Colostral Management: How Good Is Your Program?

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At birth, the baby calf is highly susceptible to disease and has been provided with very meager nutritional reserves. The dam's colostrum specifically provides elements that enhance the calf's disease defenses and supplement other nutritional needs. Therefore, colostrum can be viewed as the single most important nutritional factor for the newborn calf and management practices that enhance the appropriate supplementation of colostrum to newborn calves are critical for increasing calf survival. The focus of this talk will be on factors that influence colostral quality and colostral management practices that support the health of the newborn calf.

Immune Defenses Of The Newborn Calf

The mammalian system of defense against invasion by disease-causing organisms has multiple components. Chief among these are:

1) humoral immunity, which is provided by circulating and local tissue immunoglobulins;

2) cellular immunity provided by certain subsets of lymphocytes;

3) other white blood cells including neutrophils and macrophages; and

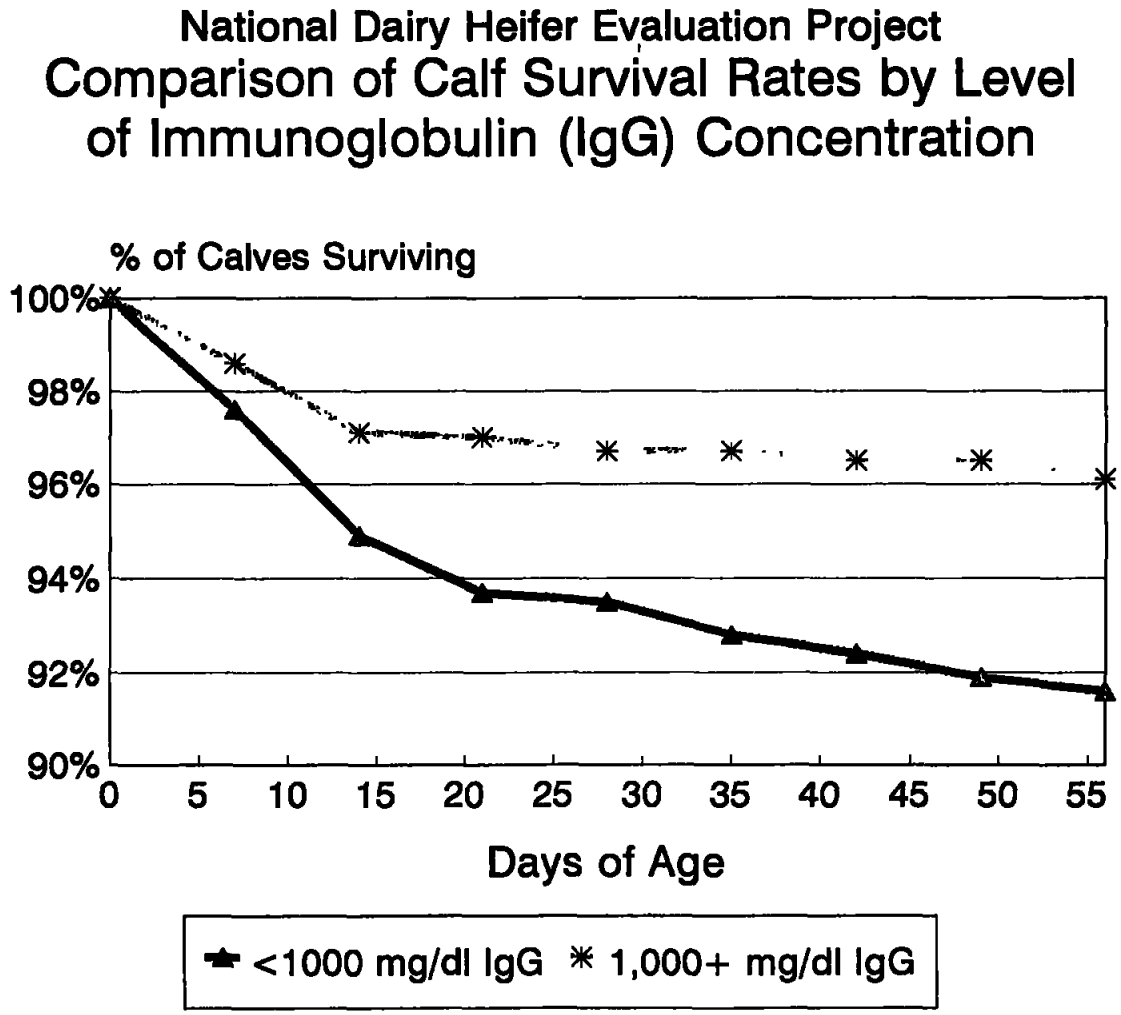
4) other defense proteins including complement, kinin, and other inflammatory proteins. Compared with older animals, the newborn calf is unique because it has not previously encountered disease organisms and its immune system is functional but has not had the "experience" of recognizing specific disease agents. Further, the bovine placenta does not allow the passive transfer of protective immunoglobulins to the calf. As a result, the newborn calf relies on colostral consumption to prime its immune system with elements made by its more experienced dam.

The aspect of colostral immune protection that has been most thoroughly described pertains to its content of immunoglobulin. It is clear that colostrum has elements that enhance the other immune functions listed above but the importance and specific actions of these other mechanisms have not been thoroughly researched. Therefore we look at colostrum as providing critically important im-munoglobulin but need to recognize that it does more.

Immunoglobulins (also known as antibodies or gamma globulins) are proteins that the body manufactures to attach to invading organisms and neutralize them. Specific immunoglobulin (Ig) will therefore be manufactured against specific organisms. The process of passive transfer of Ig involves the secretion of Ig by the dam into the colostrum, the consumption of the colostrum by the newborn calf, and subsequently the absorption of the Ig through the intestinal wall and into the calf's circulation. The absorbed immunoglobulins protect the calf against systemic invasion by microorganisms, thus are a critically important aspect of the calf's immune defense system.

It is important to realize that passive immunoglobulin transfer is not a simple "yes" or "no" equation. Acquisition of Ig does not guarantee the calf a disease-free future. To protect the calf against disease, the immunoglobulin has to be present at the right place where the organism is invading, must be present in sufficient quantity to neutralize the agent, and must be of the appropriate immunoglobulin type to attach to the specific invading organism. Whether a calf remains healthy or develops disease will depend on the balance between disease exposure versus disease defenses. As mentioned above, other nonimmunoglobulin defenses are also important for the calf's disease prevention. Nevertheless, a very strong association between passive Ig transfer and calf disease resistance has been shown repeatedly and this process must be seen as the single most important factor that we can manage to enhance calf health.

Because circulating Ig is effective in preventing microorganism invasion, passive Ig transfer is primarily responsible for preventing septicemic bacterial infections. Absorbed immunoglobulin is not nearly as effective at preventing localized enteritis (neonatal calf scours). Agents such as rotavirus, coronavirus, and Cryptosporidia only affect the superficial lining of the gut wall and it appears that circulating Ig has limited efficacy in preventing this type of infection. Numerous studies suggest, however,



that the severity of diarrhea in enteric disease of neonatal calves and the ability of affected calves to survive is positively influenced by increased circulating Ig. Although passively acquired Ig cannot prevent all calf diseases, virtually all studies of neonatal calf performance show a positive benefit of increased Ig transfer on calf health and survival.

Factors Involved In Passive Transfer

A number of techniques are available for measuring the efficacy of passive Ig transfer to calves. All of these techniques involve the measurement of protein in plasma or serum. Some of these techniques (refractometric protein measurement, zinc sulfate turbidity and sodium sulfite turbidity) are quite inexpensive and can be performed at the farm. Using such measurements, we have developed a good understanding of the factors that positively influence passive Ig transfer.

The two most important factors in passive Ig transfer are the total immunoglobulin mass that is ingested, and the time after birth when the colostrum is received. The immunoglobulin mass is a combination of Ig concentration in the colostrum and the amount of colostrum fed. The product of these two factors is the total immunoglobulin available for absorption by the calf's intestine.

The volume of colostrum produced by a cow is generally not a limiting factor in dairy operations, although it may be a concern in some beef management situations. The volume of colostrum consumed, however, determines the amount available for absorption and this is determined by the amount the calf suckles or is fed. Some producers let the calf suckle the dam, and it might be expected that this would be an efficient method. Although some studies have shown that natural suckling enhances calf

Ig absorption, this method of feeding can also be associated with a significant rate of failure of passive transfer. Factors that contribute to this failure include poor mothering ability by the dam, dam sickness at parturition, poor udder conformation and/or teat structure, and poor calf viability or sucking ability. All of these factors can lead to inadequate voluntary consumption by the calf. It is noteworthy that dairy calves have less vigor and poorer suckling drive than their beef calf counterparts where this method of colostral consumption is the norm.

Colostral immunoglobulin concentration can vary tremendously between cows. Older cows generally produce higher quality colostrum than heifers, but there is also wide variation between individuals, even in multiparous cows. The immunoglobulin concentration of colostrum can be estimated by measuring its specific gravity and a commercially device is available for this purpose. This colostrometer can be valuable in helping select the cows from which colostrum is fed to the newborn calf. Variations in first milking immunoglobulin concentration can easily range from 20-80 mg/ml, or a four-fold difference.

Recommendations for the minimum immunoglobulin mass that a newborn calf should receive are about 100 gm of immunoglobulin. A more appropriate aim would be to provide between 200-300 grams; thus, 4 liters of colostrum at 50 mg/ml would provide 200 gm immunoglobulin to the newborn calf, well in excess of the suggested minimum.

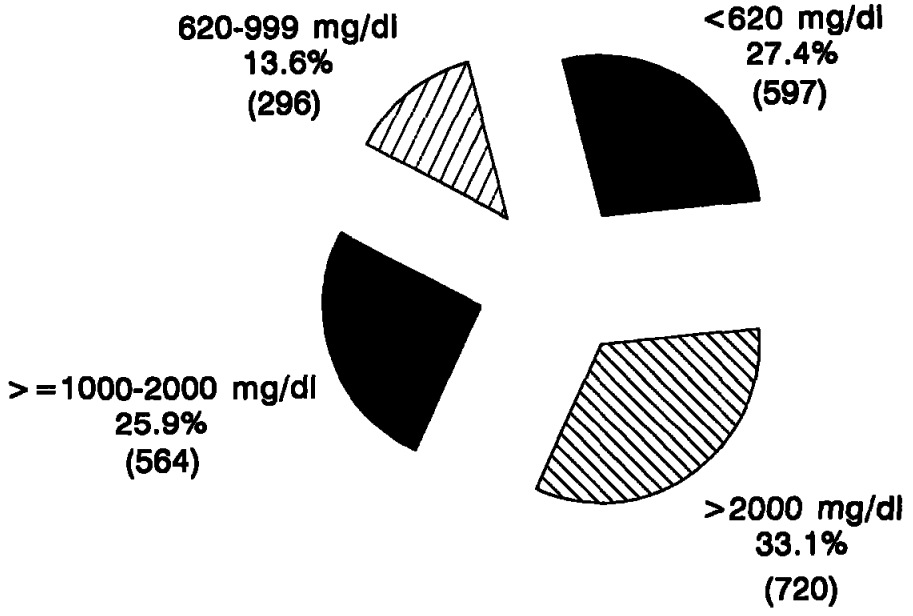
The time at which colostrum is fed to the newborn calf is also very important. It has been well established that immunoglobulins are absorbed from the intestine for only the first 24-36 hours after birth. All studies agree, however, that there is a substantial decline in the capacity of the intestine to absorb Ig throughout this time. The earlier the calf receives an appropriate amount of immunoglobulin, the better the absorption will be. The recommendation must be that colostrum is fed as soon as possible after birth and preferably within the first two hours of life. Delaying the first colostral feeding beyond six hours of life has been shown to decrease the efficiency of immunoglobulin absorption and increase the calf's susceptibility to disease.

The method of feeding colostrum to calves has also been investigated. These studies suggest that suckled colostrum provides better passive transfer to the calf. In many cases, however, this is impractical and it is frequently better to ensure colostral ingestion than to wait until the calf consumes the colostrum by nipple feeder. While suckling the colostrum from the teat of the dam may theoretically provide the calf with the most efficient absorption, it can also delay the time of first feeding and reduce the total volume consumed. These factors likely account for the high rate of failure of passive transfer seen in many dairies that practice this approach to colostral management. Feeding colostrum via nipple feeder is a good alternative, but for calves with weak suckle reflex it may require inordinate amounts of time. Although small family farms may have workers with the interest in ensuring colostral intake by this method, time constraints may limit the success of nipple feeding in larger enterprises. Administration of colostrum by an esophageal feeder will introduce the colostrum into the rumen rather than the abomasum. When sufficient volume is provided, however, the majority will pass rapidly into the abomasum and ensure adequate absorption, even though the efficiency of absorption may be slightly impaired.

Management Of Colostral Feeding

The issues discussed above suggest some practical guidelines for the management of colostral supplementation to calves. Knowing that immunoglobulin absorption is critical to optimal calf health and knowing the factors that are most influential in passive Ig transfer provides some simple guidelines for colostral feeding. Because most of the information presented above has been known for years, the most remarkable finding is the small number of dairies that monitor colostral quality, manage colostral feeding effectively and subsequently monitor passive transfer in their calves. Failure to adopt such colostral management guidelines is reflected in the recent National Animal Health Monitoring System survey

National Dairy Heifer Evaluation Project
Distribution of Immunoglobulin (IgG) Levels in Dairy Calves



Percent of Calves (# Sampled)

of dairy heifer calves, which showed that over 40% of the calves monitored on dairy farms across the country had serum IG levels below 1,000 mg/dl. Over 27% of the calves tested had levels below 620 mg/dl, which was the lowest level measurable with the testing procedure used. If we assume greater than 2,000 mg/dl of circulating serum IgG is an acceptable level of passive Ig transfer, then 67% of the calves sampled had inadequate circulating levels. As testimony to the importance of this measurement, mortality rates in calves with less than 1,000 mg/dl were two-fold greater than in calves with higher levels of circulating IgG.

A reasonable understanding of the calf disease equation suggests that there is no absolute level of circulating IgG that will ensure calf health. Likewise, there is no single recommendation for colostral management that will ensure appropriate passive transfer in all calves. At a minimum, however, we can apply some simple guidelines. A list of suggested guidelines for colostral management is provided at the end of this text. Given the information described briefly above, it is reasonable to provide calves with a minimum of 2 liters of colostrum within two hours of birth, followed by an additional 2 liters fed within 12 hours of birth. Such colostrum should at a minimum have an Ig concentration of 30 mg/ml, although 40-50 mg/ml would clearly be more desirable. Because older cows have more disease experience and provide more concentrated Ig levels in their first milking colostrum, the older animals should be selected as colostral donors for newborn calves. The variation in Ig concentration of colostrum from even aged cows means that a screening of donors with a colostrometer can be effective in excluding low Ig producers from the donor group.

Freezing maintains the quality of colostrum for providing Ig transfer to newborn calves. Therefore, the highest quality colostrum can be identified and frozen for future use as the first feed for later newborn calves.

The calves at highest risk of contracting neonatal disease are those from first calf heifers. In general, heifers will have the highest rates of dystocia and this in turn will reduce the viability of their offspring. Dystocia has far reaching effects on the well being of a calf, but included among its effects are a reduced suckle reflex and increased time to first standing. Under unmanaged or natural suckling conditions, this reduced viability contributes to a very high rate of failure of passive transfer in affected calves. In addition, the dam has poorer colostrum on average than her older herdmates, compounding the effects of delayed time to suckling and reduced volume of colostral consumption.

Although hand feeding via nipple may be the best artificial means of feeding the newborn calf, calves that fail to suckle within the first couple hours of life should be fed via esophageal intubation.

Monitoring the success of passive Ig transfer to newborn calves is a very important aspect of the colostral management program. Measuring calves' blood protein concentration can be easily and economically accomplished and should be routinely performed on a percentage of calves less than seven days old. Adjustments in the colostral program should be considered on the basis of these measurements. Equally important is a system to monitor calf health or disease problems. As discussed above, colostral transfer is very important but by no means the only factor influencing calf disease. A monitoring system that provides information on both colostral transfer and disease occurrence is invaluable in helping direct management changes to improve calf health. The herd veterinarian should be involved in diagnosis of specific disease problems. Some diseases, such as calf septicemia, can be very responsive to changes in colostral management. While others, such as calf scours, are less responsive to colostrum, and their control requires close attention to other management features. Findings from the National Animal Health Monitoring Systems survey highlight this important aspect of calf health problems. As mentioned above, mortality rates are greater in calves with poor colostral transfer. Some calves will still get sick and die, however, even when Ig transfer has been highly successful. Data from this study suggests that approximately 30% of preweaned heifer-calf deaths could be prevented by ensuring all calves exceed 1,000 mg/dl of IgG at 24 to 48 hours. This also implies that approximately 70% of deaths would not be prevented through higher serum IgG.

Nonimmunoglobulin Components Of Colostrum

It has already been mentioned that colostrum contains additional benefits for the newborn calf beyond the provision of immunoglobulin. Other factors that enhance immunity are also secreted into the colostrum. These include immune-acting cells and a variety of nonimmunoglobulin proteins. The degree of benefit that they provide the calf is unknown, and there are no practical methods at this time for their evaluation on farm.

The more standard nutritional elements are also present in far greater abundance in colostrum than in normal cows' milk. The total solids in colostrum are approximately double those found in milk. Fat percentage is approximately 50% increased, while protein content is more than quadrupled. The bulk of the increased protein is, of course, immunoglobulin but casein content is also double that found in milk. Lactose is the only major constituent of colostrum that is lower (approximately 50%) than the level in normal milk. Thus, while the newborn calf's body reserves are not extravagant, the feeding of colostrum provides the calf with an abundance of protein and energy.

Associated with the high levels of fat in colostrum, the fat soluble vitamins A, D and E are also present at 4-8 times normal milk levels. Vitamin B12 is available at an 8-fold higher concentration. The macrominerals (calcium, phosphorus and magnesium) are at double to quadruple normal milk levels, while the micronutrients (e.g. copper, iron, zinc, cobalt)

Guidelines For Colostral Management

- **Management of colostral supply:**

Selection of donors.
1. Healthy dams with prolonged residence at the farm.
2. No precalving milking or milk loss.
3. Only first milking colostrum should be used for the first 14 hours of life.

Monitor colostral quality with a colostrometer and exclude lower quality colostrum from the first feedings.

Maintain a frozen bank of high quality colostrum for use as needed.

- **Management of colostral feeding:**

Feed a minimum of 5% of body weight (typically two quarts) at each colostral feeding.
1. Feed first within two hours of birth and again within 12 hours of birth.
2. Several methods of feeding are acceptable.
3. After the first two feedings, continue to feed colostrum from later milking and of lower quality for its nutritional value.

- **Monitoring the program:**

On a routine, periodic basis (monthly), monitor calf health.
1. Incidence of specific diseases.
2. Age of disease onset.
3. Response to treatment.
4. Death rate.
5. Growth rate.

On a routine periodic basis (monthly), monitor blood of calves less than seven days old for Ig content.

are present at 5-20 times normal milk levels. Aside from its value as a source of immune enhancement, colostrum provides the calf with critically important nutrients.

Colostrum may be one of the most underutilized sources of dairy calf nutrition. Assuming that the average dairy cow produces between 40 and 50 kg of milk throughout the first six milkings, and that only 4-6 kg will be fed to the calf over the first 24 hours of life, there should be an abundance of extra colostrum available for calf feeding over the first one to two weeks of life. If a colostral management program is used whereby only first milking colostrum from mature cows is fed to newborn calves, then all heifer colostrum and aged cow colostrum from the second through sixth milkings could be made available as a source of nutrition. In many situations this may require the establishment of a colostrum storage pool. Numerous methods for pickling or fermenting colostrum have been successfully devised, allowing the use of colostrum as a nutritional source. Because of the higher solids content of colostrum, smaller amounts can be used or the colostrum can be mixed with water and similar calf performance

can be achieved as with milk replacer or discard mastitic milk. The composition of colostrum can be fairly similar to normal milk as early as the fourth postpartum milking and many dairymen will begin to market the milk by this time. It should be noted that most dry cow mastitis treatments recommend a discard time of six milkings post partum and attention to this factor may become more important as regulations on antibiotic residues in milk become more stringent with time. A good system for managing colostrum as a nutritional source for calves can be very important in the overall calf nutrition scheme.

Colostral Supplements

There are presently several commercially available products marketed as colostral supplements. These products are formulated either by spray drying dairy cow colostrum or by concentrating the whey proteins available from the manufacture of cheese. These products can be marketed as immunoglobulin supplements if they demonstrate efficacy in providing passive Ig transfer and protecting the colostrum-deprived calf against infectious challenge. Generally the products are guaranteed to contain a minimum level of bovine-origin im-munoglobulin (e.g. 25 gm bovine Ig/package).

When mixed per label directions and fed to calves that are otherwise not provided a source of colostrum, these products will indeed improve the calf's chances of survival. On the other hand, the efficacy of these products to protect the calf against disease pales in comparison with natural first milking bovine colostrum. As mentioned earlier, the minimum total immunoglobulin mass recommended for administration to the newborn calf is 100 gm. To meet this level would require the feeding of three to four packages of the typical colostral supplement product. Furthermore, recent evidence suggests that the efficiency of absorption of immunoglobulin by the calf from such products is substantially less than the efficiency of absorption from natural colostrum. This means that even if equal quantities of immunoglobulin are fed, the calf receiving a colostral supplement product will absorb only one-third to one-quarter as much immunoglobulin as it would from colostrum. With these considerations and additionally the cost of colostral supplements, they are a very poor bargain. As the label suggests, these products are supplements, not substitutes. With the considerations described above, the dairyman will be much farther ahead to establish a good colostral management program than to try to make up for management deficiencies by purchasing colostral supplements.

Summary:

In the evaluation of dairy calf nutrition, one of the most important areas is the provision of colostrum to the newborn calf. Colostrum provides not only high quality and high density nutrition in the conventional sense of energy, protein, vitamins, and minerals, but is also the single most important factor in the enhancement of neonatal calf immune defenses. A variety of factors are involved in the establishment of good passive immunoglobulin transfer to calves and most of these factors can be positively influenced by a good colostral management scheme. Despite increased knowledge about the importance of colostral management in dairy calf health, recent surveys show inadequate passive transfer in 40-65% of dairy calves with a resultant negative impact on dairy calf health and survival. The institution of good colostral management practices can have a substantial impact on overall calf performance.