Comparative study of physiological responses of cows to classical versus automatic system of milking

P.G. Marnet, H. Aupetit , J.F. Combaud, J. Portanguen & J.M. Aubry

ENSAR/INRA, Research on milk production,
65 rue de St Brieuc, 35000 Rennes, France
E-mail: marnet@roazhon.inra.fr

Summary

Eight cows were controlled during 2 weeks of classical milking technique in a side by side parlor and the first 4 succeeding weeks of adaptation to an automatic milking system (AMS). Milk production and composition, milk emission kinetics, oxytocin release and teat end reaction were measured 4 times per week during all the experiment. The milk production and lactation persistency, the milk composition and the C.C.S are not significantly affected during the adaptation period to the AMS. There is a good massaging of the teat during milking. That suggests a normal function of the liner in the special cup of the AMS. The mean flow rate have just a tendency to be lowered by AMS that confirm the good quality of the milking machine of the AMS. Therefore, there is a significant reduction of the oxytocin release when cows are milked by the AMS with a corresponding increasing number of bimodal milk emission kinetics. This result remain significant even when we take only in account the good milking procedures in the AMS (without any failure, delay in cup attachment or cluster fall). That suggests a poor efficiency of the udder pre-stimulation in our AMS. Additionally, we cannot eliminate a potential chronic inhibition of the milk ejection reflex by the robotic surroundings during the 4 weeks despite a clear improvement of the AMS efficiency with a reduction of more than 15% of the second, third and fourth trials for attachment procedures of the teat cups.

Key words: *Machine milking, milk production, milk flow, teat reaction, oxytocin*.

Introduction

It is well known that the most important stimuli are pre-milking preparation and the action of the machine milking (Woolford, 1987). In an AMS, the pre-milking preparation consists in mechanical cleaning of the teats and foremilking by the machine. When the udder or the teat are brushed, a positive effect on milk let down and oxytocin release have been described (Shuiling, 1992, Macuhova and Bruckmaier *et al.*, 2000). However, no data exists about the stimulation efficiency of foremilking with water cleaning in a liner. When teat cup attachment needs more than 3 minutes after the cows entering the stall (Ipema *et al.*, 1997) or when the lag time between udder stimulation and attachment of the cups increases (Labussière *et al.*, 1999), there is negative effect on milk yield and milking duration. In AMS, the time needed for teat cup attachment is generally around 2 min (2.8 in Kremer and Ordolff, 1992) suggesting that a significant number of milking could be less efficient than possible with AMS. At the opposite, AMS have some advantages as allocation of concentrate at milking that is well known to optimize milk ejection (Labussière *et al.*, 1999; Svennesten-Sjaunja *et al.*, 1995). There is also little evidences of lack of major "stressors" in an AMS by means of behavioral and physiological data (Hopster *et al.*, 2000). Finally, there is only scarce data about the global effect of AMS and its surroundings (automatic gate, stall size adjustment, specific noise...) on the stimulation of the animals and physiological adaptation of cows. To complete these data, this work aims to compare the physiological and zootechnical adaptations of cows subjected to a transfer from a classical milking parlor to an AMS during the beginning of their lactation.

Material and methods

Eight multiparous Holstein cows were milked in a classical milking parlor from to their 10 to 12th week of lactation. It was a 2*6 side by side parlor and milking procedure included 30 s washing and massaging, manual cup attachment and simultaneous manual cups removal when milk flow decrease under 200 ml / min. Milking parameters were 37 KPa of vacuum, 60.2 pulsation frequency and 61.2 % pulsator ratio. Then cows changed to an AMS (Prolion-Manus) as the resting part of the breed and without relocation of animals. Milking procedure differs only by concentrate allocation in the stall, automatic cup attachment and a 30-s period of automatic teat cleaning and milking by AMS. Simultaneous cups removal where performed as in classical parlor. Milking parameters were 46KPa of vacuum, 60.2 pulsation frequency and 60.2 % pulsator ratio. Cows were milked 2 times per day (6h and 17h) in the two systems of milking in order to eliminate the effect of milking frequency. Cows were fitted with indwelling intra-jugular catheters 2 weeks before experiment. The measurements during the period of adaptation to AMS lasted 4 weeks.

Milk production and quality (fat, protein and CCS) content were measured at each milking from parturition. Milk emission kinetic was recorded with an automatic prototype device during 4 milkings / week. Simultaneously, blood was sampled for oxytocin assay. Residual milk was measured after IV injection of 2.5UI of oxytocin after the last two morning milkings of each week. Teat-end thickness was recorded before and after milking using spring-loaded calipers during 4 milkings / week.

Statgraphics software was used for ANOVA and succeeding mean comparison (confidence interval). For the milk flow data, the effect of milk production and time of milking were considered as co-variables. Milk production during the AMS and classical milking system periods were compared after extrapolation of milk production during the period in classical parlor (Wood model).

Results

The milk production, fat, protein and cellular concentration of the milk never differed significantly between classical parlor and AMS excepted for one cow with mastitis at the end of the control period (24.99 ± 0.32 versus 23.86 ± 0.94 L / Day; 31.2 ± 1.7 versus 32.1 ± 2.1 %; 29.1 ± 1.1 versus 29.7 ± 1.5 %; 67274 versus 72471 C / ml, respectively for classical milking system and AMS).

The milk production and the time of milking mainly affect the parameters of milk emission kinetics. These parameters are not significantly different between AMS and classical system (Table 1). However, a tendency exists for a lower milk flow and an increased number of bimodal milk flow curves (>15%) with AMS. The percentage of residual milk is not significantly greater during the AMS period (8.0 ± 0.1 % of machine milk) than in the classical milking period (6.52 ± 0.9 %).

At the opposite, the oxytocin release pattern differs significantly (Table 1 and Figure 1) between the two milking systems even if the oxytocin release induced by AMS remain significant. There is also significant difference in the teat-end status resulting from the milking with classical milking system and AMS (Table 1). Therefore, there is no evolution of oxytocin concentrations and teat-end thickness between the different weeks of adaptation to AMS.

Table 1. Milk emission parameters, oxytocin (OT) release and teat-end reaction between classical milking system and AMS.

	Classical Milking parlor	n	AMS	n	Statistics (Anova)
Max flow (l / min)	3.68 ± 0.10	53	3.61 ± 0.05	126	NS
Mean flow (l / min)	2.2 ± 0.06	53	1.91 ± 0.04	126	P<0.075
Milking duration (min)	6.51 ± 0.21	53	6.25 ± 0.15	126	P<0.055
OT Control level (pg / ml)	29.6 ± 3.9	40	25.4 ± 2.1	123	NS
OT Maximum level (pg / ml)	102.8 ± 10.4	40	73.5 ± 5.1	123	**
OT Discharge (AUC unit)	423.6 ± 57.2	40	299.8 ± 32.6	123	P<0.065
Teat-end thickness (mm)	9.63 ± 0.11	53	10.16 ± 0.07	126	***
Teat-end reaction (mm)	0.55 ± 0.07	53	-0.35 ± 0.04	126	***

Anova use milk production and time of milking as co-variable for milk flow, milking duration and teat end thickness. Incomplete oxytocin patterns were not taken in account for ANOVA.
Teat-end reaction correspond to teat-end thickness difference (after milking minus before milking).
Data are means ± standard error means. NS: non-significant, * : p<0,05; ** : p<0,01; *** : p<0,001
AUC = area under the curve.

Table 2. Percentage of milking without problem and with infructuous trials in the AMS.

Attachment of cups	Direct	One infructuous trial	Two infructuous trials	More infructuous trials
First week in robot	68.9	5.4	1.8	25
Second week in robot	56.3	0.0	12.5	35.9
Third week in robot	73.4	10.9	0.0	15.6
Fourth week in robot	84.4	4.7	0.0	10.9

The evolution of AMS efficiency for the cup attachment is shown in table 2. When we retained only the perfect milking with AMS, there is no modification of all the results presented before.

Discussion

The first conclusion of our work is that the AMS and the classical milking system have very close results. With a similar number of milking per day, the production parameters never differed significantly suggesting a comparable efficiency of the two systems. The low percentage of residual milk and the normal milking duration confirm this point.

Nevertheless, there is a lower stimulation of the milk ejection reflex in the cows when milked by our AMS. This lower oxytocin release is in agreement with the lowered milk flow recorded with robotic unit and the increased number of bimodal emission of milk. The more probable explanation is that the stimulation is delayed with AMS because of the lack of real

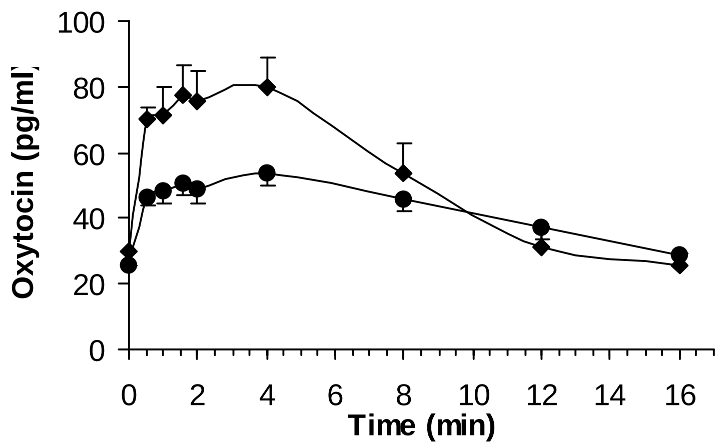

Figure 1. Oxytocin pattern of release induced by classical milking system (◆) and AMS (●).

prestimulation by the washing procedure as previously described by Bruckmaier & Blum (1996). There is also a lower total amount of oxytocin released with AMS. It is not a result of reduction of oxytocin storage by the multiple pre-stimulations by the previous trials of cup attachment: oxytocin release in the cows with immediate cup attachment is not significantly different than when all the milking where taken in account. The lower discharge could be explained for a part by a lower stimulation capability of the cluster. The fact that the massaging of the teat is really efficient (more important decongestion of the teat apex than with the classical milking system despite a very high vacuum level in our installation) suggests a good liner movement and stimulation of the teat and do not reinforce this hypothesis. The last explanation could be that the robotic surroundings are potential stressors for the animals. The teat-end thickness before milking is generally linked to the milk production and or sympathetic tone of the muscular bundles of the sphincter. Here, the more important teat thickness with AMS could be due to a stress of the cows before entering the box. We have to be aware that this stress is less acute and could be of different nature than that described by Rushen *et al.* (2001) when cows are milked in unfamiliar surroundings (24% of residual milk against 8% in our experiment). This chronic inhibition during the 4 first weeks of milking in our robot is in accordance with observations of different breeders whose notify a perturbation of cows for at least 2 months after the beginning of milking with AMS. A longer period of study with measurements of stress indicators will be necessary to conclude to a chronic perturbation of cows or to a lower stimulation capability of our AMS. This lower stimulation capability is to compare with the relative inefficiency of the AMS to produce the same rate of increase in milk production (globally 3% of increase and 55% of French producers have no significant increase in milk production, see paper of Veysset *et al.*, 2000 in this book) than with an increased number of milking in a classical milking system (see revue of Amstrong, 1997).

Concerning the adaptation of the robotic unit to the animals, it is clear that the AMS improve its efficiency for teat cup attachment with time. But the remaining 11% of total failure confirm that the animals and robotic unit are not well adapted after one month. It is clear that in a totally free access AMS, the speed of adaptation of the machine and the animals could be faster than in our experimental protocol.

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