Efficacy of the New Radiographic Measurement Method for Cervical Vertebral Instability in Wobbling Foals

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ABSTRACT. Cervical myelography and survey radiography was performed on 12 light breed wobbling foals and a new radiographic measurement method was applied for more accurate diagnosis of cervical vertebral instability. Ratios of stenosis of the spinal canal on survey radiography and myelography using relative values in an individual foal were defined on radiograms of lateral flexed position of mid-cervical region, and coincidence between the ratios and histopathological lesions in the cervical spinal cord was investigated. Five of 6 foals had ratios of stenosis on myelography more than 40% at the intervertebral sites where the most severe histopathological lesions were observed. Four of 6 foals had ratios of stenosis on survey radiography more than 40% at the intervertebral sites where the most severe histopathological lesions were observed. False-positive diagnosis of CVI was observed in 1 out of 6 foals without histopathological lesion when both ratios of stenosis on myelography and survey radiography were applied. Although the standard value of 40% should be further investigated, the new radiographic measurement method in this study is very useful in clinical diagnosis of cervical vertebral instability in wobbling foals, and the presence of lesions in the cervical spinal cord and their sites by survey radiography may be estimated more accurately.—**KEY WORDS:** cervical vertebral instability (CVI), foal, myelography, radiographic measurement method, wobbler.

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Cervical vertebral malformation is classified into cervical vertebral instability (CVI) and cervical static stenotic malformation based on the pathogenesis of cord compression [7]. Radiographic measurements of the cervical vertebrae such as the length and height of the column have been used for more accurate diagnosis of these diseases [4, 5, 7-9]. However, the evaluation using such absolute measurement values [4] is often difficult, especially in CVI, because these diseases are common in young developing horses and there are considerable variations in the physique and body weight of affected animals. We reported the relationships between radiographic findings and histopathology of the cervical spinal cord in wobbling foals [11]. In that investigation, radiographically abnormal values of the cervical vertebrae on survey radiograms and myelograms according to the measurement method by Mayhew [4] did not necessarily correspond to the histopathological spinal lesions. In addition, no compressive images on myelography was often observed at the vertebral sites with abnormal values on survey radiography.

In this study, a new radiographic measurement method using myelography and survey radiography was applied on the cervical spine of wobbling foals as a more accurate parameter for the diagnosis of CVI.

MATERIALS AND METHODS

Materials: Twelve wobbling foals (10 Thoroughbred and 2 Anglo-Arabs, 10 males and 2 females) in Hidaka district, Hokkaido were used in this study. In these foals, clinical manifestation such as proprioceptive deficits and

upper motor neuron signs occurred at 10 to 21 months of age and radiography was undertaken at 15 to 27 months of age. The foals corresponded to 12 out of 19 foals which were described in a previous study [11].

Cervical radiography: Cervical radiography including myelography in lateral flexed position was performed by the methods similar to those previously reported [11]. On these radiograms, various measurements were made on intervertebral joint of the third and fourth vertebra (C3-4), C4-5 and C5-6.

On myelography, following parameters indicated in Fig. 1 were measured: the maximum diameter of contrast column in the vertebral canal of the cranial cervical vertebra of two adjacent vertebra (a), the maximum diameter of contrast column in the vertebral canal of the caudal cervical vertebra (a'), and the minimum diameter of contrast column between two vertebrae (b). Ratio of stenosis on myelography (Sm) was calculated according to the following formula:

$$Sm = \left(1 - \frac{b}{\frac{a+a'}{2}}\right) \times 100$$

On survey radiography, ratio of stenosis is defined by the method indicated in Fig. 2. Since the maximum diameter of contrast column on myelography was frequently measured at the middle of the vertebral canal, diameters of the vertebral canals at the middle of adjacent two vertebrae were measured. Diameter of the cranial vertebra was expressed as "c" and that of the caudal vertebra as "c'". Along with the lower ends of individual

Fig. 1. Radiograph (above) and schematic drawing (below) showing measurement of the ratio of stenosis on myelography.

Fig. 2. Radiograph (above) and schematic drawing (below) showing measurement of the ratio of stenosis on survey radiography.

vertebral arches, extension lines (x and y) were drawn (Fig. 2). The minimum distance between x or y and the vertebral head of the caudal vertebra was then measured (d). Similarly to Sm, the ratio of stenosis on survey radiography (Ss) was calculated using these values according to the following formula:

$$Ss = \left(1 - \frac{d}{\frac{c+c'}{2}}\right) \times 100$$

Histopathological examination: After radiography, the foals were euthanatized and histopathological examination on the spinal cord was performed by the methods previously reported [11].

Evaluation of the ratios of stenosis between myelography and survey radiography: After calculating ratios of stenosis at individual vertebral sites on myelography and survey radiography, their relationship to histopathological findings in the cervical spinal cord was investigated. In addition, the correlation in ratios between on myelography and on survey radiography was investigated.

RESULTS

Histopathological findings: Among 12 foals investigated, 6 had severe lesions in the cervical spinal cord. As similar to the previous report [11], the lesions were located almost symmetrically in the white matter of the spinal cord, which were characterized by axonal swelling

accompanied with disappearance of myelin sheaths, a vacuolated spongy appearance and mononuclear or polynuclear gitter cells. In the remaining 6 foals, there were few or no lesions in the white matter of the cervical spinal cord. Thus, the foals were divided into 2 groups with (group I) or without (group II) severe spinal lesions for the following analyses.

Ratio of stenosis on myelography: Ratio of stenosis on

Table 1. The ratio of stenosis on myelography in the horses

Group	No. ^{a)}	C3-4	C4-5	C5-6	Site of most severe lesion ^{b)}
I	5	27.8	41.1*	39.5	5C
	6	49.1*	30.3	27.6	3D
	8	ND	28.6	48.0*	4D
	9	38.2	9.1	49.6*	5C
	10	37.0	ND	52.9*	5D
	12	43.1*	ND	ND	3D
II	3	30.5	35.4	ND	—
	4	34.1	35.8	20.2	—
	11	17.4	11.8	13.1	—
	15	20.2	25.5	7.6	—
	17	40.3*	22.1	46.9*	—
	19	23.9	27.2	22.6	—

ND: Not determined.

*: Ratio of stenosis with above 40%.

a) The number of horse reported previously [11].

b) The area of the cervical cord reported previously [11].

—: No severe lesion.

Table 2. The ratio of stenosis on survey radiography in the horses

Group	No. ^{a)}	C3-4	C4-5	C5-6	Site of most severe lesion ^{b)}
I	5	39.3	38.6	43.4*	5C
	6	42.4*	36.2	30.2	3D
	8	ND	29.3	39.0	4D
	9	33.2	11.8	48.7*	5C
	10	34.8	ND	52.6*	5D
	12	29.9	ND	ND	3D
II	3	20.3	23.2	ND	—
	4	37.5	31.7	24.8	—
	11	17.0	8.9	18.7	—
	15	18.8	16.4	8.2	—
	17	34.2	33.0	44.5*	—
	19	37.3	34.9	38.3	—

ND: Not determined.

*: Ratio of stenosis with above 40%.

a) The number of horse reported previously [11].

b) The area of the cervical cord reported previously [11].

—: No severe lesion.

Fig. 3. The scattergram representing the correlation in ratios of stenosis between on myelography and on survey radiography.

myelography of individual foals are shown in Table 1. In foals of group I, 5 out of 6 foals (83%) had ratios more than 40% in at least one site of intervertebral spaces where the most severe histopathological lesions were observed. On the contrary, 5 out of 6 foals in group II had ratios less than 40% in any sites.

Ratio of stenosis on survey radiography: Ratios of stenosis on survey radiography of individual foals are shown in Table 2. In foals of group I, 4 out of 6 foals (67%) had ratios more than 40% in at least one site of intervertebral spaces where the most severe histopathological lesions were observed. On the contrary, 5 out of 6 foals in group II had ratios less than 40% in any sites.

Correlation in ratios of stenosis between on myelography and on survey radiography: The scattergram representing the correlation in ratios of stenosis between on myelography

and on survey radiography is shown in Fig. 3. The coefficient of correlation between these parameters was 0.82 and there was a significantly positive correlation ($p < 0.01$).

DISCUSSION

In CVI mainly seen in the mid-cervical region (C3–C6), dynamic compression to the spinal cord induces clinical signs of ataxia [3, 7, 10]. It is considered that “pinching” occurs between the caudal end of the vertebral arch of one vertebra and the vertebral head of the next caudal vertebra, and that the cervical spinal cord at this site is exposed to the strongest compression [3, 10]. Such a dynamic factor concerning cervical spondylotic myelopathy due to CVI is known as “pincers mechanism” or “dynamic canal stenosis” in humans [2], on which radiographic studies have been reported [1, 6].

In veterinary field, there have been a little reports [4, 5] on radiographic measurement method of cervical vertebrae in wobbling foals. Mayhew *et al.* [4] undertook survey radiography and myelography on wobbling foals with cervical vertebral stenotic myelopathy (CSM) and measured 3 parameters, minimum sagittal diameter (MSD), minimum flexion diameter (MFD) and minimum dural sagittal diameter (MDD). Their results suggested that foals with CSM showed lower values as compared to the minimum reference limits and that the sites with lower MSD, MFD, MDD values and those with histopathological lesions in the spinal cord were well coincided.

However, in our previous report [11] using their measurement method, comparison of the values obtained from wobbling foals to normal values was not accurate because the age and body size of patients were various and radiography at the uniform position in any patients was often difficult. It was considered that MDD and MFD measurements in previous study [11] were similar to ratio of stenosis on myelography and on survey radiography, respectively. But only 2 out of 6 foals in group I in this study had severe histopathological lesions in the cervical cord at the intervertebral sites with MDD values below minimum reference limits, and 3 out of 6 in group I had severe histopathological lesions at the intervertebral sites with MFD values below minimum reference limits.

The relative measurement methods reported by Moore *et al.* [5] provided more accurate diagnosis of CSM, but they were possible to apply to only MSD measurements. Thus, the methods were not able to be used for diagnosis of CVI.

Ratio of stenosis on myelography in this study was calculated by subtracting the ratio of the minimum diameter of intervertebral contrast column to the average maximum diameter of the contrast column from 1. This means that the calculated value became larger when the compression was stronger. When the standard value was set at 40%, the coincidence rate between ratio of stenosis and histopathological lesion at the same site was as high as 83% suggesting that the standard value of 40% was almost

appropriate and useful for the diagnosis of CVI.

However, myelography cannot be routinely performed on all wobbling foals, thus it is more practical to obtain a useful measurement method on survey radiograms as a parameter for ratio of stenosis.

In CVI, the dorsal aspect of the vertebral arch is often extended caudally. When the neck is flexed, the spinal cord is compressed by the extended dorsal aspect of the vertebral arch and the cranial aspect of the next caudal vertebral body [3]. Thus, we drew extension lines along with the lower ends of individual vertebral arches and then obtained the minimum distance between these lines and the vertebral head. Its ratio to the diameter of spinal canal at the middle of the vertebra was subtracted from 1 to obtain the ratio of stenosis on survey radiography. This parameter resembles to MFD proposed by Mayhew *et al.* [4] but considered to be superior to MFD, because the base line and base points in radiograms were clear, measurement was performed easily, and it represented the degree of compression more accurately.

The coefficient of correlation in ratios of stenosis between on myelography and survey radiography was as high as 0.82 and there was a significant positive correlation with a significance level of 0.01%. Therefore, ratio of stenosis on survey radiography sufficiently reflects ratio of stenosis on myelography. In addition, when ratio of stenosis of 40% was set as the standard value, similar to that on myelograms, the coincidence rate between ratio of stenosis on survey radiography and histopathological lesions at the same site was about 70%.

Papageorges *et al.* [8] reported that about 50% of abnormalities detected on survey radiography were false positive and survey radiography was lower in reliability in the radiographic study using 306 ataxic horses. When comparing with that report, ratio of stenosis on survey radiography in this study provided a high diagnosis rate on CVI in addition to the easy measurement on radiography and easy comparison to standard values. Further works to obtain more optimal standard value of stenosis, 40% in this study, should be needed by increasing the number of patients.

In conclusion, the new radiographic measurement method on survey and contrast radiography in this study is very useful for clinical diagnosis of CVI in wobbling foals

and the presence/absence of lesions in the cervical spinal cord and their sites may be estimated more accurately.

REFERENCES

1. Epstein, J. A., Carras, R., Epstein, B. S., and Levine, L. S. 1970. Myelopathy in cervical spondylosis with vertebral subluxation and hyperlordosis. *J. Neurosurg.* 32: 421–426.
2. Fukui, K., Kataoka, O., Sho, T., Washimi, M., Fujita, M., Nabeshima, Y., and Ichijima, S. 1989. Pathogenesis and treatment of cervical spondylotic myelopathy due to cervical instability. —from the point of view concerning the conception of dynamic canal stenosis— *Clin. Orthopaedic Surg.* 24: 405–410 (in Japanese).
3. Mayhew, I. G. 1989. Tetraparesis, paraparesis and ataxia of the limbs, and episodic weakness. pp. 243–333. *In: Large Animal Neurology*, Lea & Febiger, Philadelphia.
4. Mayhew, I. G., de Lahunta, A., Whitlock, R. H., Krook, L., and Tasker, J. B. 1978. Spinal cord disease in the horse. *Cornell Vet.* 68 (Suppl. 6): 44–70.
5. Moore, B. R., Reed, S. M., Biller, D. S., Kohn, C. W., and Weisbrode, S. E. 1994. Assessment of vertebral canal diameter and bony malformations of the cervical part of the spine in horses with cervical stenotic myelopathy. *Am. J. Vet. Res.* 55: 5–13.
6. Niemeyer, T. and Penning, L. 1963. Functional roentgenographic examination in a case of cervical spondylolisthesis. *J. Bone Jt. Surg.* 45-A: 1671–1678.
7. Nixon, A. J., Stashak, T. S., and Ingram, J. T. 1982. Diagnosis of cervical vertebral malformation in the horse. *Proc. 28th Annu. Conv. Am. Assoc. Equine Pract.* 253–266.
8. Papageorges, M., Gavin, P. R., Sande, R. D., Barbee, D. D., and Grant, B. D. 1987. Radiographic and myelographic examination of the cervical vertebral column in 306 ataxic horses. *Vet. Radiol.* 28: 53–59.
9. Rantanen, N. W., Gavin, P. R., Barbee, D. D., and Sande, R. D. 1981. Ataxia and paresis in horses. Part 2. Radiographic and myelographic examination of the cervical vertebral column. *Comp. Cont. Educ. Pract. Vet.* 3: 161–171.
10. Reed, S. M., Newbrey, J., Norton, K., and Bayly, W. M. 1985. Pathogenesis of cervical vertebral malformation. *Proc. 31st Annu. Conv. Am. Assoc. Equine Pract.* 37–42.
11. Tomizawa, N., Nishimura, R., Sasaki, N., Nakayama, H., Kadosawa, T., Senba, H., and Takeuchi, A. 1994. Relationships between radiography of cervical vertebrae and histopathology of the cervical cord in wobbling 19 foals in Japan. *J. Vet. Med. Sci.* 56: 227–233.