Beef Session I

Cow-Calf Feedlot Combined

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Avoidance of Passive Transfer Failure in Calves

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Partial or complete failure of passive transfer of colostral immunoglobulins is known to be a major determinant of liability to neonatal disease and mortality in calves. When considering the causes of failure of passive transfer of colostral immunoglobulins the transfer process can be divided into three stages. These are:

1. The formation of adequate volumes of high immunoglobulin concentration colostrum in the udder.
2. The ingestion of an adequate mass of immunoglobulin by the calf early in life.
3. The transfer of immunoglobulins across the gut into the circulation of the calf.

Currently we have information on the causes of failure associated with deficiencies in the first two of these stages and there are management strategies that can be used to minimize failure associated with these stages. We have limited knowledge to allow successful intervention strategies associated with the third stage.

Formation of Colostrum

Immunoglobulin G_1 (IgG_1) is concentrated in colostrum by an active, selective, receptor mediated transfer of IgG_1 from the blood of the dam across the mammary gland secretory epithelium.[1 2] As a result of this active transport, IgG_1 is the predominant colostral immunoglobulin while IgM, IgA, and IgG_2 are present in considerably lower concentrations. The transfer of IgG_1 to colostrum begins approximately 4 weeks before calving and in most cows continues until the time of calving. This active process results in colostral IgG_1 concentrations that may be 10 times higher than maternal serum IgG_1 concentrations, and ideally results in the transfer of several hundred grams of IgG_1 into the colostrum.

Although IgG_1 is not the sole immunoglobulin in colostrum it is the predominant immunoglobulin and its selective transfer suggests that it must have major importance to protection of the neonatal calf. For this reason IgG_1 is commonly used as the marker in studies examining the efficacy of passive transfer of immunoglobulins.

Previous studies show that the calf must ingest an immunoglobulin mass of 80-100 g to achieve adequate circulating levels of immunoglobulin.[3 4] Our own studies with artificial feeding systems in Holstein calves suggest that 150 g may be more appropriate.

There are differences in the literature as to what is considered an adequate circulating immunoglobulin concentration and figures vary from 5 mg/ml to 15 mg/ml. It should be recognized that there is no particular level of circulating immunoglobulin above or below which resistance or susceptibility to disease exists. Successful passive transfer is only one determinant of neonatal health in calves and factors such as infection pressure and other management determinants can be of equal importance in many circumstances.[5 6 7] The threshold of circulating immunoglobulin concentration associated with increased disease susceptibility varies from farm to farm and on some farms there is no association between immunoglobulin concentration and disease incidence or severity (see 8). In our studies we chose a serum immunoglobulin concentration of 10 mg/ml as threshold indicator for successful passive transfer of colostrum immunoglobulins. We chose this value as one that is above the threshold for disease susceptibility on most farms and also as a goal that can be realistically achieved. In general calves must take in a mass of 150 g of IgG_1 to consistently achieve this circulating concentration.

The mass of immunoglobulin that is ingested is a function of the volume of colostrum ingested and its immunoglobulin concentration. Failure of passive transfer can occur from an inadequacy in either of these components. Thus, cows may produce colostrum of high immunoglobulin concentration but have an inadeqeuate volume to provide sufficient mass for the calf. In the other situation cows can produce large volumes of colostrum but its concentration is low and the calf cannot ingest sufficient colostrum to achieve the required mass.

Dairy cows almost invariably produce large volumes of colostrum and a production of between 10 and 20 lbs is not unusual in Holsteins. Therefore, in the dairy breeds there is not a problem in the volume of colostrum available for ingestion, however, there can be a problem in immunoglobulin concentration. In contrast, immunoglobulin concentration in beef cattle colostrum is generally quite high, but there can be deficiencies in volume production—especially in first calf heifers. The yield of colostrum varies between breeds. In experimental studies lower volumes of colostrum were produced by cows nutritionally restricted during pregnancy.[9, 10]

The concentration of immunoglobulins in colostrum varies widely between cows and this is particularly evident in dairy breeds.[11, 14] Immunoglobulin concentration is lower in first and second calf heifers than in third or subsequent lactation cows. It is also lower in high volume colostrums. However, there is still marked cow to cow variation within individual parities, and associated with a given volume, and therefore, it is not possible to select high immunoglobulin concentration colostrum on these parameters alone. Repeatability of colostral immunoglobulin concentration in the same cow from lactation to lactation has been observed[15, 16] and it is possible that the major cause of between-cow variation is due to differences in the numbers and affinity of the receptors associated with IgG_1 transfer in the udder.

The secretion of immunoglobulins into colostrum is stopped by the time of calving and second milking colostrum contains less immunoglobulin than first milking colostrum.[12] With systems that feed stored colostrum, or that feed colostrum artificially following milking of the dam, the calving to milking interval can influence colostral immunoglobulin concentration. Practically, this influence is minimal with the usual calving to milking time intervals practiced on commercial farms. Prematurity, a short dry period, premilking of the dam, and leaking of colostrum from the udder at the time of parturition are factors that can decrease colostral immunoglobulin concentration and lead to failure in individual cow/calf transfers.

Ingestion of Adequate Immunoglobulin by the Calf

Natural sucking is the desired method of intake of colostrum and is the most efficient but it is influenced by the sucking drive and vigor of the calf at birth. Beef cattle generally produce adequate volumes of high immunoglobulin colostrum and most beef calves acquire excellent levels of circulating immunoglobulin following natural suckling. Failure of adequate transfer in beef cattle is more commonly associated with factors which decrease the sucking vigor of the calf such as cold stress, nutritional deprevation of the dam, the weak calf syndrome and dystocia.[17, 20] Poor maternal instinct will also limit colostral intake in early life.

In contrast natural sucking of dairy calves is commonly associated with a high rate of passive transfer failure. In part this results from a problem of neonatal vigor and delayed sucking and the failure of 25 to 34% of calves to suck by 6 to 8 hours of age and of 18% of calves to suck by 18 hours of age have been observed.[22] These delays result in a greatly impaired immunoglobulin absorption by calves. Pendulous udders and large bulbous teats can also limit colostral ingestion by calves. However, the major cause of failure of passive transfer in naturally sucking dairy calves lies with the ingestion of colostrums with inadequate immunoglobulin concentration. There is considerable between calf variation in colostral intake by naturally sucking calves but the average intake approximates 2.5 liters.[22] At this average intake the colostral immunoglobulin concentration needs to be 40 mg/ml IgG_1 in order to achieve a mass intake of 100 g immunoglobulin. A significant proportion of colostrum do not contain this concentration and mass intakes will be even further reduced in calves that ingest volumes below the average. Experimental studies show that passive transfer failure can be minimized in natural sucking situations by assisting the calf to the udder early in its life and ensuring a long sucking period.[23] However, in our experience dairy farms that purport to do this do so only sporadically and suffer a high failure rate.

Systems of artificial feeding of colostrum to dairy calves can promote the intake of a high immunoglobulin mass providing they utilize selected colostrums and ensure a high volume intake by the calf. The volume of colostrum that is fed on many farms (2 quarts) is too low to ensure adequate passive transfer. A degree of selection for colostrums with high immunoglobulin concentrations can be made by measurement of specific gravity.[24] Feeding colostrum by nipple bottle can ensure reasonable intakes providing the feeder has patience. However, the volume of colostrum that can be administered by nipple bottle feeding is limited and in one study it took an average 20 minutes to bottle feed one hour old calves 2.5 liters of colostrum, and nearly a third of the calves failed to drink 2.5 liters in one hour.[21]

Larger volumes of colostrum can be fed by an esophageal feeder. The advantage of this method is the volume that can be fed and the speed with which it can be administered. However, colostrum administered by this method is less efficiently absorbed, probably due to retention of some colostrum in the rumen for several hours. For this reason large volumes (a minimum of 3 liters and preferably 4 liters to a Holstein calf) should be fed. If small volumes (1 to 2 liters) are fed by an esophageal feeder the absorption of immunoglobulins is usually suboptimal and yet the calf will feel satiated and not inclined to naturally suckle for the next few hours. Feeding colostrum by an esophageal feeder is an effective method for avoidance of passive transfer failure in dairy cattle.

There are suggestions that a similar practice of forced feeding of colostrum should be routinely practiced in beef herds. Bradley in Canada examined this practice and cautioned strongly against it.[18] He found although force feeding of colostrum to beef calves could result in equivalent or slightly higher serum immunoglobulin concentrations, the procedure was labor intensive, disruptive of the normal maternal calf bond and did not confer any practical advantage over natural sucking. Although force feeding colostrum to beef calves is not advocated as a routine, it is valuable in those circumstances where the potential for passive transfer failure can be predicted. In these cases it is recommended that at least 7% of the body weight be fed by an esophageal feeder. Ideally the colostrum should come from the dam, however, in many cases it is more practical to use a stored source of dairy cow colostrum. If the latter is used it should be first milking colostrum and preferably one that was selected by use of a colostrometer.

Absorption of Immunoglobulins by the Calf

The ability of the new born calf to absorb colostral immunoglobulins falls rapidly following birth. This factor interacts with delayed ingestion of colostrum to result in a significant proportion of failures in both dairy cattle and beef cattle. The only current method of avoidance is to ensure of early intake.

Seasonal variations in calf serum immunoglobulin concentrations have been observed with low levels in the winter months in temperate climates and low levels in the summer months in hot climates.[25]

Calves from heifers have lower serum immunoglobulin concentrations than calves from older cows in a number of studies. It is probable this results from inexperience at nursing, poor maternal fetal bond, and lower immunoglobulin concentrations in colostrum.

In controlled experiments where known factors associated with variation in colostral immunoglobulin absorption are standardized there is still a large amount of between-calf variability in the efficiency of absorption. At present the cause of this variation is unknown. It is possible that an unidentified external factor remains to be determined or that there are genetic differences in absorptive ability.

Genetic differences in immunoglobulin concentrations of cows and of calves and in absorptive ability are recorded. Within breed differences are recorded and at least two studies observed lower serum immunoglobulin concentrations in beef lines selected for production traits when compared to nonselected lines.[16, 19]

References

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