Plasma Ketone Levels in Neonatal Calves Fed Medium Chain Triglycerides in Milk

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ABSTRACT. Milk fortified with medium chain triglycerides (MCT) was given to neonatal calves to increase their energy intake. Tricaprylin (C_8), tricaprln (C_{10}), a mixture of C_8 and C_{10} (mixed MCT) or soya oil were given at 11-18 days of age. Feeding C_8 , C_{10} , and mixed MCT caused a transient hyperketonemia (3-HB, acetoacetate). Plasma ketone levels returned to the initial ones within 3 hr at 40 or 80 ml of mixed MCT feeding, though hyperketonemia was marked and more persistent at 120 ml dose in one meal. Hyperketonemia caused by C_8 was stronger than those caused by C_{10} . Soya oil caused no increase in plasma ketone levels.—**KEY WORDS:** calf, ketone, medium chain triglyceride.

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Medium chain triglycerides (MCT), which consist of fatty acids 8-12 carbon atoms long (medium chain fatty acid; MCFA), have different digestion and absorption properties from long chain triglycerides (LCT). Most MCFAs are absorbed from the small intestine more easily than LCT even in a patient with diminished secretion of digestive enzyme or in immature infants [2]. After absorption, most of them are transported to the liver directly *via* the portal circulation, and not incorporated directly into blood triglycerides nor deposited as adipose tissue lipids [1-3].

As neonatal calves are completely dependent upon milk for their energy intake, increasing the energy level of the milk may improve their growth performance. Feeding MCT is thought to be advantageous owing to their efficient digestion and absorption. However, in the liver MCFAs are metabolized (*via* β -oxidation), and turned into TCA cycle metabolism or ketogenesis [2]. Thus, MCT feeding results in accelerated oxidation of MCFA and increased ketogenesis [2, 3, 5]. In the present study, plasma ketone levels were measured whilst feeding several doses of MCTs to calves during the neonatal period.

Pure tricaprylin (C_8), pure tricaprln (C_{10}), a 6:4 mixture of C_8 and C_{10} (mixed MCT; Kao Co., Tokyo) and soya oil were used. The fatty acid composition of soya oil is 10.6% of $C_{16:0}$, 22.1% of $C_{18:1}$ and 56.3% of $C_{18:2}$.

Trial 1. Dose response of mixed MCT: Twin neonatal calves (male and female; Holstein) were housed in individual pens, and fed 5 kg milk daily in two meals. Both animals weighed 40 kg. Mixed MCT were fed in a morning meal when the calves were between 11 and 15 days of age. On day 1, only 2.5 kg of milk was fed (control). On days 2, 3 and 4, 40, 80 and 120 ml of the mixed MCT was fed with the milk (2.5 kg), respectively. On day 5, milk mixed with 80 ml of soya oil was fed. The doses of mixed MCT (40, 80 and 120 ml) correspond to 0.1, 0.2 and 0.3% of live weight of the calves.

Jugular blood (about 5 ml) was taken prior to feeding, and every 30 min for the following 3 hr. Plasma 3-hydroxybutyrate (3-HB) and acetoacetate (AcAc) were analyzed [4].

Trial 2. Comparison of C_8 and C_{10} : The calves

mentioned above were used in a further study when they were 17 and 18 days of age (weighing 42-43 kg). At morning feeding, 85 ml of C_{10} or C_8 was given with the milk (2.5 kg), the dose was equivalent to 0.2% of the calf's live weight. Tricaprin (C_{10}) is solid at room temperature, so it was given after heating in a water bath. Blood samples were taken as in Trial 1 for 4 hr after feeding, and plasma ketone levels were estimated.

The calves readily consumed the milk fortified with any of the fats. In one calf, diarrhea was observed after feeding 120 ml of mixed MCT, and after feeding 85 ml of C_{10} in trial 2.

Plasma 3-HB and AcAc levels at the different doses of mixed MCT and soya oil feeding (Trial 1) are shown in Fig. 1. The levels of 3-HB and AcAc were increased by 80 and 120 ml feeding of mixed MCT, though 3-HB levels increased only in one calf at 40 ml feeding. Plasma 3-HB and AcAc levels recovered within 3 hr in 40 and 80 ml feeding of mixed MCT, though hyperketonemia was more persistent at the 120 ml dose. Soya oil feeding caused no increase in 3-HB or AcAc, as in the control. This means that the accelerated ketogenesis and hyperketonemia are brought about by feeding MCT, as shown in steers [4] or monogastric animals [2, 3], and not caused by LCT which is in soya oil.

Ketone bodies are an important metabolic substrate for many tissues (for energy or precursors for lipogenesis),

Fig. 1. Plasma 3-hydroxybutyrate (3-HB) and acetoacetate (AcAc) levels after feeding fats to neonatal calves (11-15 days old). Single estimation in each calf. MCT: A mixture of tricaprylin (C_8) and tricaprln (C_{10}).

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Fig. 2. Plasma 3-hydroxybutyrate (3-HB) and acetoacetate (AcAc) concentrations after feeding 85 ml of tricaprylin (C₈) and tricaprin (C₁₀) with milk to neonatal calves (17–18 days old). Single estimation in each calf.

and are efficiently utilized in many animals [2]. It is likely that the transient increase in plasma ketone might not be a serious problem for animals if the ketone bodies are metabolized promptly. Persistent hyperketonemia in 120 ml feeding might be brought about by exceeding the

metabolic capacity of the liver and peripheral tissues. Considering not only more persistent hyperketonemia but also diarrhea incidence, feeding a dose of 120 ml in one meal seems to be excessive for newborn calves.

Plasma 3-HB and AcAc levels after C₈ or C₁₀ feeding are shown in Fig. 2. Feeding C₈ caused a higher ketonemia than C₁₀. It has been noted that, in pigs, the increase in blood 3-HB after C₁₀ feeding is less than that caused by C₇, C₈ and C₉ feeding [3]. The difference between C₈ and C₁₀ in the hyperketonemia response may be partly attributable to a shift in the absorption route. Increasing hydrophobicity with advancing chain length (*i.e.*, C₁₀ comparing to C₈) may facilitate their absorption into the lymphatic circulation [3]. These phenomena might be related to weak ketonemia and diarrhea incidence following C₁₀ feeding.

In conclusion, MCT (C₈ and C₁₀) feeding caused marked ketogenesis in neonatal calves, though hyperketonemia recovered within a few hrs after MCT feeding. The ketogenic response was stronger following C₈ feeding than following C₁₀ feeding. Feeding 120 ml of mixed MCT in one meal seems to be excessive for newborn calves.

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