Questions and Answers Regarding Rumenocentesis and the Diagnosis of Herd-Based Subacute Rumen Acidosis

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Introduction

Subacute rumen acidosis is a common and serious health and production problem in the dairy industry. The absence of a reliable diagnostic system is probably responsible in part for the current number of problem herds. Ration formulation guidelines for fiber and nonstructural carbohydrates (NSC) are helpful, but by themselves are not adequate for the diagnosis or prevention of subacute rumen acidosis. Measurement of rumen pH is a useful ancillary test in the diagnosis of subacute acidosis. Rumenocentesis is the most practical field method of collecting a rumen fluid sample free of saliva contamination.[12] An approach to problem herds has been developed where rumen pH is measured in two groups of cows: periparturient cows that have been exposed to the lactation rations for 1 to 20 days, and adapted lactating cows from 45 to 150 days in milk.[13] The approach has attracted great interest and questions from veterinarians, nutritionists, and dairy herd managers throughout North America and Europe in the past year. In a question and answer format, this paper will present the most frequent concerns and issues that have been raised by these groups.

Questions and Answers

How does subacute rumen acidosis differ from acute acidosis?

Subacute and acute rumen acidosis are simply different degrees of the same problem. Acute rumen acidosis is more severe.[15] The affected animal is depressed and usually ataxic, off-feed, with dilated pupils and an elevated heart rate. Diarrhea will be obvious. The animal may become recumbent and may die within 2 to 5 days after the insult.

Signs of subacute rumen acidosis are very different. The clinical signs at the time of the insult may include a mild diarrhea, a moderately distended and doughy rumen, a reduction in dry matter intake, and subsolar hemorrhages in the hoof.[5] Many cows with these subsolar "paintbrush" hemorrhages continue to walk absolutely normally. Modern dairy management systems of group housing and group feeding have made it difficult to recognize these symptoms because individual cows with these problems will usually not be noticed within the group.

What are the typical secondary signs of a herd with subacute rumen acidosis?

Dairy herds with subacute rumen acidosis will present some or all of the following signs: laminitis, intermittent diarrhea, poor appetite or cyclical feed intake, high herd cull rates for poorly defined health problems, poor body condition in spite of adequate energy intake, abscesses without obvious causes, and hemoptysis or epistaxis. Most of these signs are secondary to acidosis and most of them do not appear until weeks or months after the initial acidosis events.

What do the terms "epistaxis" and "hemoptysis" mean?

Both terms refer to bleeding. Epistaxis refers to bleeding from the nose or nostrils, while hemoptysis refers to the coughing of blood resulting from hemorrhage into the lungs. While individual cows can bleed from their nostrils due to trauma, a tumor, or unusual infections, repeated episodes of epistaxis or hemoptysis within a herd is almost diagnostic of a chronic subacute acidosis problem. The sign is a manifestation of the "posterior vena caval thrombosis" syndrome.[15]

Can I diagnose subacute rumen acidosis from the clinical signs in the herd?

A herd profile of the characteristic secondary clinical signs can be strongly suggestive of subacute acidosis, but each sign by itself could have other causes.

Doesn't every herd have some level of laminitis?

No, but almost true. First, laminitis must be distinguished from other causes of lameness. Ridges in the dorsal hoof wall, sole ulceration, white line lesions, sole hemorrhages, and misshapen hooves are the common clinical signs of chronic laminitis.[2] Research has not defined the prevalence of laminitis in the dairy industry, but a recent survey in Minnesota indicated a mean prevalence of clinical lameness of 15%, with a range from 0 to 33 percent among herds.[17] This prevalence of lameness was 2.5 times higher than the herd managers estimated. This returns us to the original question in that perhaps our entire industry has come to accept an abnormal prevalence of lameness as normal and overlook its importance as a diagnostic sign in our dairy herds. **Our best current guideline is this: when the annual incidence of laminitis exceeds 10 percent of the herd, laminitis should be considered a herd problem.[6]**

Isn't laminitis caused by many other factors in addition to acidosis?

Yes, laminitis is associated with rumen acidosis,[7,9,10] excess standing time on concrete,[3] and following a variety of infectious problems like toxic mastitis, retained placenta and metritis.[15] Our experience in investigating laminitis problem herds suggests that herd problems are most commonly due to acidosis, followed by excess standing time on concrete, or an interaction between the two factors.

Why do you recommend testing two groups of cows: fresh cows and cows at or beyond peak?

For practical purposes, there are two groups of cows at risk of acidosis. First, there are periparturient cows which are being adapted to a high-concentrate lactation ration. They are at risk because of three factors: their rumen papillae need time to elongate for maximal absorption of volatile fatty acids, the microbial population needs to adapt to different feeds in a lower pH environment, and the decrease in dry matter intake around the time of calving may result in an inadequate intake of forages.

The second group of cows that are at peak milk or beyond are at risk of ration formulation errors and feed delivery problems. Adaptation should not be an issue. Gross shortages of fiber, excesses of non-structural carbohydrates, and inappropriate feeding practices will be expressed in this group of cows.

By testing representative cows from each group, a diagnosis of subacute acidosis can be made and the problem can be localized to a risk group. By identifying the group at risk of acidosis on a farm, the problem can usually be identified with a high level of accuracy and efficiency.

Can I rule out acidosis as a problem if the herd milk fat percent is normal for the breed?

No. Low herd average milk fat % is frequently a result of acidosis. However, many herds with normal milk fat % have severe acidosis problems. This is particularly true if the herd problem affects primarily the periparturient cows. For example, if unadapted dry cows calve and are placed directly on the lactation ration, a period of subacute acidosis will exist for a period of a few weeks for those specific cows. Because they will usually constitute less than 5% of the herd at any given period of time, any effect on milk fat % that may exist at the individual cow level will be lost when averaged with the herd milk fat %. Even at the individual cow level, it is very difficult to evaluate milk fat % during the first 20 days in milk. For these reasons, herds with clinical signs consistent with subacute rumen acidosis and normal herd milk fat % should be evaluated for the presence of subacute rumen acidosis.

What specific management practices will cause subacute acidosis in periparturient cows?

There are two common problems, one specific to total mixed ration (TMR) systems, the other specific to component-fed rations.

First, as total mixed rations have been increasingly adopted by smaller dairy herds in the upper midwest, it has become a common practice to limit the number of rations to a single dry cow ration and a single lactating cow ration due to the time and labor required to mix each. This ration system has made it difficult to gradually introduce concentrates to individual fresh cows in the weeks after calving. If the dry cow ration does not adapt the rumen adequately for high levels of concentrates, acidosis may occur when the cow is moved to the lactation group ration.

Very limited research has been done to establish guidelines as to the maximal acceptable change between rations, but one study recommended that the net energy of a ration can be safely increased about 10% at a time (4). For example, a change from an energy density of 0.70 mcal/lb NE_l to 0.77 mcal/lb NE_l would be viewed as safe. National Research Council recommendations for dry cow rations would have 0.58 mcal/lb NE_l and many lactation TMR rations have 0.78 mcal/lb NE_l.[11] Observation of the 10% guideline would require two intermediate rations. However, practical experience suggests that most dry cow rations exceed 0.58 mcal/lb NE_l. The issue is not how many rations are fed. Rather, the issue is how great is the change between the rations. For example, if the early dry cow ration is estimated at 0.65 mcal/lb NE_l, a single intermediate ration accommodates the 10% guidelines.

The second problem is specific to component-fed rations and results from a poor conception within the

industry of the actual dry matter intake of fresh cows. The feeding of the periparturient cow has largely been confined to the realm of "art". Recommendations as to appropriate feeding schedules following calving have been highly variable from advisor to advisor. In an attempt to minimize the "negative energy balance" of early lactation, many advisors have advocated very aggressive concentrate feeding schedules early in the post-partum period. This early lactation period is a particularly high-risk period for cows fed rations as separate components for three reasons. First, concentrates are usually consumed by the cow in preference to forages. Second, forage consumption is not usually measured on an individual cow basis and is commonly assumed to approximate herd average consumption. Third, dry matter intake of periparturient cows is lower than commonly thought and is very dynamic through this period. [8] Table I lists daily DMI for two example cows at each week post-partum for four weeks.

Table 1. Dry matter intake predictions[8]

Week post-partum	First lactation, 1200 lbs BW[a], DMI, lb/day	Later lactation, 1350 lbs BW[b], DMI, lb/day
1	29	33
2	32	37
3	35	41
4	36	43

[a] First lactation cow expected to peak at 80 lbs of 3.5% fat milk
[b] Mature cow expected to peak at 100 lbs of 3.5% fat milk

Field recommendations for the feeding of component-fed concentrates during the first three weeks post-partum are commonly excessive. For example, it is common to find cows fresh 7 days consuming 20 lbs of dry matter from concentrates. Yet that cow may be consuming a total of only 30 lbs DMI and therefore would not be consuming the amount of forage assumed by the nutritionist, resulting in a fiber deficient ration likely to cause rumen acidosis.

Occasionally, the same situation applies to dry cows on component-fed "steam-up" rations as dry cows also show significant reductions in DMI in the last few days prior to parturition, frequently dropping to about under 20 lbs per day in the 5-day period prior to calving.[1] If component-fed concentrates are consumed and "free-choice" forages are refused as DMI drops, the dry cow may experience acidosis prior to calving. For example, we have encountered component-fed herds feeding as much as 15.5 lbs of concentrate dry matter to transition dry cows, leaving an estimated forage intake of less than 5 lbs per day. Analysis of rations based upon realistic estimated intakes will demonstrate significant ration problems.

What specific management practices will cause subacute acidosis in the cows 45 to 150 days in milk?

These problems here are those of ration formulation or delivery, **not** adaptation of the cows. The usual problems are those of fiber deficient rations. Suggested fiber guidelines for lactating cow diets are listed in table 2.

Table 2. Fiber guidelines for diets of lactating dairy cows.[16]

Fiber analysis	Minimum fiber as a % of dry matter
Crude fiber	15-17
Acid detergent fiber	19-21
Neutral detergent fiber	27-30
Neutral detergent fiber from forage	21-22

Usually the ration is formulated properly, but the ration may not meet fiber needs for any of three reasons: unintended shortages of forage, excess processing renders the fiber "ineffective", or short-term diurnal imbalances due to feeding sequence and intervals of component feeds.

First, unintended shortages of forages can occur because of cow choice or management error. Cows eating a component-fed ration can exercise selective consumption of preferred feeds and refuse others, most notably forages. Selective refusal of forages leading to subacute acidosis is common and is the cause of many "off-feed" cows, particularly during hot weather.

The other common cause of unintended forage shortage occurs because of a failure to adjust for changes in the moisture content of forages in total mixed rations. Our field experience suggests that a minority of TMR operators monitor moisture of forages on an at-least weekly basis. The majority of dairy operators do not monitor moisture, but observe the rate at which cows clean up the bunk and adjust the forage weight of the next batch. In the upper midwest, the predominant forage is alfalfa haylage. If cows clean up the TMR feeding quickly, the weight of as-fed haylage is increased in the next batch mix. Conversely, if TMR is left, forage is reduced in the following batch. The practice is conceptually correct if the observed change in consumption is due to dry matter changes in the forage. However, if the change in consumption is due to anything other than the forage dry matter, the subsequent adjustments are incorrect. If the group of cows reduces its DMI for any reason other than increased dry matter content of the forage, and the dairy operator subsequently reduces haylage in the TMR, the ration usually becomes fiber

deficient. Routine monitoring of the dry matter content of feed ingredients is an important task of TMR management.

The usual objection to monitoring forage dry matter is the time required to perform the test. Dairy advisory services commonly recommend the use of a microwave oven for the determination, but our investigations suggest that the procedure is frequently performed improperly in the field. Because of the time required to conduct the test with a microwave oven, the test is rarely done as frequent as desired and it is common for operators to make a determination before the sample is truly dry. Several alternative methods for on-farm determination of dry matter have been compared.[14] An electronic meter[1] required the least operator skill and time, and accuracy was acceptable for haylage and high-moisture shelled corn. The electronic tester can help overcome objections to performing the test and reduce the risk of inappropriate TMR adjustments.

Second, the issue of "effective" fiber is less clearly defined. A ration may meet the guidelines for laboratory-analyzed fiber, but not perform well if the physical characteristics of fiber are lost through fine chopping or maceration from excessive mixing. Various laboratories are offering particle size determinations, but research-based standards for interpretation have not yet been developed.

Third, problems occur that involve portion size, feeding sequence, and time interval between feedings. Field investigators have long recognized the special risks of acidosis with component-fed rations. Research has shown differences in rumen pH from dividing the total concentrate into 2, 4, or 6 portions per day.[18] Reduced portion size has been shown to be associated with less pH depression. Anecdotal information abounds about the impact of feeding sequence on acidosis. The general opinion is that some quantity of forage should be fed prior to concentrate meals, particularly in the morning feeding.

Some traditional dairies expand their stanchion-barns and continue to feed concentrates indoors in the stalls, but turn the cows outside for forages to a mechanical bunk that remains unchanged in length suitable for the original smaller herd only. To avoid crowding and competition at the bunk, half the herd is turned outside at a time. Subacute acidosis has been diagnosed in the cows that remain inside waiting for the second shift at the bunk with forages if the time interval between the first concentrate meal in the morning and access to the bunk exceeds 2.5 hours. Clinical experience suggests that this problem can be solved by extending the bunk and minimizing the interval between concentrate and forage meals for all cows, or by feeding forages in the barn at a rate of about 10% of the daily dry matter intake prior to the concentrate meal.

Why do herds differ in the clinical signs presented?

Herds differ in the variety and prevalence of clinical signs because of the variations in the severity of acidosis, whether the feeding management problem involves periparturient cows or the rest of the lactating herd, the duration of the feeding management problem, and the rate of culling of problem cows from the herd.

Why is the usual approach of ration analysis for ADF, NDF, and NSC inadequate for a diagnosis?

Fiber and carbohydrate analysis provide only part of the picture. The National Research Council recommends that fiber guidelines should be modified for fiber type, particle size and distribution, total dry matter intake, bulk density of ration, buffering capacity of the forage, feeding frequency, and body condition and production level of the animal.[11] Practices such as excessive mixing of total mixed rations and infrequent feeding of large meals increase the fiber requirement of a ration, even though the chemical analysis of the ration meets recommended nutrient densities. Finally, the dynamic changes of rumen adaptation go well beyond static measurements of fiber.

How are the rumen fluid samples collected?

The technique of rumenocentesis has been described in detail,[12] but essentially involves inserting a needle into the ventral rumen and aspirating a sample of rumen fluid. Landmarks for the puncture site are the left side, on a horizontal line level with the top of the patella about 8 inches posterior to the last rib. The site is clipped and prepared using a standard three scrub surgical preparation. Light sedation is recommended but not essential. However, physical restraint with hobbles or tail elevation is strongly recommended. A 16 gauge 5 inch stainless steel needle is thrust through the skin, then into the rumen and fluid is aspirated. The needle will occasionally become obstructed by ingesta which can be cleared by forcing a small volume of air through the needle. When the needle becomes obstructed, it is important to avoid creating a negative pressure within the syringe as CO_2 will leave the fluid and increase the pH. Typically, 3 - 8 ml of rumen fluid can be collected without difficulty. When a sufficient volume has been obtained, air is evacuated from the syringe and pH is measured immediately.

What are the risks to the cow being sampled?

The obvious concern is that the procedure could introduce rumen fluid into the peritoneal space inducing a peritonitis. We are unaware of any clinical illness resulting from the procedure, with perhaps 700 samples

[1] *1210 Silage Tester; Farmex Inc., Aurora, OH*

collected. In excess of 300 collections have been done on research cows whose individual DMI and milk production were measured daily. Clinical peritonitis has simply not been observed. We do observe a subcutaneous abscess in about 1% of sampled cows. Interestingly, the subcutaneous abscess rate appeared to increase when we abandoned the surgical site preparation for a time.

For the special cases where dry pregnant cows are introduced to the lactation rations prior to calving, the 20-day periparturient risk period would start prior to calving and would include those dry cows. Rumenocentesis must be done with special care on dry cows, as the gravid uterus often lies between the rumen and the left abdominal wall. If the rumen cannot be auscultated, the cow should not be sampled because amniotic fluid, not rumen contents, is likely to be aspirated and would introduce the possibility of contaminating that fluid which could abort the pregnancy.

When should the samples be collected?

The appropriate time of collection depends upon the type of feeding system. In component-fed herds, samples should be collected 2-4 hours after the feeding of the primary concentrate meal. In herds with total mixed rations, rumen samples should be collected 4-8 hours after the TMR is offered. In many dairies, the primary meal is consumed following discharge from the milking parlor and in those cases, sample collection should be done 4-8 hours later.

What is a normal pH reading?

The authors recommend the following ranges for classifying observed pH values:

≤ 5.5	abnormal
5.6 - 5.8	marginal
≥ 5.9	normal

It is important to avoid making a herd diagnosis based upon a single sample. If more than 30% of the samples in a sub-group of six or more cows have a pH less than or equal to 5.5, the group can be considered abnormal. This recommendation is based upon unpublished research data from feeding trials of a variety of total mixed rations. Classifying the group as abnormal is saying that enough cows have an unstable rumen environment that detrimental effects on the health and production of the herd are likely. This test should not be interpreted in isolation. The pH data must be considered a "test" to be interpreted in conjunction with the "physical exam" of the herd.

Should I calculate an average pH of the samples?

We would recommend that the interpretation be done on frequency of outliers, not on a group average.

Why do I get different pH measurements from different cows on the same ration?

The gradual nature of the adaptation process, the variation in animals' feed intake rates, the variation in chewing habits, and the biological variation between animals in characteristics like saliva production and rumination activity means there will be a range of pH values within a feeding group. In research trials of cows on a single ration, we observe a standard deviation in rumen pH of about 0.4 units.

How will samples collected by rumenocentesis differ from samples collected by stomach tube?

Samples collected by stomach tube will be contaminated by various amounts of saliva from the esophagus which will raise the pH. The amount of saliva contamination is highly variable, making pH determinations of rumen fluid collected by tube of limited value.

How will samples collected by rumenocentesis differ from samples collected through a surgically-placed rumen canula or fistula?

The samples collected by rumenocentesis will have a lower pH than samples collected through a canula by 0.4 units.[5]

Does blood in the sample cause a problem?

Yes, blood will raise the sample pH significantly and such samples should be discarded.

Is a pH meter required to measure results?

No, but it is highly recommended. The alternative of pH paper is problematic in that the gradations on the narrowest papers we can find are 0.3 pH units. In the range from 5.0 to 6.0, the color indicators are various shades of green. Frequently, the color cannot be matched to a single reference point and often one of the points is 5.4, the other is 5.7. Another practical factor is that lighting is important in reading and matching the color indicator, and poor lighting is a problem in many clinical situations.

What is the best pH meter for this use?

We have not made a complete survey of pH meters, but of the meters we have used, we recommend the Cardy Twin pH meter manufactured by Horiba.[2] It is small, durable, and packed in a field case. It has a digital readout, can function with just a few drops of fluid, and is equipped with a computerized calibration routine.

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[2] *Spectrum Technologies, Inc., Plainfield, IL (800-248-8873)*

Can I collect the samples and turn them in to a laboratory?

We do not recommend it. We have not done trials to determine the exact effect, but pH would be expected to increase as CO_2 leaves the fluid. There are advantages in communication of results if the readings are done at cowside.

What cows should I test?

Samples should be collected from approximately 6 normal cows in each group: the periparturient cows from 1 to 20 days on the lactation ration, and adapted cows from 45 to 150 days in milk. Do not sample sick or abnormal cows. Frequently, the client will want testing done on a dying cow symptomatic of acidosis. A sample collected from a dying cow that has not eaten well for several days or weeks will not yield useful information. The samples need to be collected from normal animals experiencing different phases in the feeding system. The test is herd-based and is focused on the effect of the feeding system on the cow.

How do I interpret the findings from the two groups?

Again, if any two samples from a group of six have a pH of 5.5 or less, the group is classified as positive for acidosis. Figure 1 below shows how the findings would be classified.

	Adapted cows (45-150 days-in-milk)	
	+	-
Periparturient cows (1-20 days on ration) +	Ration Problem or Ration and Periparturient Problem	Periparturient problem
-	Ration Problem	Normal herd

Figure 1 - Interpretation of rumen fluid pH results by herd group.

If the periparturient cow group is positive for acidosis, what should I do?

If the herd has a TMR system, evaluate the degree of change in fiber and concentrates between the dry cow and lactation rations. The farm may need to implement an intermediate transition ration or raise the energy density of the far-off or early dry period ration.

If the herd has a component-feeding system, evaluate the concentrate intake of cows at 1 day-in-milk (DIM), 7 DIM, 14 DIM, and 21 DIM. Subtract the dry matter from concentrates from the total estimated dry matter intake from the Kertz guidelines to estimate intake of forages. Analyze this simulated ration for nutrient adequacy and interpret according to the NRC guidelines for early lactation cows.

If the adapted cows from 45 to 150 days in milk are positive for acidosis, what should I do?

If the herd has a TMR system, evaluate the system of moisture testing and adjustment. Evaluate particle size of the blended ration. A field test for excessive mixing is sometimes useful. The individual ingredients for one cows ration are measured out and mixed by hand. This mix is visually compared to the mix from the TMR. Pointing out the differences can aid in encouraging the feeding personnel to observe recommended mixing time limits.

If the herd has component-fed rations, the solution may be found in monitoring the consumption of all forages of individual cows in their stalls. The feeding sequence should insure that cows consume at least 5 lbs of forage dry matter as the first feeding of the day.

You conducted an investigation for one of my clients, made a diagnosis of subacute acidosis in the periparturient cows, and recommended increasing the amount of corn to be fed to both the close-up dry cows and the lactating cows. How can this make sense?

This can make sense if the dry cows were not adequately exposed to concentrates and were having problems adapting to the lactation rations. We have repeatedly seen herds where steps had been taken to try to solve a herd acidosis problem, but the wrong steps were taken. The concentrates in the lactation ration may have been reduced, yet the acidosis problem remained because it was a periparturient cow adaptation problem. In these situations, the health problems remain and milk production also suffers because the wrong ration was modified.

By specifically identifying the problem as to the group at risk, we can target an effective solution.

If we make a change in the ration, should I retest the cows and if so, when?

Do not retest the individual cows. Retest the herd! Identify new cows in each group at risk and retest. Studies of the time required for rumen microbial adaption would suggest that the herd should not be retested until at least three weeks have passed since the change in the feeding program has been implemented.

The ability to retest has given us a way to evaluate the adequacy of the management interventions. Prior to our use of herd-based rumenocentesis, a diagnostic opinion of subacute acidosis would be made and feeding management changes would be implemented. However, if the problems in the herd did not subside, the diagnosis would be assumed to have been incorrect and other disease problems would be investigated. With the rumenocentesis technique, we sometimes find that

the diagnosis was correct, but that the corrective adjustments were too restrained to correct the problem. **Opinions are not usually given a second chance, but objective measurements can provide the means to progress to a satisfactory conclusion.**

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Abstract

Evaluation of an O-antigen ELISA for screening cattle herds for *Salmonella typhimurium*

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A total of 2585 serum samples from 62 dairy herds located in four different regions of Denmark were tested in an O-antigen (0:1,4,5,12)-based ELISA for the detection of antibodies against *Salmonella typhimurium*. Ten closed herds from an island with no reported occurrence of salmonellosis for several years, and 12 herds from a salmonella enzootic area which had had clinical outbreaks of *S typhimurium* were used to define a herd ELISA cut-off value. When herds with at least 5 per cent of the serum samples having an optical density of >0.5 were considered ELISA-positive, all 10 herds from the salmonellosis-free island were ELISA-negative, and all but one of the 12 *S typhimurium*-infected herds were ELISA-positive, which resulted in a herd test sensitivity of 0.92 and herd test specificity of 1.0. Eleven of the 12 *S typhimurium*-infected herds were negative in a blocking ELISA based on a monoclonal antibody to the 0:9 antigen of the serogroup D salmonellas, indicating the possibility of rapid serogroup-specific screening of herds by means of these two tests. Ten other randomly selected herds with clinical outbreaks of *S dublin* were all, to a large extent, positive in the 0:1,4,5,12-ELISA, whereas a *S dublin* (0:1,9,12)-ELISA described previously appeared to be more serogroup D-specific. Thus, the 0:1,4,5,12-ELISA appears to be useful for detecting herd infections with *S typhimurium*, and positive reactions may be further discriminated by the serogroup D-specific ELISA.