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Calf Note 186 – Serum total protein and colostrum replacers

Introduction

The importance of colostrum feeding to newborn calves is almost universally recognized. Calf raisers everywhere understand that the key to healthy calves is to feed them enough high quality, clean colostrum early enough in their lives so the calf achieves what's called "successful passive transfer of immunity" (**SPT**). Calves that don't get enough colostrum, or if they are fed colostrum of poor quality, or are fed too late, they don't get enough immunity. This is called "failure of passive transfer" (**FPT**).

Traditionally, we determine if a calf achieves SPT by measuring the amount of total protein (**TP**) in the serum of the calf after absorption of colostrum proteins is complete (about 24 hours of age). However, recent developments in technology and increasing use of colostrum replacers makes the use of serum TP more difficult and complex. To understand why this has occurred, let's start with a few definitions and some background.

First, a few definitions

Successful passive transfer occurs when a newborn (post-gut closure) has serum immunoglobulin G (**IgG**) concentrations greater than some critical level. This level varies by species – for newborn dairy calves, the generally recognized standard is 10 grams of IgG per liter of serum (also can be defined as 1,000 mg IgG/dl). Calves with serum IgG <10 g/L after 24 hours of age have FPT. Many studies have shown that calves with FPT are more likely to get sick and die. They also tend to grow more slowly, and may be less efficient than calves with SPT.

Passive immunity is determined by measuring the **IgG concentration** in the serum of the calf. By definition, FPT occurs when **serum IgG** is <10 g/L. This requires that blood be obtained from the calf after 24 h of age (as close to 24 hours as possible) and serum be collected from that blood. The IgG concentration is then measured using one of several laboratory techniques, but most typically, radial immunodiffusion (**RID**). The RID method is considered the "gold standard" for measuring IgG in serum of calves, though other methods (e.g., ELISA, HPLC, TIA) may be faster, cheaper and/or more accurate than RID.

Now, some background

Methods for measuring IgG in the serum of calves are generally time consuming and expensive. For example, the RID method requires about 24 hours before a result is known. Other methods require expensive equipment and specialized expertise to run. Therefore, most of these methods are not widely used on farm for routine testing of calves for FPT. Some companies have introduced calf-side quick tests based on these technologies, but these tests, though simple and fast, are generally expensive.

Enter the refractometer

A refractometer can be used to estimate the **total protein** content of serum. For more information on how the refractometer works, see Calf Notes #[62](#) and [183](#). Note – the refractometer measures serum TP, *not* IgG. This is an important consideration.

The refractometer actually measures the bending of light (refraction) due to differences in density in the liquid being tested. Refraction of light passing through serum is generally due to differences in protein concentration. Newborn calves fed colostrum will generally have much higher serum total protein concentrations (6.0 g of TP per 100 ml of serum) compared to calves not fed colostrum (3.5 to 4.0 g/dl). So, differences in refraction can be correlated to differences in TP. This is the logic behind use of the refractometer to measure serum TP.

Measuring serum TP on the farm with the refractometer is fast, easy and cheap. Measuring serum IgG is more difficult. However, there is a reasonable relationship between serum TP and IgG when calves are fed maternal colostrum. Although the relationship isn't 100%, it's close enough to be a good test on farm. Calves with serum TP <5.2 g/dl will generally have serum IgG <10 g/L. (NOTE: some researchers suggest 5.5 g/dl is a more appropriate cut-point.).

Because we estimate TP with the refractometer and use this to estimate serum IgG, it follows that the relationship between TP and IgG in the source material (i.e., maternal colostrum) would affect the relationship between TP and IgG in the blood. It's important to remember that absorption of molecules from the intestine during the first 24 hours in the calf is non-specific. That is, the intestine will absorb IgG protein and non-IgG protein similarly; it is only after the molecules are absorbed that non-IgG protein are either metabolized or excreted (for a review, see Calf Note #[168](#)). Therefore, the ratio of

IgG to non-IgG proteins in colostrum or a colostrum product may affect the ratio of both TP and IgG in the blood.

Let's take a look at the ratio of IgG:TP in maternal colostrum (MC) and various colostrum products available on the market (Table 1). Here you can see clearly the variation in the ratio of IgG:TP, which ranges from 25% to 71%.

Note that the plasma-derived product has a ratio similar to that of MC; however, the type of proteins in the product differ from that of MC – another source of variation.

Table 1. Concentration of IgG, protein and non-IgG proteins in maternal colostrum (MC), colostrum-derived (CDCR) or plasma-derived (PDCR) colostrum replacers.

Item	IgG	Protein	Non-IgG protein	Ratio*
	g/100 g			
MC (solids basis)	27.1	49.8	22.7	54%
CDCR #1 ^a	30.0	42.1	12.1	71%
CDCR #2 ^b	14.3	57.1	42.8	25%
CDCR #3 ^c	12.1	45.0	32.9	27%
PDCR ^d	27.1	50.0	22.9	54%

^aNurture Genesis 150, Provimi North America.

^bCalf Choice Total Bronze, Saskatoon Colostrum Company.

^cSav-A-Caf Colostrum Supplement, Milk Products, Inc.

^dLifeline Rescue Colostrum Replacer, APC, Inc.

*Ratio of IgG:Protein

Because the ratio of IgG:protein in MC and various colostrum products differ, it's unlikely that the relationship between serum TP and serum IgG in calves fed various products would be the same. Therefore, **we should re-evaluate the relationship between serum TP and serum IgG for each type of product.** My research team reported in 2002 the difference in relationship between serum TP and IgG when calves were fed plasma-based colostrum replacers (Quigley et al., 2002)

and a colostrum-based replacer (CDCR; Quigley et al. 2014). In both situations, the relationship between IgG and TP differed from that of MC.

Figure 1 is from Quigley et al. (2002) and shows the different relationship between IgG:TP in MC and in a PDCR. The point at which calves fed maternal colostrum had serum IgG = 10 g/L was 5.33 g/dl, which is quite similar to many other research reports that suggest the “breakpoint” is 5.2 to 5.5 g/dl.

Conversely, serum IgG = 10 g/L when TP was 4.85 g/dl in calves fed the PDCR. So, if you took a blood sample from one of these calves that measured, say 5.0 g/dl, you’d conclude the calf had FPT based on the assumption that <5.2 g/dl calves have FPT. You would be wrong. This study (from 2002) and others suggests that we need more than one critical breakpoint for serum TP to determine if a calf absorbed enough IgG.

Figure 2 shows another study utilizing newborn calves fed one of two CDCR. Product 1 provided 150 g of IgG in one feeding; Product 2 provided 130 g. Clearly, the relationship between the IgG and TP in these two products differed. For Product 1, the “breakpoint” to estimate when serum IgG was 10 g/L was approximately 4.3 g/dl serum TP. For Product 2, no calves achieved SPT, so there was no way to calculate the breakpoint for this product.

Figure 2 shows clearly that manufacturing methods affects the relationship between serum TP and IgG (the two products were from different manufacturers using different methods). Thus, it’s important to know what type of product is being used and how both protein and IgG are absorbed.

Summary

The relationship between serum TP and serum IgG in calves fed MC is useful. It allows us to use serum TP as a quick and easy estimate of IgG concentration. However, new technologies, including availability of colostrum replacers based on different IgG sources requires us to re-evaluate the underlying assumption of the relationship between these two variables. Manufacturers of commercial products should evaluate this relationship and calf raisers should be aware that serum TP may no longer be an appropriate measure of passive immunity.

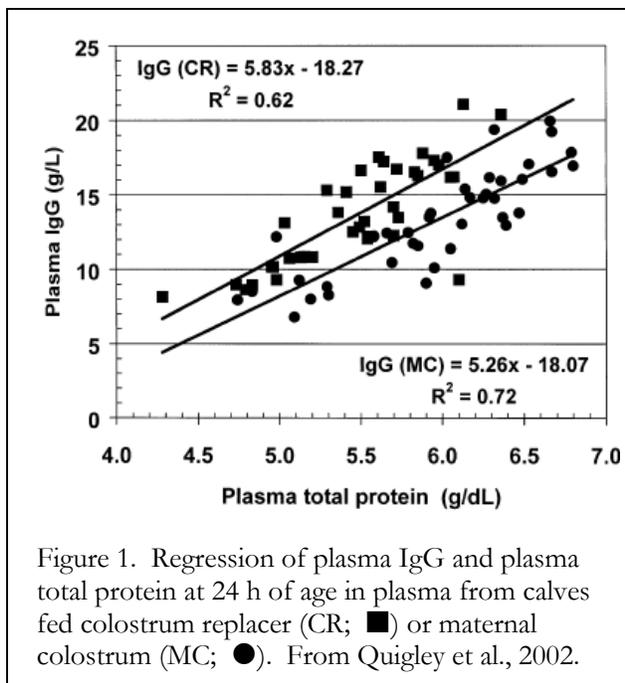


Figure 1. Regression of plasma IgG and plasma total protein at 24 h of age in plasma from calves fed colostrum replacer (CR; ■) or maternal colostrum (MC; ●). From Quigley et al., 2002.

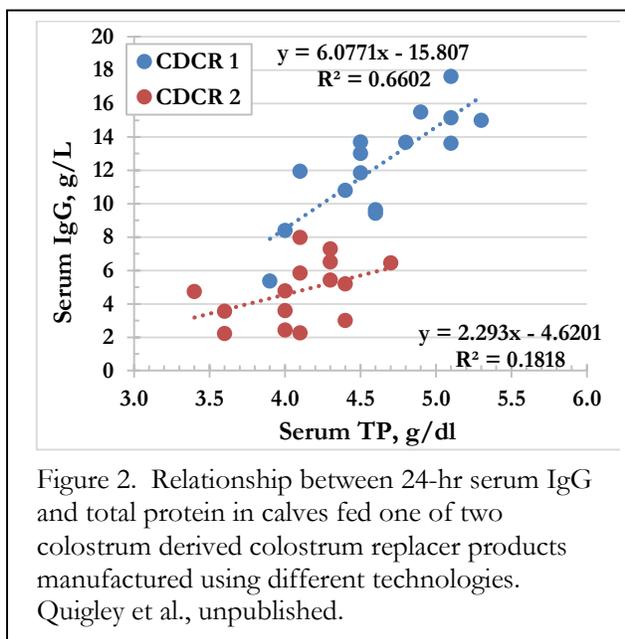


Figure 2. Relationship between 24-hr serum IgG and total protein in calves fed one of two colostrum derived colostrum replacer products manufactured using different technologies. Quigley et al., unpublished.

References

Quigley, J. D., L. L. Deikun, T. M. Hill, H. G. Bateman, II, J. M. Aldrich and R. L. Schlotterbeck. Changes in serum IgG and total protein concentrations in calves fed differing amounts of colostrum replacer. J. Dairy Sci. J. Dairy Sci. 97(E-Suppl. 1):915.

Quigley, III, J. D., C. J. Kost, and T. M. Wolfe. 2002. Absorption of protein and IgG in calves fed a colostrum supplement or replacer. J. Dairy Sci. 85:1243-1248.

Written by Dr. Jim Quigley (20 January 2016)
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