
Physiology of milk let-down during machine milking

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The release of oxytocin and occurrence of milk ejection in response to teat stimulation is crucial for fast and complete milk removal. Milk ejection and removal can be disturbed at a central or peripheral level. The central disturbance represents the lack or insufficient ejection of the alveolar milk into the cistern due to inhibited oxytocin release from pituitary. Possible effect of endogenous opioids in the oxytocin release is discussed. However their active role in the oxytocin inhibition was not confirmed. The central inhibition of oxytocin release has been often observed in dairy practice during milking of primiparous cows after parturition, suckling by alien calf, during milking after calf removal, milking of cows in the presence of own calf, relocation and milking in an unknown milking place. If sufficient oxytocin can not induce the transfer of milk from alveoli to cistern peripheral mechanisms are involved. Peripheral mechanisms are mainly related to increased activation of sympathetic nervous system.

Key words: Dairy cows, milk removal, oxytocin, catecholamines.

Milking techniques, routine and cow significantly affect the milking process of dairy cows. During the last years the techniques developed significantly. Techniques reliability improved and many of routines were partial or fully automated. The effect of people on milking process is minimised. So much more efforts must be put on the relationships between cow and machine as it was before. The high technical progress has to easily adapt the machine to the needs of the cow physiology related to milk ejection. From animal science and dairy practice requirements it is clear that milk yield, time of milking and udder health are the most important

Summary

Introduction

parameters of good relationships between machine and cow. The aim of this paper is to discuss the importance of milk ejection for fast and complete milk removal from the view of the central and peripheral regulation.

Milk ejection reflex

Availability of milk before milking is an explanation why the milk ejection reflex is important for fast and complete milk removal. Before milking about 80% of total milk in the udder is present in alveoli and small ducts (Pfeilsticker *et al.*, 1996). Milk from this part is not available for milking and milk ejection must occur.

The milk ejection reflex is an innate reflex that is not under conscious control of the animal and occurs in response to tactile stimulation of the udder. The milk ejection reflex arc consists of two components: a neural and a hormonal (Crowley & Armstrong, 1992). The neural component is responsible to transfer the impulse from the udder to brain resulting in the oxytocin release into the blood circulation - the endocrine way. Oxytocin induces contraction of myoepithelial cells and thus increases the transfer of milk from the alveoli to the cistern resulting in a rapid increase of pressure within the cistern (Mayer *et al.*, 1991). It is necessary to emphasise that the release of oxytocin not only in response to prestimulation but also throughout whole milking is necessary for fast and complete milk removal (Bruckmaier *et al.*, 1994). Therefore, synchrony between milk ejection and milk removal has to be considered in good milking management.

The importance of oxytocin in the milk ejection is based on the threshold theory that the release of oxytocin must succeed a certain concentration (about 3-5 ng/l is efficient) to induce full milk ejection (Schams *et al.*, 1984; Bruckmaier *et al.*, 1994). It means there is no correlation between the oxytocin concentration in blood and milk flow if milk ejection occurred during normal milking.

Modulation of milk ejection

Within the same milking environment milk removal can be influenced at a central (brain) or peripheral (udder) level (Goodman & Grosvenor, 1983). Under such conditions milk from the alveoli can not be completely removed causing economical loss and increased incidence of mastitis.

Oxytocin release is influenced by different kinds of tactile stimulation and environmental conditions at milk removal. Despite threshold level, the variation of oxytocin release could be an important information. It is clear that central regulatory mechanisms are involved but their relation to milk flow pattern from teat has to be answered. When treatments are compared the higher flow rate is always concomitant or induced by higher oxytocin levels (Mayer *et al.*, 1984; Svennersten *et al.*, 1995). It seems to be an important question if the higher oxytocin release represents the readiness and willingness of cows to be milked. Recently it was found that cows milked in the automatic system are less nervous than in milking parlour (Hopster *et al.*, 2000).

In the dairy practice disturbed oxytocin release was found during milk removal in primiparous cows immediately after parturition (Bruckmaier *et al.*, 1992), during milking (Bruckmaier *et al.*, 1993) or suckling (Tancin *et al.*, 2001a) in unfamiliar surroundings, during milking after calf removal (Tancin *et al.*, 1995), during suckling by alien (Silveira *et al.*, 1993) or first suckling of cows conditioned only to machine milking (Kraetzl *et al.*, 2001). Also under the conditions of more often milking per day the milk flow disturbances are increased due to reduced the amount of milk in udder. There fore the duration of pre-milking preparation should be adapted to the expected milk yield at each individual procedures (Bruckmaier & Hilger, 2001).

Thus measuring of the oxytocin concentration together with other hormones indicating stress response are important indicators of the internal reaction of organism to the milking environment.

Possible central mechanism - opioid system may have a physiological role in controlling of the oxytocin release. The presence of opioid receptors and opioids in the bovine hypothalamus and neurohypophysis (Pesce *et al.* 1987) supports the assumption that endogenous opioids could influence oxytocin secretion during milking in dairy cows as it was observed in rats. The importance of opioid and sympathetic systems in the central inhibition of oxytocin release is still not solved in dairy cows (Wellnitz *et al.*, 1997; Kraetzl, *et al.*, 2001). We have recently proved that the endogenous opioid system is an effective modulator of the oxytocin release during milking of dairy cows (Tancin *et al.*, 2000). When oxytocin is suppressed by stressor the opioid antagonist naloxone was not able to abolish this inhibition (Wellnitz *et al.*, 1997, Kraetzl *et al.*, 2001). All mentioned factors influenced oxytocin release but the mechanisms seem to be different. Possibly the signal from udder does not reach the CNS or oxytocin is actively inhibited within the CNS (Tancin *et al.*, 2001b).

Another important mechanism modulating the milk removal after occurrence of milk ejection is the *sympathomedullary nervous system* in the mammary gland.

The activity of smooth muscles in the udder is influenced by catecholamines released from sympathetic nerve terminals or released from adrenal medulla. The presence of alpha and beta receptors in smooth muscles of the teat was detected by Peeters *et al.* (1977) and in tissue around the gland cistern where large milk ducts are numerous by Hammon *et al.*, (1994). Almost no receptors were found in the mammary parenchyma (Hammon *et al.*, 1994). The administration of alpha - adrenergic agonist reduced the milk yield and maximum milk flow, but the secretion of oxytocin was not reduced. Administration of beta-adrenergic agonist only caused teat relaxation resulting in the higher milk flow during milking (Bruckmaier *et al.*, 1991). But the exact mechanism of increased milk flow

Peripheral mechanisms of milk ejection

after beta-receptor stimulation it is still unclear. Is it the relaxation of teat sphincter or better release and flow of milk from alveoli throughout the mammary ducts?

The autonomic reflex plays an important role in the regulation of milk transfer within mammary gland especially related to conditioning of ejection reflex like stereotype of milking routine. There is no clear evidence for conditioning of oxytocin release before teat stimulation.

References

Bruckmaier, R.M. & M. Hilger, 2001; Milk ejection in dairy cows at different degrees of udder filling; *Journal of Dairy Research*, 68, in press

Bruckmaier, R.M., H. Mayer, & D. Schams, 1991; Effects of alpha and beta adrenergic agonists on intramammary pressure and milk flow in dairy cows; *Journal of Dairy Research*, 58, 411-419

Bruckmaier, R.M., D. Schams, & J.W. Blum, 1992; Aetiology of disturbed milk ejection in parturient primiparous cows. *Journal of Dairy Research*, 59, 479-489

Bruckmaier, R.M., D. Schams, & J.W. Blum, 1993; Milk removal in familiar and unfamiliar surroundings: concentrations of oxytocin, prolactin, cortisol and b-endorphin. *Journal of Dairy Research*, 60, 449-456

Bruckmaier, R.M., D. Schams, & J.W. Blum, 1994; Continuously elevated concentrations of oxytocin during milking are necessary for complete milk removal in dairy cows. *Journal of Dairy Research*, 61, 449-456

Crowley, W.R. & W.E. Armstrong, 1992; Neurochemical regulation of oxytocin secretion in lactation. *Endocrine Reviews*, 13, 33-65

Goodman, G.T. & C.E. Grosvenor, 1983; Neuroendocrine control of the milk ejection reflex. *Journal of Dairy Science*, 66, 2226-2235

Hammon, H.M., R.M. Bruckmaier, U.E. Honegger, & J.W. Blum, 1994; Distribution and density of a- and b- adrenergic binding sites in the bovine mammary gland. *Journal of Dairy Research*, 61, 47-57

Hopster, H., J.T.N. van der Werf, G. Korte-Bouws, J. Macuhova, C.G. van Reenen, R.M. Bruckmaier, & S.M. Korte, 2000; Automatic milking in dairy cows: Welfare indicators of astronaut effectiveness. In. H. Hogeveen, & A. Meijering, (Ed.) *Robotic milking*, August 2000, Wageningen Pers, 309 pp.

Kraetzl, W.-D., V. Tancin, D. Schams. & R.M. Bruckmaier, 2001; Naloxone cannot abolish the lack of oxytocin release during unexperienced suckling of dairy cows. *Applied Animal Behaviour Science*, 72, 247-253

Mayer, H., R.M. Bruckmaier, & D. Schams, 1991; Lactational changes in oxytocin release, intramammary pressure and milking characteristics in dairy cows. *Journal of Dairy Research*, 58, 159-169

Mayer, H., D. Schams, H. Worstorff, & A. Prokopp, 1984; Secretion of oxytocin and milk removal as affected by milking cows with and without manual stimulation. *Journal of Endocrinology*, 103, 355-361

Peeters, G., P. Petré, & W. Quintelier, 1977; Nature of adrenoceptor sites in bovine teat muscle. *Naunyn-Schmiedebergs Arch. Pharmacol.*, 296, 111-115

Pesce, G., M. Lang, J. Russell, D. Rodbard, & H Gainer, 1987; Characterization of k-opioid receptors in neurosecretosomes from bovine posterior pituitary. *Journal of Neurochemistry*, 49, 421-427

Pfeilsticker, H.-U., R. Bruckmaier, & J. Blum, 1996; Cisternal milk in the dairy cow during lactation and after preceding teat stimulation. *Journal of Dairy Research*, 63, 509-515

Schams, D., H. Mayer, A. Prokopp, & H. Worstorff, 1984; Oxytocin secretion during milking in dairy cows with regard to the variation and importance of a threshold level for milk removal; *Journal of Endocrinology*, 102, 337-343

Silveira, P., R. Spoon, D. Ryan, & G. Williams, 1993; Evidence for maternal behavior as a requisite link in suckling-mediated anovulation in cows. *Biology of Reproduction*, 49, 1338-1346

Svennersten, K., R.C. Gorewit, L.O. Sjaunja, & K. Uvnas-Moberg, 1995; Feeding during milking enhances milking-related oxytocin secretion and milk production in dairy cows whereas food deprivation decreases it. *Acta Physiol. Scandinavica.*, 153, 309-256

Tancin, V., L. Harcek, J. Broucek, M. Uhrincat, & S. Mihina, 1995; Effect of suckling during early lactation and change over to machine milking on plasma oxytocin and cortisol levels and milk characteristics in Holstein cows. *Journal of Dairy Research*, 62, 249-256

Tancin, V., W.-D. Kraetzl, & D. Schams, 2000; The effect of morphine and naloxone on the release of oxytocin and on milk ejection in dairy cows. *Journal of Dairy Research*, 67, 13-20

Tancin, V., W.-D. Kraetzl, D. Schams, & R.M. Bruckmaier, 2001a; The effect of conditioning to suckling and milking and of calf presence on the release of oxytocin in dairy cows. *Applied Animal Behaviour Science*, 72, 235-246

Tancin, V., D. Schams, W.-D. Kraetzl, J. Macuhova, & R.M. Bruckmaier, 2001b; Release of oxytocin, prolactin and cortisol in response to extraordinary suckling. *Veterinary Medicine-Czech*, 46, (in press)

Wellnitz O, R.M. Bruckmaier, & J.W. Blum, 1997; Naloxone and adrenergic blocking agents fail to abolish central inhibition of milk ejection in cow. *Journal of Dairy Research*, 64, 627-631