METABOLIC DISEASE OF BOVINS AND RISKS FACTOR

V. ANDRONIE
Faculty of Veterinary Medicine, *Spiru Haret* University
viorelandronie@yahoo.com

Abstract

Most of the metabolic diseases of dairy cows – milk fever, ketosis, retained placenta (RP), and displacement of the abomasum – occur within the first two wk of lactation. In addition to metabolic disease, the majority of infectious disease experienced by the dairy cow, especially mastitis, but also diseases such as Johne's disease and Salmonellosis, become clinically apparent during the first two wk of lactation. Metabolic disease is the most commonly recognized disease on dairy farms. While the pathogenesis is well known, metabolic disorders continue to occur. Metabolic diseases are associated with one disease predisposing to another. Evidence suggests that metabolic disease affects host defense, and therefore, impacts the common infectious diseases of dairy cows. Risk for metabolic disease is affected by dietary formulation but is modified by cow behavior and intake. Regardless of dietary formulation, the cow and management factors on a given farm may determine the impact of metabolic disease.

Key words: *metabolic diseases, dairy cow, management factors.*

Introduction

Metabolic diseases are those associated with the chemical processes necessary for maintenance of life. In cattle, metabolic diseases include errors in electrolyte / mineral metabolism, of which parturient hypocalcemia (milk fever) is most common, or errors associated with energy metabolism, including ketosis and displaced abomasum. This review will make two assumptions before reviewing studies correlating metabolic disease with changes in infectious disease resistance. One of those assumptions is that mammary gland infections are less likely in animals with a *strong* immune system and that periparturient immune suppression exists and predisposes cows to mastitis and other infectious disease. Metabolic diseases are associated in that the occurrence of one increases the risk of another. These associations tend to leverage the impact of disease on the animal (Correa *et al*., 1993).

Parturient hypocalcemia and ketosis can present in either clinical or subclinical states. Clinical disease implies that cows exhibit physical abnormalities.

Subclinical disease is one where cows do not exhibit clinical signs, but the biochemical condition is present. Most producers have been content to estimate the impact of metabolic disease as a function of occurrence of clinical disease. While clinical disease occurs at a modest rate, subclinical disease has become recognized as common.

Occurrence of Metabolic Disease

Clinical parturient hypocalcemia affects an average of 6% of cows and has been associated with a 3-fold increased risk of dystocia, retained placenta, and displaced abomasum, and a nearly 9-fold increased risk for clinical ketosis and mastitis (Curtisetal., 1983; Keltonatal., 1998). Subclinical hypocalcemia, defined as plasma calcium of 5.5-8.0 mg/dl within 48 hours of parturition, has been preliminarily reported to occur in 25.3, 43.9, and 57.8% of lactation 1, 2, and 3+ cows (Reinhardt *et al.*, 2004).

Clinical ketosis is estimated to affect about 6% of cows (Kelton *et al.*, 1998). However, subclinical ketosis, defined by postpartum serum beta hydroxybutyrate, affected 59% of cows (Duffield *et al.*, 1998). Ketosis is associated with a decrease in milk production and increased risk of other postpartum diseases (Rajala-Schultz *et al.*, 1999). It is known that the risk of displaced abomasum is increased as a consequence of subclinical ketosis in lactation (Geishauser *et al.*, 1997) or in the 2 weeks leading up to calving (LeBlanc *et al.*, 2005).

These data may be interpreted several ways. They do suggest that there are a high proportion of cows very near "the edge" of clinical disease. This further suggests that any limited stressor, acting to tip the balance in favor of disease, may cause a very considerable proportion of cows to be clinically affected.

In the most parsimonious terms, metabolic disease, both electrolyte related and energy related, may be considered a problem associated with diet formulation, diet consumption, and/or individual (i.e., genetic) factors. Of these, diet consumption is probably the most variable. Therefore, if a single risk factor "root cause" of metabolic disease is to be considered, that "root cause" would focus on the factors associated with dry matter intake (DMI) in late gestation/early lactation cows. This is particularly and directly the case for the energy related diseases.

Energy Associated Disease

Ketosis, fatty liver disease, and displaced abomasum are the common energy related metabolic diseases. Energy related disease is generally thought to occur as a result of excessive lipolysis (fat breakdown) that leads to ketosis/fatty liver. Lipolysis is stimulated when energy output exceeds intake. Endocrine drivers of lipolysis include decreased insulin (low insulin allows lipolysis to continue), increased glucagon (which increases lipolysis), increased glucocorticosteriods (cortisol – which increases lipolysis), and catecholamines (epinephrine/norepinephrine – the so called "fight or flight" hormones that are powerful lipolytics). While some of these mediators are beyond direct control, the glucocorticosteriods and

catecholamines are important mediators that are, to at least a partial degree, dictated by and within control of management.

Energy related disease occurs as a *consequence* of energy distress. Energy distress can be pictured as a non-adaptive or inappropriate cow response to negative energy balance. Since all cows are expected to go through a period of acute negative energy balance postpartum, the key to health is really how the cow responds to the total environmental stress. Negative energy balance occurs prior to calving, and lipid mobilization pre-partum is extremely rapid (Goff and Horst, 1997). Therefore, energy distress is initiated before calving. Classically, much focus has been placed on improving energy intake of cows through activities aimed at increasing voluntary DMI. The importance of maximizing dry period DMI has been recently questioned, and there has been some thought that stabilizing dry period DMI may be of principle concern (Grummer *et al*., 2004). Irregardless of whether maximizing or stabilizing DMI is found to be of primary importance, factors that contribute to acutely decreased DMI must still be identified and controlled.

Risk Factors for Altered DMI

Body condition, social interaction, and concurrent disease are a few of the many factors affecting DMI. It is well known that over-conditioned cows [body condition score **(BCS)** • 4.0] have a greater decline in DMI around calving, putting them in a position of susceptibility to energy related disease. It has been suggested that adipose cells of over-conditioned cows are more sensitive to signals to initiate fat breakdown, and fat cows may exhibit insulin resistance. Over-conditioned cows tend to have increased fat breakdown, increased liver lipid concentration, and a shift toward ketogenesis. It appears that cows near calving with BCS 4.0 have a marked propensity toward lipid mobilization, and cows with BCS 3.0 have little propensity to mobilize fat (Duffield *et al*., 1999). Therefore, the recommendation that late dry cows be in a BCS range of 3.25 to 3.75 probably represents a good tradeoff between subsequent milk production and risk of metabolic disease. However, careful managers may be able to maintain health and gain high production in cows with greater BCS if environmental conditions are optimal and energy distress is avoided (Contreras *et al*., 2004).

Social (or grouping) stress can result in alterations of cow behavior and may affect energy balance. The effects may be mediated through decreased feed intake or through the stress induced lipolysis pathways. Pen moves result in observed social disorder for 2 days, with a milk yield depression of 2 to 5% for the average cow (Hasegawa *et al*., 1997). While this is a modest effect, social stress can effect the non-dominant cow to a much greater degree. Dominate cows (usually older, larger, more senior, and gaining weight) are largely unaffected by a group change. However, non-dominate cows (typically younger, smaller body size, and/or cows losing weight) may be targets of aggressive social behavior, with resulting less opportunity for feed and rest. Clinical ketosis and fat infiltration of the liver in late pregnant cows has been observed following feed restriction of 30 to 50% or fasting

for 4 to 6 days (Gerloff and Herdt, 1984). Therefore, coupling the natural decline in DMI with social stress lasting more than two days, especially in non-dominate animals entering a marginal housing situation, a significant proportion of animals could be placed in acute negative energy balance leading to energy distress and clinical disease.

Social effects are accentuated in larger cow groups/herds, so they assume more importance as herds grow in size. The ability to measure cow interaction, and the effect it has on feeding behavior, is only beginning to be addressed. Social interaction is dependent on the constitution of the group, as well as housing, feeding, and other environmental factors. Therefore, the relationships can become complex and difficult to predict. In general, minimizing re-grouping at key times has been under investigation. These times include the period of 5 days prior to calving and 1 to 10 days after calving (Cook and Nordlund, 2004).

Relationships of Energy, Disease, and Host Defense

Three other related diseases, retained placenta, endometritis, and mastitis, are prevalent conditions that have been putatively associated with energy deficiency in cows. Endometritis and mastitis affect 17% and 13 to 45% of lactations, respectively, and are infectious in origin, but the bacterial agents are considered opportunists so that these diseases are largely determined by cow defense (Hoganetal., 1989; Epperson *et al*., 1993; USD A, 1996; LeBlanc *et al*., 2002). Neutrophils are very important in bacterial defense, and it was shown that neutrophil function declines in late gestation, reaching a nadir near calving (Kehrli *et al*., 1989). Additionally, neutrophils are important in placental release, and cows with retained placenta had a deficiency in neutrophil function in the prepartum period (Kimura *et al*., 2002). Ketone bodies appear to decrease neutrophil response (McMurray *et al*., 1990; Sartorelli et al., 1999). Cows that exhibited hepatic lipidosis, a lesion consistent with energy distress, took longer to clear experimental intramammary infection and had blunted response to vaccination (Hill *et al*., 1985; Wentiketal., 1997). In addition, *invivo* work suggests that improvements in energy balance in late gestation tended to decrease retained placenta (Duffield *et al*., 2002). While it is unclear how negative energy balance affects host defense, it is important to recognize that diseases of the mammary gland and uterus may be associated with energy distress. Energy balance should be considered a potential contributor to these energy related diseases if antioxidant vitamins and minerals are adequate.

Summary

Metabolic diseases are interrelated, so that one disease increases risk for another. The energy associated diseases include ketosis, displaced abomasum, fatty liver, retained placenta, metritis, and possibly mastitis.

Providing an environment for an adaptive cow response will remain key to health. Dairy advisors must take an active role in promoting quantitative monitoring to assist the producer. In addition to tracking average DMI, monitoring

energy balance using milk or blood NEFA or ketone assays may be essential, and may provide an early warning of problems to come. Since disease represents failures (those cows who could not negotiate stress), analysis of disease incidence records must be conducted and compared to known risk factors, including BCS, DMI, pen moves, and concurrent disease. These areas are obvious points where nutritionists and veterinarians can interact in a cooperative relationship.

References

1. Contreras, L.L., C.M. Ryan, and T.R. Overton, *Effects of dry cow grouping strategy and prepartum body condition score on performance and health of transition dairy cows*. J. Dairy Sci. 87, 2004, pp. 517-523.

2. Cook, N.B., andK.V. Nordlund, *Behavioral needs of the transition cow and considerations for special needs facility design*. In: Cook, N.B., and K. V. Nordlund, editors. Veterinary Clinics of North America Food Animal Practice 20:3. Philadelphia: W.B. Saunders, 2004, pp. 495-520.

3. Correa M.T., H. Erb, and J. Scarlett, *Path analysis for seven postpartum disorders of Hol stein cows.* J. Dairy Sci. 76, 1993, pp. 1305-1312.

4. Curtis, C.R., H.N. Erb, and C.J. Sniffen, *Association of parturient hypocalcemia with eight periparturient disorders in Holstein cows*. J. Am. Vet. Med. Assoc. 183, 1983, pp. 559-562.

5. Duffield, T., R. Bagg, DesCoteaux, *et al*., *Prepartum monensin for the reduction of energy associated disease in postpartum dairy cows*. J. Dairy Sci. 85, 2002, pp. 397-405.

6. Duffield, T.F., K.E. Leslie, D. Sandals, *et al*., *Effects of prepartum administration of monensin in a controlled-release capsule on milk production and milk components in early lactation*. J. Dairy Sci, 82, 1999, pp. 272-279.

7. Duffield, T.F., D. Sandals, K.E. Leslie, *et al*., *Efficacy of monensin for the prevention of subclinical ketosis in lactating dairy cows.* J. Dairy Sci., 81, 1998, pp. 2866-2873.

8. Epperson, W.B., K.H. Hoblet, K.L. Smith, *et al*., *Association of abnormal uterine discharge with new intramammary infection in the early postpartum period in multiparous dairy cows*. J. Am. Vet. Med. Assoc. 202, 1993, pp. 1461-1464.

9. Geishauser, T., D. Habil, K. Leslie K, *et al*., *Evaluation of aspartate transaminase activity and B-hydroxybutyrate concentration in blood as tests for prediction of left displaced abomasum in dairy cows.* Am. J. Vet. Res. 58, 1997, pp. 1216-1220.

10. Gerloff, B.J., and T.H. Herdt, *Hepatic lipidosis from dietary restriction in nonlactating cows*. J. Am. Vet. Med. Assoc. 185, 1984, pp. 223-224.

11. Goff, J.P., and R.L. Horst, *Physiological changes at parturition and their relationships to metabolic disorders.* J. Dairy Sci. 80, 1997, pp. 1260-1268.

12. Grummer, R.R., D.G. Mashek, and A. Hayirli, *Dry matter intake and energy balance in the transition period*. In: Cook, N.B., and K.V. Nordlund, editors. Veterinary Clinics of North America Food Animal Practice 20, 2004, 3. Philadelphia: W.B. Saunders, pp. 447-470.

13. Hasegawa, N., A. Nishiwaki, K. Sugawara, *et al*., *The effects of social exchange between two groups of lactating primiparous heifers on milk production, dominance order, behavior, and adrenocortical response*. Applied Animal Behavior Sci. 51, 1997, pp. 15-27.

14. Hill, A.W., I.M. Reid, and R.A. Collins, *Influence of liver fat on experimental E. coli mastitis in periparturient cows*. Vet. Rec. 117, 1985, pp. 549-551.

15. Hogan, J.S., K.L. Smith, K.H. Hoblet, *et al*., *Field survey of clinical mastitis in low somatic cell countherds*. J. Dairy Sci. 72, 1989, pp. 1547-1556.

16. Kehrli, M.E., B J. Nonnecke, and J.A. Roth, *Alterations in bovine neutrophil function during the periparturient period*. Am. J. Vet. Res. 50, 1989, pp. 207-214.

17. Kelton, D.F., K.D. Lissemore, and R.E. Martin, *Recommendations for recording and calculating the incidence of selected clinical diseases of dairy cattle*. J. Dairy Sci. 81, 1998, pp. 2502-2509.

18. Kimura, K., J.P. Goff, M.E. Kerhli, *et al*., *Decreased neutrophil function as a cause of retained placenta in dairy cattle*. J. Dairy Sci. 85, 2002, pp. 544-550.

19. LeBlanc, S.J., T.F. Duffield, K.E. Leslie, K.G. Bateman, G.P. Keefe, J.S. Walton, and W.H. Johnson, *Defining and diagnosing postpartum clinical endometritis and its impact on reproductive performance in dairy cows*. J. Dairy Sci. 88, 2002, pp. 1305-1312.

20. LeBlanc, S J., K.E. Leslie, and T.F. Duffield, *Metabolic predictors of displaced abomasum in dairy cattle*. J. Dairy Sci. 88, 2005, pp. 1305-1312.

21. McMurray, R.W., R.W. Badsher, R.W. Steele *et al*., *Effect of prolonged fasting in obese persons inin vitro markers of immunity: Lymphocyte function and serum effects on normal neutrophils*. Am. J. Med. Sci. 299, 1990, pp. 379-385.

22. Rajala-Schultz, P.J., Y.T. Grohn, and C.E. McCulloch, Effects of milk fever, ketosis, and lameness on milk yield in dairy cows. J. Dairy Sci. 82, 1999, pp. 288-294.

23. Reinhardt, T.A., J. Goff, and R. Horst, *Molecular, nutrient and endocrine basis for metabolic disease in the transition dairy cow*: *Periparturient diseases of cattle*. 2004. Annual Report. Accessed on March 18, 2005 at http://www.ars.usda.gov/ research/proj ects/proj ects.htm?accn_no=405010

24. Sartorelli, P., S. Paltrinieri, andF. Agnes, *Non-specific immunity and ketone bobies. I: In vitro studies on chemotaxis and phagocytosis in ovine neutrophils*. J. Vet. Med. A. 46, 1999, pp. 613-619.

25. USD A., *Reference of 1996 dairy management practices*. USD A: APHIS: VS, CEAH, National Animal Health Monitoring System. Ft. Collins, CO, 1996.

26. Wentink, G.H., V.P.M.G. Rutten, T.S.G.A.M. van den Ingh, *et al*., *Impaired specific immunoreactivity in cows with hepatic lipidosis*. Vet. Immun. Immunopath. 56, 1997, pp. 77-83.