J. Dairy Sci. 101:1–14
https://doi.org/10.3168/jds.2017-13151

A randomized controlled trial on the effect of incomplete milking during early lactation on ketonemia and body condition loss in Holstein dairy cows

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ABSTRACT

Limiting milk production for a short period of time in early lactation could be a relevant strategy to prevent hyperketonemia (HYK). From December 2013 to March 2015, 838 multiparous Holstein cows from 13 herds were enrolled in a randomized controlled trial evaluating the effect of incomplete milking in early lactation on ketonemia and its effect on body condition score (BCS) loss. Cows were randomly assigned 4 wk before expected calving date to 1 of 2 treatment groups, (1) a conventional milking protocol (CON) for which cows were completely milked or (2) an incomplete milking protocol (INC) for which a maximum of 10 to 14 kg of milk/d were withdrawn during the first 5 d in milk (DIM). β-Hydroxybutyrate (BHB) concentrations were measured from blood samples collected on each cow 3 times at weekly intervals. Hyperketonemia was defined as BHB ≥1.4 mmol/L. Body condition score variation in the postcalving period was calculated by subtracting BCS assessed at wk 7 from BCS assessed at first week after calving. Effect of treatment on ketonemia and prevalence of HYK were evaluated for 4 specific time periods: 1 to 3, 4 to 7, 8 to 17, and 18 to 26 DIM. Effect of treatment on ketonemia was investigated using linear mixed models with natural logarithm of BHB measurements as outcome and treatment groups as fixed effect. Generalized linear mixed models with HYK as outcome, using logit link, and treatment groups as fixed effect were used to investigate effect of treatment on odds of HYK. A logistic regression model with BCS loss (<0.75 or ≥0.75) as outcome and treatment groups and herd as fixed effects was used to study effect of INC on odds of having BCS loss ≥0.75. A total of 813 lactations had complete data and were used for statistical analysis of ketonemia and HYK. A total of 709 lactations had complete data and were used for analysis of BCS loss. Geometric means of blood BHB concentrations during the 1 to 3, 4 to 7, 8 to 17, and 18 to 26 DIM periods were, respectively, 0.72 (95% confidence interval = 0.66, 0.80), 0.66 (0.60, 0.73), 0.90 (0.80, 1.01), and 0.93 (0.83, 1.05) mmol/L for INC, and 0.65 (0.59, 0.72), 0.79 (0.72, 0.87), 0.94 (0.84, 1.06), and 0.92 (0.82, 1.04) mmol/L for CON. Cows in INC group had lower ketonemia during the 4 to 7 DIM period. Predicted prevalence of HYK during the 1 to 3, 4 to 7, 8 to 17, and 18 to 26 DIM periods were, respectively, 2.8 (3.2, 15.1), 4.6 (2.0, 10.0), 13.4 (8.4, 20.0), and 23.0% (17.4, 29.7) for INC and 2.6 (2.5, 13.8), 10.7 (5.6, 19.3), 19.4 (13.0, 27.9), and 21.3% (16.0, 27.8) for CON. The INC treatment reduced the prevalence of HYK during the 4 to 7 and 8 to 17 DIM periods. No association was observed between INC and BCS loss in the postcalving period. Overall, the incomplete milking protocol was effective for reducing ketonemia and prevalence of HYK during the early postpartum period.
Key words: dairy cow, ketosis, body condition score, incomplete milking, randomized controlled trial

INTRODUCTION

The peripartum transition period is generally defined as the interval from 3 wk before to 3 wk after calving (Wang et al., 2012). This period covers the end of pregnancy, parturition, and early lactation. Major hormonal, metabolic, and nutritional changes occur during this period while the animal aims to maintain homeostasis, to start lactogenesis, and to allow growth of the fetus and the cow itself (Bauman and Currie, 1980). In parallel to these changes, the cow's DMI increases from its nadir at calving to peak between wk 10 and 14 of lactation (NRC, 2001). Unfortunately, this peak of

Received May 12, 2017.
Accepted January 9, 2018.
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DMI is not synchronized with milk peak yield, which is usually observed between the fourth and eighth week of lactation (Keown et al., 1986). Because of the gap between DMI and milk peaks, an unavoidable period of negative energy balance (**NEB**) occurs (Holtenius et Holtenius, 1996). During NEB, carbohydrates are depleted quickly and cows have to use fat and protein reserves as source of energy (Tamminga et al., 1997; Herdt, 2000). This fat mobilization usually leads to ketone bodies production, an important source of energy for ruminants (Herdt, 2000). When excessive ketone bodies accumulate in blood, hyperketonemia (**HYK**) can occur and is associated with various health issues (Suthar et al., 2013; McArt et al., 2015). Thresholds of blood BHB values from ≥1.0 to ≥1.4 mmol/L have been suggested to define HYK (Geishauser et al., 2000; Duffield et al., 2009; Ospina et al., 2010). Using milk BHB values, Santschi et al. (2016) showed that the overall prevalence of HYK in dairy herds in Quebec (Canada) was 22.6%, with a higher prevalence for older cows (27.6%). Using blood BHB values from 126 commercial dairy herds in Quebec (Canada), Dubuc and Denis-Robichaud (2017) observed a similar median herd prevalence (18%) with important variation (range = 4.0–75.0%). Average cost per case of HYK was estimated at Can$203 (Gohary et al., 2016) in Canada, €257 (Raboisson et al., 2015) in Europe, and $289 (McArt et al., 2015) in the United States.

To modulate NEB, most research focused on optimizing energy input during the transition period. Nonetheless, it is also possible to improve energy balance by reducing energy output. The latter could be achieved by limiting the amount of milk harvested for a few days at the beginning of lactation. In a previous study, this was achieved by milking cows once a day during the first week of lactation (Loiselle et al., 2009). In another study, the volume of milk harvested was restricted during the first 5 DIM without altering milking frequency (Carbonneau et al., 2012). Whereas both strategies proved to be efficient for limiting NEB, milking cows once a day during the first week of lactation resulted in a reduction of 8.1% of the daily milk production over the first 13 wk of lactation compared with cows milked twice a day. This important milk yield reduction makes this approach less applicable in a commercial dairy context. When limiting milk extracted without altering milking frequency, however, no negative residual effect of treatment on subsequent milk production was observed (Carbonneau et al., 2012). The strategy proposed by Carbonneau et al. (2012) shows great potential but needs to be evaluated in a commercial farm environment. Therefore, the main objectives of our study were to evaluate the effect of an incomplete milking protocol (**INC**) on ketonemia and prevalence of HYK in early lactation. A secondary objective was to evaluate its effect on body condition loss from calving to milk peak; our hypotheses were that those NEB markers would be improved by the proposed strategy.

MATERIALS AND METHODS

A randomized controlled trial (**RCT**) was conducted to achieve study objectives. Research protocol was approved by Animal Ethics Committee of the Université de Montréal (13-Rech-1701). The reporting guidelines for Randomized Control Trials in Livestock and Food Safety statement (REFLECT) was used for planning the study and for preparing this manuscript (O'Connor et al., 2010).

Participants

A convenient sample of 13 commercial dairy herds located within 50 km of Saint-Hyacinthe (Quebec, Canada) were selected for this RCT. To be eligible, dairy producers had to (1) milk multiparous cows (≥2nd lactation) as indicated by the research team following the randomization process; (2) record specific health events occurring on enrolled cows (dystocia, clinical hypocalcemia, and retained placenta) ; (3) allow minimally invasive sampling on their animals by the research team such as venipuncture of coccygeal vessels; (4) share DHI records with the research team; and (50 manually or electronically record milk production of each enrolled cow at least twice a week for the first 3 wk of lactation. Results from ketonemia measurements were made available to dairy producers, as many of them already used these measurements as part of their monitoring program. No recommendation was made, however, regarding the decision to treat an animal, the treatment, or for modifying the general farm management.

Sample Size Estimation

Sample size calculations were conducted a priori for each of the outcomes studied in this RCT using the POWER procedure of the SAS 9.4 software (SAS Institute Inc., Cary, NC). The outcome requiring the largest sample size was odds of HYK. Assuming a prevalence of HYK of 12% in the CON group (Chapinal et al., 2011) and of 6% in the INC group (Carbonneau et al., 2012), a type I error rate of 0.05, and using a 2-tail Fisher's exact test (Fisher, 1935), we estimated that a sample size of 386 animals per treatment group was required to achieve a power of 90%. As these calculations did not