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Post-Mortem Diagnosis of Nutritional Myopathy in Livestock and Horses

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Introduction

Nutritional myopathy is primarily the result of selenium deficiency, usually accompanied by concurrent vitamin E deficiency. This condition is most commonly encountered in young animals due to inadequate dietary intake. Pigs, cattle and sheep are most susceptible, horses and goats are moderately susceptible, while individual cases have been reported in dogs, cats, primates and a variety of herbivorous and omnivorous zoo animals as well as "farmed" antelope species. Vitamin A, Vitamin C, and Vitamin E are all-natural antioxidants, so there is a potential role for low vitamin A in the nutritional myopathy syndromes of livestock and horses.

Metal contaminants in feed mixtures, including silver, copper, cadmium, cobalt, vanadium, tellurium, zinc and possibly other metals, can induce nutritional myopathy by increasing the requirement for vitamin E and/or selenium. It is believed that these metals somehow bind to selenium or prevent its participation in protection against free radical damage. Typical histological lesions in myocardial and skeletal muscle are strong indicators of a primary nutritional myopathy in most species.

The muscle histopathology of nutritional myopathy (skeletal and cardiac) is characterised by a multifocal polyphasic pathology, i.e. widespread in the musculature and at various stages (acute/subacute/chronic) of degeneration necrosis, leukocytic infiltration, regeneration and dystrophic mineralisation. These characteristic histological changes result from ongoing insults occurring over a prolonged period. By matching these histological characteristics to various distribution patterns of lesions within the skeletal muscle system and myocardium, post-mortem assessment (gross and histopathology) are handy diagnostic tools for diagnosing nutritional myopathy in domestic ruminants, pigs and horses.

Sheep

Nutritional myopathy in sheep can occur at all ages of animals.

Typical skeletal muscle pathology, disseminated involving many muscle groups, and myocardial lesions may be detectable in **foetuses** at least two weeks before parturition.

Congenital nutritional myopathy does occur in lambs, but not often. The typical disease may occur as an outbreak among lambs from 1 day to 2 months of age or beyond. Mortality at this stage may be very low or may reach 50%. Tongue and neck muscles used in suckling movements often contain the most severe lesions. Skeletal muscle lesions are bilateral and symmetrical.

Clinical deficiency syndromes are most frequently reported in **lambs (4-8 months)**, recently turned out onto the first green pasture or feedlots. Where copper has been made unavailable by top-dressing with molybdenum on pastures, outbreaks in lambs and yearlings have been reported.
Mortality is not usually very high, but the subclinical disease is. Lesions are most commonly encountered in the major muscles of the shoulder and thigh but also back, neck, and respiratory (diaphragm and intercostal) muscles. At the same time, myocardial necrosis is considered a typical lesion in this age group. Lambs typically have pale muscle tissue, so gross detection of the characteristic "white flecking" can be highly challenging. Histopathology only can confirm the suspicion by sampling these target muscle sites.

In **yearling sheep, "hoggets"** lateral and medial vastus muscles of the thigh are the target muscles affected, as they contain primarily type II fast twitch fibres. The vastus intermedius, predominantly comprised of type 1 fibres, is usually unaffected.

Nutritional myopathy in **mature sheep** is clinically apparent sporadically, but the subclinical disease may involve 5-30% of a group. Under exceptional circumstances, the incidence of clinical disease and mortality may rise dramatically. The disease has been precipitated by stress from lousy weather, prolonged winter feeding, subsistence on root crops, forced activity, and feeding on stubble, legume pastures, dry pastures, and pastures with too much copper. Lesion distribution in adults is bilaterally symmetrical in the thigh muscles, frequently predominating in / or confined to the intermediate head of the triceps or the tensor fascia latae.

Lesions in **pregnant ewes** may be more or less confined to the abdominal muscles subjected to increased work-load from supporting the pregnant uterus.

Table 1. Preferred Biopsy sites for Post mortal diagnosis of Nutritional Myopathy in Sheep.

AGE	MUSCLE SITES WITH DIAGNOSTIC HISTOPATHOLOGY
Aborted foetus (last trimester)	Myocardial and most skeletal muscles.
Neonatal (days to weeks)	Tongue, neck muscles
Lambs (weeks to months)	Major muscles of the shoulder and thigh, plus muscles of the back, neck, intercostal muscles and diaphragm. Myocardium.
Hogget (1-2 years)	Vastus lateralis and vastus medius muscles of the thigh.
Adults	Thigh muscles, always including the intermediate head of triceps and tensor fascia latae.
Pregnant ewes	Abdominal muscles

Cattle

In the **bovine foetus,** myocardial necrosis is frequently accompanied by fibrinoid vasculitis of interstitial vessels. Liver lesions of cardiac failure (chronic cardiogenic congestion) are documented. Disseminated skeletal muscle lesions are also usually noted. Most abortions are late stage with gross abnormalities

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characterised by ascites, cardiac dilation with degeneration and/necrosis and hydropericardium, pulmonary oedema, skeletal muscle degeneration and/necrosis, cardiogenic hepatic congestion and in some instances, thyroid goitre.

In affected **neonates,** extensive lesions are usually encountered in the highly active tongue and neck muscles and occasionally in the voluntary muscles of the rectum, urethra, and oesophagus.

Gross pathology in **calves** is characterised by marked mineralisation of necrotic skeletal and/or cardiac muscle. When the cardiac muscle is involved, the intercostal muscles and diaphragm are usually involved, but the involvement of other skeletal muscles is variable. Heart lesions in calves involve the left ventricle more than the right. In those cases where skeletal muscle pathology predominates, the most extensive lesions are found in the large weight-bearing muscles of the thigh and shoulder, with other muscle groups less severely affected. Skeletal muscle lesions are consistently bilaterally symmetrical.

In **adults,** skeletal muscle lesions predominate with the heart infrequently involved. Nutritional myopathy in adults is frequently accompanied by myoglobinuria with myoglobinuric nephrosis.

Table 2. Preferred Biopsy sites for Post mortal diagnosis of Nutritional Myopathy in Cattle.

AGE	MUSCLE SITES WITH DIAGNOSTIC HISTOPATHOLOGY
Foetus (3rd trimester)	Heart, skeletal muscles plus liver (lesions of chronic cardiogenic congestion)
Neonatal	Tongue plus muscles of neck, rectum, urethra, and oesophagus.
Calves	Heart (left ventricle), intercostal muscles, diaphragm, weight-bearing muscles of shoulder and thigh.
Adult	Skeletal muscles plus kidney (myoglobinuric nephrosis).

Pigs

Nutritional myopathy is well reported in the swine, with the condition most commonly occurring in growing pigs of all sizes, particularly weaned pigs from 6 - 20 weeks of age. In descending order of frequency, the lesions encountered are myocardial degeneration (mulberry heart disease), hepatic necrosis (hepatosis dietetica) and myopathy. The longissimus dorsi muscles are growing pigs' most commonly affected skeletal muscle site. Extensive myo-degeneration has also been reported in neonatal piglets associated with iron injections. Heart and liver pathology is grossly visible, while skeletal muscle lesions are microscopic, emphasising the importance of collecting target muscles for histopathology. The skeletal muscle of pigs usually is pale, so identifying muscular lesions at the gross level is difficult.

Table 3. Preferred Biopsy sites for Post mortal diagnosis of Nutritional Myopathy in Pigs.

AGE	MUSCLE SITES WITH DIAGNOSTIC HISTOPATHOLOGY
Neonatal	Extensive skeletal muscle lesions involving most muscle groups.
Weaners (6-20 weeks)	Heart, liver, longissimus dorsi muscles.
Adults (recently farrowed sows)	Major weight-bearing muscle groups of the shoulder and thigh.

In adult pigs, nutritional myopathy is most commonly reported in sows that have recently farrowed and involve the shoulder and thigh's major weight-bearing muscles.

Horses

In **foals** (1 day – 12 weeks), myocardial necrosis is a common and significant lesion, particularly in acute cases. The presence of myocardial pathology distinguishes nutritional myopathy from exertional, metabolic and ischemic myopathies in equines. In subacute disease, pathology is characterised by bilaterally symmetrical involvement of shoulder, neck and thigh muscles. At the same time, lesions are also described in the tongue, pharyngeal and masticatory muscles, digital flexors, and extensors. Myoglobinuric nephrosis is a commonly associated pathology.

Equine diseases that develop in the face of vitamin E / selenium deficiency in **yearlings** include equine neuroaxonal dystrophy and equine degenerative myeloencephalopathy.

In **adult horses,** severe involvement of masticatory and tongue muscles (masseter muscle myopathy) is reported. Vitamin E / Selenium deficiency-associated syndromes in adults include Equine motor neuron disease (EMND) and non-exertional rhabdomyolysis.

Table 4. Preferred Biopsy sites for Post mortal diagnosis of Nutritional Myopathy in Horses.

AGE	MUSCLE SITES WITH DIAGNOSTIC HISTOPATHOLOGY
Foals (1 day – 12 weeks)	Myocardium, tongue plus muscles of neck, shoulder, thigh, pharynx, masticatory system, as well as digital flexors and extensors. Kidney (myoglobinuric nephrosis)
Yearlings	Brain and spinal cord
Adults	Masticatory muscles and tongue.

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QUESTION 1

Which of the following elements is most commonly associated with nutritional myopathy in livestock and horses?

a. Copper
b. Cobalt
c. Selenium
d. Vitamin A
e. Vanadium

QUESTION 2

Histopathology is a key diagnostic tool for diagnosing nutritional myopathy; which of the following would be considered key features?

a. Combinations of inflammation, degeneration and necrosis at various stages in conjunction with the regeneration
b. Extensive replacement fibrosis with myofibre loss and minimal inflammatory infiltrate
c. Acute degeneration and necrosis in the absence of any inflammation or regeneration
d. Chronic fibrosis with mineralisation, but no significant inflammation or regeneration
e. Extensive degeneration with associated regeneration but the absence of necrosis and inflammation.

QUESTION 3

In congenital nutritional myopathy of sheep, which of the following sites would offer the best possibility of demonstrating diagnostic lesions?

a. Shoulder muscles
b. Thigh muscles
c. Heart
d. Tongue
e. Diaphragm

QUESTION 4

Which is the most common age group of sheep in which clinical nutritional myopathy occurs?

a. Last trimester foetus
b. Yearlings (1 to 2 years of age)
c. Lambs 4 to 8 months of age
d. Neonatal lambs (less than 1 week)
e. Lambs less than 2 months of age

QUESTION 5

Which would be considered the target muscle group in yearling sheep for the collection of samples for histological assessment for features of nutritional myopathy?

a. Vastus intermedius
b. Intermediate head of the triceps muscle
c. Tensor fascia lata
d. Abdominal muscles
e. Vastus lateralis and vastus medius

QUESTION 6

In the bovine foetus, where is the most characteristic pathology found?

a. Diaphragm
b. Heart
c. Tongue
d. Intercostal muscles
e. Oesophagus

QUESTION 7

When the cardiac muscle of calves is affected by nutritional myopathy, which are the most common skeletal muscle sites that concurrently also show lesions?

a. Longissimus dorsi
b. Tongue and masseter muscles
c. Intercostal muscles and diaphragm
d. Large muscles of the shoulder
e. Large muscles of the thigh.

QUESTION 8

In weaner pigs (6-20 weeks) which is the most common anatomical site to find diagnostic lesions associated with nutritional myopathy?

a. Liver
b. Kidney
c. Diaphragm
d. Heart
e. Longissimus dorsi muscle.

QUESTION 9

Which of the following pathologies are most commonly observed in young foals associated with vitamin E selenium deficiency?

a. Myoglobinuric nephrosis
b. Myopathy of the extensor and flexor muscles of the limbs
c. Myopathy of the pharyngeal muscles
d. Necrosis of the muscles of the tongue
e. Myocardial necrosis

QUESTION 10

Which of the following is considered a vitamin E selenium deficiency-associated syndrome of adult horses?

a. Equine neuroaxonal dystrophy
b. Non-exertional rhabdomyolysis
c. Equine degenerative myeloencephalopathy
d. Nutritional myodegeneration
e. Myoglobinuric nephrosis

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