

SELENIUM AND TOCOPHEROL LEVELS IN CALVES WITH WHITE MUSCLE DISEASE OF CARDIAC AND SKELETAL MUSCLE TYPE IN JAPAN

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Introduction

White muscle disease (WMD) in calves is a nutritional degeneration of skeletal and cardiac muscle caused by tocopherol deficiency¹⁾, selenium deficiency²⁾ or both³⁾. Author et al. researched WMD in livestock (calves, lambs, foals) in Japan and clarified that the disease is caused by deficiencies of selenium and tocopherol^{4, 5, 6)}. In this study, cases of WMD in calves in Japan were divided into skeletal muscle type with degeneration of skeletal muscle and cardiac muscle type with degeneration of cardiac muscle. We compared the clinico-pathological observations and the levels of tocopherol and selenium.

Clinical Findings

The 23 calves examined were beef calves between 16 and 130 days old, most during the suckling period. The breed of the calves was Japanese Black in 17 cases, Aberdeen Angus in 5 cases and Hereford in one case. WMD occurred during the winter and spring seasons, during the housing period or just after pasturing. All Japanese Black calves showed the skeletal muscle type, of which clinical symptoms were mainly recumbency or stiff gait, and diarrhea, anorexia, tachycardia and tachypnea in several cases. WMD in all Aberdeen Angus and Hereford calves was the cardiac type. In the six cases of cardiac type, two calves showed sudden death and four calves showed signs of poor circulation such as tachycardia, cyanosis and tachypnea without recumbency. All four died within five days of the onset of treatment with vitamin E and selenium.

Pathological Findings

By the necropsy in three cases of the skeletal muscle type, lesions were found to be limited to skeletal muscle. The fibers of limbs, girdles, diaphragm and intercostal muscles had a pale color. These lesions were not found in cardiac muscle. In the six cases of the cardiac type, the gross lesions were grayish white streaks of the left ventricle and interventricular septum, but skeletal muscle was not affected.

Histopathologically, in the skeletal muscle type severe degeneration of muscle fibers, with swelling, fragmentation, granulation and vacuolation, was observed as lesions of the skeletal muscles of the whole body, diaphragm and tongue. A slight degeneration of cardiac muscle cells was observed in only one case. Of

Table 1. Serum enzyme activities in calves with white muscle disease.

	Skeletal muscle type (n=17)	Cardiac muscle type (n=4)
GOT (KU) ^{a)}	5,743 ± 4,495	715 ± 586
CPK (IU) ^{b)}	47,823 ± 43,073	2,132 ± 1,656
LDH (WU) ^{c)}	36,661 ± 31,699	9,401 ± 5,039
LDH isoenzyme (WU)		
LDH ₁	4,000 ± 2,710	4,223 ± 2,197
LDH ₂	5,609 ± 3,437	3,174 ± 1,710
LDH ₃	7,958 ± 5,264	1,399 ± 854
LDH ₄	7,549 ± 8,124	300 ± 135
LDH ₅	11,429 ± 14,329	282 ± 174

a) Karmen Unit. b) International Unit.

c) Wroblewski Unit.

Table 2. Serum tocopherol, selenium levels and blood GSH-Px activities in calves with white muscle disease.

	Skeletal muscle type (n=17)	Cardiac muscle type (n=4)	Control (n=8)
Serum tocopherol (µg/100ml)	54 ± 45	66 ± 44	219 ± 42
Serum selenium (ng/ml)	14 ± 8	10 ± 6	56 ± 13
Blood GSH-Px (e.u)	16 ± 7	9 ± 1	48 ± 7

Table 3. α -Tocopherol and selenium concentrations in organs.

	Skeletal muscle type (n=3)	Cardiac muscle type (n=5)	Control (n=3)
α -Tocopherol ($\mu\text{g/g}$ wet weight)			
Skeletal muscle ^{a)}	0.42 \pm 0.41	0.26 \pm 0.10	1.15 \pm 0.56
Heart	0.88 \pm 0.13	0.31 \pm 0.15	1.79 \pm 1.40
Liver	1.06 \pm 0.35	0.51 \pm 0.17	2.15 \pm 0.59
Adrenal gland	1.18 \pm 0.27	0.64 \pm 0.17	5.53 \pm 0.67
Kidney	—	0.25 \pm 0.07	2.05 \pm 0.63
Selenium (ng/g wet weight)			
Skeletal muscle	22 \pm 11	15 \pm 5	47 \pm 13
Heart	32 \pm 20	39 \pm 12	126 \pm 32
Liver	45 \pm 13	37 \pm 6	219 \pm 72
Adrenal gland	128 \pm 21	71 \pm 14	206 \pm 34
Kidney medulla	107 \pm 23	97 \pm 37	220 \pm 33
Kidney cortex	495 \pm 264	301 \pm 18	650 \pm 57

a) *M. longissimus cervicis*.

the cardiac muscle type, degeneration of cardiac muscle, with fragmentation, granulation, proliferation of phagocytes and calcification, was prominent in the left ventricle and interventricular septum, and was also found in the right ventricle in three cases. Degeneration of skeletal muscles at the several positions was slight. In one case there was no degeneration of skeletal muscle at any of the 18 positions examined.

Serum enzyme activity

Serum GOT, CPK and LDH activities in calves with WMD increased markedly with severe myodegeneration, and the activities in the skeletal muscle type showed higher levels than in the cardiac muscle type. Upon examination of the LDH isoenzyme, the skeletal muscle type showed a pattern of severe elevations of LDH₅ and LDH₄ by degeneration of skeletal muscle. Of the cardiac muscle type, the LDH isoenzyme pattern showed marked elevations of LDH₁ and LDH₂ by degeneration of cardiac muscle, and slight increases of LDH₃ and LDH₄.

Tocopherol and selenium levels in sera and organs

Serum tocopherol levels in calves with WMD in both the skeletal muscle type and cardiac muscle type were very low. All the calves showed markedly low levels of serum selenium below 35 ng/ml with low blood glutathione peroxidase (GSH-Px) activities. Furthermore, tocopherol and selenium concentrations in organs (skeletal muscle, heart, liver, adrenal gland, kidney) showed extremely low levels in the two types of WMD. Consequently, both types of WMD in Japan are caused by deficiencies of tocopherol and selenium.

Tocopherol and selenium contents in feedstuffs

Feedstuffs supplied to dams on the farms with WMD were hay, corn silage, paddy straw, bean hulls and beat pulp. The α -tocopherol content of these feeds ranged from 0.2 to 3.9 mg/100g in dry matter, and mostly showed deficient levels below 3 mg/100g in dry matter. The feed selenium contents were also deficient - below 0.1 ppm in dry matter in the greater part of the samples (a range from 0.009 to 0.105 ppm in dry matter).

Summary

Both the skeletal and cardiac muscle type of WMD occurred in calves in Japan. Clinical symptoms of the skeletal muscle type were mainly motor disturbances with recumbency and stiffness; the cardiac muscle type calves showed sudden death or poor circulation with tachycardia, tachypnea and cyanosis. Calves with WMD showed severe elevations of serum GOT, CPK and LDH activities, and characteristic patterns of the LDH isoenzyme as markedly increases

of LDH_s and LDH_v in the skeletal muscle type, and of LDH_s and LDH_v in the cardiac muscle type. Consequently, WMD in both the skeletal and cardiac muscle types in Japan were nutritional muscular dystrophy caused by deficiencies of tocopherol and selenium. The results suggest that the sensitivity of organs to these deficiencies is relevant to the breed of cattle.

References

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