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Determining the Cost-Effectiveness of Treating Dairy Cows with Subclinical Ketosis during the First Week of Lactation

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Abstract

The objective of this study was to determine the cost effectiveness of treating dairy cows with subclinical ketosis (SCK) at 4 DIM. Healthy cows had blood β-hydroxybutarate (BHB) concentrations<1.2mM/L and did not receive treatment. Treatment (TRT) cows were deemed with SCK, defined by a blood BHB of 1.2 to 2.9mM/L, and received 250mL of 50% dextrose solution intravenously and 300mL propylene glycol (PPG) orally for 3 d. Cows that also were subclinical (same criteria as TRT) but did not receive the PPG and dextrose were designated as "NTRT". Cows with >2.9mM/L BHB were not enrolled in the trial. Milk yield was similar for healthy and TRT cows, but milk yield was lower for NTRT cows compared to healthy cows. Milk yield tended to be higher for TRT versus NTRT. The increased milk yield was an average over 90 DIM, so the return over cost of treating SCK was $30/cow for this period. These results provide evidence that it is cost-effective to treat SCK in recently fresh dairy cows using the protocol in this study, even without the consideration in reduced risk for other metabolic diseases.

Introduction

Ketosis is a major metabolic disorder of dairy cattle in the United States, affecting an estimated 40% of all lactations in the industry, between clinical and subclinical cases [1]. Clinical ketosis is characterized by high levels of ketones in the blood and is manifested by lethargy and anorexia in the peri-partum dairy cow [2]. Subclinical ketosis (SCK) requires a blood, milk, or urine test to diagnose. Even though it is not outwardly noticeable, it is still estimated to cost the farmer $289/case due to both the direct and indirect costs, especially with the loss in milk yield [3].

It has been shown that ketosis and negative energy balance have negative consequences on reproduction and immune function [4]. Subclinical ketosis is often defined as blood BHB concentrations of >1.2mM/L and < 3.0 mM/L [1]. McArt et al. [5] showed that PPG has merit as a treatment for SCK, but Carrier et al. [6] revealed that a combination of treatments (PPG, dextrose, dexamethasone, and niacin) is not always cost effective in the treatment of SCK.

The objective of this study was to determine the cost effectiveness of treating dairy cow's with SCK versus no treatment of cows diagnosed with SCK. The treatment protocol was a combination of 250mL of 50% dextrose solution IV and 300mL PPG orally to cows with blood BHB concentrations >1.2mM/L, a protocol often used for treating clinical ketosis [7] except that the dextrose was reduced in half for the SCK. We hypothesized that it would be cost effective to treat SCK cows based on revenues from milk alone.

Material and Methods

This study was conducted on a 3,300 cow Holstein farm in northwest Ohio during the 2014 summer. Cows were enrolled into an experimental group at 4 DIM (4 d post-calving) when they received a health check that was consistent with on-farm protocols. There was a healthy and two groups with SCK for this trial with all cows being multiparious. Randomly selected healthy cows (n=165) from the herd had <1.2 mM/L BHB, appeared free from disease, and did not receive treatment. Cows with SCK were randomly assigned to one of two treatment groups. One group of cows (n=58) with SCK as defined by a BHB of 1.2 to 2.9 mM/L but appeared otherwise healthy received 250 mL 50% dextrose solution intravenously on d 1 and 300mL PPG orally for 3 d (TRT).

Another group of cows (n=60) were SCK (same criteria as TRT) and appeared otherwise healthy but did not receive the PPG and dextrose (NTRT). Cows with >2.9 mM/L BHB or any other diseases identified by the health check were not enrolled in the trial. Animals were excluded at 4 DIM if they had lameness, mastitis, metritis with a fever, milk fever, or displaced abomasums. Cows were milked 3 times daily.

Blood samples were drawn from the tail vein/artery and BCS (1= thin to 5=fat) were taken on cows at -14 to -3 d pre-partum. The samples were centrifuged, the serum was pipetted off, and it was frozen until after the trial, when NEFA assays were conducted using a HR Series NEFA-HR kit from Wako Diagnostics (Mountain View, CA). To determine treatment assignment, blood was collected at 4 DIM and tested for BHB concentration using a Precision Extra Meter (Abbott Laboratories, Chicago, IL), and if BHB was in the appropriate range (1.2 to 2.9mM/L) and the cows fit the other health criteria, they were placed randomly into TRT or NTRT using the RAND function of Microsoft Excel.

It has been established that the highest incidence of SCK is at about 5 DIM, certainly within the first 7 DIM, and that cows within this time period with SCK even produce less milk during the first 30 DIM compared to cows experiencing SCK at 8 DIM or later [8]. Thus in our study, a second blood sample was taken at 11 DIM and BHB concentration measured, as well as a BCS recorded. Any animal with a BHB>1.2mM/L was treated with dextrose and PPG. If any animal's appearance warranted a health check after treatment, blood was drawn and checked for BHB concentrations, a BCS was taken, and if the BHB concentration was >1.2mM/L BHB, the animal was treated with dextrose and PPG regardless of the experimental group in which they were enrolled at 4 DIM. If a cow was re-checked after 6 DIM (end of medication with PPG) but before 11 DIM, the cow had a second BHB analysis and a BCS was assigned at the time of the second bleeding, so they did not get scored on 11 DIM. Animals were followed for 90 DIM for recording of daily milk yield and health events, including mastitis, lameness, and displaced abomasums. BCS was recorded at first breeding and reproduction data were collected from Dairy Comp 305 (Valley Ag Software, Tulare, CA).

Expenses associated with treating subclinical ketosis were obtained from the farm records and included labor, PPG, and dextrose. The costs of the Precision Extra meter and test strips were not included because every cow gets checked at 4 DIM, as per the on-farm protocol. Labor cost was assumed at $13/h. The value of the increased yield of milk was determined using the average price of milk over the time the trial was conducted ($20/45 kg).

Minimum sample size was calculated and exceeded based on previously reported data with BHB. Data were analyzed using the GLM procedure of SAS (SAS Institute, Inc., Cary, NC). Data were analyzed as a randomized complete block design with repeated measures in time using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). The selected covariance structure of error was the first-order autoregressive [AR (1)] structure. The FREQ procedure of SAS was used with the Chi-square Fisher test for percentage data on reproduction and health events. Significance was declared at P< 0.05 and trends at P < 0.10.

Results

Pre-partum NEFA concentrations were similar between TRT and NTRT but lower for healthy cows (Table 1). BCS pre-partum were 3.47 for healthy cows, 3.62 for TRT, and 3.59 for NTRT, with BCS being lower for healthy cows than the other two groups with SCK. BHB at 4 DIM was similar for TRT and NTRT but lower for healthy cows, with a similar pattern at 11 DIM. BHB concentrations were similar between TRT and NTRT at 4 DIM and 11 DIM. At 11 DIM, the following number of cows had BHB > 1.2mM/L and thus was treated for ketosis: 10, 20, and 23 for healthy, TRT, and NTRT, respectively. BCS at 11 DIM was similar for NTRT and healthy cows but was higher for TRT cows. Milk yield was similar for healthy and TRT cows (42.7 and 42.1 kg/d, respectively), but milk yield was lower for NTRT cows (41.2 kg/d) compared to healthy cows. There was a trend (P = 0.06) for milk yield to be higher for TRT versus NTRT cows (42.1 vs 41.2 kg/d).

Table 1. Non-esterified fatty acids (NEFA), serum BHB, BCS, milk yield and services per conception for healthy and treatment cows[1]

Variable	Healthy	TRT	NTRT	SE
Pre-partum NEFA, μ Eq/mL	240^{b}	316^{a}	299^{a}	19
Pre-partum BCS[2]	3.47^{b}	3.62^{a}	3.59^{a}	0.03
4 DIM BHB, mM/L	0.70^{b}	1.66^{a}	1.69^{a}	0.04
11 DIM BHB, mM/L	0.69^{b}	1.34^{a}	1.46^{a}	0.1
11 DIM BCS	3.33^{a}	3.45^{b}	3.31^{a}	0.03
Milk, kg/d (wk 1 to 13)	42.7^{bc}	42.1^{abc}	41.2^{ad}	1.2

[1]Healthy= <1.2mM/L BHB, TRT = 1.2 to 2.9mM/L BHB received propylene glycol (PPG) and dextrose, and NTRT = 1.2 to 2.9mM/L BHB but no PPG and dextrose at 4 DIM.

[2]Based on 1 (thin) to 5 (fat) scale.

[ab]Means in the same row differ (P < 0.05)

[cd]Means in the same row tended to differ (P = 0.06)

Through the first 2 services, there were no differences in conception rate across groups, but the healthy cows had a higher conception rate at the third service when compared to TRT and NTRT cows (41.8 vs 24.1 and 35.0%, respectively; Table 2). There were no differences among healthy and SCK groups for services per conception. Through 90 DIM, there were no differences among groups in incidence of mastitis, metritis, lameness, or culling. There were, however, more displaced abomasums (DA) in TRT and NTRT (20.7 and 11.7%, respectively) than in the healthy cows, where there were no DA recorded (Table 2).

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Table 2. Reproduction and health data for healthy and treatment cows[1]

Variable	Healthy	TRT	NTRT
Reproduction:			
Conception rate 1st Service, %	27.9	25.9	33.3
Conception rate 2nd Service, %	26.7	20.7	26.7
Conception rate 3rd Service, %	41.8[a]	24.1[b]	35.0[b]
Services per conception	2.32	2.5	2.1
Health Events:			
Mastitis, %	24.9	34.5	31.7
Lame, %	19.4	18.3	19
Metritis, %	3	5.2	3
Displaced abomasums, %	0.0[a]	20.7[b]	11.7[b]
Culled 90 DIM, %	1.8	5.2	1.7

[1]Healthy= <1.2mM/L BHB, TRT = 1.2 to 2.9mM/L BHB received propylene glycol (PPG) and dextrose, and NTRT =1.2 to 2.9mM/L BHB but no PPG and dextrose at 4 DIM.

[ab]Means in the same row differ ($P<0.05$)

The increased milk production from TRT versus NTRT equals $0.40/d ($20/45kg for milk price). Since it cost the farm $5.90 to treat each case of subclinical ketosis (Table 3), the increased milk production would have to be sustained for 15 days to cover the cost of treatment. The increased milk yield was an average over 90 DIM, so the return over cost of treating subclinical ketosis was $30/cow for this period (TRT produced 81 kg more milk than NTRT).

Table 3. Cost of treatment per case of subclinical ketosis and net return on investment of increased milk yield for 90 DIM

Item unit	$/unit	Dose/ unit	$/ dose	Dose/ case	$/case
Propylene glycol (PPG)	$900/207 L	690	$0.81	3	($2.43)
Dextrose	$2.36/ 500 mL	2	$1.18	1	($1.18)
Labor for PPG	$13/h	40[1]	$0.33	3	($0.99)
Labor for dextrose	$13/h	10[1]	$1.30	1	($1.30)
Total cost per case					($5.90)
Revenue from increased milk yield[2]					$36.00
Net return on investment per case					$30.10

[1]Assumed 40 and 10 doses could be administered per hour based on time required at the dairy farm used in the study

[2]Assumed 0.9 kg/d increased milk yield for 90 d (Table 1) and $20/45 kg for milk price. Number of cows treated for ketosis at 11 DIM was not considered in this calculation since 34 to 38% of cows on TRT and NTRT were treated at this time.

Discussion

It has been shown previously that elevated blood NEFA concentrations in close-up cows are positively correlated with postpartum metabolic disorders, such as ketosis and DA [9]. Elevated pre-partum NEFA concentrations also are associated with less milk production and decreased reproductive performance [9, 10]. The results from the NEFA in our study were consistent with previous research as the two groups with increased BHB concentrations at 4 DIM both had increased NEFA concentrations pre-partum in comparison to healthy cows. The blood BHB concentrations of TRT and NTRT were similar at 4 DIM, which is what we expected, and the healthy cows had lower BHB concentrations. At 11 DIM, the 2 groups that started out with SCK still had similar concentrations of BHB and were decreased in comparison to 4 DIM.

However, the BHB concentrations at 11 DIM were still, on average, in the subclinical range, although the standard error was greater than at 4 DIM, suggesting a greater variation in concentrations at 11 DIM. These values still being above 1.2mM/L begs the question of whether this treatment was as effective as we desired. In the study by McArt et al. [10], the subclinical cows were given PPG until they had BHB concentrations below 1.2mM/L and was not restricted to just 3 d as in our study. However, continual monitoring of BHB is both an analytical and labor cost to the farmer.

The increased BCS at 11 DIM for TRT, about a tenth point greater, was as expected in comparison to NTRT, given that TRT were likely in a less negative energy balance by receiving the dextrose and PPG. Healthy animals had a BCS that was similar to NTRT at 11 DIM, and this is possibly because they started out with a lower BCS, and therefore, were less predisposed to ketosis and also probably lost less condition. The lower milk yield for NTRT compared to healthy cows was as expected, concurrent with previous research whereby SCK cows produced less milk [1]. One possible explanation for this is NTRT cows likely consumed less DM while they were SCK, which would result in less nutrients available for milk synthesis, even though they likely mobilized more adipose tissue in an attempt to support that milk yield.

This decreased milk yield was consistent throughout the first 13wk of lactation. With the trend for milk yield for TRT cows to be higher than for NTRT, this could have large economic implications, especially on large farms as used in this study. The gain in milk yield returned $30/cow for the 90d period, showing economic benefit to treat cows with SCK. Although energy balance and milk yield appeared to favor TRT in comparison to NTRT, services per conception were similar, which may have occurred because SCK is less likely to impact reproduction efficiency than clinical ketosis. Other considerations are, at the time the data were examined, not all the animals in all the groups had been confirmed pregnant and additional animals would be needed to provide sufficient sample size to determine differences in reproductive performance. Evidence exists that animals with an elevated blood BHB concentration in the first 3wk post-partum are less likely to become pregnant after their first insemination [11].

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The net return associated with medication and labor was favorable for the monitoring and treatment of SCK based on the protocol used in this study. Other protocols also should be evaluated for cost effectiveness. In addition, it must be considered that SCK is a risk factor for occurrence of other diseases among periparturient dairy cows.

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