Fat and protein mobilization in early-lactation in dairy cows

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Dairy cows experience negative energy balance (NEB) for several weeks after parturition, and fat reserves and muscle protein are mobilized to compensate for the energy deficit. Muscle protein mobilization occurs mainly in the first few weeks after calving, whereas fat mobilization can continue to more than 8 weeks postpartum (Tamminga et al., 1997; Van Knegsel et al., 2007). Information on the biological variation in protein mobilization is limited, and most knowledge on protein mobilization of dairy cows was obtained in experimental feeding trials. Although cows can mobilize less energy from muscle protein than from fat reserves (Tamminga et al., 1997; Van Knegsel et al., 2007), muscle breakdown is of significant importance during NEB, as mobilized glucogenic amino acids can be used for gluconeogenesis in the liver. It could be speculated that mobilization of protein might be relevant to reduce the risk on hyperketonemia in early lactation, because a larger breakdown of muscle breakdown will supply more glucose precursors in the period of most severe fat mobilization. It was, therefore, hypothesized that the risk of hyperketonemia decreases when mobilization of muscle protein is relatively large compared to that of fat.

We performed an observational study with thirty-four cows from the university farm of the Faculty of Veterinary Medicine to obtain information on variation between dairy cows in muscle and fat tissue mobilization around parturition (Van der Drift et al., 2012). Cows were monitored weekly from four weeks before until eight weeks after calving. Mobilization of muscle protein was investigated by analysis of plasma 3-methylhistidin (3-MH) concentrations and ultrasound measurements of longissimus muscle thickness. Plasma 3-methylhistidin can be used as an indicator of muscle protein breakdown in cattle, and we recently developed a HPLC tandem mass spectrometry method to analyze 3-MH separately from 1-methylhistidin, another histidine derivative in blood (Houweling et al., 2012). Mobilization of fat tissue was monitored by serum non-esterified fatty acid (NEFA) concentrations and ultrasound measurements of backfat thickness. Time patterns were investigated by linear mixed-effects models. We investigated whether cows’ indicators for protein and fat mobilization in blood were associated with weekly analyzed serum β-hydroxybutyrate (BHBA) concentrations by calculating the area under the curve (AUC) for all variables followed by multivariate linear regression analysis. Results from the study are presented and discussed at today’s symposium.

Large variation occurred in the onset and duration of periparturient protein and fat mobilization in cows from our study. The average coefficient of variation for plasma 3-MH concentrations in individual weeks was 42.2%. Cows mobilized 18% ± 9% of longissimus muscle thickness and 35% ± 26% of backfat thickness. Cows with higher longissimus muscle and backfat thickness at four weeks prepartum mobilized a greater amount of muscle (tendency, P < 0.10) and fat thickness (P < 0.001) during the study. Muscle protein started to be mobilized before parturition in most cows, which continued until approximately week four of lactation. In contrast, fat mobilization occurred on average from parturition until the end of the study (8 weeks postpartum). This indicates that significant muscle breakdown may occur before parturition and in advance of fat mobilization, which suggests differences in the regulation of protein and fat mobilization in dairy cows. Regulatory mechanisms of protein mobilization are unfortunately still poorly understood, but insulin and amino acids seem to play key roles. Low availability of
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Fat and protein mobilization in early lactation in dairy cows, amino acids is thought to reduce the inhibitory effect of insulin on proteolysis, thus facilitating muscle protein degradation (Prod’homme et al., 2004; Tesseraud et al., 2007). It was, therefore, suggested that the prepartum muscle breakdown in our study was caused by a pre-partum amino acid deficiency in absence of NEB. Unfortunately, the protein intake of cows was unknown, because feed intake measurements were not feasible during this study.

In the majority of cows (n = 31), higher plasma 3-MH concentrations were associated with lower serum BHBA concentrations (P < 0.05). This observation supports our hypothesis that, under similar dietary conditions, ketone body production could be restricted in cows that mobilize more muscle protein relative to fat tissue after parturition. The remaining cows (n = 3) in our study suffered from severe hyperketonemia postpartum (mean postpartum serum BHBA concentration > 1.20 mmol/L). Plasma 3-MH concentrations and especially serum NEFA concentrations were very large in these animals. It could be suggested that in these animals, muscle protein mobilization was too small to “counteract” the effect of fat mobilization on ketone body formation. Clearly, the validity of our hypothesis needs to be confirmed by controlled feeding trials, but our study indicates that the role of protein mobilization in the etiology of hyperketonemia in dairy cows deserves further investigation.

Cows with larger intrinsic capacity to mobilize muscle may benefit from a larger glucogenic amino acid supply after parturition. For all cows, however, mobilization of muscle protein before parturition, such as occurred in our study, should be avoided. With all current efforts in practice to prevent fattening of cows with energy-controlled dry cow diets, care should be taken to provide dry cows with sufficient dietary protein, so that protein mobilization is not initiated before parturition.

References