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Proton MR Spectroscopic Characteristics of a Presumed Giant Subcortical Heterotopia

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Summary: A newborn presented with a mass replacing the left cerebral hemisphere. Although the internal signal characteristics of the lesion were suggestive of disorganized gray and white matter, a true neoplasia such as a ganglioglioma could not be totally excluded. Biopsy is not recommended in these cases since the results may be misleading. Proton MR spectroscopy was used; this technique also suggested the hamartomatous nature of the lesion. Based on the clinical course and the imaging features, conservative therapy and observation were undertaken instead of surgery. At 6 months of age, the patient is stable and the lesion is unchanged.

Index terms: Magnetic resonance, spectroscopy; Brain neoplasms, in infants and children; Migration anomalies

Rarely, gray matter heterotopias attain a very large size and simulate true masses both clinically and radiographically (1). The large size of these lesions and the shift of the intracranial structures may lead to surgical excision and/or open or stereotactic biopsy (2). Stereotactic biopsy may erroneously lead to the conclusion that the hamartoma is a ganglioglioma and to unnecessary excision or radiotherapy. We describe the utility of proton magnetic resonance spectroscopy (PMRS) in the diagnosis of a giant hamartomatous malformation of a cerebral hemisphere in an infant.

Case Report

Routine prenatal ultrasound at 21 weeks of gestation showed an absence of the left lateral ventricle in an otherwise normal male fetus. A 3310-g baby boy was delivered vaginally after 40 weeks of gestation to a G1P0 22-year-old mother. Apgar scores were 8 at 1 minute and 9 at 5 minutes. The head circumference was 36.5 cm (90th percentile for age). Ultrasound of the head obtained during the first 24 hours of life showed a large mass in the left cerebral hemisphere (Fig. 1). The echogenicity of the lesion was similar to that of normal brain. The atrium of the right lateral ventricle was dilated. He had no dysmorphic features were observed.

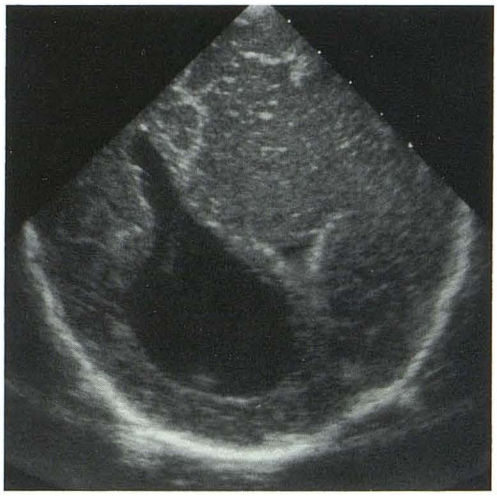

Fig. 1. Coronal sonogram demonstrating a large mass in the left cerebral hemisphere. The mass is isoechoic to normal brain. There is midline shift to the right and dilatation of the right lateral ventricle.

The newborn began having frequent episodes of right upper extremity and facial jerking and eye blinking (right eye more than left) at 4 days of life. An electroencephalogram at this time showed focal delta brushes and sharp transients in the left hemisphere and the occurrence of electrographic seizures. These seizures have been controlled with carbamazepine. Pre- and postcontrast computed tomography studies showed that the lesion contained multiple areas of low and intermediate density; no contrast enhancement was present (Fig. 2). Magnetic resonance (MR) T1- and T2-weighted images showed that the mass contained multiple islands of tissue that were isointense to gray and white matter (Figs. 3 and 4). The lesion crossed the interhemispheric fissure and compressed and distorted a smaller right cerebral hemisphere. The cortex overlying the lesion was thin with shallow sulci. Following gadolinium-DTPA administration, the mass did not enhance (Fig. 3). MR follow-up obtained at 2 months of age demonstrated the lesion to be unchanged. Clinically, the possibility of a

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true neoplasia could not be totally excluded and after informed consent proton spectroscopy was performed. Volumes of interest in both the lesion (4 × 4 × 4 cm) and the contralateral cerebral hemisphere (5 × 4 × 2 cm) were determined from prior axial MR images (Figs. 5A and 5B). Proton spectroscopy used the PRESS spin-echo localization sequence (3) and water suppression was accomplished using the water elimination Fourier transform inversion recovery sequence (4). Spectra were obtained using echo times of 65, 136, and 272 msec and a repetition time of 3000 msec (Figs. 6A and 6B). A total of 64 scans were averaged for each sample volume. At 6 months of age the patient continues to be treated conservatively and the lesion remains stable.

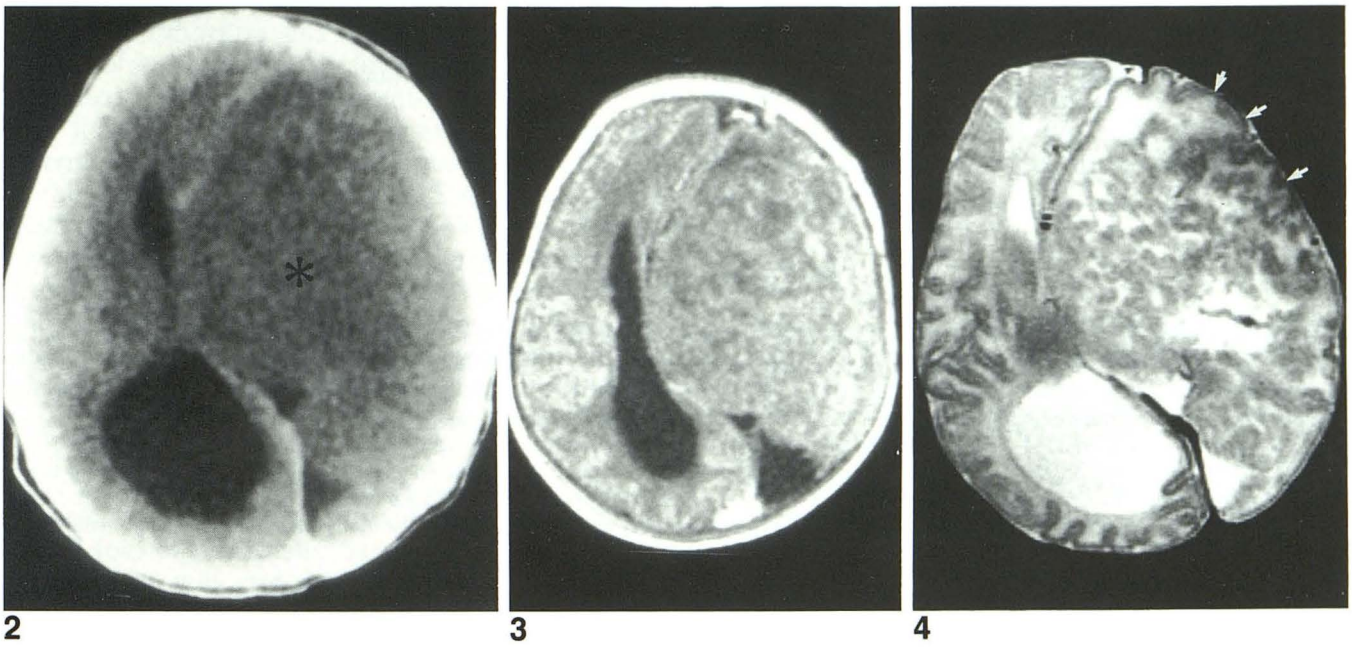

Fig. 2. Contrast-enhanced CT section shows the lesion to contain multiple areas of attenuation similar to those of gray and white matter. The lesion does not enhance.

Fig. 3. Axial MR T1-weighted image (440/25) after gadolinium-DTPA administration shows an enlarged and disorganized left hemisphere that contains multiple areas or low and high signal intensity similar to that of white and gray matter in the opposite hemisphere, respectively. No enhancement is present. The lesion crosses the midline and compresses the right lateral ventricle which is moderately enlarged.

Fig. 4. Axial MR T2-weighted image (3000/100) slightly inferior to Figure 1. Again, the disorganized tissues within the lesion follow the signal intensities of white and gray matter suggesting the hamartomatous nature of the mass. The overlying cortex is thin and the gyri are shallow (*arrows*).

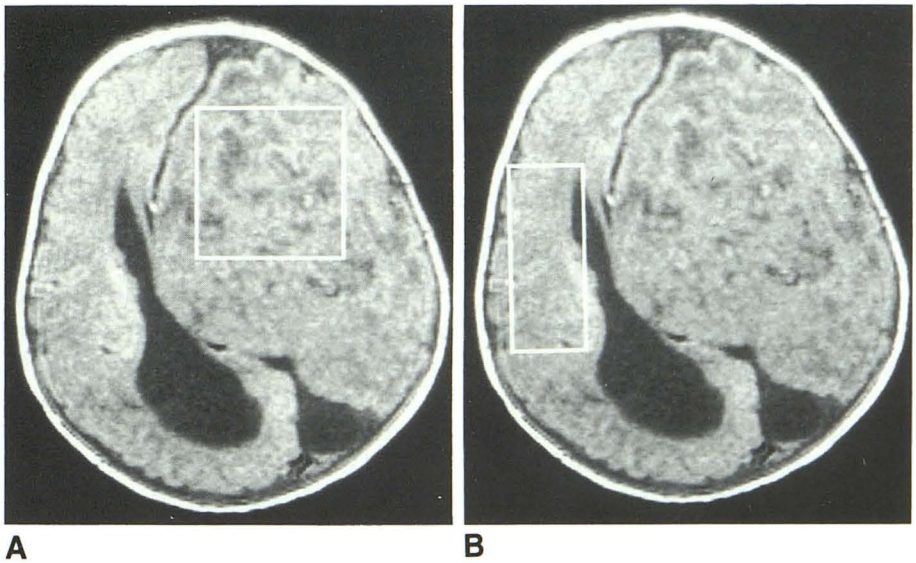

Fig. 5. *A*, Axial MR T1-weighted image (500/16). The box represents the selected volume (4 × 4 × 4 cm) used for spectroscopic measurement of the abnormality.

B, Axial MR T1-weighted image (500/16) illustrating the selected volume (5 × 4 × 2 cm) used for spectroscopic measurement of the spared cerebral hemisphere.

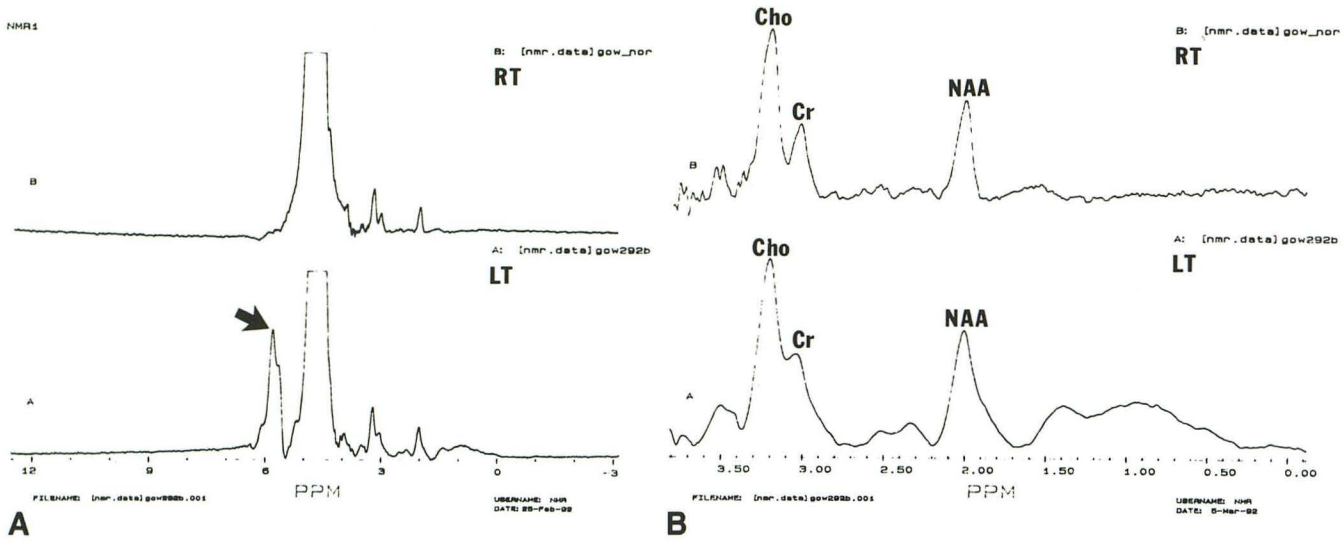

Fig. 6. *A*, Upper spectra (*RT*) (3000/136/64) (TR/TE/excitations) correspond to the right cerebral hemisphere (volume shown in Fig. 3A). Chemical shifts are given in parts per million (ppm) and referenced to 2.0 ppm for the CH3 group of NAA. Lower spectra (*LT*) correspond to the lesion (volume shown in Fig. 3B). A very large peak is noted for vinyl protons of unsaturated fatty acids (*arrow*) groups indicating abnormal metabolism from the lesion. The significance of this finding is uncertain.

B, Upper spectra is a detailed view of the one obtained for the normal brain (to the right of the water peak). The peaks for NAA (labeled *NAA*), creatinine/phosphocreatine (labeled *Cr*), and choline/phosphocholine (labeled *Cho*) are characteristic of normal brain tissues. Lower spectra (3000/136/64) is a detailed view of that obtained from the lesion. Notice that the peaks for *NAA, Cr,* and *Cho* maintain the characteristics of normal brain tissues. Since visually the gray and white matter is disorganized, the abnormality presumably represents a hamartoma.

Discussion

In the presence of neuronal migration anomalies the degree of neurologic impairment is directly related to the size of the abnormality (1). Deficits also tend to be more obvious with increasing age. However, affected children may rarely show only seizures and/or mild to moderate developmental delay. Also, depending upon the size of the abnormality, different degrees of contralateral muscle disabilities may be present (5). Mild to moderate forms of neuronal migration disorders include subependymal and subcortical focal gray matter heterotopias and closed-lip schizencephalies (1). Severe neuronal migration anomalies include complete or incomplete band heterotopias, open-lip schizencephalies, and giant heterotopias. Very large masses of heterotopias may contain multiple vessels and/or cystic spaces (1). These are related to the presence of infolding dysplastic cortex carrying with it subarachnoid spaces and superficial blood vessels (1). Therefore, strict attention to the normal signal intensity of the tissues contained within these masses is imperative to avoid mistaking them for true neoplasias. Furthermore, differentiation from a true tumor may be even more difficult when mass effect is present. It has been suggested that if these lesions are stereotactically biopsied and the pathologist is provided with a history of brain mass, the lesion may be erroneously interpreted as a ganglioglioma (1, 2) because atypical astrocytes (probably resulting from recurrent seizures) may be present in the specimen (1). Gangliogliomas are tumors characterized by the presence of neurons and atypical astrocytes (6), and are usually treated by surgical resection and/or radiation therapy (6).

PMRS has been successfully utilized in the diagnosis of brain tumors (7, 8); moreover, PMRS of tumors is known to differ from that of normal brain tissues (7). Spectra are also different and reproducible in histologically different tumors (7). These spectral differences reflect variations in the concentrations and relaxation times of free metabolites in tumor tissues. In most brain tumors, choline is elevated, while *N*-acetylaspartate (NAA) is consistently low (Fulham MJ, Bizzi A, Sobering G, et al. Evaluation of cerebral tumors with proton MR spectroscopic imaging and positron emission tomography (PET) with [18F]fluorodeoxyglucose (FDG). Presented at the 29th Annual Meeting of the American Society of Neuroradiology, Washington DC, June 1991). Lactate is also detectable in all tumors (8). In the evaluation of brain tumors, phosphorus spectroscopy of the neonatal brain is not recommended because the phosphomonoes-

ter groups (which are elevated in brain tumors) are normally high in these very young patients (9).

In our case, the multiple components of the lesion followed the signal intensities of gray and white matter on both T1- and T2-weighted sequences, suggesting the presence of normal tissue in abnormal locations (hamartoma) (Figs. 3 and 4). Supporting this observation was the absence of enhancement following either iodinated contrast media or gadolinium-DTPA, as well as the lack of growth in a 2-month interval. As mentioned earlier, biopsy of these lesions is not totally reliable; therefore, PMRS was performed to exclude the diagnosis of glial tumor, thereby avoiding surgery. We sampled large volumes to include as much of the lesion and of the contralateral hemisphere as possible (Figs. 5A and 5B). However, an MR spectrum represents the average signal of spins within a chosen volume of interest and, therefore, since in our case the sampled volume did not include the entire lesion, the spectrum does not represent all of the lesion. Therefore, the remote possibility of there being small foci of neoplastic tissue in a region of the lesion that was not sampled cannot be totally excluded. Perhaps a better spectroscopic evaluation could have been obtained by using a 2-D or 3-D chemical shift image of the entire brain to observe the PMRS characteristics of the entire lesion. At this time, we do not have the capability to perform such a technique. The lesion in our patient showed detectable NAA which correlates with the presence of neuronal cells and myelin. Glial cells do not contain NAA. The peaks for choline/phosphocholine and creatinine/phosphocreatine were also normal (Figs. 6A and 6B). The large heterotopia also demonstrated elevation of unsaturated fatty acid groups, possibly indicating abnormal lipid metabolism as judged by the resonances at approximately 0.8, 1.2, 1.5, and 6.0 ppm. These resonances were resolved at an echo time of 65 msec, but at an echo time of 136 msec appear as broad resonances that correspond to the methyl, methylene, allylic, and the vinyl protons of unsaturated fatty acids (Fig. 6A). We are not certain of the significance of this finding.

In conclusion, the heterotopic tissue in our patient showed proton spectra remarkably similar to that of normal brain. We suggest that PMRS holds promise of differentiation of neoplastic from hamartomatous tissue.

References

1. Barkovich AJ, Kjos BO. Gray matter heterotopias: MR characteristics and correlation with developmental and neurologic manifestations. *Radiology* 1992;182:493–499
2. Russell D, Rubenstein S. *Pathology of tumors of the nervous system.* 5th ed. Baltimore: Williams & Wilkins, 1989
3. Moonen CTW, von Keinlin M, van Zijl PCM, et al. Comparison of single-shot localization methods (STEAM and PRESS) for in vivo proton NMR spectroscopy. *NMR Biomed* 1989;2:201–208
4. Moobery ES, Krugh TR. Proton Fourier-transform NMR spectroscopy in H_2O solutions. *J Magn Reson* 1975;17:128–131
5. Friede RL. *Developmental neuropathology.* 2nd ed. Berlin: Springer-Verlag, 1989
6. Castillo M, Davis PC, Takei Y, Hoffman JC. Intracranial ganglioglioma: MR, CT, and clinical findings in 18 patients. *AJNR: Am J Neuroradiol* 1990;11:109–114
7. Bruhn H, Frahm J, Gynengell ML, et al. Noninvasive differentiation of tumors with use of localized H-1 MR spectroscopy in vivo: initial experience in patients with cerebral tumors. *Radiology* 1989; 172:541–548
8. Luyten PR, Marine AJH, Heindel W, et al. Metabolic imaging of patients with intracranial tumors: H-1 MR spectroscopic imaging and PET. *Radiology* 1990;176:791–799
9. Younkin DP, Delivoria-Papadopoulos M, Wagerle LC, Chance B. In vivo 31P NMR spectroscopy in neonatal neurologic disorders. In: Plum F, Pulsinelli WA, ed. *Cerebrovascular diseases.* New York: Raven Press, 1985:149–156