoma multiforme in previous studies [1]. A high PME was observed in the current study in high-grade gliomas but not in low grade gliomas and meningiomas, which is likely related to the proliferative nature of the high grade gliomas. Both PC and PE were elevated relative to their glycerol derivatives with PC elevation shown to reach significant levels. High-grade gliomas appear different from low-grade gliomas and meningiomas also in pH. Meningiomas differ from gliomas with a characteristic reduction of high-energy phosphates. In conclusion, ^{31}P MRS may provide metabolic information unique to the understanding of the metabolic behavior of different intracranial tumors.

REFERENCES

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