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Using thermography as a diagnostic tool for omphalitis on newborn calves

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ABSTRACT

The objective was to verify if thermography is able to detect inflammatory signs on the skin surface by comparing the umbilical region of healthy calves and calves presenting omphalitis. Twenty healthy calves (control group) had their lateral umbilical region and abdominal region examined with a thermal imaging camera in order to obtain a regional thermograph. The thermographic examination was then performed on 27 calves (Omphalitis group) presenting omphalitis diagnosed by physical examination. The maximum temperature of the lateral umbilical region in calves (aged < 30 days) was 35.7 °C ± 1.8 for the control group and 37.0 °C ± 1.1 for the omphalitis group and was significantly different ($p = 0.002$). No difference was found on the temperature of the abdominal umbilical region. In the abdominal and lateral region the highest temperature site was differently positioned between the groups. In conclusion, thermography is able to detect inflammatory signs on the skin of newborn calves and has advantages as a non-invasive, fast and safe method of supporting veterinary diagnosis.

1. Introduction

Omphalitis comprises all inflammatory disease occurring on the extra-abdominal portion of the umbilicus within the first few days of life and sometimes persisting for weeks (Radostits et al., 2002; Figuerêdo, 1999; Smith, 1993). On cattle, omphalitis is of major importance due to its occurrence around the first 30 days of life, leading to animal welfare concerns and economic losses, if not readily diagnosed and treated (Seino et al., 2016; Radostits et al., 2002).

The diagnosis of omphalitis on newborn calves is obtained through anamnesis and physical examination by bimanual abdominal palpation (Feitosa and Benesi, 2014; Dirksen et al., 2005; Figueirêdo, 1999). However, on a large number of animals, this method may take too much time as animals need to be physically restrained and examined individually. The thermographic examination is fast and accurate, representing no harm or stress to the animal (Mccafferty, 2007). This technology is improving diagnosis for buiatric practice (Stewart et al., 2005) because it is capable of identifying physiological and pathological changes due to systemic disease, through the detection of skin temperature, vascularization and blood flow variations (Sathiyabarathi et al., 2016; Mccafferty, 2007). In veterinary medicine, this tool is being widely used (Sathiyabarathi et al., 2016; Nogueira et al., 2013; Redaelli, 2013; Schaefer et al., 2012;Polat et al., 2010; Mccafferty, 2007; Schaefer et al., 2007; Stewart et al., 2005; Schaefer et al., 2004, Eddy et al., 2001). Considering the importance of omphalitis in newborn calves and the sensitivity thermographic imaging, the aim of this study was to evaluate the thermography efficacy on the diagnosis of omphalitis of newborn calves up to 30 days of life.

2. Material and methods

2.1. Animals

For this study 47 Holstein black and white calves were divided into 2 groups. Control group: twenty healthy calves from a dairy farm in São Paulo State, kept at the Bovine and small ruminants hospital of the School of Veterinary Medicine and Animal Science of the University of São Paulo (FMVZ-USP) up to 30 days of life. Omphalitis group: twenty seven calves from a dairy farm in São Paulo State presenting omphalitis on physical examination, monitored from birth to 30 days of life. Omphalitis group was kept at the dairy farm being periodically examined and when omphalitis symptoms were detected thermographic imaging and abdominal palpation was performed. Both groups were fed with colostrum for the first 3 days, receiving a volume comprising 10% of their body weight two times a day. After the third day, animals were fed with powdered whole milk reconstituted with filtered water, receiving a volume comprising 10% of their body weight two times a day; besides water and grain based animal food "*ad libitum*". All calves in the study presented a similar body size and weight, within age standards for their breed. The purpose of the control group was to obtain a regional thermograph of the umbilical and abdominal region of animals presenting physiological involution of the structures to compare with animals presenting omphalitis.

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2.2. Thermography

The thermographic examination was performed with a thermographic camera (FLIR SYSTEMS AB, Sweden; Model: T620 25°; resolution: 640 × 480 pixels; precision of ± 2 °C) with the following standard parameters: emissivity of 0.95; room temperature at 23 °C and 50% relative humidity; camera distance between 0.5 and 1.0 m; and color scheme at rainbow HC. Images of the external umbilical region were captured with animals standing (left and right lateral view) and images of the abdominal region were captured with calves on dorsal recumbency. To avoid interferences from dirty and humidity on the thermal imaging, before images were taken, animals were kept standing on a dry and clean place, away from direct sunlight for at least 15 min. All images from healthy and omphalitis groups where obtained during the morning to avoid circadian variations. The site with the highest temperature was considered for every position (point of maximum temperature [T max], indicated with a red arrow on the figures), comparing the control group with calves presenting omphalitis and its intra-abdominal complications. The average maximum temperatures on the left and right lateral regions and abdominal region was determined and compared between groups.

The thermographic images were analyzed with the software FLIR Tools®, where, for each region, a geometric analytic tool (rectangular or elliptical) that best suited the region was chosen. Within this area the software determined the maximum temperature (Tmax), the minimum temperature (Tmin) and the average temperature (Tmed) in Celsius degrees (°C).

2.3. Omphalitis diagnosis

To establish which animals presented omphalitis the specific examination of umbilical region was performed following the recommendations proposed by Dirksen et al. (2005), Figueirêdo (1999) and Feitosa and Benesi (2014). To examine the umbilical region, animals were kept standing for inspection and bimanual palpation was undertaken. On lateral recumbency animals were examined by abdominal palpation to verify possible internal organ alterations. The palpation was performed after the thermography to avoid changes due to local manipulation.

2.4. Statistical analysis

For data analysis, the statistical software Minitab 16 ® (Minitab Inc., State College, PA, USA) and GraphPad Prism5.00 ® (GraphPad Software, Inc., San Diego, CA, USA) were used. Normality was verified using the Anderson-Darling test. Homoscedasticity was verified by Bartlett's test. The average lateral maximum temperatures and average abdominal temperature was compared by Student´s T test. Differences of $p < 0.05$ were considered statistically significant. Data is expressed as mean ± standard deviation.

3. Results and discussion

The average maximum temperature observed at the lateral regions of the control group was 35.7 °C ± 1.8 and 37.0 °C ± 1.1 for the omphalitis group with a significant difference between the groups ($p = 0.002$), showing an increased temperature for the omphalitis group, due to local inflammation, detected by thermography (Fig. 1). The average maximum temperature observed at the abdominal region of the control group was 38.8 °C ± 1.18 and 38.7 °C ± 1.06 for the omphalitis group with no significant difference between the groups ($p = 0.791$), as control group was highly variable (Fig. 2). As previously described by Rekant et al. (2016) volume and hair density may have an influence on local temperature measurement. On the abdominal region of calves there are hairless sites, low presence of hair sites (groin) or abundant hair elsewhere. Variation in hair cover may therefore have influenced

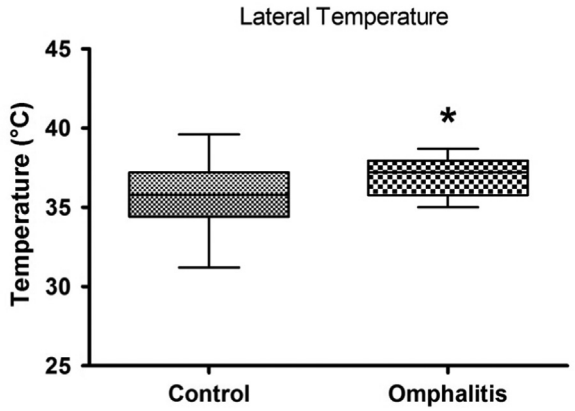

Fig. 1. The average maximum temperature obtained by thermography of newborn calves at lateral umbilical regions, comparing control (35.7 °C ± 1.8) and omphalitis (37.0 °C ± 1.1) groups. (Values expressed as mean and standard deviation; *: p-value = 0.002 with significant difference).

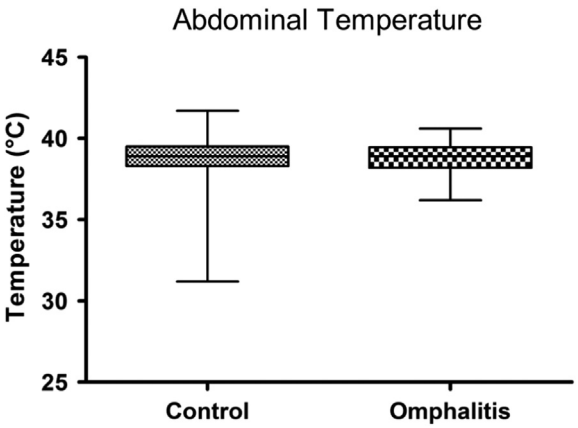

Fig. 2. The average maximum temperature obtained by thermography of newborn calves at the abdominal region, comparing control (38.8 °C ± 1.18) and omphalitis (38.7 °C ± 1.06) groups. (Values expressed as mean and standard deviation; p-value > 0.05 with no significant difference).

temperature measurement.

Thermographic images of healthy calves show that T max of the lateral umbilical region was located cranially to the navel, close to the abdominal wall insertion (Fig. 3). Whilst on omphalitis group animals T max was mostly located at a distal point to the navel.

With thermography of the abdominal region of healthy calves placed on dorsal recumbency, T max was located at the dug, whilst on omphalitis group T max was located cranially, close to the navel (Fig. 3). The results show that when there was an inflammatory process at the umbilical structure the point with the maximum temperature is dislocated to the umbilical region.

When comparing the thermography results with the physical examination by abdominal palpation (Feitosa and Benesi, 2014; Dirksen et al., 2005; Figueirêdo, 1999) it was observed that the thermographic exam was able to confirm omphalitis equally as well as the traditional method; showing that the lateral umbilical temperature was greater than the same site for the control group. It was also possible to see on the images the displacement of the highest temperature site on the lateral and abdominal region in the omphalitis group, showing that the thermographic exam is able to detect omphalitis on newborn calves.

Previous studies have successfully used thermography to detect skin surface inflammation such as mastitis, laminitis and other inflammatory diseases (Hovinen et al., 2008; Sathiyabarathi et al., 2016; Berry et al., 2003; Eddy et al., 2001). The present study shows that thermography is capable of detecting warming of the skin surface associated with

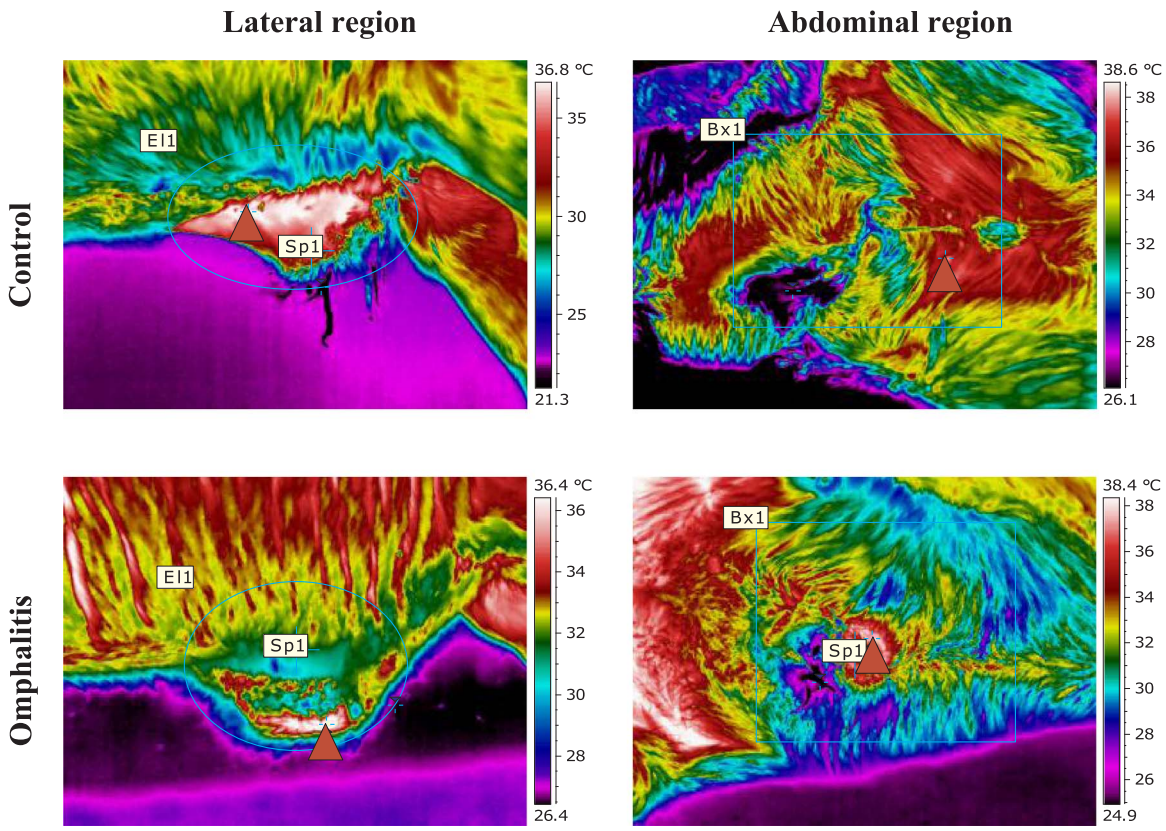

Fig. 3. Thermographic image of the left lateral umbilical and abdominal region of a calf in control and omphalitis groups. The red arrow indicates the maximum temperature site.

omphalitis in newborn calves. It should be noted that further thermographic studies should be designed that involve blind testing of calves with and without omphalitis to confirm validity of this method as a veterinary diagnostic technique.

4. Conclusions

Thermographic examination found that on average the maximum temperature of the lateral umbilical region in calves (aged < 30 days) that were diagnosed with omphalitis was on average > 1 °C warmer than animals clear of disease. No differences were found on the temperature from abdominal umbilical regions.

Thermography highlighted also differences in the position of the maximum temperature of abdominal and lateral umbilical regions. Thermography is a non-invasive, fast and safe method of detecting skin temperature changes and therefore is highly valuable for veterinary medicine.

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