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The effect of manual and mechanical stimulation on oxytocin release and milking characteristics in Holstein cows milked 3 times daily

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ABSTRACT

Prestimulation administered to a cow before attachment of the milking unit has historically been performed manually. Development of innovative milking technology has allowed manual stimulation to be replaced by mechanical forms of stimulation. Holstein cows (n = 30) were enrolled in a crossover design to determine the effect of manual stimulation (forestripping and drying) and high-vibration pulsation on oxytocin profiles, milk yield, milk flow rates, incidence of delayed milk ejection causing bimodal milk flow curves, and residual milk in Holstein cows milked 3 times daily (3×). All cows were subjected to all treatments. Cows received manual (forestripping and drying) or mechanical (high-vibration pulsation) stimulation along with lag times of 0, 30, or 90 s for 21 consecutive milkings. Forestripping involved the manual removal of 2 streams of milk from each teat and drying of the teats. High-vibration pulsation involved increasing the pulsation cycles from 60 to 300 pulses/min and reducing the vacuum in the pulsation chamber to 20 kPa. The 5 treatments were (1) immediate attachment of the milking machine under normal pulsation (T0); (2) dip plus forestrip and drying with 30-s lag time (FD30); (3) dip plus forestrip and drying with 90-s lag time (FD90); (4) high-vibration pulsation for 30 s (HV30); and (5) high-vibration pulsation for 90 s (HV90). Milk yield per milking averaged 14.0 kg and was significantly different among treatments; however, the maximum difference detected among treatments was 0.8 kg/milking. Milking unit on-time, which represents the time when the milking unit is under normal pulsation and harvesting milk (excluding the high-vibration pulsation time of 30 or 90 s), was shortest (245 s) for cows subjected to 90 s of high-vibration pulsation (HV90) and ranged from 256 to 261 s for all other treatments. Milk harvest may have begun during high-vibration pulsation; however, only 0.13 and 0.32 kg of milk was harvested during high-vibration pulsation for HV30 and HV90, respectively. The incidence of bimodal milk curves was lowest for FD90 (7%) and highest for T0 (21%). The somatic cell count was $<72 \times 10^3$ cells/mL for all treatments. Residual milk obtained by giving 10 IU of oxytocin in the jugular vein followed by 2 min of milking unit attachment represented 12 to 14% of the total milk and did not differ among treatments. Endogenous oxytocin profiles peaked between 12.4 and 18.3 pg/mL for all treatments, and the peak occurred sooner in manually stimulated cows; however, we detected no difference in oxytocin concentration beyond 2 min after milking unit attachment. High-vibration pulsation elicited a similar oxytocin release when taking the start time of stimulation from manual stimulation or high vibration into consideration. Forestripping for visual observation of milk combined with the use of high-vibration stimulation may reduce variation in the milking routine. A predetermined lag time with minimal variation may be achieved via the time spent in high-vibration stimulation instead of a lag period dictated by milking personnel.

Key words: mechanical stimulation, premilking routine, lag time, milking unit on-time

INTRODUCTION

Initiation of milk ejection from the alveolar tissue is necessary to harvest the majority of milk from dairy cows, whereas a small, cisternal portion of milk can be harvested without any form of stimulation (Bruckmaier et al., 1994). The premilking routine is the main method used to elicit the milk ejection reflex that starts the expulsion of the alveolar milk fraction. The initiation of the cascade of events involved in the milk ejection

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reflex has historically been achieved via contact with a liner, by suckling of the calf, or through milk stripping by the human hand (Bruckmaier and Blum, 1996). Another form of stimulation comes from the interaction of the milking machine liner and the teat; this stimulation is maintained throughout the milking procedure while the milking unit is attached (Bruckmaier et al., 1997). Even without proper prestimulation before attachment of the milking unit, the alveolar fraction of milk will eventually be harvested; however, an interruption in milk flow may be observed as the cisternal fraction is removed before alveolar milk expulsion. With the advancement of milking technology and the introduction of milking robots, forms of stimulation other than the human hand have been used. Current technology in robotic milking systems uses mechanical stimulation as an attempt to initiate the release of oxytocin (Schams et al., 1984). Forms of mechanical stimulation that have been used are rotating brushes, different forms of pulsation, and simply the attachment of the milking unit in the milk mode. The attachment of the milking unit in the milking phase is a form of stimulation to which the pressure-sensitive neural receptors on the teat will respond. The use of vibrating pulsation at 300 cycles/min with a maximum vacuum level of 20 to 22 kPa in the pulsation chamber (keeping the liner closed) has also been investigated. Worstorff et al. (1987) investigated the use of a high-cycle and low-vacuum pulsation (300 cycles/60 s at 20–22 kPa) compared with manual stimulation and determined that vibration stimulation was an adequate method to cause the ejection of milk from the alveolar region. The type of liner used in conjunction with vibration stimulation (300 cycles/60 s) is also known to affect milk flow rates (Karch et al., 1988).

Manual stimulation of the teat for 15, 30, or 45 s followed by either 30 or 45 s of lag time causes a similar and unchanged oxytocin release throughout milking (Kaskous and Bruckmaier, 2011). When a lag time of 90 or 120 s and forestripping were involved, >60% of milk was harvested in the first 2 min of unit on-time for late-lactation cows. When the degree of udder filling was <40%, a lag time of 45 s decreased unit on-time independent of how long tactile stimulation took place (Kaskous and Bruckmaier, 2011). Recent data indicated that when lag time is >60 s in Holstein cows milked 3× daily, a reduction in milking unit on-time is seen in late-lactation cows (Watters et al., 2012). Weiss and Bruckmaier (2005) reported that a shortened (20–40 s) prep-lag time would increase the number of cows per milking stall in the case of milking cows with full udders in early lactation, whereas a prolonged (90 s) prep-lag time might be beneficial when milking cows in later lactation with udders at a low degree of filling.

Improper milking techniques may prevent the complete harvest of alveolar milk from the mammary gland. Milk remaining in the alveolar fraction after completion of milking is referred to as "residual milk" and this fraction may represent around 10% of the total milk (Turner, 1955; Goff and Schmidt, 1967; Negrão and Marnet, 2006). Residual milk may be evaluated by providing a supraphysiological amount of exogenous oxytocin through intravenous injection. Total milk stored in the udder can be determined by adding the milk yield from normal milking and the obtained residual milk. It has been reported that first-lactation cows have less residual milk compared with older cows (Schmidt, 1972). The use of brushes or vibration stimulation in a robotic milking system did not improve residual milk, which was between 14.8 and 15.9% of total milk (Macuhova et al., 2003), and these methods can therefore be defined as sufficient to elicit normal milk ejection compared with conventional milking.

Previous research has tested and analyzed high-vibration pulsation; however, the parameters used to evaluate the outcomes of this form of stimulation were generally limited and did not include, for example, the evaluation of residual milk, milk harvest during high-vibration pulsation, incidence of bimodal milk flow curves, oxytocin profiles, or milk quality. In addition, the use of high-vibration pulsation has not been evaluated in high-producing Holstein cows milked 3× daily.

Therefore, the objective of this experiment was to determine if high-vibration pulsation without any form of manual stimulation before harvest of milk is an adequate form of stimulation for Holstein cows milked 3× daily in a conventional parlor. We were interested in defining the adequacy of stimulation using milk flow curves, plasma oxytocin profiles, residual milk, and milk quality using several manual and milking machine-induced premilking routines for Holstein cows milked 3× daily.

MATERIALS AND METHODS

Cows and Treatments

Holstein cows (n = 30) were selected from the 500-cow dairy herd at the Cornell University Teaching and Research dairy facility (Ithaca, NY). Cows were milked 3× daily in a dedicated research parlor, housed in a 4-row freestall barn, and fed a TMR that either met or exceeded NRC (2001) requirements. Pen size was 30 cows for the cows enrolled in the study. The experiment was conducted from March through May 2010. All cows assigned to the study had 4 functioning quarters, no recorded incidence of clinical mastitis during the current lactation, and were less than 350 DIM at the time