Contract session: An overview of postpartum hyperketonaemia and its association with cow health and performance in pasture-based dairy systems

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Introduction

Following calving, dairy cows undergo a period of negative energy balance during which they mobilise body tissue (such as fat) to support the demands of lactation. When the negative energy balance is severe, the inability of the liver to process all the mobilised fatty acids can lead to hepatic lipidosis (i.e., fatty liver disease) and incomplete fatty acid oxidation. The latter results in the hepatic production of ketone bodies, predominantly β-hydroxybutyrate (BHB), which are released into the circulation as the product of ketogenesis. The increased concentration of ketones in blood is known as hyperketonaemia.

Severe hyperketonaemia (blood BHB ≥3.0 mmol/L) is associated with clinical ketosis, a metabolic disorder that may present in either nervous/excitable or lethargic/anorexic forms, often with a characteristic acetone smell on the breath, and requires treatment. However, postpartum cows are more likely to have moderately elevated BHB in blood (≥1.0-1.4 to <3.0 mmol/L). Data from cows fed total mixed rations in housed systems indicate that moderate hyperketonaemia is diagnostic for subclinical ketosis and can reduce cow performance (Duffield 2000; Raboisson et al. 2014). However, blood BHB is also affected by the carbohydrate source in the diet. Cows fed predominantly forage diets (e.g., pasture or pasture silage) produce more ruminal butyrate but less propionate and, therefore, have greater basal circulating BHB than those eating a diet high in starch (e.g., grains or total mixed ration; Roche et al. 2010). Hence, in cows fed pasture, moderately elevated blood BHB is not always associated with subclinical ketosis and reduced performance.

Incidence and prevalence of hyperketonaemia

The incidence of hyperketonaemia can vary between studies depending upon the BHB threshold, timeframe, and BHB testing method and frequency. In housed systems, the incidences of moderate hyperketonaemia (or subclinical ketosis) during early lactation average 54%, but can be as high as 80% in some herds (Duffield 2000). In contrast, the incidence of clinical ketosis is 2 to 15% (Duffield 2000). Recent New Zealand (NZ) studies indicate that hyperketonaemia is also common in many postpartum cows when managed in a pasture-based system (Compton et al. 2014; 2015; Phyn et al. unpublished data).

Compton et al. (2015) tested 565 cows from 15 commercial herds across the Waikato and Canterbury regions at weekly intervals during spring 2010. They reported that, on average, 68% of cows had at least one blood BHB test ≥1.2 mmol/L during the first five weeks after calving, however, there were large variations among herds in this incidence rate (min 12; max 100%), and in the degree and timing of peak prevalence of hyperketonaemia.

A 2016 study (Phyn et al. unpublished data) of 1,000 cows across three herds (Scott Farm, Waikato; Taranaki Agricultural Research Station (TARS), Taranaki; Lincoln University Dairy Farm (LUDF), Canterbury) had similar findings. Cows were tested thrice weekly for five weeks postpartum to obtain a very accurate measure of incidence that accounted for potential recovery from hyperketonaemia (BHB <1.2 mmol/L), which can be missed with weekly sampling (McArt et al. 2011; 2012). Preliminary analyses indicate that the mean herd-level incidence of moderate hyperketonaemia (BHB ≥1.2 to <3.0 mmol/L) was 75% (min 65%; max 82%) and severe hyperketonaemia (BHB ≥3.0 mmol/L) was 12% (min 6%; max 18%). As reported previously, there was marked variation among herds in the pattern of moderate hyperketonaemia after calving; however, the peak incidence and prevalence occurred in the first 7-10 days across all herds (Figure 1) consistent with reports from housed systems (McArt et al. 2012). Overall, a comparison of recent NZ studies with those in overseas housed systems indicates that postpartum hyperketonaemia is widespread, irrespective of production system.

Associations between hyperketonaemia and cow performance

In housed cows, hyperketonaemia is associated with increased risk of other parturient diseases, early culling and death, and deleterious effects on milk production and reproduction (reviewed by Raboisson et al. 2014). For example, Duffield et al. (2009) reported that the risk of developing metritis (severe uterine infection and inflammation) increased significantly at or above 1.2 mmol/L BHB during the first week post-calving. Ketotic cows are also two times more likely to develop mastitis than healthy cows (Oltenacu & Ekesbo 1994). Furthermore, reduced first-service calving rate, and longer intervals from calving to first service and calving to conception, have been associated with subclinical ketosis in housed cows (Raboisson et al. 2014). The timing and degree of subclinical ketosis is also important. McArt et al. (2012) reported that the earlier that cows first tested positive

Figure 1 The daily prevalence (% of cows tested) that had moderate hyperketonaemia (BHB ≥1.2 to <3.0 mmol/L) across three farms. DIM = days in milk post-calving.

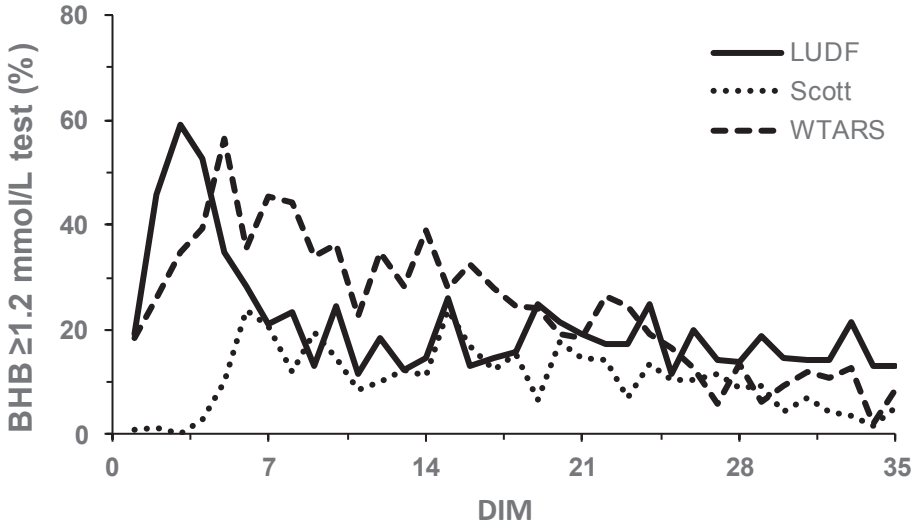
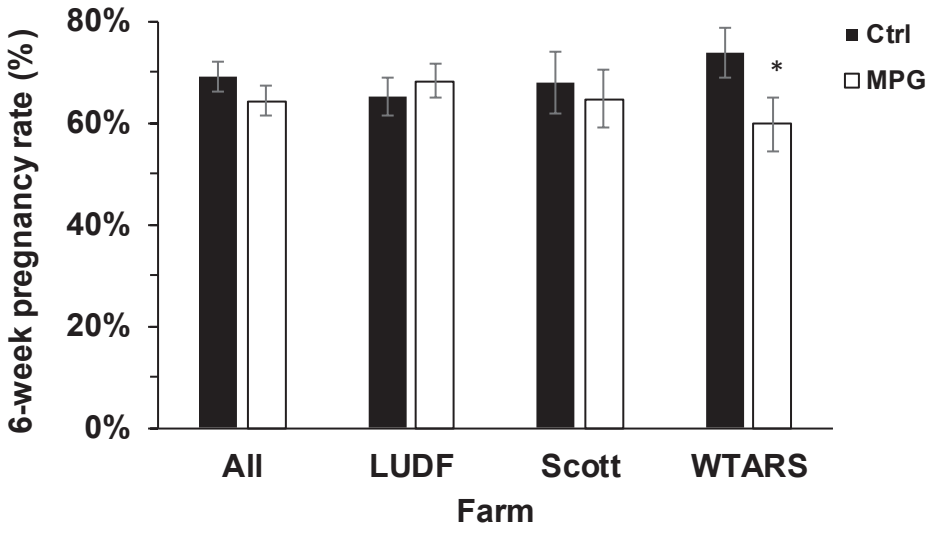


Figure 2 The effect of using monopropylene glycol (MPG) drench to treat cows diagnosed with moderate hyperketonaemia (BHB ≥1.2 to <3.0 mmol/L) on six-week pregnancy rate across three farms. *P=0.05.



for subclinical ketosis (BHB ≥1.2 to <3.0 mmol/L) after calving, and the higher the BHB at the first positive test, the greater the risk of negative outcomes for health and performance.

In pasture-based systems, the associations between hyperketonaemia and cow performance are less clear. Compton et al. (2015) reported that cows with BHB ≥1.2 mmol/L within five days of calving had a 2.5 x increased risk of uterine infection at week five of lactation. Furthermore, a BHB test ≥1.2 mmol/L at any stage within five weeks post-calving was associated with a 7% lower pregnancy rate at six weeks after the planned start of mating. The recent 2016 study (Phyn et al. unpublished data), however, was unable to determine a consistent association between moderately elevated blood BHB (≥1.2 to <3.0 mmol/L) and lower six-week pregnancy rates in the three herds studied. Preliminary analyses indicate that cows with BHB tests ≥1.6 to <3.0 mmol/L during the first 5 weeks post-calving had a lower six-week pregnancy rate at LUDF; however, the opposite relationship was detected at TARS and Scott farms where BHB tests ≥1.4 to <3.0 mmol/L were associated with a greater six-week pregnancy rate. Therefore, the relationship varies among herds. More data analyses are being undertaken to determine if the pattern of hyperketonaemia postpartum (Figure 1) and factors such as cow age, breed, feeding level, other blood metabolites (e.g., fatty acids), and body condition score (BCS) can explain these different relationships.

Treatment of hyperketonaemia

It is well known that an excessive BCS at calving increases the risk of cows succumbing to metabolic disorders after calving. However, even slightly over-conditioned cows (BCS 5.5) are at much greater risk of hyperketonaemia (Roche et al. 2013), and within pasture-based herds managed for the optimum target BCS at calving of 5.0, a significant proportion of cows will still have hyperketonaemia during early lactation (Figure 1; Phyn et al. unpublished data). Hence, treatment strategies may be worthwhile in addition to preventative measures.

Treatments for hyperketonaemia typically increase blood glucose concentrations, lower blood fatty acid concentrations, and/or alter lipid metabolism in the liver to reduce BHB concentrations. Monopropylene glycol (MPG) has long been used to treat clinical ketosis, but recent studies conducted in housed systems have focused on the development of drenching strategies whereby MPG is administered either prophylactically to all cows in the herd (i.e., irrespective of blood BHB concentrations) or to individual cows that have been identified as either "at-risk" using prognostic screening, or as subclinically ketotic using diagnostic testing. This method requires daily oral drenching, but has been confirmed to be cost-effective in housed systems, especially in herds with incidences of subclinical ketosis (BHB ≥1.2 to <3.0 mmol/L) greater than 25% (McArt et al. 2014). When administered to cows

with ≥1.2 mmol/L BHB during the first 3 to 17 days in milk, MPG has been reported to resolve subclinical ketosis, prevent clinical ketosis, improve milk production in early lactation, reduce cow removal and incidence of displaced abomasum, and improve reproductive performance (McArt et al. 2011; 2012), however, its effectiveness and practicality in a pasture-based system with moderate-yielding cows of a very different genetic background is uncertain.

Preliminary findings from the NZ 2016 study (Phyn et al. unpublished data) indicates that drenching cows with MPG when they test positive for BHB ≥1.2 to <3.0 mmol/L during the first five weeks after calving reduced the percentage of cows with moderate hyperketonaemia, however, the effect on reproductive performance was inconsistent among herds (Figure 2). At TARS farm, six-week pregnancy rates declined in hyperketonaemic cows that were treated with MPG, and this effect became stronger when data were analysed with an increasing BHB threshold for treatment (≥1.2, 1.4, 1.6, 1.8 mmol/L). At LUDF or Scott farms, however, there were no significant effects of MPG drenching on six-week pregnancy rates. These results indicate that, unlike in overseas housed cows, using a MPG drench to treat moderate hyperketonaemia is not a wide-spread strategy to improve performance in pasture-based cows and may, in some cases, have adverse effects.

Nevertheless, given the among-herd differences, further analyses are warranted to investigate if there are certain conditions whereby MPG may have a positive effect when hyperketonaemia is associated with reduced cow performance. For example, do the degree and timing of elevated BHB concentrations (Figure 1), cow age, blood fatty acid concentration, and BCS parameters affect this response?

Conclusion

In summary, moderate hyperketonaemia is common in postpartum cows regardless of production system. However, in pasture-based cows, it is not necessarily associated with ill-health or reduced performance. Accordingly, the effect of treatment with MPG drench varies between herds. Evidence to date indicates that it should not be used to treat moderate hyperketonaemia (without additional signs of malaise) until it is determined if there are conditions whereby a positive and economically viable outcome can be obtained.

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References

Compton CWR, McDougall S, Young L, Bryan MA 2014. Prevalence of subclinical ketosis in mainly pasture-grazed dairy cows in New Zealand in early lactation. New Zealand Veterinary Journal 52: 30-37.

Compton CWR, Young L, McDougall S 2015. Subclinical ketosis in post-partum dairy cows fed a predominantly pasture-based diet: defining cut-points for diagnosis using concentrations of beta-hydroxybutyrate in blood and determining prevalence. New Veterinary Journal 63: 241-248.

Duffield T 2000. Subclinical ketosis in lactating dairy cattle. Veterinary Clinics of North America: Food Animal Practice 16: 231-253.

McArt JAA, Nydam DV, Ospina PA, Oetzel GR 2011. A field trial on the effect of propylene glycol on milk yield and resolution of ketosis in fresh cows diagnosed with subclinical ketosis. Journal of Dairy Science 94: 6011-6020.

McArt JAA, Nydam DV, Oetzel GR 2012. A field trial on the effect of propylene glycol on displaced abomasum, removal from herd, and reproduction in fresh cows diagnosed with subclinical ketosis. Journal of Dairy Science 95: 2505-2512.

McArt JA, Nydma DV, Oetzel GR, Guard CL 2014. An economic analysis of hyperketonemia testing and propylene glycol treatment strategies in early lactation dairy cattle. Preventative Veterinary Medicine 117:170-179.

Raboisson D, Mounié M, Maigné E 2014. Diseases, reproductive performance, and changes in milk production associated with subclinical ketosis in dairy cows: a meta-analysis and review. Journal of Dairy Science 97:7547-7563.

Roche JR, Kay JK, Phyn CVC, Meier S, Lee JM, Burke CR 2010. Dietary structural to nonfiber carbohydrate concentration during the transition period in grazing dairy cows. Journal of Dairy Science 93: 3671-3683.

Roche JR, Macdonald KA, Schütz KE, Matthews LR, Verkerk GA, Meier A, Loor JJ, Rogers AR, McGowan, J, Morgan SR, Taukiri S, Webster JR 2013. Calving body condition score affects indicators of health in grazing dairy cows. Journal of Dairy Science 96: 5811-5825.