Short communication: Improving passive transfer of immunoglobulins in calves. III. Effect of artificial mothering

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ABSTRACT

The objective of this study was to investigate the effect of artificial mothering, simulated by verbal and physical stimulation of the newborn, on passive transfer of IgG in the dairy calf. Newborn heifer calves born without dystocia were removed from the dam before suckling and randomly assigned to 1 of 2 treatment groups: no tactile or verbal stimulation other than that required for feeding (group 1; $n = 20$), or artificial mothering, consisting of 15 min of vigorous physical and verbal stimulation conducted within 1 to 2 h of birth at the time of colostrum feeding and repeated 1 to 2 h later (group 2; $n = 21$). All calves were fed 2.25 L (150 g of IgG) of a commercially available colostrum replacement using an esophageal tube feeder. Blood samples collected at 24 h of age showed that serum IgG levels and the apparent efficiency of absorption of the IgG were similar in both groups of calves. Artificial mothering by physical and verbal stimulation had no significant effect on IgG passive transfer in dairy heifers born without dystocia.

Key words: colostrum, passive transfer, immunoglobulin, mothering

Short Communication

Passive transfer of colostral immunoglobulin is a critical prerequisite for calf health and survival. A variety of factors, including mass of immunoglobulin fed, time to first feeding, the volume consumed, and method of feeding have been shown to affect passive transfer of IgG (Stott et al., 1979a; Godden et al., 2009a,b). However, even calves that receive early feeding with ample amounts of colostrum with high IgG concentrations have considerable variability in the levels of passive transfer. Although the reasons for this variation are not understood, one factor that may affect passive transfer and has not been well studied is the effect of mothering.

Mothering refers to the typical behavior of cows and heifers following the birth of their calves. Usually, dams engage in immediate licking of the calf over the entire body, accompanied by vocalization. Beef cows lick continuously for about 48 min and dairy cows for about 33 min (Selman et al., 1970a). As calves stand and seek the teat for suckling (Selman et al., 1970b), typically the grooming and vocalization of the mother intensifies.

Studies conducted in the 1970s suggest benefits of mothering on passive transfer in calves. In one study, mothered calves (calves allowed to remain with their dams) had significantly enhanced serum IgG levels compared with those of calves without contact with their dams (Stott et al., 1979b). That study used natural suckling so the IgG concentration and volume of colostrum ingested were not controlled. In an intriguing study where calves were fed standardized amounts of pooled colostrum and were muzzled to prevent suckling, those remaining with their dams for the first 18 h had increased concentrations of serum IgG compared with concentrations in calves removed from the dam (Selman et al., 1971a). An explanation for improved passive transfer in mothered calves is unknown. One possibility is that a labile factor is present in fresh suckled colostrum that contributes to improved absorption (Stott et al., 1979b). Another, and perhaps more likely explanation, is that the stimulation provided by the prolonged grooming may have a beneficial effect on IgG absorption (Selman et al., 1971b). A recent study examined this concept in calves fed a standardized amount of colostrum and housed with the cow but confined within a feed trolley that prevented the calf from moving about freely or suckling (Veira, 2008). This study reported no differences in apparent efficiency of absorption (AEA) among calves either separated from their dams after 30 min or allowed to remain in close proximity for up to 24 h. Although these findings suggest that maternal stimulation has no beneficial effect on AEA, all groups were allowed an initial 30 min of dam/calf contact in which vigorous stimulation of the calf typically occurred. Furthermore, although the dams did interact with the calves when confined nearby, it was observed

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that the grooming and stimulation of the calf was not as vigorous as that which occurred in the first 30 min and may have been less than would have occurred if the calves remained free with the cow.

For a variety of reasons, management practices among dairy cattle dictate that calves be removed from the dam as soon as possible after birth (McGuirk and Collins, 2004). It is possible that the absence of the tactile and vocal stimulation of the dam has a negative effect on the ability of the calf to absorb IgG in the critical first hour after birth. Whereas modern management practices likely preclude allowing dairy calves to suckle or to remain with the dams, it is possible that personnel responsible for the care of dairy calves could develop handling methods for simulating the actions of the dam, should such attention benefit the calf.

The objective of this study was to determine if stimulation of the calf, designed to mimic maternal behavior, has a positive effect on passive transfer of colostral immunoglobulin. The hypothesis is that passive transfer of colostral IgG is enhanced by tactile and verbal stimulation of newborn dairy calves. Calves stimulated during and following colostrum ingestion will have higher mean serum IgG levels and less calf-to-calf variation in IgG absorption compared with unstimulated calves.

The protocols for enrolling and treating calves in this study were approved by the University of Minnesota Institutional Animal Care and Use Committee (IACUC, University of Minnesota, Minneapolis). The study was conducted between June and August 2006, on a commercial dairy facility that housed 400 dry and transition cows (Emerald Dairy II, Emerald, WI). When calving was imminent, cows were moved from a freestall pen into individual maternity pens. Heifer calves from observed calvings were removed from the dam within 20 to 30 min of birth and before suckling could occur. To be eligible for enrollment, calves had to be single birthed, weigh ≥ 31.7 kg, and have a calving-ease score ≤ 3 (possible score of 1 to 5). Cows were scored on a 5-point scale, with 1 = unassisted, 2 = easy pull, 3 = moderate pull, 4 = very hard pull, and 5 = Cesarean section. Calves with a score of 4 or 5 were excluded.

Before colostrum was fed, a blood sample was collected from the jugular vein using a 10-mL serum Vacutainer tube (Becton Dickinson and Co., Franklin Lakes, NJ). Eligible calves were then randomly assigned to one of 2 treatment groups:

1. No mothering: 22 calves were fed using the standard management practice for the farm, except that care was taken to minimize tactile and verbal stimulation of the calf during the first 24 h of life. Farm personnel minimized touching the calf during feeding and refrained as much as possible from speaking in close proximity of the calf.
2. Mothered: 22 calves were stimulated during and after colostrum feeding by animal care personnel. Prior to, during, and immediately following colostrum feeding, the newborn calf was vigorously dried using soft towels for about a 15-min period. During this process, the handler spoke to the calf repeatedly and attempted to engage her attention. The stimulation process was repeated 1 to 2 h following colostrum feeding.

All calves were fed a commercially available colostrum replacer (**CR**; Land O'Lakes Colostrum Replacement, Land O'Lakes Inc., Arden Hills, MN) using an esophageal tube feeder. The product provides 100 g of IgG per dose and calves were fed 1.5 doses (150 g of IgG). The CR was mixed according to manufacturer's label directions and fed within 2 h after birth. Enrollment data recorded included calving-ease score, colostrum treatment group assigned, and time of colostrum feeding. At 24 h of age (± 1 h), a postcolostral blood sample was collected from the jugular vein using a 10-mL serum vacutainer tube (Becton, Dickinson and Company).

Precolostral (0–1 h) and postcolostral (24 h) blood samples were refrigerated and allowed to clot overnight, then centrifuged for 12 min at $1,000 \times g$ (model # 226, Fisher Scientific, Pittsburgh, PA) and the serum separated within 24 h of collection. Zero and 24-h serum total protein (**TP**, g/dL) concentration were determined using a commercially available hand-held refractometer (VET 360, Reichert, Inc., Depew, NY). Sera were then frozen at -20°C until submission, on ice, to the Prairie Diagnostic Services Laboratory (University of Saskatchewan, Saskatoon, SK, Canada). Zero and 24-h serum IgG samples from all calves were tested for total IgG concentration (mg/mL) by means of radial immunodiffusion assay as described previously (Chelack et al., 1993). The AEA of IgG (%), an estimate of the proportion of the total IgG mass fed absorbed into the calf's circulation, was calculated using a formula described previously by Quigley et al. (2002), assuming a plasma volume of 9.9% of birth weight.

Descriptive statistics were generated to describe calf characteristics and measures of passive transfer in calves, including 0- and 24-h serum IgG (mg/mL) and TP (g/dL) concentrations, adequate passive transfer rate (%; defined as serum IgG ≥ 10 mg/mL at 24 h), and AEA of IgG. Linear regression (Proc MIXED in SAS, version 9.1. SAS Institute, Cary, NC) was used to describe the relationship between treatment group (explanatory variables: mothered and not mothered) and each of the continuous dependent variables of interest

Table 1. Description of newborn heifer calves either artificially mothered by verbal and physical stimulation (mothered) or handled with minimal stimulation (not mothered) before and after colostrum feeding

Item	Treatment group		<i>P</i> -value
	Not mothered (n = 20)	Mothered (n = 21)	
Birth weight ¹ (kg)	39.9 ± 4.3 (34.9 to 49.9)	37.5 ± 4.8 (31.8 to 47.6)	0.11
Age at colostrum feeding ¹ (min)	44.8 ± 18.5 (20 to 105)	38.3 ± 10.2 (25 to 60)	0.17
Calving-ease score ²	1 (1 to 2)	1 (1 to 2)	0.40

¹Reported as mean ± standard deviation (range in parentheses).

²Reported as median (range in parentheses).

(serum TP and serum IgG at both 0 and 24 h and AEA of IgG at 24 h). Logistic regression (Proc GENMOD in SAS, version 9.1) was used to describe the relationship between treatment group and adequate passive transfer. Final significance was declared at $P < 0.05$. Parameters describing calf birth weight (kg), calf age at first feeding (min), and calving-ease score (1–3) were initially offered as additional covariates in all models. However, as none of these terms was significantly associated with the outcomes of interest, and none interacted with the variable describing treatment group, they were subsequently removed from all models.

This is the first study to examine the effect of simulation of bovine mothering behavior on passive transfer of immunoglobulin. A commercial CR was fed, instead of maternal colostrum, to standardize the volume, concentration, and total mass of IgG (g) fed. Twenty-two calves were enrolled in each of the treatment groups. Birth weights (kg), dystocia scores, and age at colostrum feeding were not different between treatment groups (Table 1).

Precolostral serum TP (g/dL) and IgG (mg/mL) concentrations at 0 h were not different between the treatment groups (Table 2). Three calves were excluded from final analyses, 2 calves from group 1 [one outlier

and one for high (>1.0 g/L) pre-feeding IgG], and 1 calf from group 2 for high pre-feeding IgG.

Artificial mothering did not affect mean IgG passive transfer or reduce the variation in AEA among calves. The benefits of the mothering behavior of cattle in improving passive transfer (Selman et al., 1971b) were perhaps not adequately simulated by the strategy of this study (stimulation for two 15-min periods) compared with the more prolonged interactions typical of dams (Selman et al., 1970a).

Another possibility for the absence of effect of mothering in the present study is that the benefit of this stimulation (or that of the dam) may be more apparent in calves that have difficult births and is linked to improved calf respiratory efforts. Calves born following dystocia have diminished IgG absorption from colostrum compared with that of other calves, an effect that appears to be due to respiratory acidosis (Besser et al., 1990). In agreement with this suggestion, calves born by Cesarean section and stimulated physically have better respiratory parameters (diminished acidosis) and improved passive transfer variables compared with unstimulated calves (Uystepuyst et al., 2002; Endo et al., 2006). If mothering acts to abrogate respiratory acidosis, the present study, by excluding calves born

Table 2. Description of newborn heifer calves either artificially mothered by verbal and physical stimulation or handled with minimal stimulation (not mothered) before and after colostrum feeding

Item ¹	Treatment group		<i>P</i> -value
	Not mothered (n = 20)	Mothered (n = 21)	
Prefeeding sample (0 h)			
Total protein (g/dL)	4.5 ± 0.3 (3.9 to 5.0)	4.6 ± 0.2 (4.0 to 5.1)	0.18
IgG (mg/mL)	0.3 ± 0.1 (0.2 to 0.5)	0.2 ± 0.1 (0.2 to 0.6)	0.38
Postfeeding sample (24 h)			
Total protein (g/dL)	5.3 ± 0.2 (4.9 to 5.6)	5.4 ± 0.3 (4.9 to 6.0)	0.10
IgG (mg/mL)	13.9 ± 2.9 (8.0 to 19.8)	15.0 ± 2.5 (10.4 to 18.8)	0.21
AEA of IgG ² (%)	36.4 ± 6.8 (21.8 to 47.4)	36.7 ± 4.3 (30.6 to 45.0)	0.86
Number with APT ³	19 (90)	20 (100)	0.084

¹Reported as mean ± standard deviation (range in parentheses).

²Apparent efficiency of absorption of IgG at 24 h.

³Adequate passive transfer (serum IgG at 24 h ≥10.0 mg/mL; % in parentheses).

following dystocia, eliminated much of the potential for positive effects.

Stimulation of healthy newborn dairy heifer calves, delivered without dystocia, to simulate dam mothering behavior had no effect on the passive transfer of maternal IgG.

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