Physiology & Behavior 139 (2015) 281–289

Contents lists available at ScienceDirect

Physiology & Behavior

journal homepage: www.elsevier.com/locate/phb

Heart rate and heart rate variability in multiparous dairy cows with unassisted calvings in the periparturient period

L. Kovács [a,b,*], J. Tőzsér [b], F.L. Kézér [a,b], F. Ruff [c], M. Aubin-Wodala [a], E. Albert [a], A. Choukeir [a], Z. Szelényi [a,d], O. Szenci [a,d]

[a] Hungarian Academy of Sciences (HAS) - SZIE Large Animal Clinical Research Group, Üllő-Dóra Major H-2225, Hungary
[b] Institute of Animal Science, Faculty of Agricultural and Environmental Sciences, Szent István University, Páter Károly utca 1, Gödöllő H-2100, Hungary
[c] Institute of Economics, Law and Methodology, Faculty of Economics and Social Sciences, Szent István University, Páter Károly utca 1, Gödöllő H-2100, Hungary
[d] Department and Clinic of Food Animal Medicine, Faculty of Veterinary Science, Szent István University, Üllő-Dóra Major H-2225, Hungary

HIGHLIGHTS

- We investigated heart rate variability in dairy cows in the periparturient period.
- Vagal tone activity decreased before the onset of calving restlessness.
- Vagal tone increased before calving and decreased after birth.
- Autonomic nervous system activity remained altered until 4–8 h after birth.
- Duration of calving affected cardiac activity during calving and 12–24 h after birth.

ARTICLE INFO

Article history:
Received 31 May 2014
Received in revised form 10 November 2014
Accepted 12 November 2014
Available online 20 November 2014

Keywords:
Behaviour
Heart rate
Heart rate variability
Dairy cows
Unassisted calving

ABSTRACT

Behavioural changes before calving can be monitored on farms; however, predicting the onset of calving is sometimes difficult based only on clinical signs. Heart rate (HR) and heart rate variability (HRV) as non-invasive measures of autonomic nervous system (ANS) activity were investigated in Holstein–Friesian cows ($N = 20$) with unassisted calvings in the periparturient period to predict the onset of calving and assess the stress associated with calving. R–R-intervals were analysed in 5-min time windows during the following three main periods of measurement: 1) between 0 and 96 h before the onset of calving restlessness (prepartum period); 2) during four stages of calving: (I) early first stage; between the onset of calving restlessness and the first abdominal contractions; (II) late first stage (between the first abdominal contractions and the appearance of the amniotic sac); (III) early second stage (between the appearance of the amniotic sac and the appearance of the foetal hooves); (IV) late second stage (between the appearance of the foetal hooves and delivery of the calf), and 3) over 48 h following calving (postpartum period). Data collected between 72 and 96 h before calving restlessness was used as baseline. Besides HR, Poincaré measures [standard deviation 1 (SD1) and 2 (SD2) and SD2/SD1 ratio], the root mean square of successive differences (RMSSD) in R–R intervals, the high-frequency (HF) component of HRV and the ratio between the low-frequency (LF) and the HF components (LF/HF ratio) were calculated. Heart rate increased only following the onset of the behavioural signs, peaked before delivery of the calf, then decreased immediately after calving. Parasympathetic indices of HRV (RMSSD, HF_{norm} and SD1) decreased, whereas sympathovagal indices (LF/HF ratio and SD2/SD1 ratio) increased significantly from baseline between 12 and 24 before the onset of calving restlessness. The same pattern was observed between 0 and 1 h before calving restlessness. Following the onset of behavioural signs, parasympathetic activity increased gradually with a parallel shift in sympathovagal balance towards parasympathetic tone, which was possibly a consequence of oxytocin release, which induces an increase in vagus nerve activity. Parasympathetic activity decreased rapidly between 0 and 0.5 h following calving and was lower than measured during all other stages of the study, while sympathetic activity peaked during this stage and was higher than measured during any other stages. Between 0 and 4 h after calving vagal tone was lower than baseline, whereas sympathovagal balance was higher, reflecting a prolonged physiological challenge caused by calving. Vagal activity decreased, whereas sympathovagal balance shifted towards sympathetic tone with increased live body weight of the calf during the late second stage of calving,

* Corresponding author at: Hungarian Academy of Sciences (HAS), SZIE Large Animal Clinical Research Group, Üllő-Dóra Major H-2225, Hungary. Tel.: +36 30 9443990.
E-mail address: Kovacs.Levente@mkk.szie.hu (L. Kovács).

http://dx.doi.org/10.1016/j.physbeh.2014.11.039
0031-9384/© 2013 Elsevier Inc. All rights reserved.

suggesting higher levels of stress associated with the higher body weight of calves. All HRV indices, measured either at the late second stage of calving and between 12 and 24 h after calving, were affected by the duration of calving. Our results indicate that ANS activity measured by HRV indices is a more immediate indicator of the onset of calving than behaviour or HR, as it changed earlier than when restlessness or elevation in HR could be observed. However, because of the possible effects of other physiological mechanisms (e.g. oxytocin release) on ANS activity it seems to be difficult to measure stress associated with calving by means of HRV between the onset of calving restlessness and delivery. Further research is needed to enable more precise interpretation of the prepartum changes in HR and HRV in dairy cattle.

© 2013 Elsevier Inc. All rights reserved.

1. Introduction

Optimal reproduction is one of the most important aims of the dairy industry. Parturition is a natural event that involves stress and pain to the dam, therefore the period around calving is a very sensitive time for dairy cows [1]. Monitoring individual cows in the periparturient period is of great importance for decreasing neonatal losses, which is a key to maintaining profitable production on dairy cattle farms [2].

Studying clinical and behavioural signs prepartum is of particular interest in studies involving dairy cattle [3–5]. Labour is traditionally described using three stages [6,7], although there is no clear end and start to these stages, as they progress gradually [1]. The first stage begins with uterine contractions when the cow becomes restless [8,9].

Changes in behaviours associated with calving can be monitored automatically on farms [10] using sensors validated especially for the measurement of lying behaviour [11,12]. Studies on predicting the onset of calving based on non-behavioural external signs such as relaxation of the broad pelvic ligaments [13,14] or hyperplasia of the udder [15] have been carried out extensively; however, variation in the external signs was too great to obtain any valuable information [16,17].

In addition to clinical signs, several physiological markers have been used to predict the time of calving with varying results. Although there is evidence that dairy cows exhibit a distinct decrease in vaginal and rectal temperatures commencing approximately 48 h before calving [13,18,19], the detection of this decrease does not determine the onset of calving precisely [20]. A drop in P4 concentrations before calving has been detected using different on-farm tests [16,21], however, without measuring any clinical or behavioural parameters.

Calving is physically challenging, causes considerable distress to cows [9] and was ranked as one of the most painful conditions experienced by cattle [22]. In animals, the parasympathetic branch of the autonomic nervous system (ANS) plays a key role in regulating heart rate (HR) in response to stress [23–25]. The non-invasive measurement of HR and heart rate variability (HRV), i.e. the short-term fluctuations in successive cardiac interbeat intervals, has increasingly been used for the assessment of pain in calves [26,27] and cows [28,29]. Measurement of cardiac vagal tone by means of the root mean square of successive differences (RMSSD) in consecutive R–R intervals and the high-frequency (HF) component of HRV has been found useful in numerous studies investigating stress in dairy cattle under different physiological conditions [30]. Reduced vagal tone was found in cows subjected to waiting after parlour milking with non-voluntary exit [31], during milking in a novel milking environment [32] and in calves exposed to external stress or pathological loads [33].

The HF component is generally recognised to reflect parasympathetic modulation of the heart influenced by baroreceptor input of vagal receptivity [34,35]. Briefly, decreases in the values of HF reflect a shift towards sympathetic dominance, while increased values indicate a shift towards vagal activity. The low-frequency component (LF) is thought to be closely associated with fluctuations of the peripheral vasomotor tone and reflects the 10-s periodicities, or so-called Mayer waves, of blood pressure [36,37]. LF has been used as a stress indicator in dairy cattle [30], but in most cases it was found to be a poor marker of sympathetic activity [33,38,39] as it is influenced by baroreceptor modulation of both vagal and sympathetic pathways [34,40].

The LF/HF ratio provides essential information on the state of sympathovagal balance in dairy cattle [30]. An increase in the LF/HF ratio is interpreted as a regulatory shift towards sympathetic dominance [41].

To calculate the geometric means of HRV, non-linear Poincaré plots have also been used in dairy cattle studies [31,42] for assessing the vagal regulation of cardiac dynamics. For a recent review on the use of HRV for stress assessment in dairy cattle, see Kovács et al. [30].

To date, prediction of calving based on continuous and detailed monitoring of the ANS in parallel with the animal's behaviour has not been done.

The present study had a dual purpose. First, we investigated HR and HRV parameters to test their usefulness in predicting the onset of calving by the assessment of stress-related changes in ANS activity associated with parturition. The second objective was to identify the impact of certain circumstances of calving (time of day at birth, body condition of the cow, live body weight of the calf, duration of calving) on the animal's cardiac activity 1) between the appearance of the foetal hooves and delivery of the calf and 2) between 12 and 24 h after calving.

2. Materials and methods

2.1. Animals

Our study was conducted as part of a larger research project on metabolic, behavioural and physiological aspects of parturition at the Prograg Agrárcentrum Ltd. in Ráckeresztúr, Lászlópuszta, Hungary, which has a herd of 900 Holstein–Friesian cattle.

A total of thirty-five multiparous cows that calved between October and December 2013 were selected from clinically healthy animals for this study. Three animals that had assisted calving as well as two cows, which were disturbed during parturition (one by her group mates and another due to pharmacological treatment), were not included. Three of the cows that calved before their expected calving date were also excluded from the experiment due to too short measurement lengths. One cow was excluded because she started to calve during data downloading. Three cows that calved in standing position were also excluded as it is well known that HRV is different in standing and lying posture in cattle [39]. Two animals with postpartum health problems (one with retained placenta and one that suffered from downer cow syndrome) were also excluded from the study. Finally, 20 cows (means $\pm$ SD; parity $= 3.4 \pm 1.2$; BCS $= 2.8 \pm 0.3$, locomotion score: 1.6 ± 0.2) were included with spontaneous calving that required no calving assistance or other procedures.

2.2. Selection of animals

From approximately 4 weeks before calving, cows were kept in a 35 m $\times$ 20 m group pen including 60–70 animals, bedded with deep straw. Animals were checked twice a day (at 7:00 a.m. and 6:00 p.m.). During each observation, cows were first visually inspected from a distance for signs of raised tail or a suddenly enlarged, tense udder. Then, after entering the pen, each cow was examined physically in standing position. Criteria used for the selection of the experimental animals included 1) enlargement of the vulva, 2) tenseness and filling of the

Download English Version:

https://daneshyari.com/en/article/5923956

Download Persian Version:

https://daneshyari.com/article/5923956

Daneshyari.com