An Evaluation of Protein/Fat Ratio in First DHI Test Milk for Prediction of Subsequent Displaced Abomasum in Dairy Cows

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ABSTRACT

First DHI test milk that was sampled prior to displaced abomasum (DA) diagnosis was used to evaluate milk protein/fat ratio (PFR) for prediction of subsequent DA in dairy cows. Odds ratio, sensitivity, specificity, and likelihood ratio were determined. Twenty-seven DA cases were matched to 3 controls per case by herd and calving date. Milk was tested at a median of 19 d after calving, which was 8 d prior to the median time of DA diagnosis. Adjusted for parity and days in milk, a protein/fat ratio \( \leq 0.72 \) was 8.2 times more likely to come from a cow subsequently diagnosed with DA than a protein/fat ratio \( > 0.72 \). Using the cut off value of 0.72, the sensitivity of PFR for DA was 80% and the specificity was 68%. A receiver operating characteristics curve indicated that the minimum sum of false negative and false positive results was at a PFR cut off value of 0.72. The likelihood ratio indicated that protein/fat ratios \( \leq 0.62 \) are 3.8 times more likely to come from cows that are diagnosed subsequently with DA than from cows without DA. The protein/fat ratio in 1st DHI test milk may predict subsequent DA in dairy cows.

RÉSUMÉ

Du lait prélevé avant un diagnostic de déplacement de caillette (DC) fut utilisé pour évaluer le ratio protéine/gras du lait (RPG) dans le but de prédire un événent DC chez les vaches laitières.vingt-sept cas de DC furent pairs à trois témoins par cas par troupeau et date de mise-bas. Le lait fut testé à un temps médian de 19 j suite au vêlage, ce qui est 8 j plus tôt que le temps médian du diagnostic de DC. Après un ajustement pour la parité et le nombre de jours en production, un RPG \( \leq 0.72 \) avait 8,2 fois plus de chance de provenir d'une vache éventuellement diagnostiquée avec un DC qu'un RPG \( \geq 0.72 \). En utilisant la valeur seuil de 0,72, la sensibilité du RPG pour prédire un DC était de 80% et la spécificité de 68%. Le ratio de probabilité indiquait que des RPG \( \leq 0.62 \) avaient 3,8 fois plus de chance de provenir de vaches qui seraient éventuellement diagnostiquées avec un DC que de celles sans DC. Le RPG dans des échantillons de lait pourrait prédire un événent DC chez les vaches laitières.

INTRODUCTION

The lactational incidence risk of left displaced abomasum in Ontario dairy herds is currently about 2% (1). This disease causes losses due to treatment costs, discarded milk, decreased milk yield (2,3), culling (4) and death (5).

Left displaced abomasum might be prevented by genetic selection as it is a hereditary trait (6,7). Decreased milk mass or milk protein percentage, and increased milk fat percentage or milk fat/protein ratio (PFR) in the 1st milk test by the Dairy herd Improvement Corporation (DHI) were studied as possible risk factors for subsequent displaced abomasum (DA) in dairy cows. The findings pointed toward an energy deficit in cows 1–3 wk prior to DA diagnosis as increased milk fat percentage and increased PFR are indicative of energy deficiency (8–10). This is in accordance with clinical studies reporting ketosis prior to displaced abomasum diagnosis (11–13), and epidemiological studies reporting ketosis as a significant risk factor for left displaced abomasum (14–17).

In Ontario, milk is first tested within 1 mo after calving by DHI. Many cases of DA are diagnosed in the early post-partum period (17–19). We hypothesize that some cows at risk for DA might be detected using 1st DHI milk parameters. In practice, fat/protein ratio or protein/fat ratio (PFR) might be useful in detecting cows at risk for DA as they were not significantly affected by days in milk.

Materials and methods

The Ontario Veterinary College (OVC) herd health data base was used to identify cases of displaced abomasum in dairy cows that had been diagnosed within 8 wk after calving and whose 1st DHI test date occurred before DA diagnosis. All DA cases were diagnosed by OVC clinicians. Lactation number and days in milk at DA diagnosis, side of displacement (left or right), as well as days in milk (DIM), and milk protein/fat ratio, at 1st milk test were determined. Three controls, never diagnosed with displaced abomasum, were matched per case. Three controls were available
per case and included to increase power. Matching criteria were herd and calving date in order to limit herd and seasonal effects such as feeding. Cows having calved closest to the case were selected as controls. PFR at 1st milk test was determined in controls as in the cases.

Descriptive statistics are given as medians and 10th and 90th percentiles. DIM was transformed using a natural log (ln). Parity was a binary variable indicating lactation number (0 = first lactation, 1 = lactation number ≥ 2).

The association between PFR and DA was evaluated using logistic regression (20). Parity and DIM were adjusted for as possible confounders in each model. The association between PFR and DA, adjusted for parity and DIM, was quantified using odds ratios. The odds ratio is a measure of how much more likely (or unlikely) the outcome is among observations with a given risk factor compared with those without the risk factor (20). 95% confidence intervals (95% CI) of the odds ratio are given. The fit of the models was assessed by means of the Hosmer-Lemeshow goodness of fit test (20).

Sensitivity (proportion of positive test results in DA cows), and specificity (proportion of negative test results in controls), were determined using 2 × 2 tables and different cut off values. Cut off values were found using the median as a starting point and going in 0.05 steps from there. 95% CI are given for sensitivity and specificity (21). A receiver operating characteristics (ROC) curve was used to examine changes in sensitivity and specificity at various cut off points for PFR. Assuming the costs associated with false positive and false negative results were equal, the cut point that was closest to the upper left hand corner of the ROC curve was deemed superior (22). The likelihood ratio for a positive test result (true positive rate/false positive rate) was determined at several levels (22). Calculations were performed using SAS (23).

RESULTS

Twenty-seven cases of displaced abomasum having occurred in 15 Holstein herds between June 1989 and December 1995 were selected and matched to 81 controls. They represented 20% of all DA cases recorded in the DHI data base in this period. Thirteen (48%) cases were diagnosed in the 1st lactation, 6 (22%) in the 2nd and 8 (30%) in the 3rd or higher lactations; twenty-five (83%) abomasums were displaced to the left side, 2 (7%) were displaced to the right side. Displacement was diagnosed 26 d (10th, 90th percentile: 12, 51) after calving.
The milk of these cases was first tested 8 d (10th, 90th percentile: 31, 4) before DA diagnosis. Controls had calved 4 d prior to cases (10th, 90th percentile: 56 d before, 43 d after). Milk was first tested at 19 d in milk (10th, 90th percentile: 6, 34) in all cows. The PFR frequency distribution indicated a left shift in DA cows compared to controls (Figure 1). In DA cows median PFR was 0.67 (10th, 90th percentile: 0.57, 0.85), and in controls 0.76 (10th, 90th percentile: 0.61, 0.98).

PFR in first DHI test milk, using cut off values, \( \leq 0.82 \), \( \leq 0.77 \), \( \leq 0.72 \), \( \leq 0.67 \), or \( \leq 0.62 \) was significantly associated with DA, when adjusted for parity and DIM. In the models using cut off values \( \leq 0.82 \), \( \leq 0.72 \), \( \leq 0.67 \) or \( \leq 0.62 \) the Hosmer-Lemeshow test indicated that the number of predicted cases was not significantly different from the number of observed cases. The fit of the model using cut off value \( \leq 0.77 \) was questionable. Parity and DIM had no significant effect in any of the models. Adjusted for parity and DIM, a protein/fat ratio in the first DHI milk test of \( \leq 0.72 \) was 8.2 times more likely (95% CI 2.7 to 25) to come from a cow subsequently diagnosed with DA than a protein/fat ratio \( > 0.72 \) (odds ratio) (Table I).

Eighty percent of cows diagnosed with DA had protein/fat ratios \( \leq 0.72 \) (sensitivity) and 68% of non DA had PFR > 0.72 (specificity). The sensitivity of PFR in 1st DHI test milk for subsequent DA diagnosis decreased when cut off values were lowered from 0.82 to 0.62, and the specificity increased by the same order (Table II). Using a ROC curve the cut off value, which resulted in the smallest sum of false negative and false positive results, was 0.72 (Figure 2). A protein/fat ratio between 0.67 and 0.719 was 1.9 times more likely to come from a cow subsequently diagnosed with DA than from a cow without DA (likelihood ratio) (Table III).

**DISCUSSION**

Our findings suggest that the protein/fat ratio in the first DHI test may predict subsequent displaced abomasum diagnosis in dairy cows. Other studies revealed negative associations between the fat/protein ratio and dry matter intake as well as between fat/protein ratio and energy balance (8–10). Fat/protein ratios \( > 1.4 \) were indicative of energy deficiency (10,24). In our study the inverse of the fat/protein ratio was used. PFR < 0.72 identified cows at increased risk for DA. Hence our findings might point toward a relationship between an energy deficit and subsequent DA diagnosis. The effect of an energy supplementation in cows at risk for DA might be studied.

Milk was first tested by DHI at a median of 19 d after calving. However, many cases of DA are diagnosed prior to first DHI milk test. In other studies left displaced abomasum was diagnosed at a median 8.5 d (18) and 16 d (17) after calving. Thus, objectives of further research might be to find and evaluate tests for subsequent DA that are applicable prior to first DHI milk test.

**REFERENCES**


**TABLE III. Likelihood ratio of protein/fat ratio in 1st DHI test milk at several levels for displaced abomasum in dairy cows**

<table>
<thead>
<tr>
<th>Level</th>
<th>Likelihood Ratio</th>
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<tr>
<td>( &gt; 0.82 )</td>
<td>0.33</td>
</tr>
<tr>
<td>0.77 to 0.819</td>
<td>0.3</td>
</tr>
<tr>
<td>0.72 to 0.769</td>
<td>0.23</td>
</tr>
<tr>
<td>0.67 to 0.719</td>
<td>1.88</td>
</tr>
<tr>
<td>0.62 to 0.669</td>
<td>1.97</td>
</tr>
<tr>
<td>( \leq 0.62 )</td>
<td>3.81</td>
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