Absorption of Colostral Immunoglobulins by Newborn Dairy Calves

Abstract

Twenty-seven calves obtained at birth were fed colostrum at 2.5% of body weight immediately and at 12 hours after birth, and at 3.75% of weight at 24 and 36 hours. Blood samples were taken at 3, 12, 24, 48, 96, and 168 hours after birth. Colostrum samples taken at parturition and at 12 and 24 hours were available from 19 cows.

Average blood serum immunoglobulin increased from .29 g per 100 ml before initial feeding to 1.54 g per 100 ml at 24 hours, and declined slowly thereafter. Approximately 68% of the variation in blood serum Ig in calves at 24 hours could be attributed to differences in Ig consumed per unit of weight. It was estimated that 45% of Ig ingested immediately after birth and at 12 hours was absorbed prior to 24 hours.

Introduction

Since newborn calves have low innate resistance to disease, transfer of immune globulins by way of colostrum is of particular importance. Intestinal permeability to immune globulins persists for only 24 to 48 hr (2, 3), after which “closure” is presumed (13). Exceptionally low serum immunoglobulin (Ig) concentration has been observed in calves known to have consumed colostrum within a few hours after birth, leading some researchers (7, 8, 11) to suggest that certain calves fail to absorb colostral Ig and remain virtually agammaglobulinemic until a mature serum pattern develops.

The objective of this work was to quantify the relationship between Ig intake and blood Ig concentration in calves under conditions of controlled colostrum intake.

Experimental Procedure

Twenty-seven dairy calves (11 Ayrshires, 9 Holsteins, 5 Guernseys, 2 Jerseys) were obtained at birth from the University herd. Each calf was fed colostrum from its dam by nipple pail at 2.5% of body weight at birth and 12 hr later, and at 3.75% at 24 and 36 hr after birth. Immediately after parturition, only enough colostrum was taken to feed the calf the first time, whereas the cows were milked out completely at 12, 24, and 36 hr afterwards. From 3 to 15 days of age, calves were fed whole milk from cows well along in lactation at 5% of initial weight at each of two daily feedings.

A blood sample was taken by jugular venipuncture from the dam of each calf immediately after parturition. Blood samples from each calf were taken immediately after birth (before feeding) and at 3, 12, 24, 48, 96, and 168 hr thereafter. Sera from these samples were analyzed for total protein by refractometry and for immunoglobulin by microzone electrophoresis (5).

Colostrum samples were from 19 cows at parturition and at 12 and 24 hr thereafter. Casein and noncasein proteins of the colostrum samples were determined by AOAC methods, and fat by conventional Babcock procedure. Total immunoglobulin in the colostral whey was determined by electrophoresis.

Observations on the incidence of diarrhea and general health of the calves were recorded throughout the experiment.

Results and Discussion

There was a rapid decline in the total protein and immunoglobulin in colostrum at successive milkings after calving (Table 1). These observations agree with data previously reported by other workers (12) although total protein and Ig content declined less precipitously than other workers have indicated. Of considerable interest was the range of Ig in the colostrum of different cows immediately after parturition. Concentrations ranged from 1.7 to 8.7% Ig on a whole colostrum basis, with the lower values not associated with any particular breed.

Concentration of Ig in colostral whey at parturition was considerably higher than in blood serum of the cows (Fig. 1). Noncoagulating
TABLE 1. Concentration of protein and total immunoglobulins (Ig) in colostrum of cows at different times after calving.

<table>
<thead>
<tr>
<th>Time after calving</th>
<th>Total protein</th>
<th>Noncasein protein</th>
<th>Total Ig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediately</td>
<td>13.74 ± 3.3a</td>
<td>8.19 ± 2.2</td>
<td>6.03 ± 1.9</td>
</tr>
<tr>
<td>12 hr</td>
<td>10.01 ± 3.1</td>
<td>6.03 ± 2.1</td>
<td>4.25 ± 1.8</td>
</tr>
<tr>
<td>24 hr</td>
<td>7.04 ± 1.8</td>
<td>3.93 ± 1.2</td>
<td>2.41 ± .9</td>
</tr>
</tbody>
</table>

*Mean ± standard deviation.

![Image of chart](image-url)

FIG. 1. Concentration of immunoglobulin in blood serum of calves and their dams. (Means with standard deviations indicated by bars.)

...tained in the calves (Fig. 1) which is consistent with results reported by other workers (7, 11). The rather wide variation in blood serum Ig in the cows did not appear to be associated with breed nor age. Causes of this variation are largely unknown and represent an area that can possibly be elucidated in further work involving a larger number of animals.

As expected, calves had low serum Ig of .29 g/100 ml prior to initial feeding. In most calves, concentration increased markedly after ingestion of colostrum and reached a peak at 24 hr after birth. In four calves, peaks occurred at 12 hr, whereas the highest value was at 48 hr in six calves. There was no definite relationship between the time at which peak Ig occurred and either amount of Ig consumed or maximum serum value in the calves. After 24 hr, average Ig concentration tended to decrease slightly, presumably reflecting catabolism of the material or transfer to other metabolic pools. Pierce (10) noted an increase in proteinuria in calves up to 17 to 26 hr after birth with a subsequent decline to a low level by 40 hr, and McDougall (8) presented evidence that slow-moving electrophoretic components of calf urine during early life are degraded immune lactoglobulins.

In four of 27 calves, serum Ig remained below 1.0 g per 100 ml throughout the study. Other workers (7, 8, 11) likewise have observed hypogammaglobulinemia in some calves known to have consumed colostrum and have suggested a failure of the mechanism of absorption as a possible cause for the condition. To study this problem further, blood serum Ig values at 24 hr were examined in relation to the amount of Ig consumed by 19 calves at the
first two feedings, viz., immediately after birth plus that at 12 hr (Figure 2). The correlation between these variables, i.e., .82, was relatively high (P < .01). Hence, approximately 68% of the variation in blood serum Ig in the calves could be attributed to differences in amount of Ig consumed per unit of weight. Since the calves in this experiment were fed a specified amount of colostrum per unit of weight, the importance of Ig content of colostrum from individual cows is readily apparent. However, other factors undoubtedly also play a role in determining the concentration of serum Ig in the calf after ingestion of colostrum, and it is possible that malabsorption exists in some calves. Although the amount of colostrum actually ingested was not measured in the work of Klaus et al. (7), there was a lack of correlation between the amount of IgG and IgM in the colostral whey of cows and that in blood serum of their calves subsequent to nursing. Similarly, Smith et al. (11) found low serum Ig in calves was not correlated with Ig concentration in colostral whey.

It was of interest to estimate the overall efficiency of Ig absorption by calves during the first 24 hr of life. With a blood volume of 93 ml per kilogram body weight at one day of age (9), it was calculated that 45% of the Ig ingested at the first two feedings was present in the blood serum of the calves at 24 hr. Since proteinuria has been observed in calves prior to 24 hr (10), one may assume that slightly more Ig was actually absorbed than that calculated in the serum at 24 hr. Balfour and Comline (1) reported experiments in which 12 to 25% of 131I-labelled bovine serum globulin administered into the duodenum in fresh colostral whey was recovered from the lymph within 5 hr. Further studies aimed at determining both the causes for the wide variation among cows in concentration of colostral Ig and factors affecting efficiency of absorption by calves are needed.

Maximum Ig blood serum concentration in the calves was not closely related to incidence or severity of diarrhea. Since calves were obtained for the experiment over 7 months, exposure to pathogenic agents was not uniform, and these results are not considered conclusive on this point. Other workers (4, 6) have noted that calves with low blood serum Ig are more apt to succumb to infection than calves with higher blood Ig.

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