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Changes in Ruminoreticular Temperature and Body Activity After Akabane Vaccination in Pregnant Hanwoo (Bos taurus coreanae)

Running title: Ruminoreticular Temperature and Body Activity After Akabane Vaccination in cows

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Abstract

Akabane disease causes life-threatening deformities in newborn calves, such as arthrogryposis and hydranencephaly syndrome. Early vaccination is currently being done in some countries to prevent Akabane disease prior to breeding age, but no data have been reported on changes in body temperature and activity following vaccination. Therefore, this study aims to investigate changes in ruminoreticular temperature and body activity according to vaccination using biosensors. In this study, ruminoreticular temperature and body activity measurements were collected every 10 min from 110 cows (40 pregnant cows, 70 non-pregnant cows) using the biocapsule sensor. Ruminoreticular temperature increased from 6 h to about 16 h after Akabane vaccination. In particular, the frequency of maintaining a high temperature (>40 °C) after vaccination was 16.4% higher among pregnant cows than among non-pregnant cows. Therefore, biosensors can be used to predict fever caused by the Akabane vaccine in real-time through changes in ruminoreticular temperature and body activity after the Akabane vaccination, which can help the veterinarian's examination and predict miscarriage and stillbirth.

Keywords : Akabane virus, Akabane vaccination, ruminoreticular temperature, body activity, Hanwoo

1. Introduction

Akabane disease is caused by infection with the Akabane virus of the genus *Orthobunyavirus* in the family *Bunyaviridae*, which is transmitted to cattle primarily by biting gnats of the *Culicoides* genus. Miscarriage and stillbirth can occur when pregnant cows are infected (1-3). Infection with the Akabane virus mostly affects the developing central nervous system, with congenital arthrogryposis and hydranencephaly syndrome as the main symptoms (4-8).

The disease has been reported to have occurred in temperate and tropical regions of Australia, Southeast Asia, East Asia, and the Middle East. Vaccination is recommended in the Republic of Korea to prevent the Akabane disease, and so far, there have been no reports of side effects from the vaccination. However, an increase in rectal body temperature and a decrease in milk production due to Q fever virus vaccination in cows have been reported (9), and an increase in body temperature has been reported due to the vaccination of infectious bovine rhinotracheitis virus in beef calves (10). Various reports on the foot-and-mouth disease (FMD) vaccination have found an increased incidence of sperm abnormalities due to vaccine stress and anaphylactic shock, resulting in an increased incidence of miscarriage and early embryo death, delayed ovulation, decreased conception rates, and increased ruminoreticular temperature and body activity, besides injection site granuloma/abscess formation (11-14).

Beyond the reproductive repercussions, the physiological reactions to elevated body temperature post-vaccination can impact feed nutrition, animal reproduction, and milk secretion (15). Some reports found a close association between milk secretion and increased body temperature (9, 16, 17).

It has been reported that the rectal temperature increased significantly by 0.41 °C compared to the control group after 1 day of multivalent killed vaccines in dairy cows (18), and in the Netherlands, body temperature increased by 0.45 °C post-injection of the bovine herpesvirus 1 vaccine into non-lactating cows (19).

Technology has recently been developed that can detect ruminoreticular temperature, body activity, and pH in real-time by inserting a biocapsule sensor into the cow's rumen (14, 20-25).

However, there have been no studies on major side effects, such as miscarriage and stillbirth, and changes in ruminoreticular temperature and body activity according to pregnancy pre- and post-vaccination. Therefore, in this study, a biosensor (ruminoraticular bolus system) is inserted into the rumen to confirm the changes in temperature and activity in the rumen according to Akabane vaccination and pregnancy.

2. Methods

2.1 Animals

The 110 cows (40 pregnant cows, 70 non-pregnant cows) used in this study were bred by the Gyeongsangbuk-do Livestock Technology Research Institute, fed according to the Korean Feeding Standard for Hanwoo, and bred in a sufficient space (breeding space = 300 m^2/15 cows) equipped with stanchions. All experiments were conducted with the approval of the Animal Ethics Committee of the Gyeongsangbuk-do Livestock Research Institute (Approval number: protocol code GAEC/140; approved on December 14, 2021). Table 1 shows the month of age, pregnancy day, and parity of the cows used in the experiment. Before the start of the experiment, cows with no abnormalities in the ovaries and uterus were selected through ultrasound examination for this study.

2.2 Ruminoreticular Temperature and Body Activity

Six months before the start of the experiment, one biocapsule sensor (LiveCare, uLikeKorea Co., Inc., Korea) was placed in the cow's rumen through oral administration, and an adaptation period was set for 6 months. The information on the sensor used in the experiment and the method of measuring temperature and activity every 10 min in the rumen are described in detail in the literature (11-14, 25, 26).

2.3 Akabane Vaccination

For Akabane vaccination (DS Akabane CattleVac, Daesung Microbiological Labs Co., South Korea), the vaccination site was disinfected with 70% alcohol tissue and then subcutaneously injected (2 mL/cow) into the neck of the cow using a disposable syringe.

2.4 Pregnancy Test

One month before the start of the experiment, a pregnancy test was checked using rectal ultrasound equipment (DRAMINSKI iScan mini, Dramiński S.A., Gietrzwałd, Poland). Six months before the start of the experiment.

2.5 Statistical Analysis

Changes in ruminoreticular temperature and body activity according to pregnancy after Akabane vaccination were statistically analyzed by a two-way ANOVA using GraphPad Prism (version 8.0.1; GraphPad Software, Inc., La Jolla, CA, USA). A p-value of 0.01 or less was considered significant.

3. Results

In this study, a biocapsule sensor was inserted in the rumen of pregnant and non-pregnant Hanwoo to analyze the biological changes caused by Akabane vaccination. Based on our data, the body temperature of cattle decreased rapidly after vaccination. This was attributed to a recurring pattern every 24 hours, as the cattle consumed feed and water at the same time each day. Therefore, we conclude that this effect was not due to the vaccination (Figure 1).

It was observed that the average temperature of pregnant cows was approximately 38.8°C, and that of non-pregnant cows was around 38.6°C, both 1 day before and 1 day after the Akabane vaccination. Typically, the pregnant cows maintained a temperature about 0.2°C higher than the non-pregnant group. However, following the Akabane vaccination, the average temperature of pregnant cows between 6 to 16 hours post-vaccination was 39.1°C, indicating an average increase of 0.3°C compared to pre-vaccination levels. Furthermore, this increase in body temperature showed significant differences compared to non-pregnant cows (Figure 1).

Analysis of the amount of body activity before and after the Akabane vaccination showed that the amount of activity was unusually low only at the time of feed intake, regardless of the Akabane vaccination (Figure 2). Overall, there was no significant change in the amount of activity depending on Akabane vaccination and pregnancy (Table 2).

To examine the ruminoreticular temperature variations following Akabane vaccination in detail, the distribution was assessed by dividing into three groups based on data collected every 10 minutes for 16 hours post-vaccination. Upon analysis, it was observed that the percentage of cows maintaining a temperature of 40.0 °C or higher was 25.0% in pregnant cows, approximately 2.9 times higher than that of non-pregnant cows (8.6%).

Additionally, it was found that 27 pregnant cows (67.5%) and 57 non-pregnant cows (81.4%) exhibited ruminoreticular temperatures within the normal range (38.0–40.0 °C), with no significant impact of Akabane vaccination on temperature fluctuations observed between pregnant and non-pregnant cows. Moreover, cows with low ruminoreticular temperatures below 38.0 °C did not display any significant differences based on pregnancy status.

4. Discussion

Our research team recently reported that the ruminoreticular temperature and body activity rise after FMD vaccination in Hanwoo, as measured using a biocapsule sensor (11, 13). The same methodology was performed in this study to determine the ruminoreticular temperature and body activity after Akabane vaccination according to pregnancy status.

As mentioned above, body temperature is an important factor in studying the physiological response of animals. Recent data have reported negative side effects, such as elevated body temperature and decreased milk production and productivity due to vaccination with the Q fever virus vaccine and the infectious bovine rhinotracheitis virus vaccine (9, 10). Other studies have reported that miscarriage and stillbirth may occur intermittently depending on vaccination and that the main cause is an increase in body temperature due to vaccination (27-30). Furthermore, we recently published research data on miscarriage and premature birth as well as increased ruminoreticular temperature after FMD vaccination, and in particular, the conception rate decreases due to ovulation delay caused by FMD vaccination was confirmed (11, 13).

In the present study, our results showed an increase in the ruminoreticular temperature for about 16 h after Akabane vaccination in pregnant cows, which was similar to the increase in rectal temperature by 0.41 °C after 1 day of multivalent vaccination in cows (18). Comparing the increase in ruminoreticular temperature

after vaccination between the FMD vaccine and the Akabane vaccine, the difference in ruminoreticular temperature change according to pregnancy was clearly shown, although it was lower than that of the FMD vaccine (11, 13). Through this, it is judged that not only the rectal temperature but also the ruminoreticular temperature is an important parameter that can represent the heat stress caused by vaccination.

5. Conclusion

In this study, Akabane vaccination of pregnant cows is considered likely to cause miscarriage and stillbirth because the rate of maintaining high temperatures (>40 °C) that can cause miscarriage and stillbirth is relatively higher than that of non-pregnant cows. Therefore, it is believed that the side effects of vaccination (e.g., abortion, stillbirth, and premature birth) can be minimized because the biocapsule sensor can detect real-time changes in body temperature after vaccination. In-depth research on acute immune responses and miscarriage rates is needed in the future, just like the FMD vaccine study.

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Data Availability Statement

The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

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Figure & Table Legends

Table 1. Information of experiment group (n=110)

Group	n	Months of age	Pregnant days	Parity
Pregnant cows	40	31.3±1.7	154.0±2.5	0.7±0.12
Non-pregnant cows	70	41.0±2.0	Non-pregnant	1.4±0.14
Total	110	37.5±1.5	-	1.1±0.10

Table 2. Relative frequency of ruminal temperature by pregnancy after Akabane virus vaccine

Ruminoreticular temperature	Pregnant No. of cows (%)	Non-pregnant No. of cows (%)	Total No. of cows (%)
High (>40°C)	10 (25.0%)	6 (8.6%)	16 (14.5%)
Normal (38~40°C)	27 (67.5%)	57 (81.4%)	84 (76.4%)
Low (<38°C)	3 (7.5%)	7 (10.0%)	10 (9.1%)
Total	40 (100.0%)	70 (100.0%)	110 (100.0%)

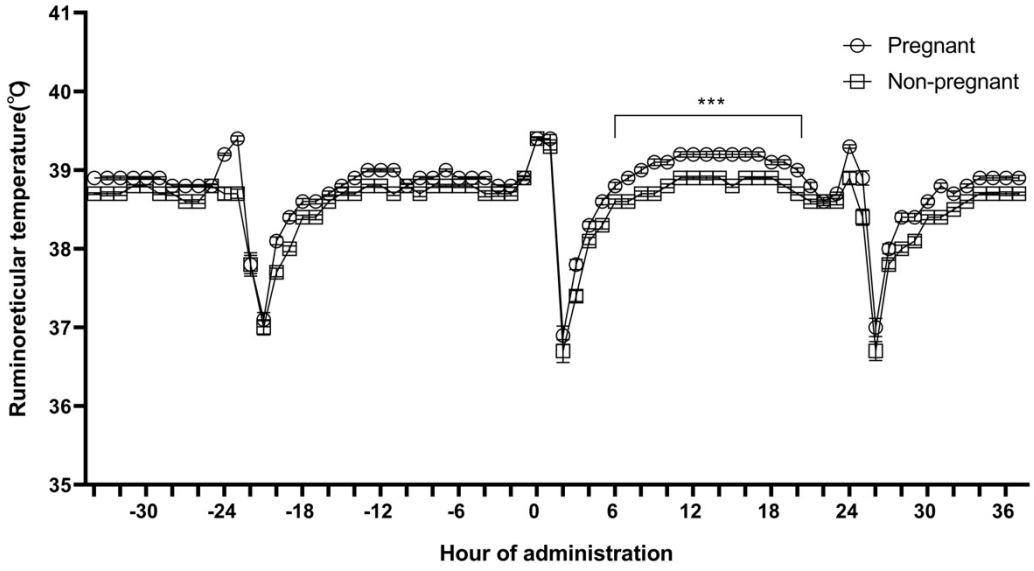

Figure. 1. Change in ruminoreticular temperature depending on pregnancy and Akabane vaccination (n = 110). Ruminoreticular temperature of pregnant cows and non-pregnant cows' group. The black line connected by "○" represents mean "Pregnant" group. The black line connected by "□" represents mean "Non-pregnant" group. 0 day is the time of the Akabane vaccination and error bar was presented as SEM. The significance level was set at ***$p < 0.001$

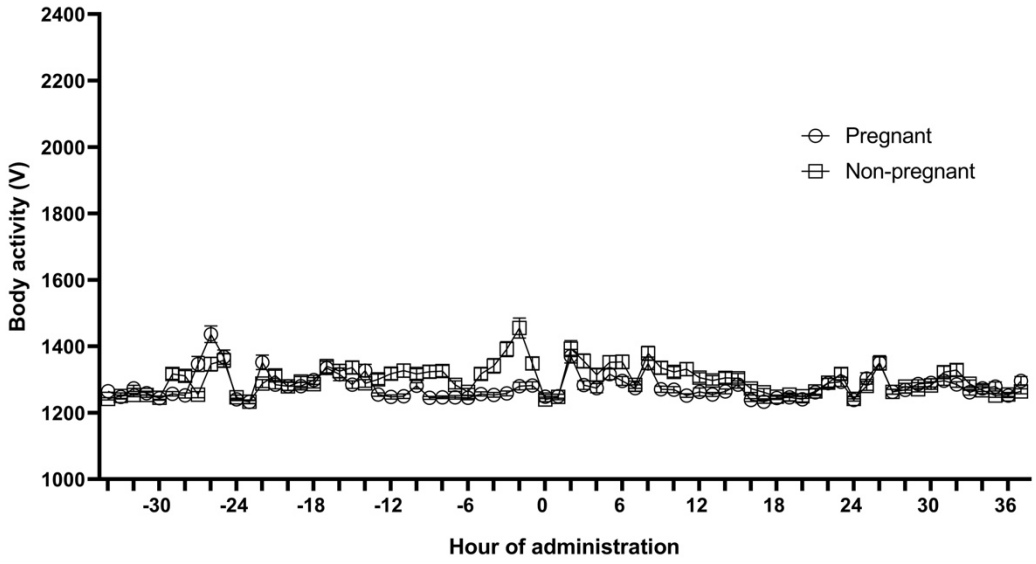

Figure. 2. Change in body activity depending on pregnancy and Akabane vaccination (n = 110). Body activity of pregnant cows and non-pregnant cows' group. The black line connected by "○" represents mean "Pregnant" group. The black line connected by "□" represents mean "Non-pregnant" group. 0 day is the time of the Akabane vaccination and error bar was presented as SEM. The significance level was set at ***$p < 0.001$.