

THE EXPERIMENTAL INDUCTION OF HYPOMAGNESAEMIA IN ADULT WETHER SHEEP

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Summary

A method by which hypomagnesaemia can be induced in sheep by means of the intra-abomasal infusion of a milk diet either low or adequate in magnesium content is described. This technique was used as a model for studying the interactions and relative importance of variations in plasma concentrations of calcium (Ca), magnesium (Mg) and inorganic phosphorus (P) in the induction of hypomagnesaemic tetany. The results were statistically treated by both linear and non-linear regression and it was found that the rate of fall of plasma Mg concentration was greatest in animals which manifested clinical signs similar to those of the disorder known as grass tetany. Plasma Ca concentration was also significantly lower in these animals. The importance of these results with regard to the pathogenesis of grass tetany is emphasised.

I. INTRODUCTION

Grass tetany is a nervous disorder occurring in grazing ruminants, the incidence being highest in cows during early lactation. It is characterized by tetany, convulsions and high mortality. In Australia, grass tetany occurs in the colder southern states where there are marked differences between pasture production in winter and early spring.

Although the rat has proven to be a satisfactory species in which to induce hypomagnesaemia experimentally, a simple and reliable method has not yet been developed in non-lactating ruminants. This is of particular importance, as the aetiological factors involved in the pathogenesis of grass tetany have not been clearly defined. The relative importance of various factors in promoting the onset of convulsions can only be determined in the hypomagnesaemic animal and consequently the primary requirement for the study of such factors must be the ability to reproduce hypomagnesaemia in a ruminant species under laboratory conditions. This was the purpose of our work and it was successfully achieved by means of the infusion into sheep, via an abomasal cannula, of milk diets either low or adequate in Mg content. This technique was then used as a model for studying the interactions and relative importance of variations in plasma concentrations of Ca, Mg and P in the induction of tetany.

II. METHODS

The sheep used were two-tooth Merino and Merino-cross wethers of between 26 and 38 kg body weight. Each sheep had been fitted with an abomasal cannula at least 3 weeks prior to infusion. The basic milk

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diet was described by Black, Robards and Thomas (1973) and contained 150.0g spray dried cow's milk and 61.5g sodium caseinate respectively per kg milk solution. To this diet were added mineral and vitamin supplements, with the omission of Mg from the mineral supplement.

Two types of milk diet were given as intra-abomasal infusions. The first was described above and will be referred to as the non-supplemented diet. In the case of the second, or supplemented diet, sufficient Mg was added to the above diet to raise the average daily Mg intake of the sheep to approximately 600 mg per day. This is greater than the recommendation of the Agricultural Research Council (A.R.C.) for maintenance of a 30 kg wether (A.R.C. 1965).

The animals were initially offered a control diet of 800g of oaten chaff per day (a diet known to be low in Ca and P content) and their initiation to the milk diet was gradual in order to avoid scouring. After day 6 no dry matter was offered and the infusions were continued for a duration of between 11 and 23 days, this being determined by the level of hypomagnesaemia attained and the clinical signs exhibited. Fourteen non-supplemented and 5 supplemented infusions were given to a total of 15 wethers. After termination of the infusions the animals readjusted rapidly to a roughage diet.

Blood samples were taken daily from each animal and analysed for Ca, Mg and P concentration. At least 2 control blood samples were taken from each animal.

III. RESULTS

For analysis of the data the animals were divided into 3 groups - A, B and C. Group A represented the 5 animals which received the supplemented diet and groups B and C together represented the 14 animals which were infused with the non-supplemented diet. The non-supplemented group was then split into 2 sub-groups, B and C respectively, the criterion being the presence or absence in the animals during infusion of clinical signs resembling those of hypomagnesaemic tetany. Four animals exhibited such clinical signs and these were designated as group C. Group B therefore comprised the remaining 10 animals.

From the raw data it could be seen that there was a tendency for the plasma Ca and Mg concentration of some animals to fall more rapidly and of plasma P concentration to rise more rapidly than others. Linear regression analyses were performed on the data and the results from each group are shown in Table 1. It was also shown by linear regression analysis that the regression coefficients for plasma Ca, Mg and P concentration for group C were significantly different from those of either group A or group B.

In order to examine more closely the overall response of plasma Mg concentration with time to each treatment, the data from each group were fitted to a non-linear model. The predicted plasma Mg concentration (y) can be obtained for any given day (x), from the equation:

$$Y = a + \frac{b}{x^2 + c}$$

where a, b and c are constants. The R^2 values obtained from the plasma Mg data of groups A, B and C were 0.65, 0.77 and 0.85 respectively.

TABLE 1
Linear regression data for each group

	Plasma Mg			Plasma Ca			Plasma P		
	b [†]	F	R ^{2††}	b	F	R ²	b	F	R ²
A	-0.06	131.15**	0.59	-0.02	3.33	0.04	0.12	18.52**	0.03
B	-0.07	273.99**	0.74	-0.07	26.77**	0.54	0.08	5.99*	0.001
C	-0.11	156.03**	0.60	-0.23	63.65**	0.13	0.32	46.08**	0.11

† Regression coefficient

†† Multiple correlation coefficient

* P<0.05

** P<0.01

The higher R² values for plasma Mg concentration obtained by this analysis when compared with those obtained from linear regression analysis suggest that the application of this model for non-linear regression improved the overall description of the plasma Mg data, particularly of group C.

IV. DISCUSSION

In all the sheep which received abomasal milk infusions there was a highly significant fall in plasma concentration.

Four cases of tetany were observed from a total of 19 infusions and it was shown that the rate of fall of plasma Ca and Mg concentrations was significantly higher in these animals (group C) than in either group A or B.

Hypocalcaemia in the presence of hypomagnesaemia on diets of adequate Ca content has been reported in many species of animals and its occurrence in ruminants concurrently with hypomagnesaemic tetany has been well documented (Herd 1965). The actual physiological state required for the manifestation of tetany and whether hypocalcaemia is an essential pre-requisite for the occurrence of tetany is not known. Hemingway and Ritchie (1965) suggested that the onset of clinical tetany might be associated with a rapid fall in plasma Ca concentration in an already hypomagnesaemic animal and the experimental findings from our work provide further evidence that this is the case.

The fact that some animals manifested a subnormal plasma Ca concentration as well as being hypomagnesaemic and yet did not develop tetany is difficult to explain. The only obvious factor common to the group C animals, and not shared by these other animals, was their extreme hypomagnesaemia. It is possible that the hyperphosphataemia which was present in the group C animals could have exacerbated their concomitant hypocalcaemia. The occurrence of tetany would therefore have reflected the combined physiological effects of these factors.

The other major question raised by this work is why the animals which received the Mg-supplemented diet (group A) became hypomagnesaemic. It must be stated, however, that the A.R.C. (1965) figures for dietary requirements are approximations and can only be used as a guide. The results of the Mg-supplemented infusions indicate that, even with an

adequate daily Mg intake, Mg was not sufficiently well absorbed from the gastro-intestinal tract (GIT) of the sheep. This may have been the result either of a reduced availability of Mg in the diet (considered unlikely) or of an insufficient net uptake of Mg from the GIT distal to the point of entry of the infusion.

A possible explanation for the hypomagnesaemia of the Mg-supplemented group is that some Mg absorption may normally occur in the forestomach of the sheep and the by-passing of this region by the infusions may therefore have resulted in a net uptake of Mg which was insufficient for maintenance of a normal plasma Mg concentration. There have been a number of studies on the sites of Mg absorption from the GIT of sheep and the consensus of opinion has favoured the small intestine as the principal site (Field 1961). The reticulo-rumen of sheep had previously been found to be unimportant as a site of Mg absorption (Phillipson and Storry 1965), but has now been implicated in this role (Pfeffer, Thompson and Armstrong 1970). The results from our work suggest that the ruminant stomach proximal to the abomasum may be an important site of Mg absorption.

The applications of this technique to the study of the interactions of Ca, Mg and P in the pathogenesis of the clinical signs of grass tetany are obvious, as it provides a method of inducing, at will, an extreme degree of hypomagnesaemia (as low as 0.2 mg/100 ml) under laboratory conditions without otherwise affecting the general health of the animal. It in fact replicates very closely the field situation and confirms observations of other workers regarding the essentiality of hypocalcaemia for the manifestation of the clinical signs of grass tetany.

V. REFERENCES

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