Energy and Nutrient Utilization by the Calf's Gut

Germain Nappert,[1] Gordon Zello,[2] Jonathan M. Naylor[3]
[1]*Department of Veterinary Medicine and Surgery, College of Veterinary Medicine, University of Missouri-Columbia, Clydesdale Hall, Columbia, MO*
[2]*Department of Veterinary Internal Medicine, Western College of Veterinary Medicine*
[3]*College of Pharmacy and Nutrition, University of Saskatchewan, Saskatoon, SK*

Introduction

Nutritional requirements across the portal-drained viscera of preruminant calves were determined using an arteriovenous difference technique. In the current studies, a bilateral subcostal approach was used to reach the portal area to provide access for proper placement of an ultrasonic transit time flow probe around the portal vein. The application of an ultrasonic flow probe provided consistent measurements of blood flow. The umbilical vein was used as an entry point for the portal vein catheter. The femoral artery was also catheterized. Using blood flow measurements and arteriovenous differences we could measure net nutrient uptake. This model has been performed successfully on healthy calves, but the study may have implications in the development of treatment to promote intestinal healing in diarrheic calves.

Materials and Methods/Discussion

The small intestine is usually the major site of glutamine utilization in the mammalian body. However, the role of glutamine as an energy source or a precursor for synthesis of other amino acids and nucleotides such as ATP, purines, and pyrimidines in the intestine of the preruminant calf is not clear. Therefore, intestinal metabolism was investigated by intravenous infusion of possible nutrients in four neonatal calves. The experimental design consisted of a series of infusions conducted on four different study days in each calf. On the study days, four separate one hour infusions of acetate, glucose, glutamine, saline (control) were administered intravenously via the jugular vein at a rate of 200 mmol/L/h in a different order. Venous and arterial blood was collected over the last 15 min of each one hour infusion. Our study shows that during acetate, glucose, and saline infusions, glucose was a greater source of energy than glutamine for the gut. However, during glutamine infusion, intestinal glutamine uptake increased significantly which was associated with a rise in ammonia production. There was net intestinal production of acetate during all the infusions. There was some tendency for PDV oxygen consumption to change between infusions. Oxygen consumption was lowest during glucose infusions and highest during glutamine infusions. If the same holds true in diarrheic calves, this work has interesting implications.

Diarrheic calves often have bacteremia. The high frequency of septicemia in preruminant calves may be explained by injury to their gastrointestinal tract, which predisposes to translocation of opportunistic bacteria in the intestine. The countercurrent blood circulation in the intestinal villi make them extremely susceptible to damage from lack of oxygen when blood flow is low. Oxygen leaves the arterioles for the venous circulation as blood passes towards the tip of the villi. In consequence, arterial oxygen content is reduced at the villous tip. This effect is enhanced when flow rates are low, as in shock, and the villous tip can become anoxic and slough. Because intravenous glucose has a tendency to reduce the intestinal oxygen requirement, it might be possible to spare the villi from some of this anoxic damage by adding glucose to intravenous fluids. The use of intravenous glucose supplementation should be recommended when bicarbonate is included in the fluids to correct acidosis, because glucose is initially converted to lactic acid. Therefore, glucose supplementation should only be required when the diarrheic calves are in shock, and tissue metabolism is failing.

Considering the results of our study on the short-term intravenous infusion of nutrients, we decided to quantify further PDV glutamine utilization, and to determine if glutamine uptake could be further stimulated either by longer term intravenous infusion or by chronic oral supplementation. Feeding glutamine orally did not alter the PDV glutamine uptake. Glutamine infusion did not increase the PDV uptake of essential amino acids. Neither chronic oral supplementation with glutamine, or infusion for periods longer than an hour, further increased intestinal glutamine uptake. Arterial

leucine concentration and intestinal uptake declined during glutamine infusion suggesting that its supply became limiting. Thus various nutrients combined with glutamine supplementation might be most successful, because glutamine supplementation increases the use of other amino acids.

Although arteriovenous concentration difference studies do not provide detailed information about transport and metabolism in individual cells, they do provide important information about how organ handling of specific nutrients changes during feeding, starvation, and disease states. Additional research is needed in calves to determine the differential utilization of nutrients depending on whether they are presented to the intestinal cells intraluminally or from the bloodstream. For the future of oral rehydration therapy, the addition of glutamine will be of interest. Investigations in laboratory animals have demonstrated that glutamine feeding improves growth and repair of the small intestinal mucosa and helps maintain intestinal immune function. Glutamine stimulates also sodium uptake by the mucosal cells of the small intestine. Our improved understanding of intestinal physiology suggests some reasons for the failure of the first study. Feeding glutamine seems to have a general trophic effect and increase the uptake of a variety of nutrients. It may be that glutamine supplementation will only be effective as part of a more balanced diet that supplies the breadth of nutrients required for the synthesis of new intestine.

Conclusion

The purpose of our study was to determine which nutrients are used by the intestine of the calf and to determine if simple supplementation with these nutrients would promote intestinal metabolism. Glutamine has a role in intestinal mucosal function and metabolism in preruminant calves. Glutamine supplementation could provide a new approach to promote intestinal healing when treating diarrheic calves. **However, additional studies must be performed before there is sufficient information to properly recommend that glutamine supplementation is safe and effective in clinical treatment.**