MRI Findings of Vermian Medulloblastoma

Seung Eun Jung, M.D., Kyu Ho Choi, M.D., Myung Hee Chung, M.D., Young Sub Park, M.D., II Kwon Yang, M.D., Kyung Sub Shinn, M.D.

Purpose: To find characteristic MRI features of vermian medulloblastoma.

Materials and Methods: MRI studies and medical records were retrospectively reviewed for 12 patients with surgically proven midline medulloblastoma. The assessment concerned appearance of the mass in relation to surrounding structures: MR signal intensity; the enhancement pattern; the mass's location and size; presence of a cystic/necrotic area, calcification, or vascular void; extension through the foramen Luschka; degree of hydrocephalus; and presence of tonsillar herniation.

Results: The midline medulloblastoma commonly showed roundish moon-surface appearance, especially on the axial T2-weighted images. All tumors showed heterogeneous signal intensities mainly due to intratumoral cystic/necrotic or hemorrhagic changes. The tumors were commonly located at mid- and/or inferior vermis. Occasionally the tumors extended through the foramen Luschka, and caused obstructive hydrocephalus of moderate to severe degree. Post-contrast study showed heterogeneous, dense contrast enhancement in the majority of patients.

Conclusion: The MR finding of the moon-surface appearance formed by both the mass and the intratumoral cystic/necrotic change as seen on axial T2-weighted images could be helpful in the diagnosis of vermian medulloblastoma.

Index Words: Brain neoplasms, MR

INTRODUCTION

Medulloblastomas are the most common tumors in the posterior fossa in children, accounting for 33% of pediatric posterior fossa neoplasms and 20–25% of pediatric intracranial neoplasms(1, 2). They comprise, however, only 0.4% of all adult brain tumors(2). They are usually midline lesions involving the mid and inferior zones of the anterior portion of the vermis. Although CT appearances of the cerebellar medulloblastomas are well described in the literature, there are not many reports on MRI characteristics of these tumors. With MRI, the tumors are described to have low to intermediate signal intensity on T1-weighted images, increased signal intensity on proton-density-weighted images, and intermediate to moderately high signal intensity on T2-weighted images(1). But this signal intensity can be seen in other tumors.

The goal of this study is to describe the characteristic MRI appearance of the midline vermian medulloblastomas in relation to surrounding structures.

MATERIALS and METHODS

Among 17 patients with surgically proven medulloblastoma during the last two years, 12 patients exhibiting the midline vermian mass were chosen in order to analyze common MRI features. Patients with tumors that originated in the hemisphere were excluded. The patients varied in age from 5 months to 46 years (mean, 12 years) with nine patients under age 15 and consisted of 7 males and 5 females. Medical records were reviewed for neurological signs and symptoms. Headache was the most common symptom, accompanied by nausea, vomiting or gait disturbance for varying periods ranging from several days to 2 to 3
months.

MRI studies were performed at 0.5 T (Philips Gyroscan, Netherlands) on 4 patients and at 1.5 T (GE Signa Advantage, Milwaukee, Wisconsin) on 8 patients to obtain spin-echo T1-(550-600/20/1-2(TR/TE/TE)-X), and proton-density and T2-(2000-2500/30, 80-90/1-2) weighted images with 256 × 192 matrix size, 20 cm FOV, and 5-6 mm slice thickness with 1.5-2 mm interslice gaps in multiple orthogonal planes. Immediately after bolus injection of gadopentetate dimeglumine(0.1 mmol/kg, Magnevist, Schering, Germany), axial and sagittal T1-weighted images were obtained for all patients. CT study of the brain was performed on Somatom DR or Plus (Erlangen, Germany) in seven patients before and after intravenous infusion of 60% iodine contrast media(2 cc/kg). The three dimensional size of the tumor was measured on post-infusion MR images.

All images were independently evaluated by two radiologists. The tumor was evaluated with respect to the appearance of the mass; its location, size, and shape; MRI signal intensity compared to that of cerebellar gray matter; presence of a cystic/necrotic area, calcification, or vascular void; peritumoral edema; tumor extension through the foramen Luschka; degree of hydrocephalus; tonsillar herniation; pattern and degrees of contrast enhancement; and intracranial metastasis. Hypo- or hyperintensity was graded mild, moderate, or marked by consensus. The degrees of contrast enhancement was also graded mild, moderate, or marked relative to that of the glomus of the choroid plexus.

**RESULTS**

All but three cases exhibited the moon-surface appearance, especially on axial T2-weighted images at the level of the pons, that was formed by the roundish hyperintense mass and central necrotic/cystic or hemorrhagic areas or more rarely, vascular signal voids (Fig. 1 and 2). In the three cases that did not exhibit the moon surface appearance, the mass was smaller or shows the mass to be slightly higher in density than the brain with central hypodensity.

e. After infusion of contrast material, CT at the same level shows dense contrast enhancement except in the central area. During surgery, hemorrhagic necrosis was found in the central area.

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**Fig. 1.** A 2-year-old female with vomiting and gait disturbance for 3 weeks.

a. On axial T2-weighted image through the posterior fossa, a mass filling the fourth ventricle is of high signal intensity with a large central hypointense area. The appearance of the mass mimics moon-surface.

b. Axial T1-weighted image shows the mass of heterogeneous hypointensities compressing the fourth ventricle.

c. Axial T1-weighted image after infusion of gadolinium shows dense contrast enhancement of the mass except the central area.

d. Preinfusion CT taken before MRI study
larger than the mean size, or invaded the adjacent cerebellar hemisphere.

The average size of the masses was $3.7 \times 4.2 \times 4.2$ cm in anteroposterior, transverse, and cephalocaudad dimensions with ranges of $2.1 - 5.3$, $2.5 - 6$, and $2.0 - 6.8$ cm, respectively. The mid and inferior portions of the anterior vermis were the most common site of involvement in seven patients. The mid or inferior portion of the vermis was involved in one each, and in three patients, the entire portion of the anterior vermis was involved. Two cases had a desmoplastic component within the tumor, and the remainder were classical medulloblastomas.

Cystic/necrotic changes, hemorrhage, or vascular signal voids within the mass contributed to the heterogeneous MRI signal intensity found in 11 of the 12 cases (Fig. 3). Intratumoral or peritumoral cystic/necrotic changes were present in 10 patients; vascular

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**Fig. 2.** A 7-year-old male with headache and intermittent nausea and vomiting for 6 months.

a. Axial T1-weighted image of the posterior fossa shows a large mass of low signal intensity relative to the brain with central hypointense areas and a curvilinear signal void (arrows) at the left lateral margin.

b. On axial T2-weighted image, the moon-surface appearance is well seen. The mass shows relatively homogeneous high signal intensity with small central hypointensities. T1 hypointensity at the left lateral margin (arrows) became hyperintense. These most likely represent either CSF in the 4th ventricle or peritumoral cyst.

c. On postinfusion T1-weighted axial image, the mass shows a contrast enhancement which resembles a sun burst. Central and left lateral marginal hypointensities are not enhanced.

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**Fig. 3.** A 5-year-old female with headache for 1 month and ataxia for 2 weeks.

a. On axial T1-weighted image at the pons level, the mass is composed of a central intermediate signal intensity and multiple hypointense areas.

b. On axial T2-weighted image, the central portion of the intermediate signal intensity remains unchanged. Peripheral hyperintense areas suggest cystic/necrotic changes.

c. Postinfusion T1-weighted axial image shows irregular dense contrast enhancement within the solid portion of the mass.
signal voids were noticed usually at the periphery of the mass in six patients; central hemorrhage was detected in two patients; and CSF trapping was seen in one patient.

On proton-density-weighted images, the tumors showed mild hyperintensity in five patients, moderate hyperintensity in one, marked hyperintensity in one, isointensity in four, and slight hypointensity in one. On T2-weighted images, tumors showed mildly low signal intensity in six patients, moderately low signal intensity in three, mild hyperintensity in two, and isointensity in one and slight low signal intensity in two. On T1-weighted images, the tumors showed mildly low signal intensity in six patients, moderately low signal intensity in four and isointensity in two (Table 1).

Following infusion of gadopentetate dimeglumine, the majority (nine patients) showed marked enhancement with the degree of enhancement similar to that of the glomus of choroid plexus. Moderate enhancement was seen in one patient and mild enhancement in two. Heterogeneity in enhancing pattern was typical in all patients, two of which exhibited the sun-burst enhancing pattern (Fig. 4).

The extension of the mass occurred through the foramen Luschka into the area of the cerebellopontine angle cistern in seven patients: four on the left, two on both sides, and one on the right (Fig. 5). In one patient, the cerebellar hemisphere was involved. There was obstructive hydrocephalus of severe degree in seven patients and of moderate degree in four patients. No hydrocephalus was present in the patient who had smallest mass (2.5 cm at its maximum diameter). No correlation could be found between the size and the degree of hydrocephalus. There was no difference in mean size between severe and moderate hydrocephalus groups which measured $3.8 \times 4.3 \times 4.0$ cm and $3.8 \times 4.3 \times 4.7$ cm, respectively. Seven patients revealed secondary herniation of the cerebellar tonsil below the level of the foramen magnum.

**DISCUSSION**

Cerebellar medulloblastoma arises from rests of undifferentiated neuroepithelial cells in the germinative zone of the medullary velum. These cells migrate upward and laterally to form the external granular layer of the cerebellar hemispheres. The tumors can arise anywhere along the path, so theoretically, the tumors arising earlier in life occur closer to the midline, whereas those arising later in life are located more la-

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+: mild, ++: moderate, +++: marked, Sl: signal intensity, PDWI: proton-density-weighted image, T2WI: T2-weighted image, T1WI: T1-weighted image
terally within a cerebellar hemisphere(3). They are the most common primitive neuroectodermal tumor of the CNS(4), and accounted for 21% of the childhood CNS tumors according to the Connecticut Tumor Registry as reported by Farwell et al(2). In their study of 143 cases of medulloblastoma children were younger than 19 years old, the male to female ratio was 1.33 : 1 and average age at diagnosis was 6.5 years. More children developed medulloblastoma in the first 5 years of life than in the second 5 years. Because of its antenatal origin and rapid growth, the tumors almost always become symptomatic in the first two decades of life. Histologically, there are classical and desmoplastic types. The classical type is composed of sheets of small cells with scant cytoplasm and relatively large hyperchromatic round or angular nuclei(4, 5). The desmoplastic type contains bands of connective tissue interspersed among the small malignant cells, is less common, and tends to occur in older patients with a better prognosis.

On MR images, the medulloblastomas are generally heterogeneous in signal intensity compared with cerebellar gray matter in studies by us and Meyers et al(1). In their report, the tumors were predominantly hypointense on T1-weighted images(48%) and hyperintense on proton-density-weighted images(48%) and T2-weighted images(56%). In our 12 cases, hypointensity was predominant on T1-weighted images in 10 cases, and isointensity with gray matter was seen in two patients. On proton-density-weighted images, slight hyperintensity and isointensity were predominant in five and four cases, respectively. On T2-weighted images, overall signal intensity was higher compared with that on proton-density-weighted images. Signal heterogeneity of the mass is due to cystic or necrotic changes within the mass as proved in histopathology of the specimen. We described this appearance as moon-surface, which represents not only round shape of the moon but also surface characteristics formed by lunar mountains, seas and craters. The prevalence of cystic and necrotic degeneration found in the study by Bourgouin et al(6) was high(82%) compared to 10–20% in most studies. It was believed to be high because their series included only adults (age range, 18-47 years [mean, 28 years]), and cystic and necrotic degeneration is presumably more common in this age group. In contrast, although our patients were much younger [mean, 12 years], all tumors were heterogeneous except in one patient. Calculifications or peri- or intratumoral blood vessels denoting low signal intensities or signal voids also contribute to signal heterogeneity(7).

When the degree of contrast enhancement within the tumors on T1-weighted images taken immediately after bolus injection of gadopentetate dimeglumine was compared with that of glomus of choroid plexus, our nine cases showed dense enhancement of similar degree. In the other three cases, the degree of enhancement was slightly less in one and markedly less in the two patients. Two cases showed sun-burst appearing contrast enhancement. Heterogeneous enhancing patterns were comparable to all 11 cases reported by Meyers et al(1). On the other hand, slightly more than half of their tumors showed only small or intermediate degrees of enhancement compared to a marked degree in the majority of our cases, although we used the same imaging method immediately after manual intravenous injection of contrast media. Desmoplastic medulloblastoma was reported to show less contrast enhancement because of a large amount of reticulin fibers in their stroma(6, 8, 9).

Medulloblastomas are well known for metastasis through the CSF pathway. Nelson et al(7) found imaging evidence of metastatic disease in 5% of 223 tumors evaluated by CT. Only one of 25 patients in a series evaluated by Meyers et al(1) had intracranial metastatic disease at the time of MR imaging. Two of our patients developed intracranial and spinal metastases through the CSF pathway: one patient, a 5-year-old female, had extensive subarachnoid seeding of the tumor in the thoracolumbar spine and head detected on the post-contrast T1-weighted images 9 months after surgery; the second patient, an 8-year-old male patient, was found to have frontal metastases on the follow-up MRI 8 months after tumor resection. Metastatic or recurrent medulloblastomas may not enhance after the administration of contrast material. Rollins et al(10) reported that three of nine recurrent medulloblastomas showed no enhancement on either MRI or CT scans of the head. Blood-borne metastases outside the nervous system rarely occur. The common sites include bones, lymph nodes, lungs, pleura, liver, and breasts(11, 12).

Treatment of medulloblastoma consists of surgical resection, irradiation, and chemotherapy. Initial treatment is virtually always surgical resection of as much tumor as possible followed by high-dose radiotherapy (1, 2). The common surgical procedures appear to range from conservative debulking to total gross removal of the tumor. The importance of radiation therapy is well established in the literature. Because of the tendency of medulloblastoma to recur locally and to spread via the CSF pathway, Landberg et al(13) advocated irradiation of the whole neuraxis from the tip of the frontal lobe to the sacral vertebrae. Chemotherapy as a primary adjunctive method in children has not been shown to improve survival times(14, 15). In our cases, all patients were treated by radiotherapy of the neuraxis following surgical resection of as much tumor as possible. Five patients expired 3 days to 2 1/2 months after operation because of postsurgical complications due to respiratory or cardiac failure, pulmonary edema, or meningitis. Factors that affect the prognosis favorably are female gender, tumor location
in the lateral cerebellar hemisphere, and older age of
patients(2). Bloom(16) noted that the desmoplastic type
had a better prognosis compared with classical me­
dulloblastomas.

In summary, MRI characteristics of the midline ver­
mian medulloblastomas include: moon-surface ap­
pearance of the mass on axial T2-weighted images,
eterogeneous signal intensities on multiple
seque
sences mainly due to intratumoral cystic/necrotic
or hemorrhagic changes, common tumor location at
mid- and/or inferior vermis, occasional extension
of the tumor through the foramen Luschka, obstructive hy­
drocephalus of moderate to severe degree, and vari­
ous patterned dense contrast enhancement. These
findings would help distinguish the medulloblastoma
from other cerebellar tumors such as astrocytoma,
ependymoma, and choroid plexus papilloma.

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