HOW BEHAVIOUR PREDICTS ACUTE ENDOTOXIN MASTITIS IN DAIRY COWS?

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SUMMARY

There is a need to distinguish sick individuals automatically in large dairy barns but we lack of knowledge of which behavioural features change in disease outbreaks. To study this, we induced acute endotoxin mastitis in one quarter of six dairy cows and filmed their behaviour continuously during the placebo day and at the mastitis day. We found that the cows' resting behaviour changed rapidly after the onset of endotoxin mastitis. No differences were noted in the number of steps the cows took. Resting and rumination are promising behaviours to use as indicators when the health status of a cow is changing and to be further tested for automatic disease detection.

INTRODUCTION

Increasing herd sizes and rapid growth of labour costs in Europe have led to a demand for automation in livestock production (de Koning & Rodenburg, 2004). There is a strong trend that the number of cows per farm increases and at the same milk yield per cow increases due to the efficient breeding of animals. Furthermore, distinguishing sick animals in dairy herds becomes more demanding. An effective human-animal-technology relationship creates a basis for animal health and welfare, as well as for optimizing the use of new technological solutions (Kaihilahti et al. 2007). For the moment, the commercially used technologies for detecting deviations in milk quality have been used to describe the udder health. However, these parameters have not been precise enough to be able to detect early signs of illness.

Automatic behaviour detection would be a feasible method, as the changes in behaviour are used by veterinarians and care-takers in the diagnosis of disease (Broom, 1987). However, we lack of knowledge of which behavioural features change, and how, in different disease outbreaks.

To study this, we induced an acute endotoxin mastitis in one quarter of 6 dairy cows each in late lactation and filmed their behaviour continuously during the placebo day (–1 day before induction) and at the mastitis day (day 0, induction day). The behavioural features where compared to clinical findings and milk parameters.

MATERIALS AND METHODS

The experimental procedures were approved by the Ethical committee for the use of Laboratory Animals at the University of Helsinki.

The experimental cows were of Finnish Ayrshire or Holstein-Friesian breeds. Five experimental cows were at their 1st lactation and one at her 2nd lactation. Cows were housed in a stanchion barn and fed high quality silage *ad libitum* and concentrates six times a day. The cows were milked twice a day at 5.30 a.m. and 4.30 p.m.

Before the experiment the health status of animals was examined and they were clinically healthy. All of the quarters were sampled for milk somatic cell counts (SCC) and bacteria during three consecutive days. All samples were free from bacteria, and the mean cell count of all four quarters was less than 250 000 cells/ml and respectively, for the studied and control quarters less than 100 000 cells/ml.

On the day –1 at 7 a.m. we infused 5ml of saline in the left front quarters. On the following day (day 0) we challenged the same quarter with 10 µg of *Escherichia coli* O55:B5 lipopolysaccharide (LPS) (Sigma®, Sigma-Aldrich, Inc., Missouri, USA) diluted in 5 ml of sterile saline. Right front quarter served as a control.

During the follow up of the inflammation, we took 8 milk samples from the study and control quarters; 0, 2, 4, 6, 8, 10, 12 and 24 hours before and after the induction. From milk samples we analysed several parameters, such as SCC, electric conductivity and N-acetyl-β-D-glucosaminidase (NAGase) activity. Clinical examination included determination of systemic signs, as rectal temperature (°C), heart rate (beats/min) and determination of local signs as palpation of the udder and visual estimation of milk appearance.

Bacterial samples were analyzed using conventional methods (Hogan et al., 1999). CMT was performed cow-side using a scale from 1 to 5 (Klastrup, 1975). Electrical conductivity was measured with a hand-held meter (Lutron CD-4301). SCC was analyzed with an electronic counter DCC (DeLaval International AB, Tumba, Sweden). Milk NAGase activity was measured with a fluorometric method (Mattila and Sandholm, 1986).

Cows were filmed continuously for 48 hours. From the videos we analysed mean hourly bout durations, frequencies and the total durations the cows spent resting or ruminating. In addition we counted the number of steps the cows took per hour.

We analysed the differences between days in behavioural and milk parameters and clinical findings with a mixed model, taking repeated observations into account. Fixed factors were hour and day, and an hour*day interaction. Cow was a random factor.

RESULTS

All cows created both systemic and local signs after the LPS challenge. Heart rate, milk electric conductivity, SCC and NAGase activity started to increase 6 hours after induction and stayed high during the following 24 hours (Graph 1.). Body temperature started to rise 4 hours after induction, reaching the peak values 6 hours after induction and returned to normal 12 hours after induction (Graph 3).
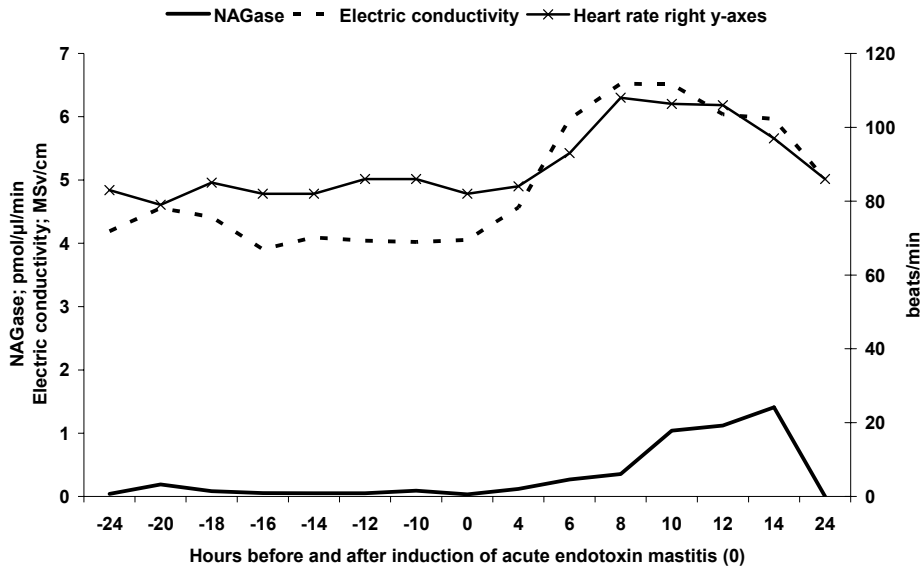
Graph 1. Mean heart rate and milk NAGase and electric conductivity 24 hours before and after induction of an acute endotoxin mastitis

Immediately after endotoxin induction, cows rested for longer, but afterwards, within the next 13 hours, the mean hourly resting time was shortened (Graph 2.).
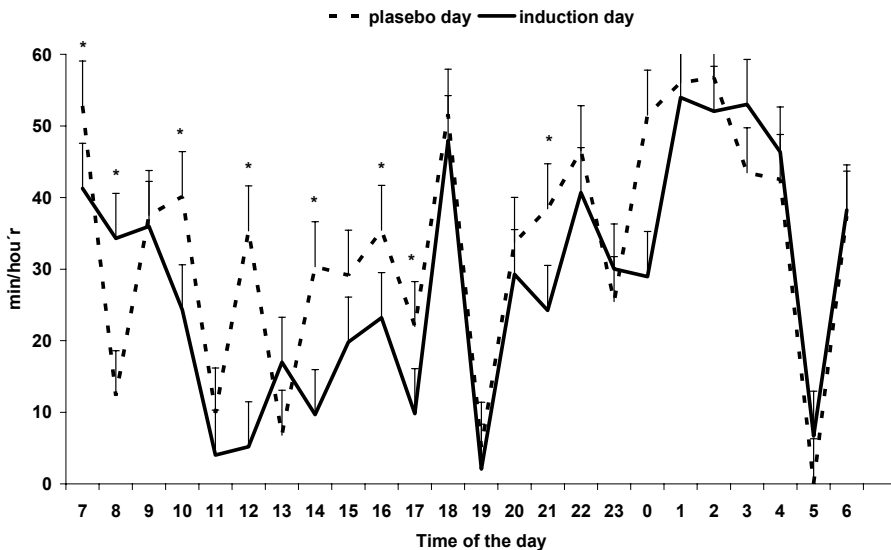
Graph 2. The mean hourly duration spent lying down in dairy cows before and after the induction of an acute mastitis

And further, within 4 to 8 hours after induction, cows ruminated less than during the according hours at the control day (Graph 3). No differences were noted in the number of steps the cows took.
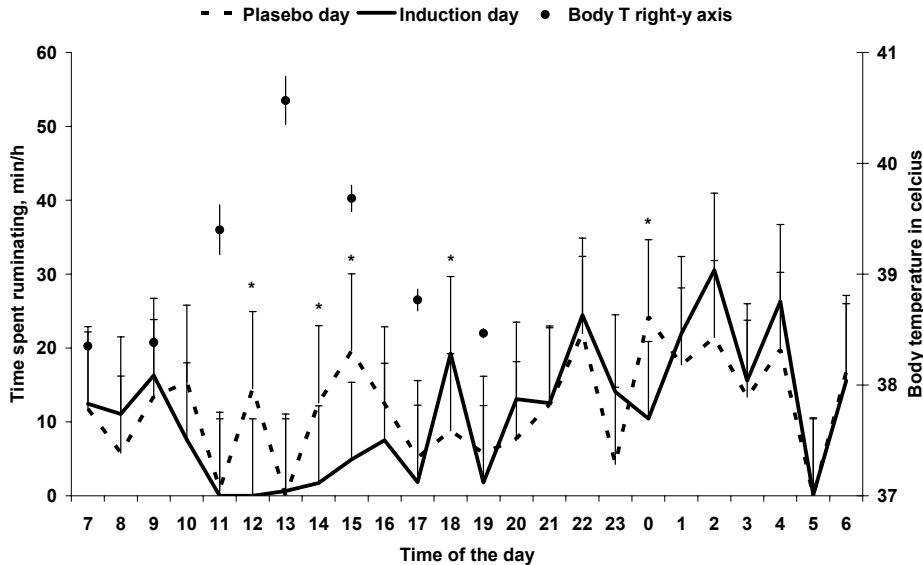
Graph 3. The mean body temperature and an hourly duration the dairy cows spent ruminating before and after the induction of an acute mastitis

DISCUSSION

We showed here that the cows adapted to ongoing mastitis by changing their resting behaviour. When the infection proceeded, it affected also the behavioural signs; during two hours after the induction of an acute mastitis, cows were resting more than during the day before. We suggest this was due to the acute effect of cytokines. And further, that reduced activity and increased sleepiness are cows´ strategies of energy conservation in order to allow the full development of a fever (Aubert 1997; Johnson 2002).

When the mastitis progressed and the clinical symptoms in the udder were more evident, the cows were resting less than the day before. We suggest that cows reduced their time spent lying down due to uncomfortable feeling and/or pain. Cows have a strong motivation to lie down (Jensen et al. 2005), but they prevent themselves from doing so, if the lying surface is uncomfortable enough (Haley et al. 2001). Sickness behaviour is the expression of a motivational state rather than the result of weakness (Aubert 1999; Johnson 2002). Thus, the pain-motivated behaviours of cows in this study overtook their sickness-motivated behaviours, such as lying down due to fever and/or weakness, similar to suggestions of Aubert (1997). The changes in behavior of the cows with an acute mastitis reflect changes in behavioral priorities (Johnson 2002).

Fever was reducing cows´ rumination. This is also in line with the adaptive response of the sickness behaviour. The energetic cost of fever is rather high e.g. a metabolic increase of 13% is

necessary to raise body temperature by 1°C (Kluger 1991). This could contribute to the inhibition of energetically expensive behaviours, such as rumination.

The changes in the resting behaviour and rumination had disappeared after 17 hours from the induction of mastitis, although the milk appearance was still changed. It might be possible that the acute feeling of sickness had then disappeared.

PRACTICAL IMPLICATIONS

Resting and rumination may be used as promising behavioural indicators to be tested further for automatic disease detection in large dairy units. More detailed scientific work is needed, to explain the multiple changes in behaviours in different infections.

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