Subacute Ruminal Acidosis: It is more than a low rumen pH issue

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Subacute ruminal acidosis (SARA) occurs when the production of fermentation acids exceeds the ability of the animal to remove or neutralize the acids produced (Allen, 1997). SARA is of great economic importance as its prevalence is widespread. Earlier surveys performed in Wisconsin indicate that 19% to 26% of cows fed TMR diets experienced SARA (Garrett et al., 1997; Oetzel et al., 1999). For a 500-cow dairy, the financial impact of reducing SARA could reach $20,000 per month as a result of increased production of milk and components (Stone, 1999).

Feeding highly fermentable diets often causes excess fermentation and results in accumulation of fermentation acids in the rumen (SARA condition). Although the current definition of SARA is based on the pH of rumen fluid, the consequences of SARA go beyond the rumen and can lead to problems such as reduced feed intake, altered milk yield and composition, poor feed efficiency, liver abscesses, inflammation, hindgut acidosis, and lameness in feedlot cattle or lactating dairy cows. Recent advances in this area extend our understanding of the correlation between ruminal episodes and systemic events of the disease.

New insights into the SARA

Inconsistent definition of SARA

The definition of SARA based on rumen fluid pH has not been consistent among the researchers. Different thresholds for pH indicating SARA were proposed; 5.2-5.6 for at least 3 h/d (Gozho et al., 2005), 5.5 (Garrett et al, 1999), 5.8 (Beauchemin et al., 2003), and 6.0 (Plaizier, 2004). In addition, pH value of ruminal fluid could be different depending on the method of the collection with the relationship of stomach tube > rumen cannula > rumencentesis (Duffield et al., 2004). Inconsistent definitions of SARA combined with variability in pH due to the rumen fluid collection...
techniques have contributed to different interpretations of the results on SARA research (Plaizier et al., 2009).

**Altered rumen microbial population**

In general, excessive rumen acidity results in a reduction in the number of cellulolytic bacteria and total ciliated protozoa while increasing the number of Gram-positive cocci and rods (Goad et al., 1998). In a recent study, Khafipour et al (2009b) explored the shifts in microbial community structure (MCS) during the induced SARA events using terminal restriction fragment length polymorphism analysis and real-time PCR of key microbial populations. Results showed that rumen MCS were different between grain- and alfalfa pellet-induced SARA although rumen fermentation conditions were similar. The most predominant shift during SARA was a decline in Gram-negative Bacteroidetes organisms – *Prevotella albensis*, *Prevotella brevis* and *Prevotella ruminicola*. The real-time PCR data indicated that the dominant organisms are different depending on the severity and the type of SARA induction. For severe grain-induced SARA, *Streptococcus bovis* and *Escherichia coli* were the dominant organisms, whereas *Megasphaera elsdenii* was dominant for mild grain-induced SARA. Alfalfa pellet-induced SARA was dominated by *P. albensis*. More recently, Khafipour et al. (2011) reported that under low rumen pH conditions induced by a high-grain diet, there is a burst in the number of *E. coli* with virulence genes that can take advantage of these rumen conditions to trigger an inflammatory response.

**Acid absorption**

While increased acid production in the rumen is nutritionally desirable with high concentrate feeding, the accumulation of protons in the rumen is problematic. Efficient proton removal, therefore, is of major interest. Lipophilic diffusion has been considered to be the primary mechanism of short chain fatty acid (SCFA) absorption in the rumen. However, in a recently published review Aschenbach et al. (2010) reported that a number of other SCFA absorption mechanisms have been discovered over the last two decades. Ruminal epithelia can secrete bicarbonate at a capacity equal to that from saliva and remove protons from the rumen via SCFA-/HCO$_3^-$ exchange. Up to 50% of the SCFA can be absorbed in a bicarbonate-dependent manner. Proton removal via NH$_4^+$ absorption across apical membrane was also suggested as another possible mechanism to remove protons from the rumen. The authors recognized the efficient SCFA absorption could become a key determinant for the individual susceptibility to SARA.

**Inflammation**

Highly fermentable diets increase ruminal concentration of gram-negative bacteria and their structural component, lipopolysaccharide (LPS), a known endotoxin. Endotoxins that enter the systemic circulations are recognized by innate immune system of animals, and elicit inflammatory responses. Ruminitis or impaired epithelial barrier functions could increase the translocation of endotoxin across the rumen wall and SARA also often increases the acute phase protein concentrations in blood (Andersen, 2010). High acidity of digesta may reduce the barrier function of the rumen and large intestine. However, the epithelium of the large intestine may be more easily compromised than that of the rumen as the epithelium in the intestine has a monolayer structure with tight junctions at the apical pole of the cell whereas rumen epithelium has a multilayer structure with the tight junctions located in middle layers (Graham and Simmons, 2005). Therefore, the translocation of LPS could occur more in the large intestine. This suggests that evaluating hindgut acidosis together with SARA would be beneficial.

**Reduced feed intake**

Depressed feed intake has been considered a clinical sign of SARA. Reduced fiber digestion and increased VFA production and osmolarity in the rumen under SARA condition may attribute to the depressed feed intake (Allen, 2000). In addition, the previously suggested correlation between inflammation of various organs and reduced feed intake (Weingarten, 1996) was confirmed in
recent study by Khafipour et al. (2009a). These results suggest inflammation could be a part of the cause of the depressed feed intake under SARA conditions.

**Laminitis**

It has been proposed the release of vasoactive substances (i.e., histamine and LPS) of bacterial origin, triggered by low rumen pH, causes damage to the capillaries of the lamellae in the foot and causing hemorrhage, inflammation and lameness (Nocek, 1997). However, in a recent study, Gozho et al. (2007) found no correlation on free LPS concentrations between rumen and peripheral blood from cows experiencing grain-induced SARA. This finding suggests that increased concentration of ruminal free LPS may play a minor role in triggering laminitis.

**Hindgut acidosis**

Hindgut acidosis is often associated with ruminal acidosis. According to Gressley et al. (2010) hindgut fermentation contributes up to 10% of dietary energy intake in cattle, and the hindgut has some capability to adapt to increased flow of OM and its fermentation. However, due to lack of salivary buffer secretion, absence of protozoa and less protective epithelial layers, hindgut epithelia might be more susceptible to damage caused by excess fermentation compared with ruminal epithelia. Symptoms of hindgut acidosis are similar to those in subacute rumen acidosis, including reductions in nutrient digestibility, fluctuations in feed intake, and milk fat depression. Additionally, watery or foamy feces, or presence of mucin in feces indicates excessive fermentation in hindgut. With hindgut acidosis, bacterial toxins and amines may enter systemic circulations, increasing the risk of health disorders such as laminitis.

**Feeding and management considerations to reduce the incidence of SARA**

*Diet specific approaches*

- Formulate diets to contain sufficient amounts of physically effective fiber
- Consider rate of fermentation of diets
- Watch and adjust changes in moisture content of forages
- Evaluate the moisture and degree of grain processing
- Use rumen buffers and neutralizing agents
- Use Diamond V Yeast Culture™
- Use rumen modifiers (i.e., monensin)
- Do not overfeed fat

*Management specific approaches*

- Gradual adaptation to rapidly fermentable high carbohydrate diets (i.e., from dry cow to lactation rations)
- Prevent overeating in the cooler nighttime under heat stress condition
- Prevent mixing errors (i.e., implement the dairy TMR audit system offered by Diamond V)
- Prevent feed sorting and slug feeding
- Provide proper bunk space and feed access time
- Consistent feeding and TMR push up schedule

**Conclusion**

The consequences of SARA are diverse and complex, and could cause significant damages in the physical health of the cows and financial health of the producers. Laminitis is regularly connected to SARA and the negative impact of organic acids on the ruminal wall may lead to parakeratosis enabling translocation of pathogens into the bloodstream provoking inflammation.
and abscessation throughout the ruminant body. Production loss through decreased milk production and component yield could be significant.

In order to achieve proper management, the cause and effect of SARA have to be understood more extensively. To minimize the risks of SARA, careful use of adaptation strategy, accurate feed formulation, mixing and delivery, and proper bunk management should be considered as well as the use of dietary buffers and rumen modifiers like Diamond V Yeast Culture.

References


