New Insights into Managing the Neonatal Calf for Health and Production

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Current Status of Neonatal Calf Health and Survivability in the U.S.

The National Animal Health and Monitoring System (NAHMS) has conducted three surveys in 1991, 1996, and 2002, of U.S. dairies that includes information on health and management practices involving dairy calves. The pre-weaning mortality rates ranged from 8.4 to 10.8% in these surveys. The NAHMS (1994) survey data also indicate that morbidity rate for preweaned calves is approximately 37%. In the 1996 survey, 60% of the pre-weaning deaths were attributable to scours and 25% to respiratory infections. Sixty-two percent of the calf deaths occurred in the first three weeks following birth. Failure of passive transfer has long been recognized as important factor contributing to calf morbidity and mortality. In 1994, NAHMS reported that 41% of 2177 calves sampled for determination of serum immunoglobulin (IgG) concentrations had failure of passive transfer (FPT) characterized by IgG concentration of less than 1 gm/dl. Wells (1996) has estimated that 31% of the dairy heifer pre-weaning deaths could be prevented through improved colostrum feeding methods including timing and volume of the first colostrum. In addition to colostrum management, the risk of calf mortality increases as the amount of time that the calf is left with the dam after birth increases and as the difficulty of calving increases.
The value of good colostrum management extends beyond just a reduction in calf mortality and morbidity. Faber reported on the effects of feeding two vs. four quarts of colostrum to Brown Swiss calves on health costs, rates of gain and milk production over the first two lactations. The calves were managed the same way in all respects expect for the difference in the amount for first colostrum fed. The calves fed four quarts of colostrum gained 0.5 lb/d more from age at weaning to breeding and weighed 170 lbs more at breeding age than calves receiving two quarts. The calves fed four quarts of colostrum produced two more pounds of milk per day during their first two lactations compared to calves receiving two quarts. In addition, treatment costs for calf diseases were reduced by $9.74 per calf for the calves receiving four quarts of colostrum. The collective values of feeding four quarts of colostrum in reduced mortality, reduced treatment costs, improved rates of gain and larger size calves at breeding and improved production suggests that a gallon of colostrum is worth about $400!!

Guidelines for Colostrum Management

The key factors affecting successful colostrum management for calves are the following: 1) the timing of the first feeding, 2) the quality of colostrum, 3) the volume of colostrum fed, and 4) pathogen and bacterial contamination of colostrum.

Timing of feeding of first colostrum. At birth, the calf's intestine has a finite capacity to absorb large molecules directly from the intestinal lumen and transfer them to the blood. This capacity is rather indiscriminant with respect to the type of large molecules that are absorbed and is gradually lost over the first 24 hours of life, which is lost more quickly following ingestion of colostrum or milk. With that said, if the feeding of colostrum is delayed until more than six hours after birth, the proportion of calves experiencing FTP increases. Therefore, the first feeding of colostrum should be completed within the first six hours of birth.

Quality of colostrum. The immunoglobulin concentration in colostrum is the primary factor affecting quality. To prevent FPT, calves need to consume about 100 gm of immunoglobulin. A calf consuming four quarts of colostrum containing a minimum of 3.5 gm/dl of immunoglobulins, will get about 100 gm of immunoglobulin. Colostrum with immunoglobulin concentrations of less than 3.5 gm/dl are usually considered to be of poor quality with about 30% of colostrums falling into this category. A colostrometer is an effective tool for screening colostrums to identify the poor quality colostrums. The colostrometer, if used properly, will identify about 50% of the poor quality colostrums, which can then be avoided for feeding calves. Other management factors that can be used to improve colostrum quality include milking fresh cows as soon as possible after freshening and avoiding pooling colostrums. Moore, et al, 2005, has shown that as the interval between calving and collection of colostrum increases, the immunoglobulin concentration in colostrum decreases. Cows that were not milked until 14 hours after calving had colostrum with a third less immunoglobulin concentrations compared to those milked within two hours of calving. It is speculated that immunoglobulins are being reabsorbed from colostrum after calving, thus lower immunoglobulin concentrations with increasing interval to harvest. Pooled colostrum batches have lower immunoglobulin concentrations than the average of the individual colostrums contributing to the pool because cows producing the largest amounts of colostrum have colostrums with the lowest immunoglobulin concentrations. Immunoglobulin concentration in colostrum from first lactation cows does not vary significantly from second and greater lactation cows. Therefore, colostrum from first lactation cows is acceptable for feeding calves.

Amount of colostrum fed. Based on the variation in the concentration of immunoglobulin in colostrum, it is recommended that the first feeding of colostrum should be a gallon to compensate for the colostrums with low immunoglobulin concentrations.

Bacterial and pathogen contamination of colostrum. Two other factors that affect the quality of colostrum and milk are the levels of either environmental bacteria contamination or pathogens. The pathogens of primary concern that can occur in colostrum and milk are salmonella, Mycoplasma, and Johne's bacteria. These pathogens can be shed into colostrum and milk and can be a source of infections for calves. In addition, pooled colostrums increase the risk that the pooled batches of colostrum or milk can be contaminated with these pathogens for a single infected cow contributing to the pool. Pasteurization of colostrum at a temperature of 145^{o} F for 30 minutes for the elimination these pathogens has been a problem in that pasteurization tends to destroy immunoglobulins and causes colostrum to attain a pudding like consistency. Godden, et al., has recently demonstrated that pasteurizing colostrum at 140^{o} F for 30 minutes can eliminate the pathogens of concern and does not destroy the immunoglobulins. In fact, calves fed colostrum pasteurized at 140^{o} F for 30 minutes had better serum immunoglobulin levels than calves fed non-pasteurized colostrum. It was speculated that bacteria in the non-pasteurized colostrum may have occupied sites for macromolecule absorption in the small intestine, leading to exclusion of immunoglobulins. High bacterial levels in colostrum or milk can be the result of either poor sanitation practices in milking cows, ineffective cooling of colostrum between the time colostrum is collected and fed, or bacterial contamination of utensils holding colostrum. Calves fed colostrum or milk with high levels of bacteria, have higher morbidity.

Take home message:

1. The first feeding of colostrum needs to be done within six hours of birth.
2. Calves need to be fed first milking colostrum from either first lactation or older cows. A colostrometer can be used to screen and eliminate half of the poor quality colostrums.
3. The current recommendation is to feed one gallon of colostrum.
4. First milking colostrum should be collected cleanly, and if not fed immediately, cooled and stored in refrigerator to prevent bacterial contamination.
5. Avoid pooling colostrum as this practice increases the chances spreading Johne's, Salmonella, and Mycoplasma to all calves fed from a pooled batch. Pooled colostrum batches have lower IgG levels than the average of individual samples contributing to the pool.
6. Pasteurization of colostrum at 140o F for 30 minutes effectively eliminated pathogens, lowered bacteria counts and did not damage IgG.

Post-colostrum feeding guidelines

For fifty years the dairy industry has followed the recommendation that calves be fed one pound of milk replacer in a gallon of water until weaning. The concept behind this restricted feeding of milk replacer was that calves would be hungrier and they would begin consuming calf starter sooner. Since calf starter is about one fifth the cost on a per pound basis of milk replacer, the end result would be a more economical program for growing calves. This feeding practice has recently received several critical reviews (VanAmburgh, 2004; Drackley, 2004). Neonatal calves when allowed *ad libitum* access to a liquid diet of milk or milk replacer will consume 16 to 24% of their body weight (BW) per day by the third to fourth week of life, which is substantially more than the 10 to 12% of BW commonly fed to Holstein calves consuming one pound of a 20% protein, 20% fat milk replacer (20:20 MR) in a gallon of water. Calves consuming one pound of a 20:20 MR have enough energy to remain in a positive energy balance until environmental temperatures drop below 50^{o} to 60^{o} F. Below these temperatures they must use body tissue to meet energy needs and will loose weight if they are not consuming adequate calf starter to complement the energy from the milk replacer. One of the companies manufacturing milk replacer reported that large Holstein bull calves lost an average of 0.25 lb/day the first week of life and an average 0.8 lb/d the second week of life. Only when calves begin consuming calf starter in the third week of life did calves start to have a positive weight gain. There is awareness that the immune system needs adequate levels of certain trace minerals and vitamins to function, but often there is failure to appreciate the importance of adequate energy for immune function. The National Dairy Heifer Evaluation Project reported that 62% of pre-weaning calf deaths occurred within the first three weeks following birth, the same period of time when calves were adjusting to extra-uterine life and were losing weight. All this information suggests that if calves were fed to a higher plain of nutrition the first two to three weeks of life, calf morbidity and mortality could be reduced. Nonnecke and Foote (2006) have shown that there was no difference in immune function of calves consuming a 20:20 MR at 1.4% of their body weight (BW) per day vs. a 30:20 MR at 2.5% of BW as long as the calves were in thermoneutral environment and in a positive energy balance characterized by weight gain.

Godden, et al., 2005, reported on a study comparing the effects of feeding milk replacer vs. feeding pasteurized discard milk on growth rate, morbidity, and mortality in calves (Table 1). The calves in the milk replacer group were fed one pound of a non-medicated 20:20 MR in one gallon of water divided into two daily feedings. The calves in the pasteurized milk group were fed one gallon of pasteurized discard milk daily. Calves fed pasteurized discard milk had significantly higher rates of gain (0.26 lb/d), higher weaning weights (12.3 lb) and lower morbidity and mortality rates than cohorts. The calves fed the milk replacer were at higher risk of treatment for diarrhea and pneumonia during the summer (12.7 vs. 4.4%) and winter (52.4 vs. 20.4%) months, respectively, and higher risk of death during the winter months (21.0 vs. 2.8%) and overall months (11.6 vs. 2.2%), respectively. The overall mortality rate for the milk replacer calves was 11.6%, which is within the range of mortality reported in the NAHMS studies. This overall mortality for calves fed milk replacer was significantly higher than the 2.2% mortality for calves fed pasteurized milk. The overall morbidity risk was significantly higher for calves born in the winter months than in the summer months. Morbidity risk was significantly higher for calves fed milk replacer during both seasons, with the incidence of scours being significantly higher for the milk replacer calves compared to the calves fed discard milk (17.2 vs. 3.1%). One difference between the two programs is that the calves fed milk replacer consumed 2.15 Mcal ME per day in one pound of a 20:20 milk replacer while the calves consuming discard milk consumed 2.44 ME per day in the gallon milk, about 13.5% more ME energy per day.

Take home messages:

1. Feeding inadequate amounts of milk or milk replacer to meet the energy needs of the calf puts the calf at increased risk of disease and death.
2. Morbidity and mortality were higher in the winter months for the calves fed milk replacer when the energy deficiency of these calves would have been the greatest.
3. There does not appear to be an enhancement of immune function by feeding more milk replacer as long as the calf is in a positive energy balance.

Determining the protein and energy need of calf

The first “nutrient” need of the calf is energy for maintenance functions. Once maintenance energy needs are met, any additional energy consumed can be partitioned for growth. The primary factors affecting the energy needs of the calf for maintenance are the size of the calf and environmental temperature. The 2001 NRC Nutrient Requirements for Dairy Cattle contains ration evaluation software which can be used to evaluate the adequacy of various calf feeding programs relative to the needs of the calf based on size of the calf and environmental temperatures. Within breed, there is greater variation in energy needs relative to the range of environmental temperatures than body size. The lower critical temperature for Holstein calves is between 65^{o} to 70^{o} F. As environmental temperatures decline below the lower critical temperature, energy requirements for maintenance increase and at 50^{o} F the energy requirements for maintenance exceed the energy provided by one pound of a 20:20 MR. The upper critical temperatures are less clearly defined for the calf and NRC model does not model increases in maintenance energy requirements with elevated environmental temperatures. Once energy needs for maintenance have been met, any additional energy will be used for growth. How that additional energy is used will be determined by the availability of protein. If sufficient protein is available, the energy will be used for the production of lean tissue. If insufficient protein is available, the energy will be used for the deposition of fat. Once the energy requirement for maintenance has been determined based on the size of the calf and the environmental temperature, the desired rate of gain becomes third determinant of the amount of energy that needs to be fed in addition to that required for maintenance. Like any other class of livestock, the amount of energy that a calf consumes is a function of the amount of dry matter consumed and the energy density of the dry matter. Milk replacers are reconstituted in the range of ten to 17.5% dry matter and are fed at the rate of eight to18 percent of body weight of the calf. This means a ninety pound calf could consume between 0.7 and 2.8 lbs of dry matter, depending upon rate of reconstitution and percent of body weight that the milk replacer is fed. The energy density of a milk replacer is primarily dependent upon the fat content. Commercial milk replacers range from ten to twenty percent fat. If whole milk with a 3.5% fat content were dried and packaged in a bag, it would have a fat content of about 30%. The point is that when milk replacer is purchased, one should compare milk replacers on the basis of cost of a megacalorie of metabolizable energy (Table 2). Once the size of calf and environmental temperatures have been established to determine the energy requirements of the calf, the amount of milk replacer should be determined to maintain the calf in a positive energy balance. Four studies have looked at the effect of feeding nutrients at 50% or greater than standard level of feeding to calves on milk production in the first lactation (Table 3). The heifers on the higher plain of nutrition produced between 1,000 and 3,000 pounds more milk than their contemporaries in the first lactation.

Take home messages:

1. Calf morbidity and mortality can be reduced by making sure calves are getting enough energy to be in a positive energy balance.
2. Calves fed at levels of 50% or greater above standard levels of intake have produced between 1000 and 3000 pounds more milk in their first lactation.

Table 1.

	Milk Replacer	Pasteurized Milk
Calves enrolled (n)	215	222
Serum total Protein (mg/dl)	5.7	5.8
Arrival Wt. (lb)	88.2	87.3
Weaning Wt. (lb)	133.8	146.1
Avg. Daily Gain (lb/d)	0.75	1.03
Morbidity Events		
All months	**32.1** (69/215)	**12.1** (27/223)
Winter months, %	**52.4** (55/105)	**20.4** (22/108)
Summer months, %	**12.7** (14/110)	**4.4** (5/115)
Scours, %	17.2	3.1
Mortality Events		
All months	11.6 (25/215)	2.2 (5/223)

Winter months, %	21.0 (22/105)	2.8 (3/108)
Summer months, %	2.7 (2/110)	1.7 (2/115)

Table 2.

Milk Replacer 22:20	1 lb MR / day	Cost / Mcal ME
$35 / Bag	$0.70 / Gal	$0.293 / Mcal
$40 / Bag	$0.80 / Gal	$0.368 / Mcal
Milk Replacer 28:20		
$45 / Bag	$0.90 / Gal	$0.41 / Mcal
$50 / Bag	$1.00 / Gal	$0.45 / Mcal
Whole Milk		
$10 / Cwt	$0.86 / Gal	$0.35
$12 / Cwt	$1.03 / Gal	$0.422
$14 / Cwt	$1.20 / Gal	$0.493

Table 3.

Study	Treatment Difference
Bar-Peled, et al, 1998	998 lbs
Foldager and Krohn, 1994	3092 lbs
Foldager et al, 1997	1143 lbs
Ballard et al, 2005	1543 lbs at 200 DIM

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Last Updated (Wednesday, 14 March 2007)

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