

Fatty Acid Profiles and Eicosanoid Biosynthesis in Transition Dairy Cows

G.A. Contreras, DVM, MSc; N.J. O'Boyle, BVSc, MRCVS; J.C. Gandy; L.M. Sordillo, PhD
Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing, MI 48824

Introduction

The onset of lactation imposes considerable changes in dietary requirements and metabolic functions. These adaptations occur during the transition period (TP) that begins 3 wks before through 3 wk after parturition. This period is associated with an elevated incidence of diseases that cause a significant reduction in the profitability of dairy herds. Energy requirements of the TP dairy cow are unable to be met by the diet and must rely on tissue reserves. Mobilization of fat from tissues releases non-esterified fatty acids (NEFA) into the blood stream which are used as energy; however, NEFA function is not limited to energy supply. These compounds can serve as substrates for the biosynthesis of inflammatory lipid mediators (LM). The two major enzymes for eicosanoid synthesis are cyclooxygenases (COX) and lipoxygenases (LOX). The increased activity of these enzymatic pathways could lead to an enhanced inflammatory response. Despite recent advances in TP dairy cow health, little is known about the relationship between variations in the plasma fatty acid (FA) profile and the production of LM through both COX and LOX biosynthetic pathways. We hypothesize that plasma FA profiles and expression of enzymes associated with eicosanoid biosynthesis shift during the transition period.

Materials and Methods

Mature dairy cows were selected upon dry-off. Blood was collected at 14 and 7 d before expected calving date, at calving, and at 7 and 14 d after calving. Plasma and isolated peripheral blood mononuclear cells (PBMC) were obtained. PBMC populations were analyzed by flow cytometry. RNA from adherent (monocyte) and non-adherent (lymphocyte) cell fractions was collected to determine gene expression for 5LOX, 15LOX-1, COX-1 and COX-2. NEFA fractions were separated from plasma total lipid extractions by serum protein electrophoresis (SPE). FAs were quantified by gas-liquid chromatography (GLC). Variables were analyzed as repeated measures using a mixed model procedure.

Results

Results demonstrated that weight percentages in total lipids extracted from plasma for linoleic acid (LA) increased significantly in early lactation. Within the NEFA fraction, palmitic (PA) and stearic acid (SA) were found at higher concentrations during early lactation compared to pre-calving values. PBMC population showed an increase in the monocyte fraction and a decrease in the T cell subpopulation at calving through 7 d post-calving. COX-1 expression remained constant through the transition period in PBMC subpopulations. Post-calving transcript expression of 5LOX and 15LOX-1 in PBMC, monocytes and lymphocytes increased compared to prepartum values.

Significance

This study demonstrated for the first time that in healthy dairy cows, PBMC (monocytes and lymphocytes) increased their transcript expression of 15LOX-1 and 5LOX in early lactation. LOX metabolite production also could be enhanced by the increase in the monocyte fraction, an important source of 5LOX and 15LOX enzymes. Furthermore, increased plasma concentrations of LA, a major substrate for LOX pathways, and saturated NEFAs, such as PA and SA, could increase LOX biosynthetic activity in early lactation. Previous studies in humans suggested that 15LOX-1 metabolites induce responses that could explain, at least in part, some physiological characteristics observed in dairy cows during TP, including delayed neutrophil migration, enhanced expression of adhesion molecules and an increased oxidation of cellular membrane lipids. Understanding the interactions between FA dynamics and LM-producing enzymes could lead to dietary interventions, or new nutraceuticals and pharmacologicals that target the biosynthesis of eicosanoids. The ability to effectively control pro-inflammatory LM production could improve the health of dairy cows during the TP.