The Use of Colostrum and Colostrum Supplements in Neonatal Calves.

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ABSTRACT

Adequate ingestion of colostrum is essential for the survival of neonatal calves. Changes in husbandry practices and in dairy cow milk yields have led to the marketing of colostrum supplements to ensure adequate passive transfer of immunity to calves. This paper reviews current knowledge about maternal and neonatal factors affecting passive transfer, managed delivery of colostrum and factors affecting immunoglobulin availability in colostrum supplements.

KEY WORDS: Bovine. Colostrum. Colostrum supplements. Immunoglobulin. IgG

INTRODUCTION

Neonatal calves are agammaglobulinaemic at birth and their survival is dependent on adequate ingestion of good quality colostrum within the first few hours of birth. Bovine colostrum contains high concentrations of immunoglobulin (Ig). Uptake of this antibody by the calf (passive transfer of immunity) is essential for humoral immunity in the first weeks of life. There is a high concentration of lipid in colostrum, which provides a highly calorific substrate for metabolism. This is significant in neonates born into cold climatic conditions, and is of particular importance in lambs which have a higher surface area to volume ratio than calves, making lambs more susceptible to hypothermia.

Fresh colostrum contains maternal leucocytes, which may be important in regulating the initiation of active immune function in the calf (Riedel-Caspari 1993). Colostrum also contains cytokines and growth factors, which may have a role in conditioning the calf's immune system (Tizard 2004).

A wide range of maternal and neonatal factors may affect the passive transfer of immunity. There is increasing evidence that calves of high yielding, intensively managed dairy cows are likely to ingest an inadequate quantity of colostrum if left to suckle from the cow. This has led to the marketing of a range of colostrum supplements to be used in addition to colostrum, with the aim of increasing ingestion of immunoglobulins by the calf.

MATERNAL FACTORS AFFECTING TRANSFER OF PASSIVE IMMUNITY.

Bovine colostral antibody comprises about 85% IgG_1 with IgG_2, IgM and IgA making up the remaining 15%. This is due to the presence of a specific transport mechanism for transferring IgG_1 from plasma to colostrum in the periparturient udder (Barrington and Parrish, 2001). The concentration of IgG_1 in cow serum 5 weeks before parturition is around 13.4g/l, and is depleted to approximately 6g/l at parturition by transfer to the colostrum.

The concentration of IgG in good quality colostrum at parturition is approximately 60g/l. This is likely to be adversely affected by mastitis or other infectious disease in the dry period. Dystocia leading to recumbency or periparturient metabolic disease may prevent suckling. First lactation heifers produce less colostrum with lower total immunoglobulin than multiparous cows (Devery-Pocius and Larson 1983). This is probably the result of continued antigenic stimulation, increased secretory capacity and a more efficient immunoglobulin transport system in older cows.

Jersey cows have been shown to produce colostrum with the highest concentration of immunoglobulin compared to other breeds. This may be in part a breed effect, but it may reflect dilution of IgG in breeds with higher milk yields (Aldridge *et al* 1992). This dilution effect may become a problem for dairy calves from high yielding breeds such as Holsteins.

The calf may need to take a volume of colostrum exceeding their appetite, to ensure adequate intake of immunoglobulin.

Milking of cows prior to calving compromises calf access to colostral immunoglobulin, as colostrum antibody level declines after the first milking following the dry period. Milk leakage from the udder prior to parturition may also affect colostral antibody levels.

No significant difference in colostrum quality occurred between cows with dry periods of 28 and 56 days, but quality was adversely affected if no dry period occurred before calving (McGuirk and Collins 2004). A study in beef cows showed no effect of body condition score at calving on colostrum immunoglobulin content (Odde 1988). Increased anionic salts in the diet of dairy cows did not affect uptake of colostrum by calves (Morrill *et al* 2010).

NEONATAL FACTORS AFFECTING PASSIVE TRANSFER

Uptake of immunoglobulin by the small intestine of neonatal calves into the circulatory system is by non- specific enterocyte pinocytosis, initiated by the presence of macromolecules in the gut (Barrington and Parrish, 2001). Adequate Passive Transfer (APT) in the calf requires ingestion of 100- 200g immunoglobulin within 6 hours of birth (McGuirk and Collins 2004), and the apparent efficiency of absorption of IgG is 20- 35% (Quigley and Drewry 1998). Efficiency of absorption declines with age such that no further absorption of IgG_1, termed ‘closure’, occurs beyond 27 hours post-partum (White 1987).

Ideally suckling by the calf within the first 6 hours post partum should result in ingestion of an adequate quantity of colostrum to achieve adequate passive transfer (APT), however suckling may be affected by a number of factors. In a study by Edwards and Broom (1979) 46% of calves from multiparous cows did not suckle within 6 hours of birth, compared with 11% of heifers’ calves. This may be due in part to maternal udder conformation as calves born to cows in which the udder is either the highest point or level with the cow’s underbelly and suck significantly earlier than calves of cows with pendulous udders (Selman et al 1970). Competition from other calves, injury of the calf, and the calf suckling from other cows may all affect suckling from the dam. The presence of the dam seems to stimulate antibody uptake by the neonatal calf (Selman *et al* 1971). These authors also found that low ambient temperatures did not depress the immunoglobulin uptake of calves. Postnatal respiratory acidosis in the calf (possibly due to dystocia or delayed parturition) can result in hypogammaglobulinaemia, possibly as a result of reduced colostral intake (Besser *et al* 1990).

MANAGED DELIVERY OF COLOSTRUM

It is not possible to determine accurately the intake of colostrum by suckling, and if inadequate suckling is anticipated or suspected, it is necessary to provide colostrum to the calf by bottle feeding or feeding by oesophageal intubation. A useful guideline is that 6 pints (3.4 litres) of good quality colostrum should be given in the first 6 hours post partum to ensure APT. Bottle feeding may lead to better uptake of immunoglobulin than oesophageal feeding (Godden *et al* 2009). In a study delivering 1.5L of colostrum substitute to calves 100% achieved APT if bottle fed, compared with 41.7% achieving APT if the colostrum substitute was given by oesophageal intubation. The difference was attributed to failure of oesophageal intubation to stimulate closure of the oesophageal groove, resulting in a proportion of the colostrum being deposited in the immature reticulorumen. This effect was volume dependent, as both intubated and bottle fed calves achieved APT if 3L of colostrum substitute was given
It has become common practice to supplement or even replace maternal colostrum with stored colostrum, as there appears to be a high risk of Failure of Passive Transfer (FPT) in dairy calves which are left to suckle colostrum (see for instance Besser *et al* 1991).

Colostrum donor cows need to be in good health, free from mastitis, Bovine Viral Diarrhoea and *Salmonella*. Neospora caninum DNA has been demonstrated in bovine milk including colostrum, but there is no current evidence that lactogenic transmission occurs (Moskwa *et al* 2007). Donors should be tested for *Mycobacterium avium* subsp *paratuberculosis* (Johnes disease) and where appropriate for Enzootic Bovine Leucosis. Vaccination of the pregnant cow against endemic diseases such as rotavirus, coronavirus and pathogenic strains of *Escherichia coli* should be considered.

The udder should be hygienically prepared before collection of colostrum. Clean technique and milking equipment which is clean and in good working order, are necessary to minimise bacterial contamination of the colostrum. The colostrum may be stored in suitable plastic containers in a refrigerator at 4C for up to one week before use, although some degradation of immunoglobulin will occur over time. Storage of colostrum at 4C for up to 2.5 days before feeding, led to lower levels of IgG1 uptake by neonatal calves than use of fresh colostrum (Besser *et al* 1990). Bacterial contamination of stored colostrum is common on many dairy farms and has a negative impact on passive immunity. Potassium sorbate (200-1000ppm) may be added to provide bacterial control, but this does not prevent nutrient losses due to increasing acidity as the colostrum sours (McGuirk and Collins 2004). Addition of bicarbonate to colostrum replacer may increase immunoglobulin uptake by the calf (Morrill *et al* 2010).

Colostrum may be frozen for storage, although some loss of quality may occur, and refrigeration has less effect on FPT than freezing (Besser *et al* 1991). It is important that the frozen colostrum is not overheated during thawing, as this will lead to denaturing of immunoglobulin.
Increasing concerns about risk of transferring infections such as *Mycobacterium avium* subsp *paratuberculosis* have resulted in a move to pasteurisation of donor colostrum, but care must be taken to avoid denaturing the colostral immunoglobulins. Godden *et al* (2003) described a 23.6% reduction in IgG after pasteurisation at 63C for 30 mins in 57L batches, and a 58.5% reduction for 95L batches. The difference was attributed to time spent warming and cooling. Thickening of colostrum occurs if it is overheated, and may cause problems with administration.

Colostrum immunoglobulin content declines subsequent to the first milking after the dry period. The use of pooled colostrum is likely to lead to dilution of high immunoglobulin colostrum by colostrum from high yielders with low colostral immunoglobulin concentration, or by second and subsequent milkings with lower immunoglobulin content. Thus feeding of pooled colostrum to neonates is likely to result in FPT (McGuirk and Collins 2004).

COLOSTRUM SUPPLEMENTS

The difficulties in ensuring APT in dairy calves have led to commercial production of products aimed at supplementing colostral antibody and reducing the risk of FPT in dairy calves. As these products are described as ‘colostrum supplements’ rather than colostrum substitutes or replacers, they are not required to be subject to veterinary medicines licensing. Colostrum supplements typically contain bovine colostrum, cheese whey or egg as sources of immunoglobulin.

Garry *et al* (1996) reported poor apparent efficiency of immunoglobulin absorption by calves from some commercially available colostrum supplements, compared with calves receiving frozen pooled colostrum. Haines *et al* (1990) point out that commercially available colostrum supplements are not necessarily first milking colostrum, and may be of low Ig content. There is also likely to be variation between batches, as these will be derived from the colostrum of different cows. However, studies by Quigley *et al* (2001 and 2002) using specially formulated colostrum replacers based on bovine plasma immunoglobulin found apparent efficiency of absorption comparable with those of maternal colostrum, and that provided sufficient IgG mass was presented to calves, APT was possible.

Drying of immunoglobulin sources for colostrum supplements can lead to protein degradation; freeze drying, although more expensive, may be preferable to the spray drying currently used in this respect. Administration of a larger volume of lower Ig colostrum may not make up for low quality, as immunoglobulin absorption of calves is linearly related to colostral immunoglobulin concentration (Stott and Fellah 1983). Furthermore, in calves that received adequate maternal colostrum, the use of colostrum supplements did not increase mean serum IgG levels (Abel Francisco and Quigley 1993).

Pathogen specific antibody in colostrum is important to the survival of calves in a contaminated environment. Hence the dam needs to have been exposed to the endemic pathogens on a farm, if she is to produce protective colostral antibodies for the calf. Colostrum supplements should not be expected to provide the same protection to calves as good quality maternal colostrum, although there may be a role for products with high levels of immunoglobulin to specific pathogens.

SUMMARY

Ingestion of adequate immunoglobulin mass within the first few hours post-partum is critical to survival of the neonatal calf. Active management of colostrum intake appears to be necessary on dairy farms with a high incidence of FPT. Appropriate collection, storage and administration of colostrum are necessary to ensure APT

Colostrum supplements may have a role to play in dairy calf management; however, they vary widely in IgG level, and should not be used as a substitute for adequate fresh colostrum.

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