The Impact of Robotic Milkers On Cow Welfare

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■ Take Home Messages

Robotic milkers allow a high standard of animal welfare related to machine milking. The adaptation to newly introduced robotic milkers can be critical in individual animals that are susceptible to stress reactions in novel environments. However, the routine use of robotic milkers is highly suitable to fulfill high animal welfare standards. Animal well-being as indicated by the readiness to release the stored milk completely is obviously at a high level in robotic milking routines; stress situations such as too close contact with other cows in the collection yard near the milking parlour or aversive contact with humans at the time of milking is avoided. However, because of the reduced contact between farmer and dairy cows during the daily routine, careful control of milking performance and udder health is imperative to achieve the goal of high milk yield and quality along with high animal welfare level. In some aspects, such as the avoidance of milking empty teats at the end of milking, robotic milkers are clearly advantageous compared to conventional milking systems.

■ Farm Animal Well-Being and Productive Performance

Welfare in farm animals including dairy cows is an important issue for both ethical and production reasons. Only healthy animals kept under appropriate conditions allow for the production of high quality products for human consumption at a high performance level. In particular, the milking process, whose physiological regulation is under neuro-endocrine control, is sensitive to stress situations and can therefore be optimized by ensuring the cows' well-being throughout the day, and especially at the time of milking. Impaired milk removal causes not only an irreversibly reduced production but also increases the risk of intramammary infection followed by decreased milk synthesis and lower hygienic quality of the harvested milk, and hence a lower

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level of payment.

A cow's well-being during machine milking is indicated by the readiness of the animal to being milked and to release the milk stored in the udder. This readiness depends mainly on the release of the hormone oxytocin in response to teat stimulation before and during milking. Oxytocin induces milk ejection, which is a prerequisite that the milk can be completely harvested by the milking machine. Experimentally, oxytocin blood patterns can be recorded by frequent blood samples from permanent catheters, and milk flow curves are recorded to investigate the course of udder emptying.

■ Physiological Regulation of Milk Removal In Cows

The milk in the udder of a dairy cow is mostly (80 up to 100 %) stored in the alveolar compartment and only up to 20% in the cistern. The cisternal milk fraction is available for machine milking or the suckling calf before the occurrence of milk ejection. The alveolar milk, however, is only available if actively ejected. The ejection is induced by the neuropeptide oxytocin which is released from the posterior pituitary in response to tactile teat stimulation by hand or milking machine (reviewed by Bruckmaier & Blum, 1998; Bruckmaier, 2005).

Complete removal of the alveolar milk at each milking that is only achieved with a complete milk ejection is also a prerequisite to maintain milk synthesis and secretion at a high level throughout an ongoing lactation. In addition, milk that remains in the udder after the end of milking also increases the risk of intramammary infection because withheld milk is an exquisite substrate for pathogenic microorganisms in the mammary gland.

■ Milk Storage and Lag Time of Milk Ejection

Shortly after milking there is almost no cisternal milk present. Only several hours after the previous milk removal, milk is increasingly transferred into the cisternal compartment. Cisternal milk yield and fraction are highest at peak lactation and decrease towards the end of lactation. Thus, smallest amounts of milk available for milk removal before milk ejection are present after short intervals from the previous milking and in late lactational stages (reviewed by Bruckmaier & Blum, 1998; Bruckmaier, 2005). This fact needs to be considered in robotic milking because short intervals between milkings may occur.

■ Requirements for Teat Stimulation

Milk ejection occurs if tactile udder stimulation is sufficient to elevate the oxytocin blood concentration above a threshold. Even the stimulus of the teat cup liner attached without pulsation is usually a sufficient stimulus to evoke oxytocin release. Because it is only important to surmount a threshold of oxytocin, the intensity of stimulation affects the oxytocin release but not the degree of milk ejection. However, the lag time from start of tactile teat stimulation until onset of milk ejection normally ranges from 40 seconds to more than 2 minutes and depends on the degree of udder filling. The degree of udder filling is low at late stages of lactation and/or at short intervals from the previous milk removal. At extremely low udder filling milk ejection may occur only 3 minutes after the start of tactile teat stimulation.

In particular at low udder filling, an adequate pre-stimulation, i.e. a stimulation of the teats to induce milk ejection without simultaneously removing milk at the full vacuum level, helps to avoid negative effects of milking on empty teats at the start of milking on the further course of milk removal. Thus, the duration of stimulation is crucial and related to the degree of udder filling whereas the intensity of stimulation is not important (reviewed by Bruckmaier, 2005).

■ Reduced Oxytocin Release and Milk Ejection Indicates A Lack of Animal Well- Being

Because milk ejection is a continuous process throughout suckling or milking an emotionally stress free environment for the cow is crucial to achieve continuous oxytocin release throughout milk removal and hence complete udder emptying.

When cows have to adapt to new surroundings, especially if a new milking system is introduced, the milking-related release of oxytocin can be inhibited during the first milkings, and then gradually normalizes (reviewed by Bruckmaier, 2005). This phenomenon was also observed during the introduction of robotic milkers as described in the following paragraph (Weiss et al., 2004).

■ Adaptation To Newly Introduced Robotic Milking Systems

Besides some hormonal factors such as cortisol, the heart rate is a sensitive parameter to detect stress reactions. A study was conducted to investigate the explanatory power of heart rate measurements during the adaptation of

conventionally milked cows to a robotic milker (Weiss et al., 2004). During the adaptation period of four days cows were moved through the robotic milker without milking. At the first visit to the robotic milker, heart rate was considerably elevated as compared to the heart rate during milking in the conventional parlour. During the subsequent days of adaptation to the robotic milker heart rate normalized. However, at the first milking in the robotic milker, the obtained milk yield was dramatically reduced in most animals and the individual yields ranged from 8 to 96 % of the previous yield in the parlour. This finding indicated a complete or partial inhibition of milk ejection. To examine the relationship between the adrenal cortex sensitivity to release cortisol and the coping process during the changeover from conventional milking to an automatic milking system, an ACTH (adrenocorticotropic hormone) challenge experiment was performed independently of milking (Weiss et al., 2004). Cows that released more cortisol in response to ACTH injection had a less enhanced heart rate and a less disturbed milk ejection during the first milking in the robotic milker. The coping capacity towards new milking environment varied widely between individual cows. The course of adaptation to the novel milking environment could be predicted by testing the adrenal cortex sensitivity to ACTH. Obviously, the adaptation to a newly introduced automatic milker can be problematic for individual cows. It is important that during the adaptation period the udder is completely emptied to avoid production loss and intramammary infection. If necessary, exogenous oxytocin should be used for a few days until the animals have adapted.

■ Animal Well-Being During Milking In Robotic Vs. Conventional Milking Systems

Overall, the robotic milking procedure seems to be very cow friendly as soon as the animals have adapted to the system. No elevated plasma concentration of any of the hormones related to stress reactions (cortisol, adrenaline, noradrenaline) were detected in automatic milking systems compared to milking in milking parlours, except for elevated concentrations of adrenaline and noradrenaline in the moment of entering the conventional parlour (Hopster et al., 2002). Another study found similar concentrations of cortisol in the milk harvested by a robotic milking system and by a conventional parlour (Gygax et al., 2006). Because cortisol in milk represents a long-term average of cortisol plasma concentrations, it can be assumed that robotic and conventional milking including the related housing and feeding systems are similarly suitable with respect to animal welfare. Interestingly, heart rate, a highly sensitive parameter to detect stress reactions, was low in both milking systems, however it was significantly higher in conventional than in robotic milking already during the 30 minutes before milking and remained higher until the end of milking (Hopster et al., 2002). Together with a short-term elevation of adrenaline and noradrenaline at the time of entering the

conventional parlour this seems to be an indication of a short-term stress situation until milking is in progress. In the conventional system, cows are rushed by humans to the collection yard. It was shown that cows show clear stress reactions in response to human handling, and in particular if unpleasant treatment is involved (Rushen et al., 1999). In addition, the distance between individual animals is small while the animals are waiting to enter the parlour. Low ranking cows have no chance to keep the necessary distance from high-ranking animals. When entering the robotic milkers cows have plenty of space, and probably it is more convenient for a low ranking animal to let a high-ranking cow pass to enter the milking system before herself and thus to avoid a conflict.

An important advantage of robotic milking is the individual milking of each teat. In contrast to conventional systems, robotic milkers attach each teat cup individually, and the teat cups are removed individually as soon as milk flow ceases in each individual quarter. This avoids milking on empty teats and thus teat tissue damage at the end of milking which is not possible in conventional milking where the milking cluster remains attached to all four teats at least until milk flow stops in the last quarter.

■ Oxytocin Release, Milk Ejection, and Milk Removal During Robotic Milking Procedures

In a number of studies oxytocin release and milking characteristics in robotic milking were investigated. Compared to conventional systems the release of oxytocin was similar or even higher in robotic milking (Dzidic et al., 2004 a,b; Hopster et al., 2002; Macuhova et al., 2003). These studies showed also that the teat cleaning systems of the various robotic milking systems are highly suitable to induce oxytocin release and milk ejection before the start of milking. Teats are not cleaned altogether but sequentially one by one. This way of teat cleaning provides an excellent stimulatory effect on the teats and hence causes a sufficient release of oxytocin to induce milk ejection (Macuhova et al., 2003; Dzidic et al., 2004a,b). The sequential stimulation of teats one by one does not cause a reduced release of oxytocin. The stimulation of one teat is a sufficient stimulus to induce full milk ejection (Bruckmaier et al., 2001).

After teat cleaning teat cups are attached and it may take up to one minute or sometimes even longer until teat cups are attached. It was shown that a latency time between pre-stimulation and teat cup attachment of up to one minute has no negative effects on subsequent milk removal. The short interruption of tactile contact supports the relaxation of the teat tissue and can even facilitate the removal of milk (Kaskous & Bruckmaier, unpublished).

Even if the attachment of teat cups is not successful, which happens occasionally in robotic milkers, the action of the robotic devices on the udder maintains the release of oxytocin even if the unsuccessful attempts last for up to 7 minutes (Macuhova et al., 2004).

■ Conclusion

As in all other animal production systems the avoidance of stress situations for the animal and for the farmer has to be aimed for in robotic milking. Overall, robotic milking systems are as suitable as conventional milking systems in allowing a high level of animal welfare standards. In some aspects robotic milkers are even advantageous with respect to animal welfare compared with conventional systems.

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