Physiology & Behavior 165 (2016) 202–210

Contents lists available at ScienceDirect

Physiology & Behavior

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

Timing of obstetrical assistance affects peripartal cardiac autonomic function and early maternal behavior of dairy cows

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HIGHLIGHTS

- Calving in a group is less stressful than calving in a maternity pen.
- Appropriately timed obstetrical assistance supports expression of maternal behavior.
- Premature obstetrical assistance results in high levels of stress during parturition.
- Premature assistance elongates SNS activation and inhibits early maternal behavior.

ARTICLE INFO

Article history:
Received 14 June 2016
Received in revised form 23 July 2016
Accepted 1 August 2016
Available online 02 August 2016

Keywords:
Obstetrical assistance
Cardiac autonomic function
Stress
Early maternal behavior
Heart rate variability
Dairy cows

ABSTRACT

Peripartal autonomic nervous system function and early maternal behavior were investigated in 79 multiparous Holstein-Friesian cows. Animals were allocated into four groups based on the technology of calving management: 1) unassisted calving in a group pen (UCG; $N = 19$), 2) unassisted calving in an individual pen (UCI; $N = 21$), 3) assisted calving with appropriately timed obstetrical assistance (ACA; $N = 20$), and 4) assisted calving with premature obstetrical assistance (ACP; $N = 19$). Heart rate, the high frequency (*HF*) component of heart rate variability (*HRV*) as a measure of vagal activity and the ratio between the low frequency (*LF*) and HF components (*LF/HF ratio*) as a parameter of sympathetic nervous system activity were calculated. Heart rate and HRV parameters were presented as areas under the curves (*AUC*) for the following periods: 1) prepartum period (between 96 h before the onset of calving restlessness and the onset of restlessness), 2) parturition (between the onset calving restlessness and delivery), and 3) postpartum period (during a 48-h period after delivery). Pain-related behaviors were recorded during parturition (i.e., the occurrence of vocalization and stretching the neck towards the abdomen) and during a 2-h observation period after calving (i.e., the occurrence of vocalization, stretching the neck towards the abdomen and the duration of standing with an arched back). Early maternal behavior was observed during the first 2 h following calving as follows: 1) latency and duration of sniffing calf's head/body, and 2) latency and duration of licking calf's head/body. No difference was found across groups in autonomic function before the onset of calving restlessness. Area under the heart rate curve was higher in ACP cows during parturition (39.6 ± 2.5 beats/min × h) compared to UCG, UCI and ACA animals (AUC = 13.1 ± 0.9 beats/min × h, AUC = 22.3 ± 1.4 beats/min × h and AUC = 25.0 ± 2.1 beats/min × h, respectively). Area under the heart rate curve did not differ across the UCG, UCI and ACA groups during the postpartum period (AUC = 65.2 ± 16.7 beats/min × h, AUC = 58.0 ± 14.2 beats/min × h and AUC = 62.9 ± 12.1 beats/min × h, respectively) but it was higher in ACP cows compared to the former groups (AUC = 269.1 ± 36.3 beats/min × h). During parturition, area under the HF curve reflected a lower vagal tone (AUC = -30.5 ± 1.6 n.u. × h) in cows with premature obstetrical assistance than in animals that calved individually without farmer assistance (AUC = 2.7 ± 0.4 n.u. × h) or with appropriately timed assistance (AUC = 3.2 ± 1.2 n.u. × h). During parturition, LF/HF ratio showed greater sympathetic activity in ACP cows than in animals from any other group. Area under the HF curve was similar across UCG, UCI and ACA cows (AUC = -232.1 ± 42.0 n.u. × h, AUC = -163.4 ± 35.6 n.u. × h and AUC = -331.4 ± 56.2 n.u. × h, respectively) during the postpartum period and was the lowest in ACP cows (AUC = -1025.6 ± 44.2 n.u. × h) reflecting a long-term stress load in the latter group. During parturition, both vocalization and stretching the neck towards the abdomen occurred more often in UCG cows than in cows from any other groups, and the incidence of both behaviors was statistically higher in ACP cows than in

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http://dx.doi.org/10.1016/j.physbeh.2016.08.001

UCI and ACA animals. There were no significant differences across groups in these behaviors during the 2-h postpartum observation. UCG cows had a shorter latency and a longer duration of maternal grooming during the first 2 h following delivery compared to any other groups. UCI and ACA dams spent more time with licking the calf within the 2-h period after calving and had a shorter latency to sniff and lick the offspring compared to cows that received premature assistance. Group calving is less stressful for cows than calving in an individual pen either with or without obstetrical assistance. Calving in a group or with appropriately timed farmer assistance supports the expression of early maternal behavior and lead to a rapid postpartum recovery of the autonomic nervous system. Premature obstetrical assistance means stress for cows during parturition, leads to a prolonged postpartum recovery of the autonomic nervous system and inhibits the expression of early maternal behavior.

1. Introduction

Parturition is a natural process; however, it is a challenging and high-risk event for both the cow and her offspring. Thus, careful management during the peripartal period is crucial in terms of welfare and production. However, less time is available for individual attention in large scale farms [1], which is already occurring with the 'lost in the herd' and 'loser cow' syndromes [2]. Careful assistance can help minimize unnecessary pain and distress during calving, care must be taken when deciding on the necessity and timing of assistance during calving as unnecessary or premature intervention can cause injuries in the birth canal [3]. Based on our personal experience, assisted calvings in Holstein-Friesian cows occur in around half of the births in Hungarian large-scale farms. It is thus questionable whether the assistance given is necessary in all of the cases and whether unnecessary assistance has consequences in terms of animal stress and behavior.

Parturition a complex process triggered by the fetus, it involves alterations in autonomic nervous system (*ANS*) activity [4]. In recent years, heart rate and heart rate variability (*HRV*) have become generally accepted indicators of animal stress reflecting on the balance of the ANS [5] and therefore, they are often used in dairy cattle welfare studies [6]. Assessment of the activity of cardiac vagal tone by means of the normalized power of the high frequency (*HF*) component of HRV is increasingly used for investigating acute [7,8] and chronic [9] physiological effects of stress in dairy cows. The low-frequency (*LF*) component of HRV is closely associated with fluctuations of the peripheral vasomotor tone and reflects the 10-s periodicities, or the so-called Mayer waves, of blood pressure [10]. There are several studies reporting LF to be a poor marker of sympathetic activity in humans [11] and in dairy cattle as well [12–14] as it is influenced by baroreceptor modulation of both vagal and sympathetic pathways [11,15].

However, the *LF/HF ratio* [the ratio of the LF and the HF components] is an appropriate indicator of stress in domestic species [5] as it provides information on the sympathovagal balance and sympathetic activation of the ANS, even in dairy cattle [6]. We found that both HF and LF/HF parameters are better predictors of approaching calving than the onset of calving restlessness, and postpartum stress was also reflected by decreasing vagal activity parallel with a rapid sympathetic activation in multiparous cows with spontaneous calving [4]. In contrast to the numerous studies available on dystocia (difficulties at calving), only a few studies have examined the effects of any assistance provided at the time of calving. Although pain, distress and injuries caused by dystocia in individual animals receive less attention in large-scale herds [16] no research has evaluated the effect of the timing of obstetrical assistance on the stress status of cows during parturition and in the early postpartum period using physiological indicators.

Starting immediately after giving birth the dam used to nurse her calf during the first day [17]. However, in modern dairy farming systems, cow and calf are usually separated after calving, which has production efficiency and health concerns [18]. In dairy cattle, as in most other mammals, the dam licks the calf (within 90 min after calving) and some of them may eat the afterbirths (usually between 2 and 6 h after calving). These processes have roles in terms of evolution, adaptation and health; therefore, in some dairies cow and calf are kept together for the first 2 h after birth. Licking the calf has obvious advantages as an anti-predator behavior [19], ensures the continuity of the dams' entodiniomorph rumen ciliates [20], stimulates the calf to stand and is considered to essential for calves' later social behavior [17].

Expressions of early maternal behaviors and parent-offspring interactions have been studied in individual calving pens [21] and in semi-natural environments [22]. However, the effect of any assistance given at calving on the early contact between the dam and her offspring is not known so far. The few works on the associations between peripartal behavior and obstetrical condition focused mainly on behavioral changes before parturition [23,24].

The main aim of the present study was to find out whether the timing of obstetrical assistance (premature vs. appropriately timed) and the management of calving (individual vs. group calving) have an impact on cow stress status during calving and in the early postpartum period. Our second aim was to identify differences in early maternal behavior associated with the animals' obstetrical condition. For this purpose, besides heart rate we calculated ANS-related HRV parameters from the consecutive R–R intervals as indicators of animal stress. It was hypothesized that premature assistance at calving could impair cows' ANS function both during the delivery process and in the early postpartum period and affects early maternal behavior as well.

2. Materials and methods

2.1. Animals

This field study was carried out in a commercial dairy farm in Hungary with around 900 lactating Holstein-Friesian cows having a 48% prevalence rate of assisted calving in the study year. One hundred and twenty multiparous cows that calved between 15 October and 13 December 2013 were allocated for the investigation. Cows with any pharmacological treatment ($N = 2$) or with a recent history (less than two months) of clinical mastitis ($N = 6$), as well as animals suffering from lameness ($N = 10$) were excluded. Cows which were disturbed due to pharmacological treatment during parturition ($N = 5$) were not included. Fifteen cows that calved before their expected calving date were also excluded from the experiment due to the too short measurement lengths. Three animals were excluded due to malfunction of heart rate receivers. Finally, 79 cows (means ± SD; age = 5.9 ± 0.5; parity = 3.2 ± 0.3; body condition score = 3.3 ± 0.1) were involved in the experiment. Before calving, cows were kept in a pre-calving group pen, which included around 50 animals. Housing and feeding of the animals are described in our recent study [4].

2.2. Parturition management and experimental groups

According to the farm practice, cows calved in the group pen or in a separated maternity pen measured 4 × 5 m where obstetrical assistance was provided. Supervision of the dams during calving, the decision to move them into the maternity pen or to provide assistance was made by the farm personnel. Calving personnel moved cows to the separated maternity pen if the calving would have been disturbed by group mates or if assistance was required. Based on the decision of farm staff,