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Summary

Failure of calves to ingest and absorb immunoglobulin from colostrum is a risk factor for illness and decreased performance. Blood samples were taken from 752 calves at three SDSU research units. Total protein in blood, closely correlated to colostral immunoglobulin absorption, was determined and calf health records were collected. Using this data, a classification table of sensitivity and specificity was constructed to determine the relationship between total protein and calf illness and to classify calves as having adequate colostral absorption or inadequate colostral absorption (failure of passive transfer). Along with sensitivity and specificity, positive and negative likelihood ratios were calculated to identify a suitable cutoff point to separate calves that would become ill from those that would remain healthy. The cutoff point selected was a serum total protein level of 5.5 g/dL, which produced a sensitivity of 30% and specificity of 87%. Calves with total protein levels below 5.5 g/dL were 3.07 (95% CI 1.73-5.43, p=0.0002) times as likely to become ill as calves with total protein levels above 5.5 g/dL. In beef production situations similar to those in these herds, producers should be able to limit disease if calves' total protein at 24 hours following birth is equal to or greater than 5.5 g/dL.

Keywords: Colostrum, Total Protein, Calf Illness

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Introduction

Calves are born with little immunoglobulin (antibody), which is important to limit infection and maintain health (1). To acquire antibody, calves must absorb immunoglobulin by passive transfer from colostrum, the first milk produced by their dam. After twenty-four hours, calves' ability to absorb immunoglobulin decreases dramatically, so it is important that calves ingest and absorb an ample amount of colostrum soon after birth (2). If a calf does not ingest enough colostrum the calf has a high risk of illness and subsequent poor performance (3).

Total protein in blood is well correlated with immunoglobulin levels, so it is directly related to successful absorption (passive transfer) of colostrum (4). Identifying herd problems of inadequate colostral absorption, termed failure of passive transfer **(FPT)**, can help focus management effort. The purpose of this study was to establish a serum total protein cutoff point that would define FPT and predict illness in beef calves under South Dakota conditions.

Materials and Methods

The data for this study were taken from beef cattle herds on three South Dakota State University research units--the Beef Breeding Unit **(BBU)** and Cow/Calf Research & Teaching Unit **(CCU)** located in Brookings, and the Range & Livestock Station located near Cottonwood, South Dakota.

Beginning in 1996, ranch personnel obtained blood samples from calves when they were approximately 1-3 days old. The date and time of blood sample collection and calving were recorded. Blood samples were centrifuged and stored frozen as serum or plasma. After the calving season, refractometry was used to measure plasma and serum total protein. Refractometry has been shown to be an accurate measure of total protein, and total protein has been shown to closely correlate with the amount of immunoglobulin in serum and plasma (4). Plasma differs from serum in that plasma contains the protein fibrinogen, which increases total protein readings. Fibrinogen averaged 0.3 g/dL in 45 plasma samples, so the total protein result from plasma was decreased by 0.3 g/dL to make plasma protein readings equivalent to serum protein readings. Only observations for calves that had a blood sample taken between 20 and 168 hours (7 days) after birth were used in this analysis.

Comprehensive calf health records from birth to weaning were available for 1998 from BBU and for 1996-1998 and through June 1999 from CCU and Cottonwood. Only total protein values from calves born at these ranches during the specified years were used. All illness events were diagnosed by ranch personnel.

A classification table was created to establish the relationship between total protein and calf illness. Specificity and sensitivity at each protein level was calculated. Sensitivity is the probability of a positive test result (a total protein level lower than the cutoff point) in those calves that became ill. Specificity is the probability of a negative test result (total protein level higher than the cutoff point) in calves that did not become ill. Sensitivity was calculated as:

$$\frac{\text{\# of ill calves with total protein} < \text{the cutoff point}}{\text{total \# of ill calves}}$$

Specificity was calculated as:

$$\frac{\text{\# of non-ill calves with total protein} \geq \text{the cutoff point}}{\text{total \# of non-ill calves}}$$

Positive and negative likelihood ratios **(PLR, NLR)** were calculated for several total protein points. PLR is a ratio of the probability of a positive test in calves that become ill compared to the probability of a positive test in calves that did not become ill. Conversely, NLR is the ratio of the probability of a negative test in calves that become ill compared to the probability of a negative test in calves that did not become ill. The ideal cutoff value would have a PLR of infinity (100/0) and a NLR of zero (0/100). Likelihood ratios give an indication of relative confidence in cutoff points, and are useful when assessing a test (5).

This study was a prospective, longitudinal study. The individual calf was the experimental unit. Data was compiled using an electronic spreadsheet (Microsoft [R] Excel 97, Microsoft Corp., Redmond, WA). A statistical package (SAS v6.12, SAS Institute, Cary, NC) was used to calculate summary statistics and create tables to calculate sensitivity and specificity. Another statistical package (EpiInfo 6.04b, CDC, Atlanta, GA) was used to calculate the odds ratio and confidence intervals.

Results and Discussion

A total of 84 of 752 calves became ill (11.2%). Of the 84 calves, 19 (22.6%) had two reported illnesses. The most common illnesses were fever of unknown origin, diarrhea, respiratory disease, and foot rot (Table 1). Ill calves had an average total protein level of 6.19 g/dL, while calves that did not become ill had a significantly higher total protein level of 6.74 g/dL ($p<0.0001$). Total protein results for all calves ranged from 3.5 g/dL to 9.8 g/dL.

Since it was the goal to determine the best total protein cutoff point that separates calves that would be healthy, and who presumably obtained adequate colostral antibody, from those calves that would get sick and presumably did not receive adequate colostrum (i.e. calves with FPT), a classification table was constructed (Table 2). As the cutoff point in the table is increased, the sensitivity (ability of the test to accurately identify ill calves) increases, while specificity (ability of test to accurately identify healthy calves) decreases, which naturally occurs when the total protein levels of ill and healthy calves overlap (Fig. 1).

Moving to a lower cutoff point does not drastically change specificity, but sensitivity decreases relatively quickly, since calves becoming ill are being classified incorrectly. If a producer had a purebred operation or a high-value calf, a higher total protein cutoff point might be considered. This would increase sensitivity and decrease specificity, thereby classifying more calves that would become ill as having FPT. However, more healthy calves would be incorrectly classified as having FPT, resulting in these calves receiving unnecessary attention and/or treatment.

Likelihood ratios can be used to determine an appropriate cutoff value. The PLR and NLR for several total protein values were calculated (Table 3). A higher PLR reflects a relatively larger degree of test accuracy in describing calves that become ill, while a lower NLR reflects better accuracy in describing calves that do not become ill.

In this data, a high specificity and high PLR are desired, since the goal is to identify calves with FPT that are at increased risk of illness. However, identifying an excessive number of calves as having FPT that do not become ill (false-positives) wastes valuable resources. Given this, 5.5 g/dL was chosen as the cutoff value. Using this cutoff point, calves with total protein levels below 5.5 g/dL are defined as having failure of passive transfer. At the 5.5 g/dL point, sensitivity was 30%, which means 30% of the calves that become ill are correctly identified as having FPT. Specificity was 87%, which means 87% of the calves that do not become ill are correctly identified as not having FPT. The 5.5 g/dL cutoff point still has relatively low sensitivity, but this is not atypical when a single test is used to predict disease.

At the 5.5 g/dL point, 96 calves (12.8%) in this study had FPT. A calf with a total protein level below the 5.5 g/dL cutoff point was 3.07 (95% CI 1.73-5.43, p=0.0002) times more likely to become ill than calves with a total protein level equal to or above 5.5 g/dL.

A study of 263 crossbred dairy and beef calves proposed an FPT cutoff level of 4.8 g/dL in plasma samples (6). Another study of dairy calves classified calves as having at least partial FPT if their serum total protein level was below 5.2 g/dL (7). A study of beef calves proposed a serum total protein of 4.2 g/dL as the cutoff value for FPT (8). In that study, calves were grouped as having failure of passive transfer, partial failure of passive transfer, and normal passive transfer. To be classified as having normal passive transfer, calves needed a total protein level of 5.5 g/dL or greater, as proposed here (8).

It is important to note that the cutoff level for determining FPT is relative and only one of a series of risk factors in disease. Calves exposed to high levels of stress and disease-causing organisms on a given ranch could become ill regardless of their total protein level. On such operations, it would be appropriate to increase the cutoff point used to determine FPT and the risk of subsequent illness. Likewise, calves in herds with little disease challenge would not necessarily have a high risk of becoming ill, even with a low total protein level. Total protein, though an important part of calf health and related to calf disease, is not the sole determinant of illness.

Monitoring calves for FPT may allow producers to better assess nutrition and calving time management of the herd. By monitoring FPT and taking steps to lower the rate of FPT, producers may reduce calf illness and death.

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Figure 1 – Distribution (%) of Total Protein in Ill and Healthy Calves

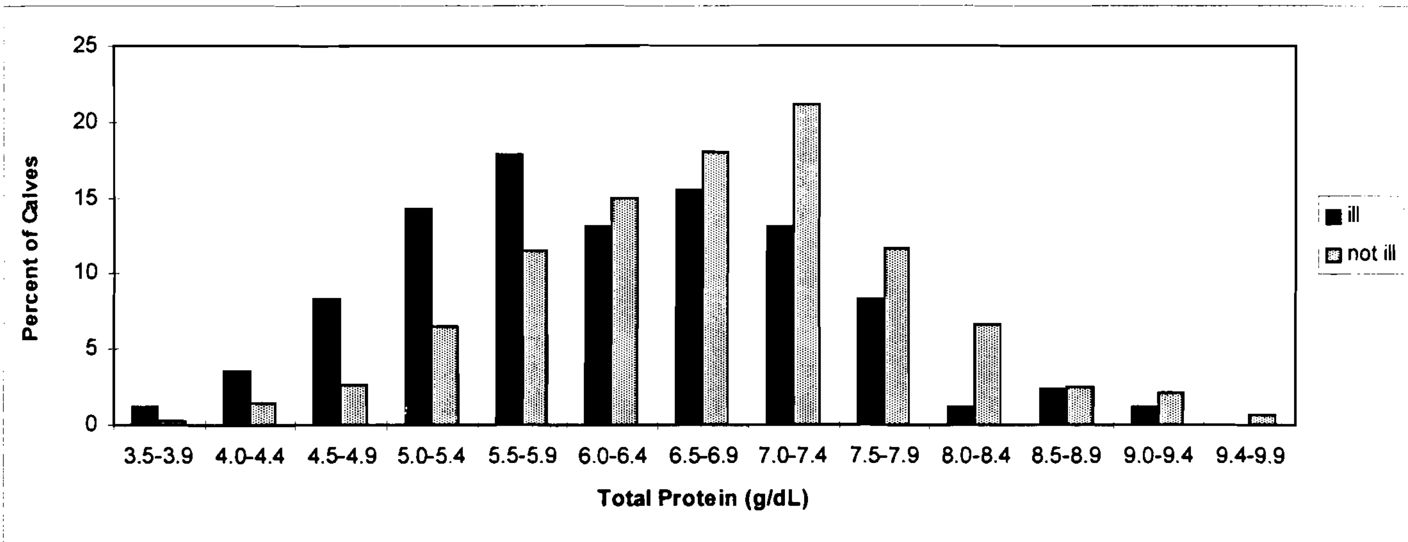

Table 1 – Frequency of Reported Illnesses

Type of Illness	# cases as 1st illness	% cases as 1st illness	# of total illnesses	%of total illnesses
Diarrhea	21	25.0%	22	21.4%
Fever of unknown origin	19	22.6%	23	22.3%
Respiratory	12	14.3%	16	15.5%
Foot Rot	10	11.9%	15	14.6%
Navel Ill	9	10.7%	11	10.7%
Injury	6	7.1%	7	6.8%
Other	7	8.3%	8	7.8%
Total	84	100.0%	102	100.0%

Table 2 – Sensitivity and Specificity Classification Table

Cutoff (g/dL)	Sensitivity (%)	Specificity (%)	Cutoff (g/dL)	Sensitivity (%)	Specificity (%)
5.0	11	93	7.1	78	37
5.1	12	93	7.2	80	32
5.2	15	92	7.3	85	28
5.3	17	90	7.4	86	25
5.4	23	89	7.5	90	21
5.5	30	87	7.6	90	18
5.6	33	85	7.7	91	16
5.7	35	83	7.8	93	14
5.8	40	80	7.9	95	12
5.9	43	78	8.0	96	10
6.0	47	74	8.1	96	9
6.1	49	72	8.2	96	7
6.2	51	70	8.3	96	6
6.3	53	67	8.4	96	5
6.4	57	64	8.5	98	4
6.5	64	59	8.6	98	4
6.6	68	55	8.7	98	3
6.7	72	52	8.8	99	3
6.8	72	47	8.9	99	3
6.9	73	45	9.0	99	2
7.0	78	40			

Table 3 – Positive (PLR) and Negative (NLR) Likelihood Ratios for Various Total Protein Cutoff Levels

Total Protein (g/dL)	PLR	NLR
5.0	1.6	0.95
5.2	1.8	0.93
5.4	2.2	0.86
5.5	2.3	0.81
5.6	2.0	0.82
5.7	2.1	0.78
5.8	2.0	0.75
6.0	1.8	0.72
6.5	1.6	0.60
7.0	1.3	0.55
7.5	1.1	0.47