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THE EFFECT OF GLUCOSE ADMINISTRATION ON PLASMA POTASSIUM IN CATTLE

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Summary

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The aim of this study was to confirm whether a rapid intravenous glucose administration can lead to a significant drop in blood potassium levels in cattle. For this study seven cattle were used according to internationally recognised guidelines for animal welfare. Glucose at a dose of 1 g/kg body weight was administrated intravenously and then blood samples were taken according a time schedule of 0, 0.5, 1, 2, 4, and 6 h for measurement of potassium and glucose blood concentrations. The results have shown a slight decrease in blood serum potassium levels at the time of maximum blood glucose concentration of (0.26 mmol/L). We have shown that glucose does have a potassium-lowering effect when administered in a single large IV dose, however, without clinical effects.

Key words: cattle, glucose, potassium

INTRODUCTION

Potassium is recognised as an essential nutrient in animal nutrition. It is the third most abundant mineral element in the animal body and the main ion of the intracellular fluid. Most of the total potassium in the body is located in muscle tissue (Leeson *et al.,* 1998). The most significant role of potassium is in relation to nerve innervation and muscle excitability, and it is also involved in carbohydrate metabolism (McDonald *et al.,* 2002). Glucose requirements of the dairy cow are dominated by the necessity of the mammary gland for milk synthesis. With greater milk yield comes larger requirements for glucose, which is mainly met through glucose synthesis in the liver (Reynolds, 2005). According to the research by Leonhard-Marek *et al.* (2012), a relationship was found between hypokalemias, insulin imbalances and ketosis in high yielding dairy cows. These changes in glucose homeostasis and hypokalemia might according to the researcher be a contributing factor to the pathogenesis of abomasal displacement resulting from decrease in abomasal tone.

The study aim was to confirm whether rapid intravenous glucose administration can lead to a significant drop in blood potassium levels in cattle.

MATERIAL AND METHODS

The group of the experimental animals consisted of five heifers and two Holstein-

Friesian dairy cows which were admitted to the clinic for treatment of various health disorders. They were clinically healthy at the moment of the study. Blood was collected by venepuncture of the jugular vein before and 0.5, 1, 2, 4, and 6 hours after administration of glucose. Each animal was given one gram of glucose per kg body weight, which resulted in 1000 mL of 40% glucose solution for a 400 kg cow on maximum infusion speed. The average time of administration was 25 min, approximately. The plasma concentrations of glucose were assayed with the kits supplied by Randox Laboratories Ltd. on spektrophotometer Alizé (Lisabio, France). The serum potassium concentrations were determined by flame AAS method (Perkin Elmer AAnalyst 100). For statistical analysis of glucose effects on both glucose and potassium levels one way analysis of variance (ANOVA) for repeated measures was used.

RESULTS

The glucose administration resulted in plasma increase from 4.2 mmol/L to 21.2 mmol/L within first minutes after the administration. From the peak in plasma glucose at 30 min, there is a steady decrease in the plasma glucose concentration to 3.36 mmol/L. ANOVA showed a strong significant effect of the glucose administration on plasma glucose levels ($P<0.001$). The serum potassium tended to decrease within the first hour after the glucose injection and then there was a steady increase of potassium serum concentration. ANOVA showed a weak significant effect ($P<0.05$) of the glucose administration on serum potassium levels (Table 1).

DISCUSSION

Potassium is one of the major elements and has an important role together with other elements such as sodium, chlorine and bicarbonate ions. Together they control the acid- base balance and the osmotic regulation of fluids in the body (McDonald *et al.,* 2002) as serum potassium serves as regulator of aldosterone secretion in which high serum levels of potassium increases plasma aldosterone levels (Betancourt-Calle *et al.,* 2001). The most abundant role of potassium is in relation to nerve and muscle excitability, and is also involved in carbohydrate metabolism (McDonald *et al.,* 2002). Potassium deficiency is rather rare in farm animals under normal conditions, due to a high concentration of potassium in plants, for example 25 g/kg DM in grass. Symptoms of deficiency in calves given milk replacement low in potassium includes severe paralysis (McDonald *et al.,* 2002). In general, hypokalaemia will increase the

Table 1. Plasma glucose and serum potassium (mean±SD) before and after glucose administration

Collection times (h)	Glucose (mmol/L)	Potassium (mmol/L)
0	4.22±0.59	3.56±0.74
0.5	21.2±5.02	3.41±0.74
1	15.4±3.97	3.30±0.75
2	8.41±3.05	3.52±0.83
4	3.83±0.66	4.03±0.74
6	3.36±1.39	3.75±0.96
P value	P<0.001	P<0.05

membrane potential, resulting in a hyperpolarization block causing weakness of muscles or paralysis, ileus, cardiac arrhythmias, rhabdomyolysis and renal dysfunction (Kokko & Tannen, 1986; Dow *et al.,* 1987a, b). Hypokalaemia is commonly the result of gastrointestinal losses from either diarrhoea or vomiting or excessive renal losses due to diuretics, overload of mineral-corticoids or renal tubular acidosis (Kokko & Tannen, 1986) but also from excessive rapid bicarbonate administration, insulin with glucose administration or catecholamine release (Kaneko, 2008). As a very frequent use of glucose in the treatment of many bovine diseases it was essential to test the hypothesis of the in *vivo* study (Leonhard-Marek *et al.,* 2012), as it was stated that when glucose was administered in a single rapid dose of (500 mL, 40%) the serum concentration of potassium strongly decreased.

The results presented in this thesis did reveal a small serum potassium-lowering effect when each of the seven animals was given 1 g/kg (500 mL, 40 %) of IV glucose within 30 min after glucose administration. This little drop in blood potassium was not associated with any clinical sign. However, the most of the experimental animals had the serum potassium levels slightly below the physiological range prior to the glucose administration. Thus, a slight decrease of potassium was might be too low to start some abnormal physiological processes in the organism adapted to lower potassium body pool.

CONCLUSIONS

According to the results of this study it can be concluded that a single intravenous administration of the glucose is not associated with a sever risk of metabolic and health impairment in cattle due to the strong drop in blood potassium. Thus, use of the glucose in energy deficiency treatment in cattle can be recommended.

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