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Magnesium absorption from the large intestine of sheep

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ABSTRACT

Five mixed-age Coopworth ewes were offered a pelleted low Mg (1.0 g Mg/kg DM) diet at the rate of 800 g/d for 2 months. Five levels of Mg (0, 0.5, 1, 2 and 4 g Mg/d) in 230 ml deionised water were infused into the distal ileum for 48 h, followed by a recovery period of 24 h. The treatments were randomly allocated to each animal using a latin square design. Mg absorption from the large intestine was estimated from changes in plasma Mg concentration and urinary Mg excretion rate. Twelve h after commencement of infusion, plasma Mg concentration was higher at 4 g Mg than at 0g. There was a positive relationship between the amount of Mg infused and urinary Mg excretion. However, the percentage of infused Mg that was absorbed declined from 18.2% to 6.9% when Mg infusion rate was increased from 0.5 to 4 g Mg/d.

In a second experiment, using a cross-over design, increasing the amount of water infused, with 4g Mg/d, from 230 to 2300 ml decreased urinary Mg excretion.

The results show that Mg can be absorbed from the large intestine in significant amounts and indicate that a passive transport mechanism may be involved.

Keywords Absorption; infusion; large intestine; magnesium; passive; sheep

INTRODUCTION

Under certain dietary conditions net absorption of Mg may be restricted with resultant hypomagnesaemia. Examples are forages high in K or low in Na, which induce a high negative potential difference between blood and rumen contents or which predispose to high ruminal pH. As a consequence, attention has centred on the rumen as the site of Mg absorption. Data are available, however, which suggest that Mg may be absorbed from the large intestine (Meyer and Busse, 1975; Reynolds *et al.*, 1984), but the importance of this site and the mechanisms by which Mg is absorbed have not been systematically investigated. This study was carried out to determine the nature and extent of absorption of Mg from the large intestine in an attempt to determine the extent to which compensatory absorption can occur in this part of the tract.

MATERIALS AND METHODS

Five mixed-age Coopworth ewes were fitted with a T-piece cannula inserted into the ileo-caecal junction one month prior to use. They were housed in metabolism crates and offered a pelleted low Mg diet (1.0g Mg/kg DM) at a rate of

800 g/d for 2 months. All sheep were offered feed once daily at 07.30 h and had continuous access to water. Urine and plasma samples were collected daily for 3 weeks before treatments were imposed.

Experiment 1 was a 5x5 Latin Square design balanced for residual effects. The infusate, an aqueous solution of MgCl₂, containing 0, 0.5, 1, 2 or 4 g of Mg was given into the caecum at a calculated rate of 0.23 litre/d by multi-channel peristaltic pump. Solutions were infused for 24 h and a rest period of 48 h followed before reallocation of infusion rate.

During the infusion period, and for a further 24 h, urine was collected at 12 h intervals. The total urine volume was acidified with conc. HCl to pH 2 and a representative 40 ml stored at 4°C. Ten ml of jugular blood were taken by heparinised vacutainer at 6 h intervals for the first 12 h and every 12 h until 48 h. Samples were centrifuged at 2250 rpm for 20 min and stored at -20 °C until analysed.

Experiment 2 was a crossover design using 4 of the ewes from Experiment 1. The infusate, 4 g Mg/d, was given in either 230 ml or 2300 ml of deionised water to 2 sheep for 24 h followed by a collection and rest period of 48 h, after which the treatments were reversed. The timing of blood and

urine sampling was the same as in Experiment 1 but, in addition, faecal samples were taken at 12 h intervals after the start of infusion.

The diet contained (kg/100 kg) - whole oat hulls, 20; ground oat hulls, 20; ground maize, 15; maize gluten, 8; sugar, 18; casein, 5; sodium bicarbonate, 3; corn oil, 3; dicalcium phosphate, 3 & 1.25 Pfizer Beef/Dairy vitamin and mineral Premix.

Faeces were freeze dried for 24 h, ground through a 1 mm mesh and wet ashed by the methods of Thompson and Blanchflower (1970). Urine, plasma and faeces digest Mg concentrations were determined by atomic absorption spectrophotometry after dilution with 1% strontium chloride in 0.1M HCl.

The 5x5 Latin Square results for urinary Mg were analysed by analysis of variance. All other urine, plasma and faecal results were subjected to a two tailed t-test.

RESULTS

Experiment 1

Infusion Rate

The mean infusion rate for all 5 animals across all Mg levels was 235.7 ± 6.3 ml/d.

TABLE 1 Plasma Mg concentration (mg/litre) - immediately prior to (time 0) and 12 h after commencement of infusion.

Infusion rate	Time 0	12 h	Difference	Signif.
H ₂ O	18.9	20.3	+ 1.4	*
0.5 g/d	19.1	19.8	+ 0.7	NS
1.0 g/d	19.2	20.2	+ 1.0	**
2.0 g/d	19.0	21.2	+ 2.2	**
4.0 g/d	19.0	21.8	+ 2.8	***

Plasma Mg

Plasma Mg concentrations increased with time for the 24 h of Mg infusion but only after 12 h was there a significant difference ($P < 0.025$) from the pre-infusion period concentration. All treatments except 0.5 g Mg/d showed a significant increase

after 12h (Table 1). The increase to 24 h was followed by a general downward trend in plasma Mg concentration, but which was not statistically significant. There was a significant ($P < 0.025$) difference in mean 12 h plasma Mg concentration between 0 and 4 g Mg/d rates of infusion (Table 1). Excluding water, there was a graded response in the increase in plasma Mg between time 0 and 12 h after the commencement of infusion with increasing Mg infusion rate (Table 1). 5.

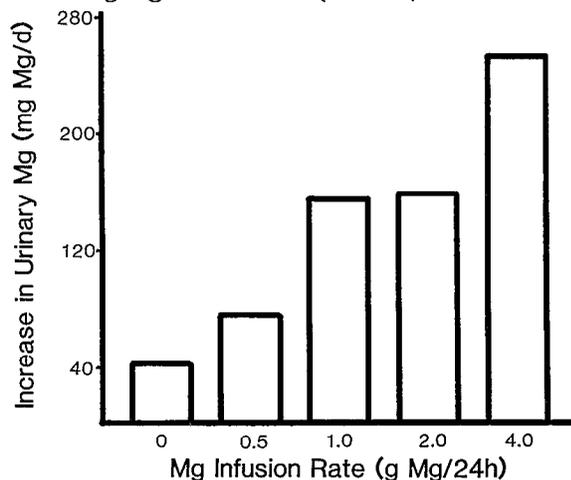


FIG. 1 Mean increases in urinary magnesium excretion (mg Mg/d) after 24 h infusions of magnesium chloride into the large intestine of sheep at 5 different concentrations.

Urinary Mg Excretion

Urinary Mg excretion increased from a mean of 4.0 ± 1.8 mg/h during the pretrial period to a mean of 11.1 ± 5.0 mg/h following the infusion of 4 g Mg/d. There was an increase ($P < 0.01$) in urinary Mg excretion with increasing rate of Mg infusion (Fig. 1). Mg excretion increased by 2.1 ± 1.3 mg/h simply as a result of a 230 ml water infusion.

The proportion of infused Mg that was absorbed and appeared in urine after infusion of 0.5 g Mg/d was $17.1 \pm 3.9\%$, while only $5.8 \pm 3.6\%$ of the 4 g Mg/d infused was absorbed. However, in absolute amounts, Mg excretion rates of 48.3 ± 25.5 mg/24 h and 171.5 ± 89.9 mg/24 h were observed for infusions of 0.5 and 4 g Mg/d, respectively.

Experiment 2

Plasma Mg

There was no significant difference in 12 h plasma Mg concentrations between the high (2342 ± 38) and low (250 ± 9) rates of water infusion, values being 21.5 and 21.8 mg Mg/litre; $0.05 < P < 0.1$) from zero time.

TABLE 2 Change in urinary Mg excretion (mg/h) after infusion of 230 or 2300 ml/24 h of water containing 4 g Mg.

	230 ml/24 h	2300 ml/24 h
Sheep 1	+ 8.8	+ 2.7
Sheep 2	+ 8.9	+ 5.3
Sheep 3	+ 4.7	+ 2.7
Sheep 4	+ 11.8	+ 8.8

Urinary Mg

Urinary Mg excretion was elevated at both infusion rates but was greater at the low than at the high rate for all 4 sheep (Table 2).

Faecal Mg Excretion

Mg excretion during the high water infusion was greater ($P < 0.001$) than that during the low water infusion (Fig 2).

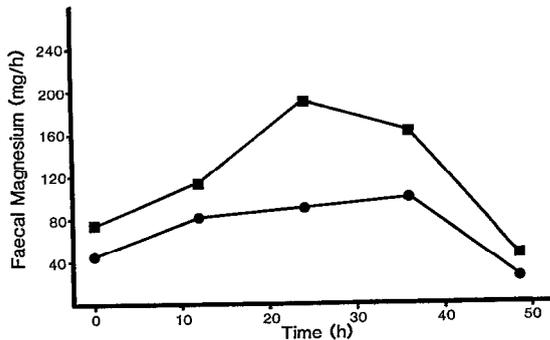


FIG. 2 The effect of low (○) and high (■) water infusions containing 4 g Mg/d into the large intestine of sheep on faecal magnesium excretion (mg/h).

DISCUSSION

There was evidence in the present study that Mg is absorbed from the large intestine at a rate positively related to the Mg concentration. These

results support those of Meyer and Busse (1975), Reynolds *et al.* (1984) and Bell *et al.* (1978) all of whom observed increases in plasma Mg within 1-2 min of giving a MgCl₂ enema. Bell *et al.* (1978) obtained average plasma Mg increases of 1.56 mg/100 ml within 20 min of inserting a 30% MgCl₂ solution enema. The results reported here were not as great but we did observe an increase in plasma Mg of 2.82 mg/100 ml within 12 h of infusing a 1.7% Mg solution.

Grace *et al.* (1974), using digesta marker techniques, also observed that quantities of Mg excreted in the faeces were less than the amounts entering the large intestine, at high dry matter intakes. This confirmed earlier work of Grace and MacRae (1972) who concluded that there was net Mg absorption from the large intestine of sheep.

Mineral solubility and absorption in the gut is likely to be pH dependent. The relatively high pH in the rumen militates against high solubility; considerable absorption occurs at this site, however, by an active process (Care *et al.*, 1984). Perhaps surprisingly, little Mg absorption occurs from the region of high pH and solubility in the small intestine, which appears, in fact, to be a site of net secretion (Ben-Ghedalia *et al.*, 1975; Bown *et al.*, 1988). As pH increases towards the terminal ileum (Ben-Ghedalia *et al.*, 1975; van't Klooster, 1967) the solubility of Mg decreases and less absorption might be anticipated. Nevertheless the large intestine has been shown to be an important site of Mg absorption (Ben-Ghedalia *et al.*, 1975). While the proportion of soluble Mg in faeces was low, their results showed that the concentration of soluble Mg in the faeces was about four times higher than in digesta passing through the upper small intestine. In the formation of faecal pellets there is intense absorption of water along the large intestine and associated with this is the concentration of solutes which would facilitate the absorption of Mg by passive transfer.

There were two pieces of evidence in this trial that support the theory of passive Mg absorption from the large intestine. In experiment 1 both plasma Mg and urinary Mg excretion increased 8. linearly with increasing Mg infusion. This supports the results of Field and Munro (1977) who observed a constant but low efficiency of Mg

absorption from the region distal to the duodenum and speculated that a passive diffusion or an active but unsaturated mechanism was involved. Secondly, in both experiments a small amount (230 ml) of water appeared to enhance the absorption of Mg from the large intestine. However, in experiment 2 a 10-fold increase in the amount of water infused considerably reduced the proportion of infused Mg that was absorbed, though there was still a positive effect.

On the basis of published results (Alam *et al.*, 1987; Hogan and Phillipson, 1960; Goodall and Kay, 1965; Hogan 1973; Thornton *et al.*, 1970), the 2.3 litre/d we infused into the large intestine in experiment 2 represents a 51-150% increase in caecal water flow. If indeed Mg absorption from the large intestine does rely on solvent drag, such a phenomenon may explain the higher rate of absorption of Mg at low rates of water addition. At the high rate of water infusion increases in solvent drag may have been offset by Mg dilution.

Although Mg can be absorbed from the large intestine in sheep, it is unlikely that this is a major site of uptake since a large proportion of available Mg will generally be absorbed in the rumen. However, because the results show significant Mg absorption from the large intestine it is important that this site be included in future models devised to explain Mg absorption from the entire gastro-intestinal tract.

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REFERENCES

- Alam M.R.; Poppi D.P.; Sykes A.R. 1987. Comparative aspects water intake and its flow through the gastro-intestinal tract of kids and lambs. *Journal of agricultural science, Cambridge* 108:253-256.
- Ben-Ghedalia D.; Tagari H.; Zamwell S.; Bondi A. 1975. Solubility and net exchange of calcium, magnesium and phosphorus in digesta flowing along the gut of sheep. *British journal of nutrition* 33:87-94.
- Bell M.C.; Oluokun J.A.; Ramsey N.; Beckmann G.E. 1978. Magnesium treatment of cows for grass tetany. *Feedstuffs* 50 (February 6): 24-25.
- Bown M.D.; Poppi D.P.; Sykes A.R. 1988. The effects of a concurrent infection of *Trichostrongylus colubriformis* and *Ostertagia circumcincta* on calcium, phosphorus and magnesium transactions along the digestive tract of lambs. *Journal of comparative pathology*. (In press).
- Care A.D.; Brown R.C.; Farrar A.R.; Pickard D.W. 1984. Magnesium absorption from the digestive tract of sheep. *Quarterly journal of experimental physiology* 69:577-587. 10.
- Field A.C.; Munro C.S. 1977. The effect of site and quantity on the extent of absorption of magnesium infused into the gastro-intestinal tract of sheep. *Journal of agricultural science, Cambridge* 89:365-371.
- Grace N.D.; MacRae J.C. 1972. Influence of feeding regimen and protein supplementation on the sites of net absorption of magnesium in sheep. *British journal of nutrition* 27:51-55.
- Grace N.D.; Ulyatt M.J.; MacRae J.C. 1974. Quantitative digestion of fresh herbage by sheep. 3. The movement of Mg, Ca, P, K and Na in the digestive tract. *Journal of agricultural science, Cambridge* 82:321-330.
- Goodall E.D.; Kay R.N.B. 1965. Digestion and absorption in the large intestine of sheep. *Journal of physiology, London* 176:12-23.
- Hogan J.P. 1973. Intestinal digestion of subterranean clover by sheep. *Australian journal of agricultural research* 24:587-598.
- Hogan J.P.; Phillipson A.T. 1960. The rate of flow of digesta and their removal along the digestive tract of sheep. *British journal of nutrition* 14:147-157.
- Meyer H.; Busse F.W. 1975. Zur rektalen Absorption von Magnesium beim Wiederkauer. *Dtsch. Tierärztl. Wochenschr.* 82:140-144.
- Reynolds C.K.; Bell M.C.; Sims M.H. 1984. Changes in plasma, red blood cell and cerebrospinal fluid mineral concentrations in calves during magnesium depletion followed by repletion with rectally infused MgCl₂. *Journal of nutrition* 114:1334-1341. 11.
- Thompson R.H.; Blanchflower W.J. 1970. Wet ashing apparatus to prepare biological materials for atomic absorption spectrophotometry. *Laboratory practice* 20:- Vol 2. Original Contribution. 859.
- Thornton R.F.; Bird P.R.; Somers M.; Moir R.J. 1970. Urea excretion in ruminants. 3. The role of the hind-gut (caecum-colon). *Australian journal of agricultural research* 21:345-354.
- van't Klooster A.Th. 1967. The state of calcium, magnesium and some other minerals in gut contents and faeces of ruminants in relation to their absorption. *Meded. Landbouwhogesch Wageningen* 65-67:1-136. 12.