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Original article

Autosomal recessive myotonia congenita in sheep

GA Moore [1], KR Dyer [2], RM Dyer [3], DP Sponenberg [4*]

[1] *Department of Large Animal Clinical Sciences;*
[2] *Department of Small Animal Clinical Sciences;*
[3] *Department of Clinical Sciences, Maryland;*
[4] *Department of BioSciences and Pathobiology, Virginia-Maryland Regional College of Veterinary Medicine, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA*

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Summary – Myotonia congenita in sheep causes episodes of muscular rigor following various stimuli. Episodes are transitory and do not harm the animal. Incidence in the flock of origin included three ewe lambs and three ram lambs. Two of the affected animals resulted from the mating of one specific unaffected ram to the unaffected daughters of a second unaffected ram. This mating produced 25 normal animals in addition to the two myotonic animals, which is consistent with the hypothesis of an autosomal recessive gene responsible for the condition, assuming the sire and maternal grandsire were the only ancestors carrying the gene ($\chi^2 = 0.64$, 1 df, $P > 0.25$). The four other affected animals had these two introduced rams in their pedigrees on both maternal and paternal sides, suggesting that these two rams might indeed have introduced the gene into this flock.

sheep / myotonia congenita / genetics

Résumé – Myotonie congénitale autosomale récessive chez le mouton. *La myotonie congénitale chez le mouton cause des épisodes de raideur musculaire suite à divers stimuli. Ces épisodes sont passagers et ne sont pas nuisibles à l'animal. Elle concernait trois agneaux mâles et trois agneaux femelles dans le troupeau d'origine. Deux des animaux affectés résultaient de l'accouplement d'un bélier non affecté avec les filles non affectées d'un second bélier non affecté. Cet accouplement a produit 25 animaux normaux en plus des animaux myotoniques, ce qui est cohérent avec l'hypothèse d'un gène autosomal récessif responsable du syndrome, en supposant que le père et le grand-père maternel étaient les seuls ancêtres portant le gène ($\chi^2 = 0,64$, 1 df, p > 0,25). Les quatre autres animaux*

* Correspondence and reprints.
Correspondence to be sent to Dr DP Sponenberg, Veterinary College, Virginia Tech Blacksburg, VA 24061.

affectés avaient ces deux béliers dans leurs pedigrees, tant du côté paternel que du côté maternel, ce qui suggère que ces deux béliers pourraient avoir introduit le gène dans le troupeau.

ovin / myotonie congénitale / génétique

INTRODUCTION

Myotonia congenita is a condition of skeletal muscles, which is characterized by rigid contraction of the muscles, generally following a startling stimulus. Myotonia congenita has been described in humans, goats and other species (Bryant, 1979; Ptacek et al, 1993). Myotonia congenita is distinct from hyperkalemic periodic paralysis, paramyotonia, as well as from myotonic dystrophy. Myotonia congenita in humans has two major forms. One is due to an autosomal dominant gene and the other is due to an autosomal recessive gene (Ptacek et al, 1993).

Myotonic animals are consistently heavily muscled, and this development of muscle is related to the myotonia. The heavy muscling of myotonic animals may offer some advantages to meat production systems. Myotonic sheep occurred in a single flock, and flock records were studied to determine the mode of inheritance within this flock.

MATERIALS AND METHODS

Myotonia congenita in sheep was detected in a flock that was used for the production of show lambs. Two affected sheep from the flock were evaluated by routine blood and urine analyses. These two sheep were also evaluated by electromyography. Samples from the biceps femoris muscle were evaluated histologically following routine processing for hematoxylin- and eosin-stained tissue sections. Flock records of pedigrees, production data, and evaluation of lambs as affected and unaffected, were evaluated for evidence of mode of genetic transmission of the myotonia congenita.

RESULTS

Clinical investigation of two affected animals from the flock revealed normal complete blood counts, normal biochemical profiles, and normal levels of creatine kinase. Urine analysis was also normal. The only histological change was hypertrophy of both type I and type II myofibers in the biceps femoris muscles.

Several muscles of each lamb were investigated electromyographically, and all of these exhibited classic myotonic potentials (Kimura, 1983). The myotonic discharges occurred as sustained runs of positive or negative waves up to 1 mV. These ranged about 50–100 impulses per second, which produced a diminishing buzz over the speaker of the electromyograph. This diminishing buzz is characteristic of myotonia congenita.

Evaluation of herd records revealed that myotonia congenita was only expressed in lambs descended from two specific rams that were themselves unaffected, and

not from two other unaffected rams that were also used in the flock. The two rams capable of producing affected lambs produced six affected lambs, three ram lambs and three ewe lambs. Two of the affected lambs resulted from the mating of one specific ram to the unaffected daughters of the other ram, this specific combination also producing 25 unaffected lambs. The other four affected lambs were the progeny of animals that were offspring or paternal grandoffspring of one of the rams, and maternal grandoffspring of the other. No affected lambs were produced from any mating that did not have at least one of these rams in both the maternal and paternal portion of the pedigree. These two rams were both brought into the flock from other sources, neither was born into the flock.

DISCUSSION

The clinical investigation was consistent with this disease being myotonia congenita. The electromyography was consistent with this, and the hypertrophy of the skeletal muscles was consistent with myotonia congenita and not with dystrophic diseases characterized by myotonia.

If an allele is recessive and is newly introduced into a population by an heterozygous male, then the mating of this heterozygous male to daughters of an heterozygous male (himself or another) should produce a 1:7 ratio, which fits the production of 25 unaffected and two affected lambs by one ram from daughters of another ($\chi^2 = 0.64$, 1 df, $p > 0.25$). This logic is correct only if the original flock lacked animals heterozygous for this gene, in which case the original frequency of the gene is zero. The pedigree information behing the four myotonic lambs that were not produced by the specific sire $\times$ maternal grandsire matings are consistent with the gene being introduced by the two rams and not existing in the flock before their use.

The only instances of affected lambs in this flock followed matings in which these two rams appeared in both the maternal and paternal pedigrees. In no other instance were affected lambs produced, which is evidence against this gene existing in the flock before these two rams were introduced. The overall production of three ram and three ewe lambs affected with myotonia congenita further indicates a lack of sex linkage for the gene responsible for this trait in sheep. The name *Myotonia congenita* is suggested for the locus of this allele, with the symbol *Mc*. The allele name *myotonic* is suggested for the recessive allele, with the symbol Mc^m. This allele was unfortunately not documented prior to the publication of *Mendelian Inheritance in Sheep (MIS 196)* (Lauvergne et al, 1996), and the authors suggest that it be included in the next catalogue with the proposed names and symbols.

Myotonia congenita in sheep is similar to that in goats (Bryant, 1979) and humans (Ptaced et al, 1993). Clinical signs in the lambs were first noted at a few weeks to a few months of age. The first clinical sign was that the affected lambs had dirty fleeces. This is unusual in normal sheep since they rarely if ever recline laterally or roll, which generally keeps fleeces clean and free of soil. The affected lambs were then observed to exhibit extensor rigidity in the face of various stimuli, as is common with myotonia congenita in other species. This rigidity can occasionally cause them to fall over, and this accounts for the dirty fleeces as the lambs begin to express the trait.

The affected lambs were subjectively considered by the flock owner to have heavier muscling than the unaffected lambs. Further study of this aspect of myotonia congenita was not studied since only affected lambs were donated for evaluation. If further studies indicate that myotonic lambs are more heavily muscled than non-myotonic lambs, then this allele might have applications in meat producing systems. Another recently documented gene with large effect on muscling is the *callipyge* gene (Jackson and Green, 1993), which unfortunately also results in toughness of some portions of the carcass. The non-expression of the *callipyge* allele in animals inheriting it from the dam also may limit its usefulness in production systems (Cockett et al, 1996).

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