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Calf Note #60 – Transfer of Immunoglobulins to the Intestine

Introduction

Consumption of colostrum within the first 24 hours results in an increase in circulating immunoglobulin G (IgG) concentrations in the calf's bloodstream. These IgG provide immunological "experience" to help protect the calf against pathogens in the environment.

This transfer of IgG to the calf by way of colostrum is termed *passive transfer*. The concentrations of IgG decline over time as the IgG leave the circulation. At the same time, the animal's own immune system will be challenged by pathogens in the environment, and will begin to produce its own complement of Ig. This production of IgG is termed *active immunity* and is critical to the long term health of the calf.

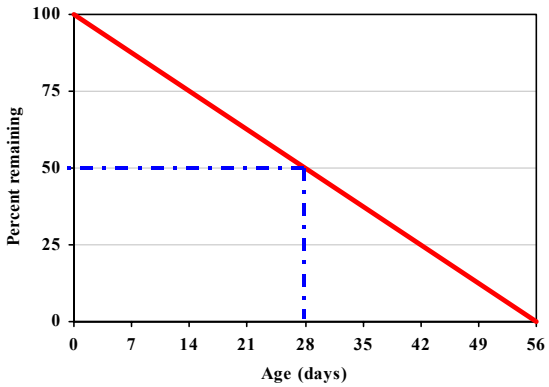

Figure 1. Calculation of half-life of IgG in bloodstream.

The reduction in concentration of passively acquired IgG in the blood is usually measured using the concept of half-life. The half-life is the time required for the concentration of IgG to reach 50% of the original concentration. An example of the calculation of half-life is shown in Figure 1.

Where do the Ig go?

A question of interest is where the IgG go after they have been absorbed into the blood. Research done at Washington State University by Dr. Tom Besser and coworkers investigated this phenomenon.

The researchers conducted two studies to determine the metabolic fate of IgG that entered the bloodstream. In the first study, calves were injected with a radioactive (^{125}I) labeled IgG directly into the blood. The calves (a total of 24) were colostrum deprived and were obtained from a commercial dairy. The excretion of the radioactive label was then monitored over time by collecting urine and fecal samples and determining the

	^{125}I Excretion (%/day)	
Item	Total	Protein bound
Urine	2.52	0.08
Feces	1.50	1.23
Urine + feces	4.02	1.31
Moved to gi tract	2.60	…

Table 1. Excretion of ^{125}I-labelled IgG in the urine and feces of calves intravenously injected with ^{125}I-labelled IgG. From: Besser et al., 1988.

amount of radiation they contained. The excretion of total radiation and the total radiation still bound to protein (an estimate of the "intact" IgG) were measured.

Results are in Table 1. An average of 2.52% of the ^{125}I was excreted in the urine every day. Most of this was not bound to protein (only about 3% of urinary excretion), indicating that the IgG excreted in urine had been previously catabolized (degraded). Also, 1.5% of injected ^{125}I was excreted by way of the feces. Most of this (82%) was still bound to protein, indicating that these IgG were not degraded prior to excretion in the feces.

The total excretion of ^{125}I was 4.02% per day of the amount injected. Regression analysis indicated that the half-life of the injected ^{125}I containing IgG was 17.9 days.

Calves were euthanized and the amount of ^{125}I was determined in various compartments of the intestine to estimate directly the amount of IgG that moved from the circulation into the intestine. The total values corresponded to a daily transfer of 2.60% of the total infused ^{125}I into the gastrointestinal tract. Most of this IgG appears to be secreted into the intestine as intact IgG, but a portion apparently is degraded by intestinal enzymes.

The authors estimated that if a calf were to consume and absorb 100 g of IgG from maternal colostrum within the first 24 hours, it would subsequently secrete 1 to 4 grams of IgG back into the intestine daily for the first two weeks of life. Absorption of 100 grams of IgG would be possible if the calf was fed 4 liters of maternal colostrum containing 83 g of IgG/L and the IgG were absorbed with a 30% efficiency. The authors also suggested that calves with higher circulating IgG might be expected to secrete more IgG into the intestine than calves with lower circulating IgG.

In a second experiment, Besser and coworkers fed newborn calves colostrum containing antibodies against a specific strain of rotavirus. Dry cows were immunized with a vaccine against the rotavirus at 6 and 3 weeks prior to expected calving to produce colostrum containing the specific antibody. The amounts of specific antibody were then measured in the blood and gastrointestinal contents following sacrifice at 5 or 10 days of age.

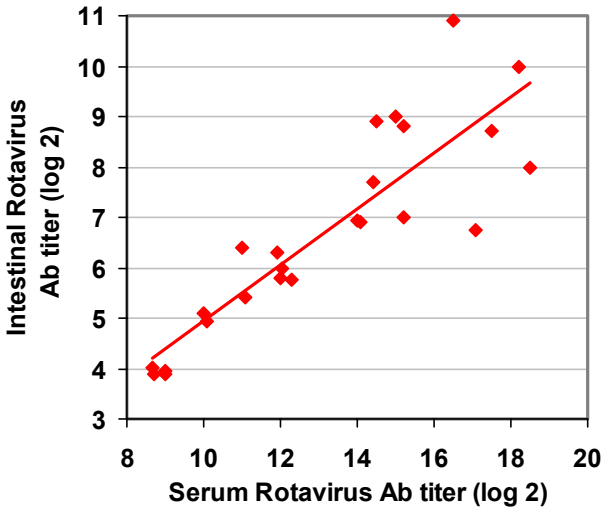

Figure 2. Relationship of serum and intestinal rotavirus antibody titers. From: Besser et al., 1988.

The correlation between serum rotavirus antibody and intestinal rotavirus antibody (Figure 2) showed a close correlation. This means that calves 1) absorbed the specific antibody from the colostrum consumed within the first 24 hours, 2) the specific antibodies then moved from the circulation into the lumen of the intestine, and 3) the movement of specific antibodies into the intestine occurred in proportion to concentrations in the blood.

The Value of Intestinal IgG

Many bacteria and viruses that infect calves are enteric – that is, they colonize the intestine, where they infect typically causing intestinal damage and signs of disease (diarrhea, dehydration). Immunoglobulins in the intestine could assist the animal to mount an effective immune response when they attach to the antigenic binding sites on the specific pathogen. Therefore, movement of IgG from the circulation into the intestinal lumen would be one way to provide immunity in response to the pathogens that infect the animal by the fecal-oral route.

To determine if there is any value to circulating IgG in dealing with intestinal pathogens, Besser and coworkers injected calves subcutaneously with 1.25 liters of whey extracted from the colostrum of cows immunized against rotavirus or colostrum from non-immunized cows. A control group was fed colostrum from non-immunized cows. These calves were then challenged with a pathogenic strain of rotavirus at 72 and 96 hours after birth.

Item	*Immune Whey*	*Non-Immune Whey*
Rotavirus Ab titer (1/log2)	14.85	9.10
% of calves infected	20.0	100.0
Incubation time (hr)	72.0	32.0
Duration time (hr)	64	135
Days with diarrhea	0.10	2.83

TABLE 2. Effects of subcutaneous injection of immune whey (containing rotavirus Ab) versus non-immune whey (not containing rotavirus Ab) on response to disease challenge with oral rotavirus. From Besser et al., 1988.

Administration of IgG by subcutaneous injection protected calves against rotavirus infection as can be seen in table 2. Calves treated with subcutaneous "immune" whey (whey containing rotavirus antibody) had higher serum antibody titers against rotavirus and were more protected against oral rotavirus challenge than calves that were injected with "non-immune" whey. Presumably, the mode of action for the immune whey was via movement of the IgG from the circulation into the intestinal lumen, where the rotavirus was present. It is important to note that these calves were fed no colostrum, so the only source of antibody was through subcutaneous injection.

Conclusions

These research studies indicate that:

1. Immunoglobulins in the intestine play an active role in the resistance to pathogenic organisms that infect calves via the oral route, such as rotavirus.
2. Immunoglobulins in the intestine are sufficiently resistant to digestion to provide immune response. Studies have documented the relative resistance of IgG to proteolytic degradation in the gut.
3. A major source of IgG in the intestine of newborn calves is from circulating IgG that are absorbed from ingestion of colostrum within the first 24 hours.
4. Larger concentrations of IgG in the serum generally produce larger concentrations of IgG in the lumen of the intestine.

Immunoglobulins are important to the health, growth and profitability of dairy calves. It is important that calves are fed sufficient immunoglobulin within the first 24 hours of life. These research trials show that immunoglobulins play an active role in all areas of the body – including the intestine, where many pathogens cause disease. Future research should be directed to determining the nature of the movement into the gut (some data suggest that there is an active transport of IgG

into the intestine, although other data indicate no transport) and the role that other sources of immunoglobulins may play in this complex immunological system.

References

1. Besser, T. E., T. C. McGuire, C. C. Gay, and L. C. Pritchett. 1988. Transfer of functional immunoglobulin G (IgG) antibody into the gastrointestinal tract accounts for IgG clearance in calves. J. Virology. 62:2234-2237.

2. Besser, T. E., C. C. Gay, T. C. McGuire, and J. F. Evermann. 1988. Passive immunity to rotavirus infection associated with transfer of serum antibody into the intestinal lumen. J. Virology. 62:2238-2242.