NOTE *Internal Medicine*

Peripartum Back Fat Thickness of Multiparous Holstein–Friesian Cows with Displacement of the Abomasum or Ketosis

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ABSTRACT. To establish a method to predict postpartum diseases using prepartum back fat thickness (BFT), the peripartum BFTs of 54 healthy multiparous cows before calving, which were diagnosed with postpartum displacement of the abomasum (DA), clinical ketosis or subclinical ketosis were compared with those of healthy cows from 8 weeks before the expected calving date to 8 weeks after calving. The peripartum BFTs of the cows with DA or clinical ketosis were significantly higher than those of healthy cows. The peripartum BFTs of the cows with subclinical ketosis were not significantly higher than those of the healthy cows.
KEY WORDS: back fat thickness (BFT), clinical ketosis, displacement of the abomasum (DA), obese cow.

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Obesity is the most important risk factors for peripartum lipid metabolic diseases [6]. At many farms, obesity is evaluated routinely by body condition score (BCS), as it is an easy means of evaluation. Many studies have shown the relationships between BCS before or at calving and the postpartum diseases such as displacement of the abomasums (DA) [1], fatty liver and ketosis [4], and it is of common knowledge that BCS is a useful tool for herd management. However, for individual cows rather than a herd, BCS cannot be expected to have much predictive accuracy for postpartum diseases because it is a subjective method and has a large variation between observers [3]. Meanwhile, measurement of back fat thickness (BFT) by ultrasound has been established as an objective method to evaluate obesity with high measurement accuracy [10]. We proposed the hypothesis that the higher the prepartum BFT was, the more the risk of postpartum lipid metabolic diseases would increase. Prepartum BFT might make it possible to predict DA, as well as ketosis, the risk of which tend to increase along with the increase in prepartum BCS [1, 4], with high accuracy. There are some reports about peripartum BFT of healthy cows [10] or cows with fatty liver [5]. However, there is no report about those of the cows with DA or ketosis. In this study, the BFTs of the multiparous Holstein–Friesian cows with postpartum DA or ketosis were measured in the peripartum period and compared with those of healthy cows.

We studied 54 multiparous cows that calved at least once from 2009 to 2011 in a dairy herd in Hokkaido, Japan (average 305-day milk yield of the cows: 10,800 kg). The feed provided to them was based on the National Research Council feeding standards for dairy cows [7]. We excluded cows that calved earlier than 3 weeks, and also those that had chronic mastitis in the drying-off period, hoof disease within 1 month before calving and accidents at calving.

BCS and BFT were measured for all cows at 8 weeks before the expected calving date, once a week from 4 weeks before the expected calving date to 4 weeks after calving, and 8 weeks after calving. For the before calving period, only the records for 8 and 4 weeks before the expected calving date and 1 week before calving were selected for further analyses. BCS was measured using a five-point scoring system [3]. BFT was measured with a real-time, B-mode diagnostic ultrasound scanner equipped with a 5.0 MHz linear transducer (HS-101V; Honda, Tokyo, Japan). The measurement point was located in the midgluteal region at the midpoint between the caudal one-quarter of the sacrum and the caudal one-fifth of the line connecting the dorsal part of the ischial tuberosity to the coxal tuberosity [10]. All cows had a clinical examination, and blood samples were collected once a week between 4 weeks before the expected calving date and 4 weeks after calving. The serum concentration of beta-hydroxybutyric acid (BHB) was measured as a reference for ketosis. We focused on DA, clinical ketosis and subclinical ketosis as postpartum diseases. The cows with more than 2 clinical symptoms among depression, poor appetite and positive urine ketone test (>2+, N-Multistix, Biel Medical, Tokyo, Japan) were diagnosed as having clinical ketosis based on the serum BHB concentration (1400 μM [2]) between 4 weeks before the expected calving date and 4 weeks after calving. In the cows that were not clinically diagnosed as having DA, clinical ketosis, milk fever, retained placenta or mastitis, and if the serum BHB concentration was more than 1400 μM, the cow was diagnosed as having subclinical ketosis, and if the serum concentration was lower than 1400 μM,

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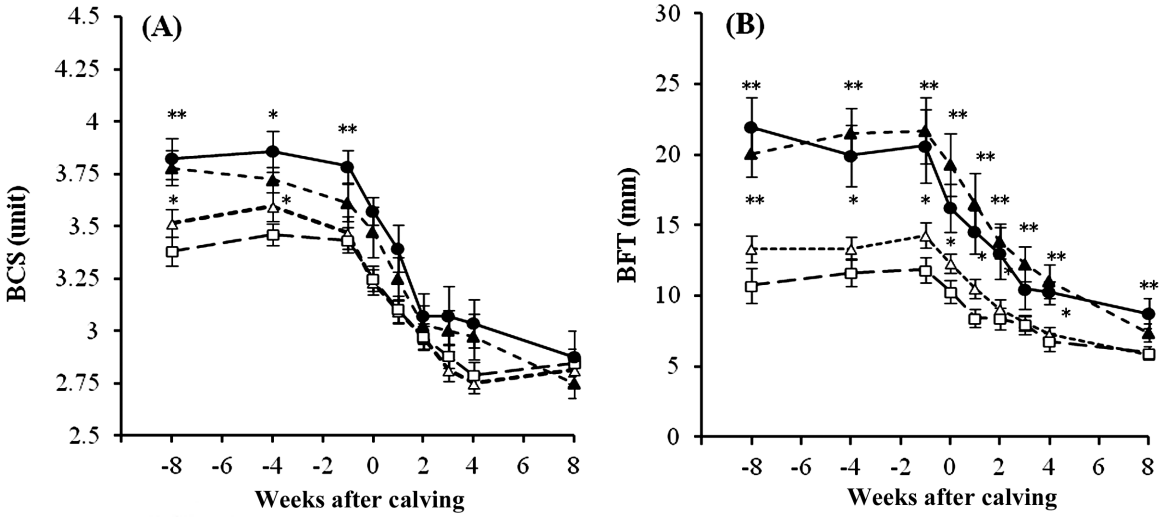

Fig.1. BCS (A) and BFT (B) from 8 weeks before the expected calving day to 8 weeks after calving in cows with DA (●), clinical ketosis (▲) or subclinical ketosis (△) and healthy cows (□). Data are shown as averages ± standard error. The effects of disease type before calving (A, B), disease type after calving (B) and time after calving (A, B) are significant ANOVA, $P<0.01$). The interaction effects between disease type and time are not significant (ANOVA). ** and *: Asterisks indicate significant differences compared with healthy cows ($P<0.01$ and $P<0.05$, respectively; Dunnett's comparison method).

Table 1. Comparison of parity, age, milking yields, days open and days dry between diseased and healthy cows

	Diseased cows		Subclinical ketosis	Healthy cows
	DA	Clinical ketosis		
Number of cows	7	11	16	20
Parity	2.86 ± 0.39	3.56 ± 0.35	3.00 ± 0.26	2.85 ± 0.23
Age at calving (months)	53.9 ± 5.8	60.9 ± 5.1	53.8 ± 3.8	50.1 ± 3.4
305-day milk yields at previous parity (kg)	10895 ± 887	11292 ± 782	11741 ± 606	10811 ± 538
Days open	249.4 ± 32.3**	176.2 ± 28.5	192.2 ± 21.4	124.5 ± 19.1
Days dry	103.9 ± 13.4*	57.4 ± 11.9	66.8 ± 8.9	54.4 ± 8.0

Values are means ± standard error.
** and *: Asterisks indicate significant differences compared with healthy cows ($P<0.01$ and $P<0.05$, respectively; Dunnett's comparison method).

the cow was diagnosed as healthy. Background information such as parity, age at calving, 305-day milk yield, open days and the days dry in the previous parity of each disease group are shown in Table 1. Comparison of this information between the disease cows and healthy cows showed that the open days and days dry of the cows with DA in the previous parity were significantly longer than those of the healthy cows (open days and days dry: $P<0.01$ and $P<0.05$, respectively). The days of onset of DA and clinical ketosis after calving and previous complications in the cows are shown in Table 2. Five cows with DA and 3 cows with clinical ketosis had some complications. The BCSs and BFTs of the cows with DA, clinical ketosis and subclinical ketosis were compared with those of healthy cows using repeated measures analysis of variance (ANOVA) (Fig. 1). The dataset for ANOVA was separated into pre- and post-calving datasets, and the two datasets were examined individually. The ANOVA model used contained the fixed effects of disease type (types: DA, clinical ketosis, subclinical ketosis and healthy), time to calving or after calving and the interaction between disease type and time. After ANOVA, if the fixed effects of disease type or the interaction were significant, post hoc Dunnett's tests were performed to compare the differences between the diseases groups. Statistical analyses were performed using JMP ver. 5.1 (SAS Japan, Tokyo, Japan). The level of significance was set as $P<0.05$.

In the ANOVA for BCS (Fig. 1A), the effect of time was only significant after calving ($P<0.01$). The effect of disease type was only significant before calving ($P<0.01$). Compared with healthy cows, the cows with DA had significantly higher BCSs at 8 and 4 weeks before the expected calving date, and the cows with clinical ketosis had significantly higher BCSs at all prepartum measurement timings. There was no significant difference in BCS between the cows with subclinical ketosis and healthy cows. In the ANOVA for BFT (Fig. 1B), the effect of time was only significant after calving ($P<0.01$). The effect of disease type was significant before and after calving ($P<0.01$). Compared with

Table 2. Days of onset of DA or clinical ketosis after calving and previous complications in the cows

Cow No.	Disease	Parity	BCS (at 1 week before calving)	BFT (at 1 week before calving)	Days of onset of DA or clinical ketosis from calving	Complications (Days of onset after calving)
1	DA	3	3.50	9.1	4	Milk fever (Day 2)
2	DA	2	4.00	24.1	6	
3	DA	4	3.50	29.6	10	Retained Placenta (Day 1)
4	DA	3	3.75	16.2	10	
5	DA	3	4.00	23.3	17	Mastitis (Day 2), Ketosis (Day 8)
6	DA	3	3.75	18.6	18	Ketosis (Day 11)
7	DA	2	4.00	18.9	26	Mastitis (Day 1), Ketosis (Day 8)
8	Clinical ketosis	4	3.00	20.0	2	
9	Clinical ketosis	5	3.75	28.5	3	
10	Clinical ketosis	4	3.75	34.0	8	Milk fever (Day 1)
11	Clinical ketosis	4	4.00	26.2	9	
12	Clinical ketosis	3	3.50	16.7	9	
13	Clinical ketosis	5	4.00	30.1	11	
14	Clinical ketosis	2	3.50	27.5	11	
15	Clinical ketosis	2	3.75	14.8	11	
16	Clinical ketosis	2	3.25	8.1	11	Mastitis (Day 4)
17	Clinical ketosis	3	3.50	13.3	13	
18	Clinical ketosis	5	3.75	14.5	28	Milk fever (Day 1)

healthy cows, the cows with DA had significantly higher BFTs at all prepartum measurement timings and at 0, 1, 2, 4 and 8 weeks after calving, and the cows with clinical ketosis had significantly higher BFTs from 8 weeks before the expected calving date to 4 weeks after calving. There was no significant difference in BFT between the cows with subclinical ketosis and healthy cows.

Before calving, the BCSs and BFTs of the cows with DA or clinical ketosis were significantly higher than those of healthy cows (Fig. 1A, 1B), and the cows in this herd were not getting fat during the dry period. Because the cows with DA or clinical ketosis were already obese at 8 week before the expected calving date during the drying off period, the obesitiy in these cows was caused from the feeding management before drying off. In particular, the open days of the cows with DA were longer than those of the healthy cows, and this prolongation seemed to worsen the obesity. In the cows with subclinical ketosis, BCS and BFT were not significantly higher than those of the healthy cows (Fig. 1A, 1B). These results showed that it seems difficult to predict postpartum subclinical ketosis, which may lead to DA or clinical ketosis, based on prepartum BFT.

After calving, there was no significant difference in BCS between the disease groups and healthy cows. In contrast, the BFTs of the cows with DA or clinical ketosis were higher than those of the healthy cows until 4 weeks after calving. In early lactation, skeletal muscles were mobilized to compensate for negative energy balance as well as body fat tissue [8]. Although a decrease in BCS indicates means mobilization of both adipose tissue and muscle, BFT values reflect only subcutaneous fat [10]. This characteristic of BFT seemed to be one of the reasons for the different changing patterns between BCS and BFT after calving. If the subcutaneous fat disappeared, BFT might converge around 5 mm, as an average skin thickness, because the BFT value includes the skin thickness [10]. After calving, as the time progresses, the BFTs of healthy cows converged around a low value, and their variation decreased; these small variations seemed to make a significant difference in BFT between the disease groups and healthy cows after calving. Although BFT has the disadvantage that it cannot evaluate the mobilization of muscle, regarding to the period before the mobilization of energy reserves, it seemed to be less of a problem to estimate the obese condition.

Previous reports showed that DA was affected by the nonobese factors, such as acute changing of the feeding contents [11] and milk fever [9], as well as obesity [1]. Among the cows with DA, one cow (No. 1) had a lower BFT than the average of the healthy cows, and it seemed to be affected by milk fever rather than obesity. The other 6 DA cows had higher BFTs than the healthy cows. The days of onset of DA in 3 cows (No. 5, 6 and 7) were later than in the other 3 cows. However, these cows were diagnosed with clinical ketosis within 11 days after calving. These results show that the DA cows, except for No. 1, were affected by clinical ketosis and obesity. Among the cows with clinical ketosis, one cow (No. 16) had a lower BFT than the average of the healthy cows, and it seemed to be affected by previous complications rather than obesity. In two cows (No. 10 and 18), milk fever preceded the onset of clinical ketosis. Because the BFT of No. 10 was 34.0 mm, it seemed that obesity affected the occurrence of both clinical ketosis and milk fever. By contrast, onset of clinical ketosis occurred in No. 18 at 28 days after calving, and this was later than the other cows with clinical ketosis. This result suggested that the factors affecting the onset of clinical ketosis in No. 18 were different from those of the other cows with clinical ketosis. The other 8 clinical ketosis cows without any complications had larger BFTs than the average BFT of the healthy cows. Although there were certain cases that

were affected by nonobese factors, such as milk fever and inflammatory diseases, the majority of cows with DA or clinical ketosis had higher BFTs than the healthy cows before calving in this study. Because BFT could measure subcutaneous fat objectively with high measurement accuracy [10], we strongly believe that BFT can be applied on its own to predict the risk of postpartum diseases such as DA and clinical ketosis.

It was concluded that the peripartum BFTs of the cows with postpartum DA or clinical ketosis were higher than those of healthy cows.

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