Metabolic Effects in Lambs Intravenously Infused with Xylitol, Medium Chain Triglycerides, and Corn Oil

B. ESKELEND and W. H. PFANDER
Department of Animal Husbandry
University of Missouri, Columbia 65201

Abstract

Our experiment determined if xylitol, corn oil, and medium chain triglycerides administered by intravenous infusion could serve as useful metabolic fuels for supporting nitrogen balance in ruminants with the lamb as the model. Xylitol at 400 kcal per day was well tolerated; it decreased urinary and fecal nitrogen and increased nitrogen balance. Xylitol infusion consistently lowered blood glucose by 20 mg/100 ml and reduced plasma urea nitrogen. Medium chain triglycerides and corn oil increased plasma urea nitrogen and the respiratory rate. The reduction in blood glucose, after medium chain triglycerides infusion averaging 10 mg/100 ml from the control, was inconsistent and variable. No significant reduction in blood glucose occurred after intravenous infusion of corn oil.

Introduction

Lambs fed a diet adequate in protein and providing energy at one to two times maintenance had greater increases in nitrogen balance after glucose was infused than after any of the three major volatile fatty acids (VFA) was infused (4). In view of the unique metabolic pathways in ruminants, it was desirable to test other potential metabolic fuels.

The pentitol, xylitol, was first encountered in 1956 as the metabolic product of L-xylulose, the substance that accumulates in the genetic disorder pentosuria (2). This polyol has been recommended and successfully used in parenteral nutrition in Germany and Japan (10) and is of special importance for patients suffering from diabetes mellitus. Opposed to glucose, xylitol did not stimulate insulin secretion at physiological levels (6) but did at higher doses. Glucose, fructose, and sorbitol, carbohydrate sources in parenteral nutrition, are all glucose-6-phosphate dehydrogenase dependent for efficient pentose production. The reason for the favorable effects of xylitol in parenteral nutrition may be its entry into the pentose pathway independent of glucose-6-phosphate dehydrogenase.

Medium chain triglyceride (MCT) mixture provides a source of fat, containing triglycerides of octanoic (71%) and decanoic (23%) acids. Hashim et al. (8) demonstrated that MCT could be used as the sole source of dietary fat for humans, and the feasibility of feeding MCT to man for prolonged periods has been proven (12). MCT preparations have proved effective in a variety of malabsorption syndromes.

The purpose of this study was to elucidate the effect of the intravenous administration of the two energy sources on nitrogen balance, plasma urea nitrogen (PUN), and blood glucose in lambs. The effect of MCT was compared with long chain triglycerides (LCT) supplied by corn oil.

Experimental Procedure

Four 6-mo old lambs weighing 32.0 to 33.0 kg were in this study. They were adjusted to life in metabolism stalls and to intravenous infusions through a preceding trial. Details of the experimental methods have been described (4).

The basal diet was composed of 40.0% cottonseed hulls, 25.8% cracked corn, 18.0% soybean meal (44.0% crude protein), 10.0% molasses (cane), 5.0% ground alfalfa hay, 5.0% dicalcium phosphate, .5% dicalcium phosphate, .7% iodized cobaltized salt, and supplemental vitamins A and D. It contained 2,670 kcal digestible energy (DE) per kg and 13.0% crude protein (CP). Each lamb received 1,280 g of feed divided into two equal meals offered at 0800 and 1600.

The experiment was preceded by a 9-day control when the lambs received 600 ml of isotonic saline solution into the jugular vein over each 24 h. A 2 X 2 Latin square design was used for the xylitol and MCT treatments followed by an extra period for in-
Intravenous infusion of corn oil. Two additional lambs served as controls for the blood measures throughout the experiment.

Xylitol was infused at .77% of metabolic body weight in a 600-ml solution, and it supplied 400 kcal per day. MCT was administered at an equal caloric proportion of .35% of BW. Emulsions of MCT and corn oil were prepared by adding 1.5% of lecithin to the oils, diluting to volume with isotonic saline solution and homogenization. Eighty percent of the globules were less than 1 μm in diameter. During infusion a magnetic stirrer was used to avoid separation. After 3 days of infusion sheep receiving MCT went off feed; the MCT then was reduced to 200 kcal and kept there for the remainder of the experiment. Corn oil was supplied at 200 kcal throughout the experiment.

Total collection of urine and feces was from the 5th day of each infusion onward for nitrogen balance study. Blood samples were withdrawn at 1300 on the 2nd, 4th, 6th, and 8th day of each infusion period.

Results

Xylitol infusion significantly improved nitrogen balance by reducing nitrogen excretion in urine and feces (Table 1). For both xylitol and control treatments there was an increase (P<.05) in daily nitrogen retention from the 6th through 9th day of infusions. Owing to refusal of feed after 3 to 4 days on MCT infusion, the nitrogen balance study was discontinued on this treatment. The 200 kcal of MCT also affected feed intake after 3 to 4 days. Addition of 200 kcal from corn oil caused little depression in feed intake.

The decrease in PUN following intravenous administration of xylitol was not significant (P<.05). MCT and corn oil infusions both increased PUN over xylitol or control periods (P<.01) (Table 2). Day to day variations in PUN of control and xylitol treatment were somewhat less than those of MCT and corn oil. There was significant fall of blood glucose during xylitol infusion (Table 3) in the beginning of the infusion (P<.01) (1st sample taken on the 2nd day); after that, the value remained constantly low. Infusion of MCT also reduced blood glucose significantly, but the effect of corn oil did not differ significantly from that of MCT or control.

Discussion

The increased nitrogen balance produced by xylitol infusion suggests that this compound may be a useful source of fuel under some conditions. The sheep remained healthy and vigorous during infusion periods. Our laboratory reported earlier (5) that intravenous infusion of volatile fatty acids and glucose decreased fecal nitrogen excretion. Xylitol also significantly lowered fecal nitrogen output.

The increased nitrogen retention in this study and the lowering trend in PUN, though nonsignificant, agree. This is expected as more energy is available for protein synthesis. The reason for the elevated PUN after MCT and corn oil treatments is not now apparent.

The significant drop in blood glucose after xylitol treatment is not in agreement with previous studies in man. In the study by Geser et al. (6), xylitol at .8 g/kg body weight did not stimulate insulin secretion in young healthy persons. This was expected as hypoglycemic reactions after xylitol infusion have never been reported. However, there was a slight increase in insulin secretion with very high xylitol. In-

<table>
<thead>
<tr>
<th>Day of infusion</th>
<th>Saline (control) (g/day)</th>
<th>Xylitol (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Uₜ</td>
<td>Fₜ</td>
</tr>
<tr>
<td>6</td>
<td>9.89</td>
<td>5.37</td>
</tr>
<tr>
<td>7</td>
<td>9.12</td>
<td>5.50</td>
</tr>
<tr>
<td>8</td>
<td>9.29</td>
<td>5.07</td>
</tr>
<tr>
<td>9</td>
<td>8.71</td>
<td>5.31</td>
</tr>
<tr>
<td>mean</td>
<td>9.25</td>
<td>5.31</td>
</tr>
</tbody>
</table>

<sup>a</sup> Each value represents the mean of four lambs.
<sup>b</sup>,<sup>c</sup> Values with different superscripts are significantly different (P<.05).
<sup>d</sup> Less than control (P<.01).
<sup>e</sup> Less than control (P<.05).
<sup>f</sup> Greater than control (P<.01).
TABLE 2. Plasma urea nitrogena on the 2nd, 4th, 6th, and 8th day of infusion of the different substrates.

<table>
<thead>
<tr>
<th>Day of infusion</th>
<th>Saline (control)</th>
<th>Xylitol</th>
<th>MCT</th>
<th>Corn oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma urea nitrogen (mg/100 ml)</td>
<td>14.3</td>
<td>12.8</td>
<td>19.3</td>
<td>17.5</td>
</tr>
<tr>
<td>4</td>
<td>13.4</td>
<td>13.0</td>
<td>17.2</td>
<td>20.0</td>
</tr>
<tr>
<td>6</td>
<td>13.2</td>
<td>11.9</td>
<td>19.3</td>
<td>18.2</td>
</tr>
<tr>
<td>8</td>
<td>13.9</td>
<td>13.4</td>
<td>20.3</td>
<td>18.3</td>
</tr>
<tr>
<td>Mean</td>
<td>13.7b</td>
<td>12.8b</td>
<td>19.0c</td>
<td>18.5c</td>
</tr>
</tbody>
</table>

*Each value represents the mean of four lambs. The blood samples were withdrawn 5 h after feeding.

b,c Values with different superscripts are significantly different (P<.05).

MCT = medium chain triglycerides.

TABLE 3. Average blood glucosea and standard error of the mean during continuous intravenous infusion of different energy sources.

<table>
<thead>
<tr>
<th>Substrate infused</th>
<th>Blood glucose (mg/100 ml)</th>
<th>Standard error of the mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline (control)</td>
<td>70.0b</td>
<td>±2.2</td>
</tr>
<tr>
<td>Xylitol</td>
<td>49.6c</td>
<td>±3.1</td>
</tr>
<tr>
<td>MCT</td>
<td>60.0d</td>
<td>±3.3</td>
</tr>
<tr>
<td>Corn oil</td>
<td>68.8e</td>
<td>±3.1</td>
</tr>
</tbody>
</table>

* Samples taken 5 h after last feeding. Each value is the mean of four lambs for 4 days.

b,c,d Different superscripts indicate significant differences (P<.01).

MCT = medium chain triglycerides.

Fatty acids of varying chain length exercise multiple effects on glucose metabolism. Those with medium chain length and their metabolites inhibit glucose uptake and use by peripheral tissues in dogs (9). This action is in concert with the hypothesis that fatty acids block the effect of insulin on transfer of glucose (13). There are also studies where MCT administration did not affect blood glucose in normal subjects (7, 16).

The mechanism responsible for enhancement of glucose tolerance by MCT was not clarified in the study by Tantibhedhyangkul et al. (17) since improvement in glucose tolerance was similar following ingestion of corn oil. We did not observe a significant decrease in blood glucose by intravenous administration of corn oil as we did during MCT infusion.

References


