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Effect of monitoring the onset of calving by a calving alarm thermometer on the prevalence of dystocia, stillbirth, retained fetal membranes and clinical metritis in a Hungarian dairy farm

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ABSTRACT

The objective of the present study was to assess the effectiveness of an intravaginal thermometer in the field prediction of the second stage of labor and to determine its impact on the health of dams and newborn calves. Holstein cows (n = 241) were randomly selected about 5 (mean ± SD: 4.7 ± 2.0) days before the expected date of calving and the thermometer was inserted into the vagina. Another 113 cattle served as controls. There was no false alarm during the experiment. The risk of dystocia (Score >1) was 1.9 times higher, the prevalence of stillbirth was 19.8 times higher, the risk of retained fetal membranes (RFM) was 2.8 times higher and the risk of clinical metritis was 10.5 times higher in the control group than in the experimental group. The prevalence of stillbirth was 7 times higher in cows with dystocia compared to cows with eutocia. The presence of dystocia and stillbirth increased the risk of RFM 4 and 5 times, respectively. The occurrence of RFM increased the risk of development of clinical metritis with a 22 times higher odds. The results indicate that the use of calving alert systems not only facilitates controlling the time of parturition and providing prompt and appropriate calving assistance but also decreases the number of dystocia cases and improves reproductive efficiency, postpartum health of the dam and newborn calf survival.

1. Introduction

Dystocia has been defined as a difficult birth resulting in prolonged calving or severe assisted extraction of a calf at birth [1]. The prevalence of dystocia ranged from 28.6% [2] to 51.2% [3] in nulliparous and from 10.7% [2] to 29.4% [3] in multiparous dams in the United States, respectively. Dystocia has negative effects on the dam and the newborn calf by increasing the stillbirth rate [3,4]. Furthermore, it increases the prevalence of retained fetal membranes (RFM), injuries of the birth canal [5], culling rate [6], risk of maternal mortality [7] and postnatal calf morbidity and mortality [3]. Therefore, the prevention of dystocia is of crucial importance in dairy farm management.

Predicting the onset of calving makes it possible to determine if there is a need for human intervention, and thus it enables the rescue of newborn calves and dams [8,9]. Several protocols have been recommended for predicting the exact time of calving by measuring hormonal changes and/or evaluating clinical signs (relaxation of the pelvic ligaments, decrease in body temperature), recording feeding and rumination behavior before calving as reviewed recently by Saint-Dizier and Chastant-Maillard [10] or determining the electrolyte concentrations in the mammary gland secretion [11]. Although these methods may help predict the time of calving, the inaccuracy and practical limitations of some methods may limit their use in the practice. On-farm devices like inclinometers and accelerometers detecting tail raising and behavioral changes, abdominal belts monitoring uterine contractions, intravaginal thermometers detecting a drop in body temperature and/or the expulsion of the allantochorion, and devices fixed in the vagina or at the vulvar lips signaling calf expulsion via

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SMS are currently marketed for automated calving detection [10].

There is a paucity of information regarding the performance of these devices on commercial dairy farms [10]; therefore, the aim of the present study was to test the effectiveness of an intravaginal thermometer in predicting calving in the field. We also aimed to determine its impact on the health of dams and the survival of newborn calves.

2. Material and methods

2.1. Housing, feeding and milking technology

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

From 28 d before the expected calving, preparturient heifers and cows were housed in a precalving group pen (measuring 45×25 m), which included 50 to 60 animals and was bedded with deep straw. If calving assistance was needed, there was an individual maternity pen (measuring 4×5 m) where the straw was changed after each assistance. Before calving, cows were fed a prepartum total mixed ration (TMR) *ad libitum* containing a dietary forage-to-concentrate ratio of 78:22 on a dry matter (DM) basis. After calving, cows were fed a postpartum TMR *ad libitum* with a 60:40 forage-to-concentrate ratio on a DM basis as described previously [12]. Water was available *ad libitum*. During the first 5 days in milk, cows were milked twice daily at 4:00 a.m. and 2:00 p.m. in a 4-stall herringbone milking parlor operated with DeLaval Control Valve bucket milking machines (DeLaval International AB, Tumba, Sweden).

2.2. Experimental groups and calving management

Five days before the expected date of calving (the mean duration of gestation for heifers and multiparous cows calculated for a year basis/n = 927/before starting the experiment was 275.9/SD: 5.8/days), healthy pregnant cows (n = 257 including 57 nulliparous cows) being in the precalving group pen were randomly selected and an intravaginal thermometer (Vel'Phone, Medria, Châteaugiron, France) was inserted into the vagina (experimental group) (Fig. 1.). Depending on the size of the cow two appendage kits were used for heifers (turquoise) and multiparous cows (white) (Fig. 1). At the same time, 116 healthy pregnant cows (including 37 nulliparous cows) served as control (control group). Parity for the experimental and the control group ranged from 2 to 5 for multiparous cows (mean ± SD: 2.9 ± 0.3 in the experimental group and 3.1 ± 0.2 in the control group). The mean ± SD body condition scores using the 5-point scoring system [13] following calving were 3.1 ± 0.2 for nulliparous cows and 3.3 ± 0.2 for multiparous cows in the experimental group and 3.4 ± 0.2 for nulliparous cows and 3.1 ± 0.3 for multiparous cows in the control group. Once the thermometer had been placed into the vagina, the Vel'Phone sent information via SMS on the expulsion of the device. The onset of the second stage of labor was determined by the 'expulsion' SMS for the experimental cows. Control animals were also kept in the precalving group pen; however, the beginning of the second stage of labor was controlled by the farm personnel by checking the animals every 60 min [14]. The onset of the second stage of labor was determined based on the presence of mucus (blood around the perineum) and/or the onset of amniotic sac appearance outside the vulva for the control animals. Supervision of the dams during calving and the decision to move them into the maternity pen or to provide obstetrical assistance was made by the farm personnel. In both groups, calving personnel moved cows to the maternity pen if the calving would have been disturbed by group mates or if assistance was required as described previously by Kovács et al. [5]. Ten minutes after moving cows to the maternity pen (either experimental or control animals), cows were examined to check the presentation of the calf. When a maldisposition was evident (e.g. appearance of one foot outside the vulva), obstetrical assistance was performed by the calving personnel.

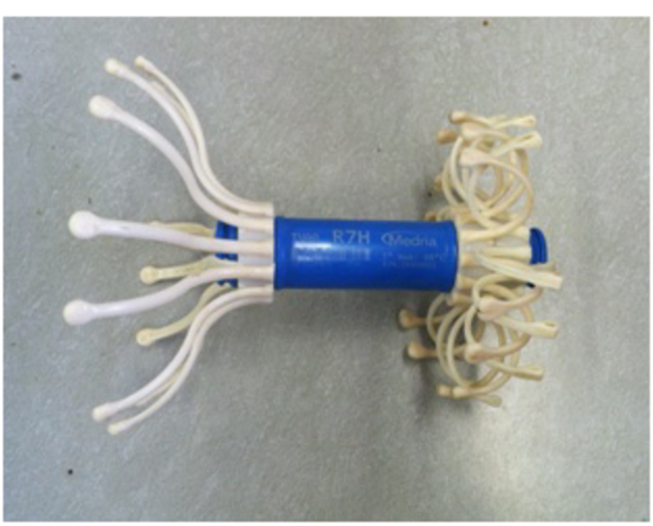

Fig. 1. Intra-vaginal thermometer (11.5 cm × 2.2 cm) used for multiparous cows.

Newborn calves were removed from their dams within 30 min after birth. Following calf removal, the dams were kept in postpartum pens for 5 d before being introduced to the milking herd.

2.3. Obstetrical assistance and dystocia scoring

The start of obstetrical assistance was considered when at least one person assisted the cow using a calving rope or a calf puller. Calving assistance by the farm personnel was performed at the latest within 90 min after the appearance of the amniotic sac in the vulva as described previously by Kovács et al. [5]. Presentation of the calf (anterior, posterior), live body weight of the calf, calving difficulties, number of personnel providing assistance at birth, and the delay of the second stage of labor were recorded using a 1 to 4 scale (Score 1 = eutocia, no assistant needed; Score 2 = delay in the second stage of labor and/or calving assisted by one person without the use of mechanical traction (light dystocia); Score 3 = mechanical traction of a calf with a calf puller or assistance by more than one person (severe dystocia); Score 4 = severe dystocia surgery needed as suggested by Meyer et al. [2], Lombard et al. [3] and Schuenemann et al. [14]). Sixteen (experimental group) and three animals (control group) were excluded from the study due to twin calving, which will be evaluated in another paper. For statistical analysis, dystocia was used as a dichotomous variable (dystocia score was one or larger than one/cows needing or not needing assistance). Stillbirth was recorded in case of death of a calf after an at least 260-day gestation during calving or in the first 24 h of postnatal life [15,16]. Postpartum diseases such as RFM and clinical (puerperal) metritis (CM) were also recorded. Each cow was examined 12–24 h after calving for RFM and until Day 20 after calving for Grade 2 CM as described previously by Buják et al. [17]. CM was diagnosed when fetid red-brown watery uterine discharge, atonic enlarged uterus, and pyrexia (>39.5 °C) were found [18].

2.4. Statistical analysis

All analyses were performed in R environment [19]. The significance level was set at $P < 0.05$.

Differences in duration of calving were analyzed by a general linear model, where parity, dystocia, body condition score, live body weight of the newborn calf, sex and presentation served as response variables.

Generalized linear models with binomial error distribution and logit link function were used to predict the risk factors influencing the occurrence of dystocia, stillbirth, RFM, and CM (as dichotomous variables). Explanatory variables to determine the risk factors for dystocia were group (control or experimental), parity, presentation, and body condition score. To determine the risk factors for stillbirth, dystocia was added as an explanatory variable to the above-mentioned variables. To identify risk factors for RFM we added dystocia and stillbirth, while for CM we added dystocia, stillbirth and RFM to the above-mentioned explanatory variables into the model.

The models were automatically built by using forward-backward simplification by 'stepAIC' (Akaike information criterion) function. The removal of the non-significant factors resulted in models with lower AIC in each case, interpreted as that the initial and final models have the same explanatory power. The exponentials of b-coefficients in the final models were interpreted as odds ratios (OR) of the outcome variables.

3. Results

All thermometers were expelled from the vagina and sent an SMS at the second stage of calving, and no false message occurred. No pathological clinical signs against the vaginal thermometer were recorded; however, signs of discomfort were shown by some heifers right after insertion. Calving was observed at 4.8 ± 2.3 days following the insertion of the device, ranging from 2 to 14 days. Average length (±SD) of gestation for heifers and multiparous cows was 278.1 ± 4.4 days in the monitored group and 278.2 ± 6.6 days in the control group ($P > 0.05$), or 280.0 ± 5.4 days in the monitored group and 276.5 ± 5.8 days in the control group ($P < 0.001$), respectively. Average length (±SD) of gestation in the monitored and the control group was 279.6 ± 5.3 and 277.1 ± 6.1 days ($P < 0.001$), respectively.

The odds for the presence of dystocia were 1.9 times higher (OR: 1.9, $P = 0.005$) in the control group compared to the experimental group, while parity and presentation of the calf did not influence the occurrence of dystocia (Table 1). Measured immediately after birth, the average weight of male calves (46.2 ± 7.1 kg) was higher ($P < 0.001$) compared to female calves (40.9 ± 6.7 kg), and thus the odds (OR: 1.9) for the presence of dystocia was higher ($P = 0.003$) if the calf was male (100/192 = 52.1%) compared to cows giving birth to female calves (58/162 = 35.8%).

The odds of stillbirth were 19.8 times higher (OR: 19.8, $P < 0.001$) in the control group than in the experimental group (Table 2). Parity did not influence the occurrence of stillbirth significantly. The odds of stillbirth were 7.1 times higher (OR: 7.1, $P < 0.001$) in cases of dystocic births compared to calvings with eutocia (the prevalence of stillbirth was 7.6% and 1.0%, respectively). The odds of stillbirth were 28.8 times higher (OR: 28.8, $P < 0.001$) in posterior presentation compared to anterior presentation (the prevalence of stillbirth was 25.0% and 2.4%, respectively).

The odds of RFM were 2.8 times higher (OR: 2.8, $P = 0.002$) in control than in experimental cows (Table 2). Parity and the presentation of the calf did not influence the occurrence of RFM significantly. The odds of RFM were 4.2 times higher (OR: 4.2, $P < 0.001$) in cows with dystocia (Score 1) compared to cows with eutocia (the prevalence of RFM was 26.0% and 7.1%, respectively). The odds of RFM were 5.3 times greater (OR: 5.3, $P = 0.007$) in the case of stillbirths compared to calvings resulting in a viable calf (the prevalence of RFM was 64.3% and 13.5%, respectively).

The odds of CM were 10.5 times higher (OR: 10.5, $P = 0.030$) in the control group compared to the experimental group (Table 2). Parity and presentation of the calf did not influence the occurrence of CM significantly. The odds of CM were 2.3 times higher ($P = 0.020$) in dystocic cows compared to cows with eutocia (the prevalence of CM was 29.1%, and 9.2%, respectively). The odds of CM were 21.7 times higher (OR: 21.7, $P < 0.001$) if RFM was present compared to calvings without RFM (the prevalence of CM was 72.8% and 8.0%, respectively).

4. Discussion

To the best of the authors' knowledge, apart from some preliminary results [20] this is the first study presenting results on the effects of sensory detection of the second stage of labor on the progress and outcomes of calving in a large study population. According to Chanvallon et al. [20] the sensitivity of the thermometer to detect calf expulsion was 100% for both heifers and cows, which is consistent with our findings because no false alarms were detected during the trial involving 241 animals. Similarly, no false alarm and no lack of alarm when using an intravaginal mechanical GSM device were recorded by Palombi et al. [21]. It seems that the second stage of calving can be detected accurately by using intravaginal sensors in a dairy farm. It is important to mention that the intravaginal thermometer did not induce any pathological clinical signs with the exception of a minor discomfort shown by some heifers. In contrast, when the intravaginal device remained inside

Table 1
Grouping of monitored and control nulliparous and multiparous calvings according to the dystocia score.

Dystocia score	Experimental group		Control group		Experimental group	Control group
	Nulliparous cows (n = 57)	Multiparous cows (n = 184)	Nulliparous heifers (n = 37)	Multiparous cows (n = 76)	(n = 241)	(n = 113)
Score 1 (eutocia)	33	113	13	37	146	50
Score 2	22	64	21	36	86	57
Score 3	2	6	3	3	8	6
Score 4	0	1	0	0	1	0
Percentage of dystocia (Score > 1)	42.1%	38.5%	64.9%	51.3%	39.4%	55.8%

Score 1 = no assistance (eutocia), n = 196.
Score 2 = delay in the assistance in the second stage of labor with assistance by one person without the use of mechanical traction; light dystocia.
Score 3 = assistance with mechanical traction of the calf with a calf puller or more than one person; severe dystocia.
Score 4 = Caesarean section.

Table 2
Prevalence of stillbirth, retained fetal membranes and clinical metritis in the control and monitored nulliparous and multiparous dairy cows.

Variable	Experimental group		Control group		Experimental Group (n = 241)	Control group (n = 113)
	Nulliparous cows (n = 57)	Multiparous cows (n = 184)	Nulliparous cows (n = 37)	Multiparous cows (n = 76)		
Prevalence of stillbirth n (%)	1 (1.7%)	1 (0.5%)	4 (10.8%)	8 (10.5%)	2 (0.8%)	12 (10.6%)
Retained fetal membranes n (%)	5 (8.8%)	18 (9.7%)	12 (32.4%)	20 (26.3%)	23 (9.5%)	32 (28.3%)
Clinical metritis n (%)	8 (14.0%)	20 (10.9%)	14 (37.8%)	22 (29.0%)	36 (11.6%)	28 (31.9%)

the vaginal canal for two consecutive weeks, Palombi et al. [21] observed no adverse effects and the animals did not exhibit any discomfort or vaginal discharge.

The prevalence rate of dystocia can be 1.7 [3] to 2.5 times [2] higher in heifers compared to multiparous cows. In contrast, in our study parity did not influence the dystocia rate significantly because its rate between nulliparous and multiparous dams was 1.1 in the experimental group and 1.3 in the control group, respectively. In agreement with the results reported by Palombi et al. [21], dystocia rate between the experimental and control groups was 1.4 in our study.

In harmony with the findings of previous studies [21], the animals monitored by us experienced significantly less obstetrical assistance (39.4% vs. 55.8%), severe (Score > 2) dystocia (3.7% vs. 5.3%), stillbirth (0.8% vs. 10.6%), RFM (9.5% vs. 28.3%) and CM (11.6% vs. 31.9%) compared to the control cows. The differences in the stillbirth rate between our experimental and control groups might be explained by the standard operating procedure of the farm, i.e. that after detecting the second stage of labor the farm personnel had to finish calving assistance within 90 min. This agrees with the recommendations of Schuenemann et al. [14] who suggested that calving personnel should start assisting cows 70 min after amniotic sac (AS) appearance (or 65 min after the appearance of feet). At the same time, it is also emphasized that the frequency of observation is critical for determining the appearance of the amniotic sac or the feet of the calf outside the vulva, therefore cows in the calving pen must be observed at least every hour in order to be able to detect the calving animal. Although there was no difference in predicting the second stage of calving by examining tail raising, stepping, clear and bloody vaginal discharge, turning the head toward the abdomen, and lying lateral with abdominal contractions between hourly observation and observation every 2 h, the area under the curve of examining the pelvic ligaments and teat filling changed only between 0.808 and 0.855 between 269 and 276 days of gestation which means that in some of the animals calving cannot be predicted accurately [22]. Besides clinical behavioral changes, mainly bloody vaginal discharge and/or the appearance of amniotic sac and fetal feet in the vulva used to be detected in the daily practice. In this way the prompt onset of calving cannot be detected in time, especially in free stalls, which may cause a delay in obstetrical assistance. Delayed obstetrical assistance can increase the stillbirth rate [10,23]. This may be one of the reasons why the prevalence of stillbirth in our control group (10.8% in heifer calving and 10.5% in cow calving) became higher. Somewhat higher stillbirth rates were reported for unmonitored heifers (16.7%) and cows (10%) in the calving barn also by Palombi et al. [21].

Complications during calving may increase the risk for stillbirth, retained fetal membranes, clinical metritis and endometritis, and mortality and culling of the dam [3]. Depending on the severity of dystocia the total cost of loss may change between 150 and 600 EUR per cow [24]. According to Saint-Dizier and Chastant-Maillard [10] the initial investment of the Vel'Phone including 6 probes, receiver, GSM subscription can be done by the financial lost caused by 6 severe dystocia. Vannieuwenborg et al. [25] have reported recently that an annual saving of 15 EUR per cow can be realized if calving monitoring devices are used in the farm.

In summary, our results indicate the benefits of the Vel'Phone calving monitoring system in terms of well-being and health of the dam and newborn calf survival, evidenced by decreased dystocia and stillbirth rates and lower prevalence of RFM and CM in the experimental group compared to the control group. According to Schuenemann et al. [23], the target prevalence (<2%) of stillbirth can be achieved in large dairy farms by using Vel'Phone through prediction of the onset of the second stage of calving, which supports appropriate and timely assistance at calving whenever it is needed.

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