CASE REPORT

MR Findings of Spinal Muscular Atrophy Type II: Sibling Cases

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We present magnetic resonance (MR) findings of siblings affected by spinal muscular atrophy (SMA) Type II. MRI of their thighs showed severe muscle atrophy and fatty infiltration. Selective preservation of the adductor longus muscle, the gracilis muscle, and the sartorius muscles was observed, suggesting a characteristic finding of SMA Type II. These findings were more severe in the older patient.

Keywords: *spinal muscular atrophy, neurogenic, sibling, MR image*

Introduction

SMA is an inherited disorder that shows progressive weakness and atrophy of skeletal muscles caused by degeneration of the anterior horn cells in the spinal cord and brain stem nuclei. This disorder is the second most common cause of the floppy infant, after Duchenne muscular dystrophy, and affects about one child in 10,000.¹ Almost all occurrences of SMA are an autosomal recessive disorder.² It is classified into three subtypes by clinical features and time of disease onset. The intermediate type, which begins at 6 months of age, is called Type II. Since MRI reveals muscle atrophy and fatty infiltration clearly and non-invasively, it is a useful method for examining children who suffer from muscle weakness. We present MRI of SMA Type II, which affects female siblings in this case report.

Case Report

Case 1: A 5-year-old girl with muscle weakness was referred to our hospital for further evaluation. She showed progressive muscle weakness and hypotonia that began at 5 months of age. Pregnancy and childbirth showed no abnormal history. The girl could creep but she had never been able to stand or walk. Her facial and pharyngeal muscles exhibited no weakness. She had no complaints regarding swallowing or respiration movements. She showed fasciculation of her fingers and tongue

at 21 months of age. She showed very slow but progressive weakness of the muscles predominantly in the proximal lower extremities. No mental faculties exhibited any problems. Computed tomography (CT) showed no abnormality of her brain and no sensory disorder. Electromyography showed giant spike and fibrillation potential, suggesting a neurogenic pattern. A muscle biopsy was performed on her right biceps muscle. The histology of these specimens showed large groups of atrophic fibers intermingled with those of hypertrophic fibers. We found small angular fibers between both groups (Fig. 1A). These findings were evidence of neurogenic muscle atrophy. Remarkably, fat had infiltrated the atrophic fibers (Fig. 1B). The diagnosis was SMA Type II. Genetic testing indicated the same diagnosis.

The MRI of this patient was performed to examine the degree of muscle atrophy and the fatty infiltration and distribution. All muscles of her thighs, except the adductor longus muscle, gracilis muscle, and sartorius muscles, showed severe atrophy and high signal intensity on T₂-weighted images (Fig. 2A). The atrophic muscles also showed high signal intensity on T₁-weighted images (Fig. 2B), suggesting the existence of fat in atrophic muscles. These findings were more prominent in the quadratus femoris muscle. Subcutaneous fat was remarkably thickened and the atrophic muscles shrank towards the bone. The bones and joint structures were normal.

Case 2: The younger sister, who was 2 years old when referred to our hospital with her elder sister, showed the same symptoms at 7 months of age. She showed slow but progressive muscle weakness

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Fig. 1. Biopsy specimen from the biceps muscle of the elder patient. **A:** Large groups of atrophic fibers can be seen on the right side of this specimen next to a bunch of mildly hypertrophic fibers on the left side. Many small angular-profile myofibers can be seen among the hypertrophic fibers. These findings suggest neurogenic muscle atrophy. **B:** Note the infiltration of fat among atrophic fibers, suggesting non-specific muscular atrophy.

Fig. 2. **A:** Axial T₂-weighted (TR/TE = 3000/90 ms, FOV = 28 cm, matrix = 256 × 192) and **B:** axial T₁-weighted (TR/TE = 300/12 ms, matrix = 256 × 256) images of both thighs of the elder patient. The muscles show severe atrophy and high signal intensity in both sequences. The selective preservation of the adductor longus muscle (white arrow), gracilis muscle (black arrow), and sartorius muscles (arrowheads) is seen. Subcutaneous fat was remarkably thickened and the atrophic muscles distributed centrally.

predominantly in the proximal lower extremities, without complaint in the motion of swallowing or respiration, a condition very similar to that of her elder sister. Her mental faculties were full and no sensory disorder was found. MRI showed muscular atrophy of her thighs and high signal intensity in T₂-weighted images (Fig. 3A) and T₁-weighted images (Fig. 3B). Selective preservation of the adductor longus, the gracilis and the sartorius muscles was shown. The atrophy of her muscles was milder than that of her sister, and it was easier to identify the individual muscles. The quadriceps muscle showed high intensity on fat-suppressed T₂-weighted images with mild atrophy (Fig. 3C). Although no biopsy was performed in the younger patient, her clinical course and MR findings were exactly same as those of her older sister, yielding a diagnosis of SMA Type II.

No history of marriage between close relatives

was found in their family. In addition, their familial history showed no other problems.

Discussion

Causes of muscle weakness can be classified into two categories: one occurs in the muscle itself, as with Duchenne muscular dystrophy (DMD) or metabolic disease; the other is in the nerve. The latter is called *neurogenic muscular atrophy*. When the cause is degeneration of the anterior horn cells in the spinal cord, it is called *spinal muscular atrophy*. It is the most common neuromuscular disease of childhood after DMD. One child in 10,000 is affected by SMA.¹

Children affected by SMA show progressive muscle weakness predominantly in the proximal extremities. SMA is classified into three types according to the age of onset and acuity. Type I is

Fig. 3. **A:** Axial T₂-weighted (TR/TE = 3000/90 ms, FOV = 22, 256 × 192) and **B:** axial T₁-weighted and **C:** axial fat-suppressed T₂-weighted (TR/TE = 3000/90 ms) images of both thighs of the younger sister. The distribution of muscular atrophy is very similar to, but milder in degree, that of the older sister. In fat-suppressed proton density-weighted images, the muscles show high intensity due to edema-like change.

the most severe variety of SMA. Affected children show severe muscular weakness before 6 months of age, sometimes at birth, and fetal progress by 3 years of age. It is also called *Werdnig-Hoffman disease*. SMA Type II is called the intermediate type. Muscle weakness appears in children over 6 months of age with a milder and slower progression. The prognosis is varied. Type III is called *Kugelberg-Welander disease*; it occurs after the 2nd year of life. It shows very slow progress and mild symptoms.

We reported MR findings of siblings affected by SMA Type II. SMA is an autosomal recessive disorder and some studies reported that the tendency of siblings to be affected by SMA was up to about 40% in intermediate and chronic types.³ Although it is not rare, to the best of our knowledge, no MR finding obtained from siblings with SMA Type II has been reported. Clinical and pathological evaluations revealed the older sister was affected more severely than the younger sister. The involved muscles of both patients showed atrophy in their thighs. On T₁-weighted images, an increase in muscle signal intensity was found, suggesting fatty infiltration. These findings were similar in both patients, but more severe in the older patient. This result suggests that this disorder progresses slowly and uniquely. In addition, increases in signal intensity on fat-suppressed

T₂-weighted images were recognized mainly in the quadriceps muscles of the younger patient. This suggested the accumulation of intracellular water or edema-like change, probably due to destruction of the involved muscles. Remarkably thickened subcutaneous fat was observed in their thighs and the atrophic muscles shrank toward the bone. SMA shows more severe subcutaneous thickening than is observed in DMD,⁴ although fatty infiltrations are also observed in atrophic muscles of SMA. They might be a characteristic finding that contrasts with DMD. Selective preservation of the adductor longus, the gracilis and the sartorius muscles was recognized in both girls. This finding is the same as previously reported.⁵

Although many studies have been carried out on SMA, unresolved questions remain. One is the selective preservation of muscles. Similar findings were reported from patients affected by muscular dystrophy and polymyositis.⁶ The rectus femoris muscle, sartorius muscle, and gracilis muscles were selectively preserved in these diseases, but no correlation was found with pathologic findings. The pathogenesis of muscle atrophy differs among muscular dystrophy, polymyositis, and SMA Type II. Instead, similar muscle volume preservation of the sartorius muscle and the gracilis muscle occurs. Liu et al. reported similar findings in patients with DMD.⁷ Lamminen et al. suggested the mechanical

and functional structures of these muscles might cause selected preservation. The sartorius muscle and the gracilis muscle extend over two joints of the lower extremities.⁶ The same mechanism might be present in muscles affected by SMA Type II. However, since the adductor longus muscle extends over only one joint, the selective preservation of this muscle cannot be explained by the same hypothesis. If anything, more severe involvement of the adductor muscles is reported in patients affected by dermatomyositis.⁸ The relation between muscular function and muscle atrophy in patients with muscular diseases remains controversial.

The important roles of MRI in this disease are to evaluate muscle atrophy and to suggest the best site for performing the biopsy, as the biopsies must certainly be performed in atrophic muscles. CT can also reveal these findings and conclude the investigation faster than MRI, but CT exposes the patient to radiation. This is a great advantage of MRI; MR spectroscopy can reveal the metabolic situation underlying many muscular disease.⁹ In neuromuscular disease, it might reveal the acuity of the disease.

In conclusion, this case report presented the MR findings of thigh muscles in sibling patients with SMA Type II. MRI is useful for inspecting the degree of progression of this disorder non-invasively.

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