MRI of Secondary Cervical Syringomyelia in Four Cats

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(Received 20 November 2008/Accepted 18 March 2009)

ABSTRACT. This report describes the use of magnetic resonance imaging (MRI) to diagnose cervical syringomyelia in 4 cats. MRI revealed enlargement of the lateral ventricle in all the cats. Of the 4 cases, MRI revealed herniation of the cerebellum in 3 cats, an isolated fourth ventricle in 1 cat, severe hydrocephalus in 2 cats and brain masses in 1 cat. In this report, the cervical syringomyelia in these cats may have been due to formation of a secondary syrinx (enlargement of the central canal) as a result of blockage of flow in the outlet of the fourth ventricle caused by FIP encephalomyelitis or secondary cerebellar tonsillar herniation caused by increased intracranial pressure due to intracranial masses or may have been due to caudal compression of the cerebellum caused by increased intracranial pressure due to hydrocephalus.

KEY WORDS: feline, magnetic resonance imaging (MRI), syringomyelia.

Syringomyelia is a condition in which fluid-filled cavities develop in the spinal cord [20]. Syringomyelia was formerly considered to be a rare disease in veterinary medicine; however, the likelihood of encountering this disease has increased in recent years due to the increased availability of magnetic resonance imaging (MRI).

One of the most common causes of syringomyelia in dogs is Chiari-like malformation in Cavalier King Charles spaniels [18–22]. Moreover, there have been reports of syringomyelia due to trauma, tumors, arachnoid cysts and hydrocephalus [9, 13, 23, 24]. In cats, diagnosis of syringomyelia by MRI has been rarely reported, though there are some reports of syringomyelia secondary to deformation or hydrocephalus [3, 4, 10, 12, 14, 25, 27]. The medical records of 1785 cats treated at Nihon University Animal Medical Center from 1995–2007 were searched retrospectively. Five cats had diagnoses of cervical syringomyelia on MRI (0.5 Tesla or 1.5 Tesla, FlexArt, Toshiba, Tokyo, Japan). However, in this report, the clinical, neurological and MRI findings of only 4 of the cats with cervical syringomyelia are reported because the authors have previously reported about one case [10].

Case 1: An 8-month-old castrated Scottish Fold with a body weight of 2.25 kg presented with ataxia (Table 1). On neurological examination, the postural reflex test was depressed in the pelvic limbs. The wheelbarrowing test was depressed in the thoracic limbs. The patellar reflex was exaggerated in the pelvic limbs. MRI revealed enlargement of the lateral ventricles and fourth ventricle (Table 2). Enlargement of the fourth ventricle was severe. Moreover, herniation of the cerebellum and cervical syringomyelia were observed (Fig. 1). The periphery of the ventricles and the meninges were enhanced in contrast T1-weighted images (T1WI). A syrinx was located in the spinal cord between the C2 and C6 cervical vertebrae (MRI was not performed in the caudal site of this region) at the center of the spinal cord on sagittal and transverse MRI images. Serum isoantibody tests for FIV and FeLV were negative; however, the result for FIP virus was not reported in the medical records. Case 1 could not be followed up after MRI (Table 3).

Case 2: A 7-month-old neutered female mongrel cat with a body weight of 1.4 kg presented with paraparesis and inability to stand (Table 1). On neurological examination, the wheelbarrowing test was depressed in the thoracic limbs. MRI revealed enlargement of the Sylvian aqueduct and the lateral, third and fourth ventricles (Table 2). Moreover, herniation of the cerebellum and cervical syringomyelia were observed (Fig. 2). A syrinx located in the spinal cord between the C1 and T3 vertebrae at the dorsal side of the spinal cord was detected on MRI. The periphery of the ventricles and the meninges of the cervical area showed hyperintensity on FLAIR images and enhancement using a contrast agent. Serum isoantibody tests for FIV and FeLV were negative; however, the serum isoantibody FIP virus titer was 1:12,800, and the CSF isoantibody titer was 1:640. Ventriculoperitoneal shunting was immediately performed, and the prognosis for the cat was good. Two weeks after the operation, MRI showed that the ventricles had decreased in size, and herniation of the cerebellum and the syrinx in the cervical spinal cord could no longer be seen (Table 3).

Case 3: An 11-year-old neutered female mongrel cat with a body weight of 3.55 kg presented with seizure and tachypnea (Table 1). On neurological examination, the postural reflex test was depressed in the thoracic limbs. The menace reaction was absent. Moreover, the owner reported that the cat was unwilling to move and presented with panting. The MRI revealed enlargement of the lateral ventricle (right > left), and the median line was shifted to the left (Table 2). A syrinx was detected in the spinal cord between the C2 and...
T1 vertebra located at the dorsal side of the spinal cord (Fig. 3a, b). The results of a CSF analysis were normal. The serum FIP virus titer was 1:3,200, and the CSF isoantibody titer was 1:20. Ventriculoperitoneal shunting was immediately performed, and the cat had a good postoperative course. Two weeks after the operation, MRI showed that the ventricles had decreased in size, and the syrinx in the cervical spinal cord could no longer be seen (Table 3).

**Case 4**: An 8-year-old castrated mongrel cat with a body weight of 3.45 kg presented with head tilt and knuckled paws of the thoracic limbs (Table 1). The owner explained that the cat appeared angry when touched. On neurological examination, the postural reflex test was absent in the right thoracic limb and depressed in the left thoracic limb and right pelvic limb. The wheelbarrowing test was negative in the right thoracic limb and depressed in the left thoracic limb and right pelvic limb. MRI revealed 2 masses in the left frontal lobe (Table 2). Herniation of the cerebellum and cervical syringomyelia were observed (Fig. 4). A syrinx was located in the spinal cord between C2 and T3 at the dorsal side of the spinal cord. Deformation of the cerebellum was seen. Serum isoantibody tests for FIV and FeLV were negative; however, the serum FIP virus titer was 1:800. This cat died 5 months after MRI (Table 3).

There have been few reports dealing with the MRI findings of syringomyelia in cats [10, 25, 27]. Of the 1785 cats brought to the Nihon University Animal Medical Center from 1995–2007, 5 cats (0.3%, including a cat reported in reference 10) were diagnosed on MRI as having cervical syringomyelia, which suggests that this is a rare condition.

In the present study, all 4 cats presented with enlargement of the lateral ventricle and cervical syringomyelia. It has been reported that the ventricles of a normal cat are too narrow to permit observation of the walls of the ventricles [8]. In the MRI findings of all 4 cats, the ventricles were considered to be enlarged because the walls of the ventricles were

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**Table 1. Characteristics of the 4 cats with Syringomyelia**

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Age at Onset</th>
<th>Sex</th>
<th>BW (Kg)</th>
<th>Chief Complaint</th>
<th>FIP/serum</th>
<th>FIP/CSF</th>
<th>Pain</th>
<th>Paresis</th>
<th>Gait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>8 m</td>
<td>C</td>
<td>2.25</td>
<td>Ataxia</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Paraparesis</td>
<td>Abnormal</td>
</tr>
<tr>
<td>Case 2</td>
<td>7 m</td>
<td>S</td>
<td>1.4</td>
<td>Dystasia</td>
<td>1:12,800</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Forelimbs paresis</td>
<td>Impossible</td>
</tr>
<tr>
<td>Case 3</td>
<td>11 y</td>
<td>S</td>
<td>3.55</td>
<td>Seizer</td>
<td>1:3,200</td>
<td>1:20</td>
<td>Unknown</td>
<td>Forelimbs paresis</td>
<td>Abnormal</td>
</tr>
<tr>
<td>Case 4</td>
<td>8 y</td>
<td>C</td>
<td>3.45</td>
<td>Proprioceptors Depression in forelimbs</td>
<td>1:800</td>
<td>NE</td>
<td>Pain</td>
<td>Forelimbs paresis</td>
<td>Impossible</td>
</tr>
</tbody>
</table>

S: spayed. C: castrated. y: years. m: months.

**Table 2. MRI findings of the 4 cats with Syringomyelia**

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Enlargement of Lateral Ventricle</th>
<th>Enlargement of Fourth Ventricle</th>
<th>Cerebellum Herniation</th>
<th>Length of Syrinx</th>
<th>Location of Syrinx</th>
<th>Ratio of Syrinx and Spinal cord</th>
<th>Periventricular MRI findings</th>
<th>Perimeningeal MRI findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>C2–6</td>
<td>Central</td>
<td>0.6</td>
<td>Gd(+)</td>
<td>Gd(+)</td>
</tr>
<tr>
<td>Case 2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>C1–T8</td>
<td>Dorsal</td>
<td>0.53</td>
<td>Flair high, Gd(+)</td>
<td>Flair high, Gd(+)</td>
</tr>
<tr>
<td>Case 3</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>C2–T1</td>
<td>Dorsal</td>
<td>0.5</td>
<td>(–)</td>
<td>(–)</td>
</tr>
<tr>
<td>Case 4</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>C2–T3</td>
<td>Central</td>
<td>0.69</td>
<td>(–)</td>
<td>(–)</td>
</tr>
</tbody>
</table>

# Height of the syrinx/height of spinal cord.

**Table 3. Treatment and Outcome of the 4 cats with Syringomyelia**

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Prednisolone</td>
<td>Unknown</td>
</tr>
<tr>
<td>Case 2</td>
<td>Ventriculoperitoneal shunting</td>
<td>Alive (2 years and 11 months after surgery)</td>
</tr>
<tr>
<td>Case 3</td>
<td>Ventriculoperitoneal shunting</td>
<td>Alive (1 year and 5 months after surgery)</td>
</tr>
<tr>
<td>Case 4</td>
<td>Prednisolone</td>
<td>Dead (5 months after MRI)</td>
</tr>
</tbody>
</table>
Moreover, 3 of the cats presented with herniation of the cerebellum. As the intracranial volume continues to increase beyond the limits of compensation, intracranial pressure (ICP) increases so precipitously that shifts of the brain parenchyma, termed brain herniation, occur [1]. In humans, it has been reported that although the Chiari anomaly is a common cause of cerebellar herniation, space-occupying lesions in the posterior fossa may lead to cerebellar herniation [17]. It has also been reported that isolated fourth ventricle (IFV) is a cause of cerebellar herniation in humans and cats [6, 10, 11]. MRI revealed enlargement of the fourth ventricle in cases 1 and 2. In case 1, IFV was considered to have occurred due to blockage of flow in the aqueduct and outlet of the fourth ventricle, and cerebellar herniation was considered to have been caused by increasing intracranial pressure [10]. In case 2, severe enlargement of the aqueduct and the lateral third, and fourth ventricles were considered to have occurred due to blockage of flow in the outlet of the fourth ventricle. The cervical syringomyelia in cases 1 and 2 are suggested to have occurred due to primary blockage of flow in the outlet of the fourth ventricle. The cause of cervical syringomyelia in case 3 was considered to be secondary occlusion of CSF flow at the fourth ventricle level after caudal displacement of the cerebellum, which occurred as a result of increased intracranial pressure due to hydrocephalus. In case 4, it was suspected that the cavity formed due to blockage of CSF flow secondary to cerebellar herniation. The cerebellar herniation occurred due to hydrocephalus and intracranial masses. A cat with intracranial meningiomas diagnosed by MRI was previously reported to have cervical syringohydromyelia and cerebellar herniation [27]. Milhorat et al. reported that hindbrain lesions that obstructed the basilar cisterns or blocked outlets of the fourth ventricle produced CSF flow obstruction and a communicating type of syringomyelia in association with hydrocephalus [15]. In cases 2 and 3 with severe hydrocephalus, ventriculoperitoneal shunting was immediately performed. Postoperative MRI showed that the ventricles had decreased in size, and herniation of the cerebellum and the syrinx in the cervical spinal cord could no longer be seen, as previously reported [25]. The syringomyelia in the 4 present cases may have been produced by the mechanism reported by Milhorat et al. [15].

It has been reported that FIP is a common infectious dis-
ease causing feline hydrocephalus [7]. Hydrocephalus has been reported to form due to the accumulation of inflammatory cells at sites of narrowing along the CSF pathway [16]. The serum FIP titer was high in case 2, though the result in case 3 was unclear [2]. Thus, case 2 was likely associated with FIP. Moreover, it has been reported that the MRI findings of FIP encephalomyelitis include enlargement of the ventricles [5, 10]. In case 1, severe enlargement of the fourth ventricle was detected, and the base of the ventricle and the meninges were enhanced on contrast T1-weighted images. In case 2, the periphery of the ventricles and the meninges of the cerebral area showed hyperintensity on FLAIR images and were enhanced on contrast T1-weighted images. The Pathological findings of FIP encephalomyelitis have been reported to include ependymitis and periventriculitis in the fourth ventricle, menigitis and choroiditis [5]. The lesions in cases 1 and 2 were similar to those in the previous report, suggesting that cases 1 and 2 were infected with FIP. In regard to cases 1 and 2, the secondary cervical syringomyelia likely occurred due to blockage of flow in the outlet of the fourth ventricle related to FIP encephalomyelitis. The cerebellar herniation also occurred as a result of the same cause.

There have been several reports on the clinical signs of syringomyelia. Pain is an important clinical sign reported to occur in 80% of humans with syringomyelia and 35% of dogs with syringomyelia [18, 19, 26]. However, in dogs, pain may be difficult to localize during clinical examination, as it is often intermittent. Dogs with syringomyelia may have other neurologic deficits, such as neck/ear/limb hyperesthesia, LMN of the thoracic and pelvic limbs, conscious proprioception deficits, facial nerve paralysis and scoliosis [20, 21]. Though it is difficult to recognize pain in cats, the authors recognized that 2 of the 4 cats (cases 3 and 4) felt pain because of signs such as unwillingness to stretch and move and anger when touched. Rusbridge reported that in Cavalier King Charles spaniels, maximum syrinx width was the strongest predictor of pain, and pain is most likely to be observed in association with a large, long and asymmetric syrinx [18]. In the present cases, the pain in the 2 cases did not appear to be associated with the width of the syrinx. On the other hand, the pain experienced by dogs with syringomyelia is likely to be multifactorial and related to obstruction of CSF flow and spinal cord damage [20]. Two of the 4 present cases presented with dystasia, and 2 of the 4 cases had severe ataxia; however, it seemed that there were no associations with syrinx width, length or location. The severity of the syringomyelia in these 4 cats was probably not associated with the clinical signs, but rather was associated with the underlying disease.

In this study, the cervical syringomyelia in these cats may have been due to formation of a secondary syrinx (enlargement of the central canal) as a result of blockage of flow in the outlet of the fourth ventricle caused by FIP encephalomyelitis or secondary cerebellar tonsillar herniation caused by increased intracranial pressure due to intracranial masses or may have been due to caudal compression of the cerebel-

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