The effects of machine milking on teat condition

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Summary

The teat is an important barrier against invasion of mastitis pathogens into the udder. Tissue changes affecting teat opening allow penetration of bacteria into the udder.

Calf suckling is nature's way of cow milking which induces little teat swelling or teat end callosity. This should be our reference. Milking machine techniques can influence (short and long-term) teat condition and milk-flow-profiles independently.

Short-term effect of milking on teats is swelling, which can be measured by ultrasound. Long-term effects are changes in teat-end tissue, resulting in a callous ring around the teat orifice. Teat-end callosity can be classified visually, e.g. by the PV-classification system. With some machine settings, cows differ in response. For example longer suction phase of the pulsator will in general decrease machine-on time, but in a substantial part of the cows will show an increase. Different liners can cause different degrees of teat swelling but not always differences in milk flow profiles.

Automated milking systems allow for more frequent milking, resulting in increased machine-on time per day and less recovery time. This development and the different reactions of cows to machine settings, cause a need for milking adapted to individual cow characteristics.

***Key words**: Teat condition, machine milking, teat end callosity, teat swelling, mastitis.*

Introduction

The mechanical forces during machine milking will result in changes in teat end tissue. Vacuum opens the teat canal and milk flows out but also blood and lymph are drawn to the teat end. The collapsing liner exerts a mechanical force on the teat end, causing the teat canal closure and transport of blood and lymph back to the udder (Hamann and Østeras, 1994). Teat tissue changes by machine milking can be seen as teat swelling (teat end, base or top), teat flattening, colour changes, openness of the teat orifice, vascular damage (haemorrhages) and teat end callosity (Hamann, 1987). Milking removes keratin out of the teat canal, which seems to be essential to the teat canal defence (Lacy-Hulbert & Woolford, 2000).

Bacteria that cause clinical mastitis must enter the udder through the teat. Therefore, the teat is an important barrier against invasion of mastitis pathogens into the udder. Tissue changes affecting teat opening allow penetration of bacteria into the udder. Changes in teat skin can also enhance bacterial colonisation on the teat. Recent developments like more frequent milking, cows with higher yields and automatic milking may increase the load exerted on teat tissue. This paper focusses on the effects of machine milking on teat swelling and teat end callosity with calf suckling as a reference.

Teat end callosity

After repeated use of the milking machine, the long-term effects are changes in teat-end tissue, resulting in a callous ring around the teat orifice. Already in 1942, observations of everted teat sphincter in machine milked teats, which became eroded, has been made (Espe and Cannon, 1942). Teat-end callosity can be classified visually. Several systems have been developed like a system of Sieber and Farnsworth in 1981 and more recently by Shearn and Hillerton in 1996. The adapted classification system developed in The Netherlands is based on marked differences in the thickness of the callosity ring, which is transformed to five classes: none [N], slight [A], moderate [B], thick [C] and extreme [D]. Average teat end callosity thickness of teats is calculated by using the unit scores from 1 to 5. Additionally the ring is classified as smooth [1] or rough [2] (Figure 1, Neijenhuis *et al*., 2000b).

Factors influencing teat end callosity

Several factors influence the amount of teat end callosity; cow factors cause the biggest difference. Important cow factors are: teat shape, teat position, parity and days in lactation (Neijenhuis *et al*., 2000b). Teat shape was shown to be the most important factor. Pointed and round teat ends are very likely to show callosity, flat or inverted teats are less susceptible. Teat end callosity increases over parity. Cows in early and late lactation show less callosity than cows in mid lactation. This might be explained by the high milk yield during mid lactation. High yielding cows are more often affected, probably because machine-on time is longer.

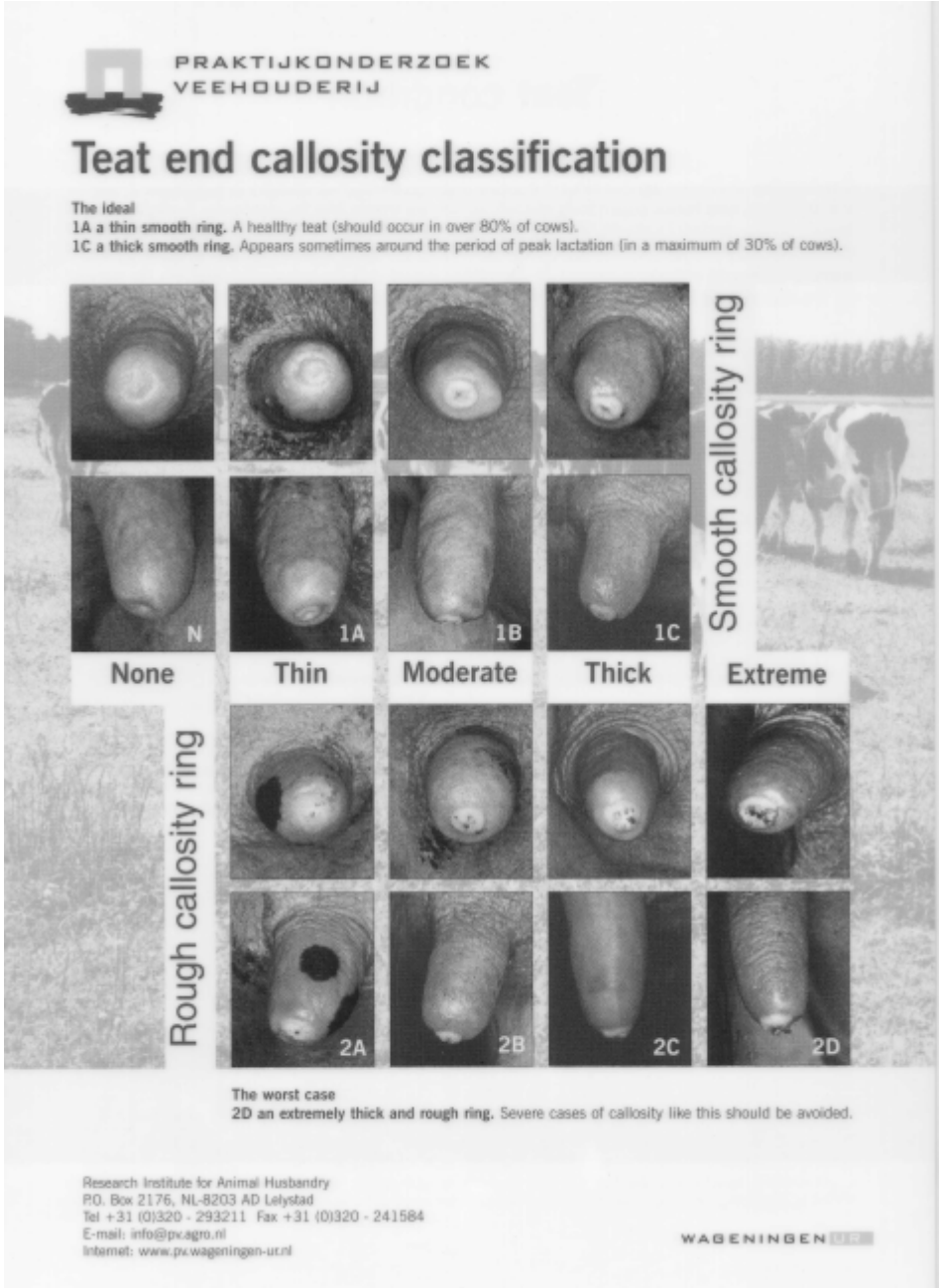

Figure 1. Teat end callosity classification system.

Between farms big differences in teat end callosity appear which can only be partly explained by differences in cow characteristics. Farms differ in teat end callosity roughness from 10 to 90% and in teat end thickness from 2.01 to 2.70. A minor part of the difference can be explained by the characteristics of the milking machine, milking method and management.

Mastitis

There is a good similarity between the macro- and microscopic ranking of the teat end callosity rings (Figure 2). Teat end callosity consists of hyperkeratose (Stratum corneum). Thicker callosity rings show parakeratosis; nuclei are still shown. Teats with a higher score for teat end callosity show perivascular reaction; infiltration of lymphocytes, granulocytes or erytrocytes (Utrecht University, 1998).

With thick callosity, the teat canal can not close as tight and micro-organisms may penetrate the teat easier. These callous ring can also get rough (category 2). The rougher it is, the easier it is for bacteria to anchor and reproduce, another factor affecting mastitis. Not all research was able to proof the relationship between teat end callosity and mastitis (Farnsworth and Sieber, 1980). In our research we found that clinical mastitis cows had more teat end callosity than their healthy pairs, particularly when clinical mastitis occurred between the second and fifth month of lactation (Neijenhuis *et al*., 2000a). The probability of clinical mastitis increases on average more than 2 times when the teat end callosity is an extreme thick rough ring (class 2D).

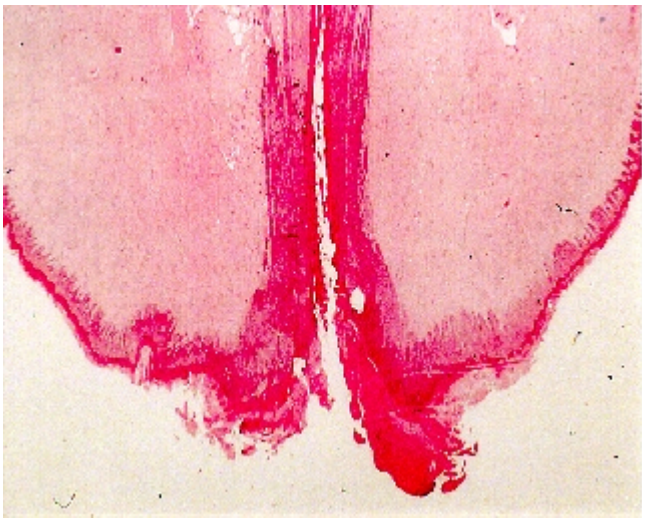

Figure 2. Microscopic view of a teat end with a thick rough callosity ring (2C). Photo: Utrecht University. Drs A. de Man, Dr Y.H. Schukken & Drs J.P. Koeman.

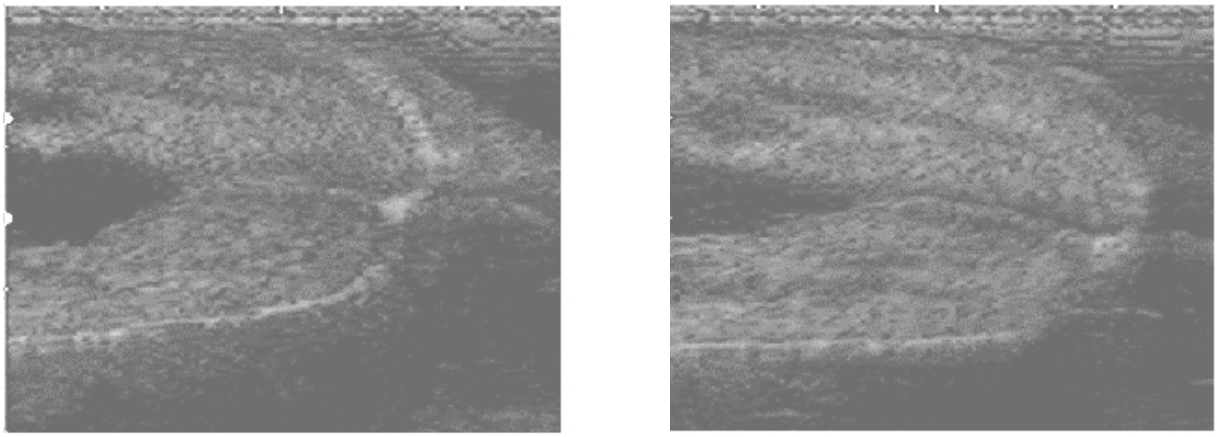

Figure 3. Ultrasound view of teat before and after milking.

Teat swelling

Short-term effect of milking on teats is swelling. A calliper instrument called the cutimeter can be used to measure the swelling of the complete teat end before and just after milking (Hamann and Mein, 1990). Another method is measuring by ultrasound (Neijenhuis *et al*., 1999, 2001). Under vacuum, strain is generated in the teat wall, which induces dilation of blood vessels and expandable compartments in the peri-vesicular tissue. This results in accumulation of fluid in the teat: blood and lymph. During the rest (massage) phase of the pulsator the liner collapses and massages the teat, relieving the congestion. Such swelling of the teat may influence the resistance of the teat canal to bacterial invasion during the recovery period after milking. Compared to machine milking, calf suckling stresses the teat tissue only slightly (Neijenhuis, 1999). Calf suckling is nature's way of cow milking which induces little teat swelling or teat end callosity. This should be our reference.

To make an ultrasonographic view, the teat is immersed into a plastic bag of warmish water before and just after milking. The probe is held against the plastic bag. A picture is made from the teat before and just after milking (Figure 3). Several teat parameters are measured from this view: teat wall thickness, teat end width, teat cistern diameter and teat canal length. For different milking machine settings the average relative change in teat parameters were: teat canal length from 10 to 30%, teat end thickness from 2 to 10%, teat cistern width from –50 to 3% and teat wall thickness from 20 to 50%. Hamann and Mein (1990) stated that the relative change in teat swelling from different milking techniques measured with the cutimeter (a calliper instrument that measures the teat end width) ranges from –10% up to more than 20%.

Table 1. Relative change in teat parameters, measured on ultrasonographic views, after machine milking and calf suckling.

	Machine milking	Calf suckling
Wall thickness	26 - 50	6
Cistern diameter	-27 - -65	-9
Duct length	19 - 28	7

Mastitis

A relative increase of teat end thickness measured with a cutimeter of more then 5% increases the new infection rate and teat duct colonization (Zecconi *et al*. 1992). However this method is different from the ultrasonographic technique.

Calf suckling

Calf suckling influences the teat swelling less than machine milking (Table 1; Neijenhuis, 1999). Hamann and Stanitzke (1990) also found with the cutimeter technique less increase with calf suckling than machine milking.

Milk flow

Milking machine techniques may influence (short and long-term) teat condition and milk-flow-profiles independently. As we found in our research, fast opening and closing of the liner causes more swelling and does not decrease milking time (Neijenhuis, 1993; Neijenhuis *et al*., 1999). With some machine settings, cows differ in response. For example longer suction phase of the pulsator will in general decrease machine-on time, but in a substantial part of the cows (25%) will show an increase (Koning and Klungel, 1998). Different liners can cause different degrees of teat swelling but not always differences in milk flow profiles (Koning and Ipema, 2000).

Recovery time

At 8 hrs after milking, teat end width and teat canal length still differed from before milking. Teat wall thickness and teat cistern width were recovered after 6 and 7 hrs (Neijenhuis *et al*., 2001). Hamann and Stanitzke (1990) found with the cutimeter technique a recovery time of 1 to 4 hrs for machine milking and only 30 minutes for calf suckling.

The results indicate that cautiousness is necessary when milking more frequently. Shorter milking intervals by increased frequency of milking, as can be found in automatic milking, may lead to incomplete recovery of teats. This may lead to a build up of teat damage.

Conclusion

Machine milking has more effect than calf suckling on teat swelling and teat end callosity. The effect of machine milking differs between cows. Negative changes in teat condition, like severe teat end callosity and teat swelling, increases mastitis incidence. Teat swelling after milking stays on for 6 to over 8 hours.

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