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The effect of milking reinitiation following extended nonmilking periods on lactation in primiparous dairy cows

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ABSTRACT

In dairy cows, extended periods of nonmilking results in reduced milk secretion, modifications in milk composition, and eventually involution of the mammary glands. The aim of this study was to determine the effect of extended nonmilking periods on the recovery of milk yield and composition, and levels of prolactin and insulin-like growth factor-I in pasture-fed cows after resuming milking. Pasture-fed, primiparous, nonpregnant, Friesian dairy cows at mid lactation (mean ± standard deviation, 97 ± 2 d in milk, 14.0 ± 2.5 L/d) were divided into 3 groups (n = 6 per group). The cows were subjected to nonmilking periods of 7, 14, or 28 d. Twice-daily milking was resumed for 7 d following the nonmilking periods. Milk yield recoveries at the end of the 7-d remilking period were 91, 51, and 29% for the 7, 14, and 28-d nonmilked groups, respectively. The somatic cell count declined to less than 400,000 cells/mL by d 3 and 6 of remilking for the 7- and 14-d-nonmilked groups, respectively, but remained greater than 800,000 cells/mL in the 28-d-nonmilked group through the 7-d remilking period. By d 7 of remilking, the somatic cell count for the 7-d-nonmilked group was not different from pretrial values. Upon remilking, the milk fat content returned to pretrial values for the 7- and 14-d-nonmilked groups, although it remained lower than pretrial for the 28-d-nonmilked group. All 3 nonmilked groups had a higher milk protein content following 7 d of remilking, compared with pretrial values. The lactose content returned to pretrial values for the 7-d-nonmilked group but remained lower for the 14- and 28-d-nonmilked groups. Circulating prolactin concentrations increased once remilking was resumed, compared with the pretrial and nonmilking periods. Prolactin concentrations did not majorly differ between the groups, with the levels upon 7 d of remilking remaining higher than the pretrial concentrations and the nonmilked periods. Plasma concentrations of insulin-like growth factor-I increased during the nonmilking period and were greater in all 3 nonmilked groups on d 1 of remilking than pretrial values and returned to pretrial concentrations following remilking for the 7-d-nonmilked group, whereas the 14- and 28-d-nonmilked groups remained higher than the pretrial values. These data indicate that the process of involution is fully reversed after remilking following 7 d of milk stasis but more extended periods of nonmilking prevent the complete recovery of lactation. However, even after 28 d of milk stasis, the milk synthesis capacity of the mammary gland could still be partially recovered.
Key words: milk production, involution, mammary gland, dairy cow

INTRODUCTION

In dairy cows, the cessation of milk removal for extended periods, such as while drying off, initiates the process of mammary gland involution, resulting in a decline of mammary secretions and changes in the composition of the secretion (Hurley, 1989). This may be reversible upon remilking following extended nonmilking periods (Noble and Hurley, 1999). Because of the dairy management system in New Zealand (seasonal, pasture based), farms are vulnerable to adverse weather conditions and calamities such as flooding, preventing cows from being milked for extended periods of time, sometimes for up to several days, and thus, it is of interest to understand the duration of nonmilking and reversibility of mammary gland involution. The extent to which mammary gland involution is reversible varies among species. In rodents, the cessation of milk removal results in involution of the mammary gland in 2 distinct stages. During the first stage, mammary engorgement leads to a rapid reduction of milk synthesis and secretion and the initiation of apoptosis. The second stage begins 72 to 96 h after mammary engorgement and involves further apoptosis, degradation of the extracel-

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lular matrix, and structural degradation of alveoli with almost complete loss of mammary epithelial cells (Jaggi et al., 1996; Lund et al., 1996; Li et al., 1997). This regression results ultimately in irreversible involution during the second stage. However, this process is reversible within the first 48 h (Jaggi et al., 1996; Li et al., 1997; McMahon et al., 2004). The reversible nature of the initial stages of involution in the rodent mammary gland has been demonstrated following resuckling of engorged rat mammary glands (McMahon et al., 2004).

In contrast to the rodent mammary gland, involution in cows does not occur to the same extent (Capuco and Akers, 1999; Wilde et al., 1999). The cessation of milk removal is followed by changes occurring within 16 to 18 h of milk accumulation, which includes distension of the mammary gland, a decline in the rate of milk secretion, an increase in intramammary pressure, a decrease in mammary blood flow, increased tight-junction permeability and lactose efflux, and an inflammatory response (Hurley, 1989; Davis et al., 1999). Milk secretion completely ceases by approximately 30 h after milking (Hurley, 1989). Milk protein gene expression declines (Goodman and Schanbacher, 1991) as early as 24 h after milking (Singh et al., 2008), and apoptosis of mammary epithelial cells increases (Wilde et al., 1997), which may occur by 72 h after milking (Singh et al., 2005), although not to the same extent as in rodent mammary glands. Morphological changes in the mammary gland occur within 7 d of nonmilking, demonstrated by a reduction in luminal alveolar area and an increase in the stromal area, as secretions are absorbed (Holst et al., 1987; Hurley, 1989). The rate of involution becomes more gradual, and by d 21 to 30 of nonmilking extensive remodeling of the mammary gland has occurred in preparation for the next lactation (Holst et al., 1987; Hurley, 1989; Capuco and Akers, 1999). However, unlike in rodents, many alveolar structures are retained (Holst et al., 1987; Hurley, 1989), which may allow for reversibility of involution following extended nonmilking periods in cows (Noble and Hurley, 1999). Milk yield can be fully restored upon remilking following nonmilking periods of up to 7 d (Farr et al., 1998; Dalley and Davis, 2006). However, only a partial recovery of milk yield was observed following an 11-d-nonmilking interval (Noble and Hurley, 1999) although a longer remilking period may have allowed for a greater milk yield recovery. Local intramammary signals are responsible for initiating involution and the loss of mammary epithelial cells by apoptosis (Li et al., 1997). The primary signal initiating the involution process is unknown but several mechanisms have been postulated including the accumulation in milk of regulatory factors such as putative feed-back inhibitory factor (Wilde et al., 1999), milk casein fractions (Shamay et al., 2003) and serotonin (Collier et al., 2012). Alternatively, physical distension of the mammary gland that results in changes in cell shape may activate mechanotransduction pathways, resulting in loss of tight junction integrity and cell–extracellular survival signaling (Davis et al., 1999; Stelwagen, 2001). Furthermore, hormonal regulation through the interaction of prolactin (**PRL**) and growth hormone via IGF-I may play a role in regulating mammary function and mammary epithelial cell survival (Flint and Knight, 1997; Accorsi et al., 2002). The aim of this study was to determine the effect of extended nonmilking periods in pasture-fed cows on recovery of milk yield and composition, and PRL and IGF-I levels.

MATERIALS AND METHODS

Animal Experiment

Eighteen nonpregnant, primiparous, Friesian dairy cows in mid lactation (97 ± 2 DIM), during spring and early summer, producing 14.0 ± 2.5 L/d of milk were used in the study. Cows selected for the study were determined to be free of intramammary infection as indicated by negative bacterial cultures and low SCC (mean: 48,980 cells/mL, range: 17,000 to 134,000). Prior to commencement of the experiment, all cows were solely pasture fed and milked twice daily. The experiment consisted of a 7-d pretrial period, a nonmilking treatment period of 3 specified lengths, and a 7-d milking reinitiation period. Cows were randomly assigned to 1 of 3 treatments (n = 6 per group) consisting of 7, 14, or 28 d of nonmilking during the nonmilking treatment period. Following cessation of milk removal, all cows were managed as a single herd away from the milking shed and had restricted pasture and additional bulk filler (straw) to facilitate cessation of milk synthesis. Upon reinitiation of milking, cows were monitored for signs of mastitis. To prevent mastitis, a systemic administration antibiotic [Mamyzin, Boehringer Ingelheim (NZ) Ltd., Manukau City, Auckland, New Zealand] was administered to all cows for 3 consecutive days before the nonmilking intervals and to remilking. Secretions were hand stripped from the involuting glands as required and before the cups were placed on the teats to further stimulate reinitiation of lactation. Following the nonmilking period, twice daily milking was reinitiated, and milk production and milk composition was measured for 7 d. The average milk yield in the reference herd of 45 primiparous cows, which were similar DIM to the trial cows, and milked during the trial period, ranged from 14.1 to 17.3 L/d.