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Short communication

Field-trial evaluation of an automatic temperature measurement device placed in the reticulo-rumen of pre-weaned male calves

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ABSTRACT

The assessment of the rectal temperature plays an important role in the early detection of bovine respiratory disease (BRD) in young calves, but the measurement is invasive and labor-intensive. The aims of this retrospective field-trial evaluation were to assess the correlation between the automatic measurements of the reticulo-ruminal (ReRu) temperature and the rectal temperature and to evaluate the diagnostic accuracy of a cumulative sum (CUSUM) control chart to detect pre-weaned calves suffering from BRD. In 150 male fattening calves (16.6 ± 3.3 d at arrival) the ReRu-temperature was obtained every 5 min automatically with a wireless device over a period of 8 weeks. Data was averaged over periods of 30 min and 4–6 h (day periods). The 30-min means were further evaluated using CUSUM control charts. All calves were inspected by trained persons at least twice a day and rectal temperatures were measured in calves showing visible signs related to BRD. A ReRu hyperthermia (ReRu temperature ≥ 40 °C) was detected in 139 calves over 30 min and in 99 calves over day periods, respectively. During the evaluation period 30 animals were affected by BRD (rectal temperatures ≥ 40 °C and one additional clinical sign). The correlations between rectal temperatures and both the corresponding 30 min as well as the day period ReRu temperatures was $r = 0.75$. The sensitivity (Se) and specificity (Sp) of ReRu hyperthermia for the 30 min means to detect BRD were 77% and 97%, respectively, whereas means of the day periods had a Se of 61% and a Sp of 97%. The CUSUM test revealed a Se of 71% and Sp of 98% to detect BRD. On average, by the CUSUM method calves with clinical signs of BRD were identified 3.5 d earlier. In conclusion, the automated ReRu temperature measurement possesses potential for the early detection of febrile responses in very young calves warranting further investigations.

1. Introduction

Bovine respiratory disease (BRD) has substantial impact on the welfare and productivity of young calves on rearing and fattening farms. The clinical signs of BRD vary greatly and range from slight increases in the respiratory rate to severe dyspnea (Cockcroft, 2015). Also, affected animals regularly display an initial early increase in body core temperature in response to infections with viral and bacterial pathogens causing BRD (Grissett et al., 2015). The typical fever peak a few hours or days after infection is commonly unnoticed by farm personnel. One reason lies in the common technique to detect an increased body core temperature which is to insert a thermometer into the rectum of the animals. This is labor-intensive as well as invasive and can compromise animal welfare. As a result, in herds in which BRD is enzootic more than 50% of the pre-weaned calves show ultrasonographic lung consolidations, but only in approximately 41% of these calves visual BRD signs were detected and treated by the producer (Buczinski et al., 2013). Previously, the application of remote reticulo-ruminal (ReRu) temperature measuring boluses has been shown to be a reliable and less invasive method for the detection of increased body core or rectal temperatures in dairy cows (Bewley et al., 2008a; Adams et al., 2013) and beef cattle (Rose-Dye et al., 2011; Timsit et al., 2011b). To our knowledge the measurement of ReRu temperature has not yet been described in pre-weaned animals. In general pre-weaned dairy calves are more frequently affected by BRD (prevalence on farms in the US of 12–16%) than calves after weaning (6–11%; Guterbock, 2014). Also, with an age of 14 days onwards male calves from different origins are often commingled and transferred to one barn for fattening which causes major stress and a greater risk of disease transmission (Svensson et al., 2003). Therefore, it was the objective of this study in pre-weaned calves to determine the relationship of the ReRu

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temperature with the rectal temperature and to determine the applicability of a cumulative sum (CUSUM) control chart to detect animals with clinical signs of BRD.

2. Material and methods

The field trial was performed according to the requirements of the federal animal welfare committee of the ministry of Schleswig-Holstein (reference number: V 242.7224.121–26). The study was conducted on a commercial rearing and fattening beef bull farm in northern Germany between September 2013 and November 2013. Pre-weaned male Holstein-Friesian calves (n = 150) with an initial age of 16.6 d (SD ± 3.3 d) and an initial weight of 53.8 kg (SD ± 5.2 kg) were bought from different farms and assigned to one of six straw bedded pens on the day of arrival. Calves were fed with a total of 38.2 kg milk replacer per calf by three automatic calf feeders over a period of 8 wk. Concentrates, hay and water were offered for ad libitum intake at all times. During the trial period of 8 wk calves' average daily gain was 778 ± 75 g/d.

The ReRu temperature was measured with an automatic temperature measuring device in the form of a bolus (70 g; 6.6 cm × 2.1 cm; Medria, Châteaubourg, France). On the day of arrival the bolus was swallowed by all animals after application with a bolus gun for small ruminants. Each bolus had an internal battery and transmitted the temperature every 5 min via radio link to the base station. Prior to the start of the experiment, the precision of all temperature measuring devices was tested in a water bath (gradual increase by 1 °C from 35.0 °C up to a maximum of 41.5 °C). Mean values for the five min bolus-temperature values were calculated for 30-min intervals and day periods (means of periods from 06.00 to 09.59 h = 'morning', 10.00–13.59 h = 'midday', 14.00–17.59 h = 'afternoon', 18.00 h to 23.59 h = 'evening', 00.00–05.59 h = 'night').

Throughout the experiment two trained persons alternately inspected all animals at least twice a day in addition to the barn personnel. If a calf displayed visible signs of BRD such as depression, ocular/nasal discharge, enforced breathing or coughing a detailed clinical inspection was performed. This included the assessment of the general condition, the evaluation of the respiratory tract (respiratory rate, lung auscultations) and the measurement of the rectal temperature as an approximation of the body core temperature. Only one digital thermometer was used throughout the trial which was inserted to a depth of approximately 8 cm into the rectum and had contact to the rectum wall throughout the measurement (HS Digital-Thermometer; Henry Schein, Wien, Austria). Calves with rectal temperatures ≥ 40 °C and, at least, one additional sign of BRD were diagnosed with BRD and treated for this condition. Follow up examinations of calves took place as long as calves displayed clinical signs related to BRD. In total, 219 clinical examinations were performed on 79 calves. Nine calves died during the trial mainly displaying clinical signs of BRD. The pathological examination of two calves which died without prior clinical signs of BRD indicated an infection with *M. haemolytica* and a rapid development of general septicemia. One calf did not wake up from anesthesia during the dehorning process. The health treatment of the animals is described in detail in the Supplementary material for this article.

The software package SAS 9.2 (SAS inst. Inc., Cry, NC, USA) was applied for the retrospective statistical analysis. The means of the ReRu temperatures for the respective time periods were analyzed separately (30-min interval and day periods). To reduce the effect of water intake which could not be observed for technical reasons all ReRu temperature values below 37 °C were excluded from analysis. The rectal temperatures obtained by the two trained persons at the health inspection procedures were regarded as comparative values. Descriptive analysis was performed to evaluate the number of calves displaying high ReRu temperatures (≥ 40 °C; ReRu hyperthermia) and markedly increased rectal temperatures (≥ 40 °C) with one further clinical sign of BRD. Pearson rank coefficients of correlations and the regression between rectal and associated ReRu temperatures (30–min intervals and day periods) were assessed. The cumulative sum (CUSUM) control chart was applied for the early detection of increased rectal temperatures (De Vries and Reneau, 2010). In this study the differences between the 30-min interval bolus temperature and the reference temperature (mean of all ReRu temperatures: 39.04 °C) were accumulated for each calf. For the CUSUM control chart four parameters were specified: the reference temperature, the standard deviation (0.46 °C) and two determinants of the process limits ($h=3$, $k=1.5$). The k-value is the reference or allowable value, which is related to the extent of change to be detected. The h-value determines the control limit; an overstepping implies that the process is 'out of control'. The k- and h-value were manually tested for best detection of ReRu hyperthermia and appropriate h-and k-values were chosen (Krieter et al., 2009). A one-sided test was performed. Thereby, only values exceeding the upper limit triggered an alarm which in this case was regarded as ReRu hyperthermia. The reliability of the ReRu temperature measurements and of the CUSUM values to assess spontaneously occurring BRD cases was further determined with regard to their sensitivity (Se), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV) (Petrie and Watson, 2013). To assess the discrimination power between BRD and non-BRD cases and to calculate the optimal cut-off value for ReRu-temperature to detect BRD, receiver operating characteristic (ROC) curves were created using PROC LOGISTIC in SAS (Zweig and Campbell, 1993). The calculated cut-off value for ReRu-temperature to detect a BRD case was at 40.0 °C.

3. Results and discussion

To the authors' knowledge, this is the first report on the use of wireless temperature measuring ReRu boluses for the early detection of clinical signs of BRD in pre-weaned calves. Remote rumen temperature boluses were previously successfully tested to continuously monitor the body core or rectal temperature in dairy cattle, beef bulls and heifers with more than 260 kg live weight (Bewley et al., 2008a; Small et al., 2008; Rose-Dye et al., 2011; Timsit et al., 2011a; Adams et al., 2013).

In the pre-trial water bath analysis, the precision and accuracy of the boluses were good (difference of 0.2 °C between the boluses and of 0.15 between mean of all boluses and the digital thermometer). Most boluses could be administered without any complications in two week old calves. No loss via feces or per regurgitation occurred during the trial period, although further long-term studies should address the sustainability and food safety of the boluses. In a few calves, the ventral throat of the calves had to be massaged in the direction of the sternum, which enabled the bolus to pass the base of the tongue. Over the trial period, more than 90% of the expected 5-min values were correctly transferred. In the beginning of the trial some data were not available due to connection problems between some boluses and the base station in the barn which could only be solved by repeated moving of the base station.

In total, rectal temperatures ≥ 40.0 °C and one further clinical sign were observed in 30 animals (Table 1). Slightly elevated rectal temperatures (> 39.4 °C, but < 40.0 °C) and one further clinical sign were detected in 14 animals and enforced breathing or other signs of respiratory distress without an increase in rectal temperature in 17 animals. The incidence of clinical BRD signs was