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## COMPARATIVE ABSORPTION OF COLOSTRAL IgG1 AND IgM IN THE NEWBORN CALF EFFECTS OF THYROXINE, CORTISOL AND ENVIRONMENTAL FACTORS

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### Résumé

ABSORPTION DES IgG1 ET IgM COLOSTRALES PAR LE VEAU NOUVEAU-NÉ. INFLUENCE DE LA THYROXINE, DU CORTISOL ET DE LA TEMPÉRATURE AMBIANTE À LA NAISSANCE.

— Douze veaux Holstein x Frison nés dans une même étable puis transférés dans des enclos individuels extérieurs ont été utilisés dans cette expérimentation. Six d'entr'eux ont reçu une injection de thyroxine (T4) à la naissance et à 24 h. Tous les animaux ont reçu le même colostrum dans les mêmes conditions. Les résultats suivants ont été obtenus :

- la capacité d'absorption des IgG1 et des IgM varie considérablement selon les animaux ;
- les injections de T4 ne modifient pas sensiblement l'absorption des IgG1 et des IgM, mais la thyroxinémie à la naissance présente une corrélation négative avec les durées des périodes d'absorption des IgG1 et des IgM ;
- des corrélations positives ont été observées entre les taux plasmatiques maximum des IgG1 et des IgM et entre les moments auxquels ils sont atteints, mais ce délai est plus court pour les IgM que pour les IgG1 ;
- la température ambiante à la naissance présente une corrélation négative avec la concentration maximale des IgG1 ;
- les IgM sont moins bien absorbées que les IgG1 (pourcentages respectifs d'absorption : 17 et 75 %). Ce résultat suggère que l'absorption intestinale des immunoglobulines pourrait être sélective chez le veau.

It is generally recognized that thyroid hormones influence the maturation processes of the foetus and the newborn. This led us to study the possible relationships between the perinatal thyroid function and the state of health of the newborn calf.

Previous works (Cabello, 1976 ; Cabello and Levieux, 1978) have allowed us to observe that, in the same herd, the young calves who suffered from diarrhea and survived, were in a

hyperthyroid state at birth. Furthermore, a negative correlation existed between the levels of thyroid hormone in the plasma at birth, and the concentration of globulins at the age of 48 h. Taking into consideration these results, the first point was to look for relationships between the perinatal thyroid function and the intestinal absorption of immunoglobulins.

Recently (Cabello and Levieux, 1978) we have studied the effects of thyroxine and envi-

ronmental factors on the absorption of gamma-globulins of the newborn calves. We have observed negative correlations between the plasma level of thyroxine at birth and the time at which the maximal concentration of IgG1 in the plasma of the calves was reached, and between the outside temperature at birth and the maximal plasma level of IgG1.

The relative efficiencies of absorption of the IgG1 and IgM classes of immunoglobulins have been very controversial. Therefore, the purpose of this paper is to observe the comparative absorption of colostrum IgG1 and IgM in the newborn calf.

### Material and Methods.

The methodology has been largely described in a previous paper (Cabello and Levieux, 1978). It can be summarized as follows :

#### 1. Animals

We used 12 male crossbred Holstein × Friesian from the same herd. Immediately after birth, the calves were transferred to open boxes outside. Six experimental animals received 2 mg/10 kg bodyweight of thyroxine (I.M.) and a second injection 24 h later with half the dose. A 120 l colostrum pool had previously been collected and kept frozen in order to give the same colostrum to all calves. This colostrum contains 40 mg/ml IgG1, 4.25

mg/ml IgM as determined by radial immunodiffusion.

The calves were bottle-fed seven times with the colostrum (the first time 8 h after birth, and then every 4 h until 32 h), in proportion to their bodyweight.

#### 2. Sampling

Blood was collected at birth, at 8 h and then every 2 h until 36 h.

#### 3. Analysis

IgG1 and IgM were measured by radial immunodiffusion (Mancini *et al.*, 1965), with specific antiserum for IgG1 and IgM (Levieux, 1974).

Thyroxine and cortisol were measured by radioimmunoassays (Methods of the C.E.A., kits Tetrak and Cortctk 125 M).

### Results

Before any treatment, there was a non statistically significant lower blood concentration of the thyroxine (T4) in the treated group ( $14.07 \pm 2.26 \mu\text{g}/100 \text{ ml}$ ) than in the control group ( $17.10 \pm 0.34 \mu\text{g}/\text{ml}$ ). As previously described (Cabello and Levieux, 1978), in treated animals, the T4 injections increased significantly the plasma concentration of this hormone, which was approximatively doubled.

Table 1. — Maximum plasma levels of IgG1 and IgM measured after ingestion of colostrum, and time at which they were reached.

Animals	IgG1		IgM	
	level (mg/ml)	time (h)	level (mg/ml)	time (h)
<i>Controls</i>				
A	18.69	30.19	0.64	28.75
D	22.15	34.25	0.78	31.25
E	28.84	29.78	2.34	30.13
F	24.12	31.43	1.14	27.61
G	21.30	27.91	0.81	28.52
K	27.49	32.08	1.14	29.07
<i>Treated</i>				
B	13.10	29.16	0.62	28.07
C	25.51	36.07	1.08	31.29
H	31.53	42.06	1.18	34.68
I	29.60	37.98	2.41	40.58
J	31.48	39.38	1.07	30.45
L	32.29	30.56	1.45	27.30

The variation in the plasma level of IgG1 and IgM during the first 36 h closely fitted a second degree curve of the type :

$$C = aT^2 + bT + c$$

with C : plasma level of Ig

T : time after birth in h.

The last square method allowed a good fit to be obtained (ris circa between 0.920 and 0.999) and gave an objective estimation of the maximal level of IgG1 and IgM and the time at which it is reached. Results concerning these two parameters are presented in table 1. We observed large individual variations in the maximal level of IgG1 and IgM and in the time at which it is reached.

The maximum level of IgG1 seemed to be reached earlier in control than in treated animals (table 2), but the statistical analysis is at the limit of significance (P = 0.05). If the individual values for the time at which this level was reached were corrected for the T4 level at birth using the regression :

$$\text{time of the maximum level of IgG1} = - 0.814 T4 + 46.08$$

with r = - 0.738,

no more significant difference remains between control and T4 treated calves, in this respect. Therefore, this difference is probably not related to the treatment.

The other parameters measured were not statistically different between the two groups of animals (table 2).

Outside temperature and hygrometry at birth were measured near the individual boxes in which the calves were housed. The matrix correlations between these climatic factors and blood parameters are given in table 3 (for all 12 calves). Among the correlations observed, we can point out the following :

— Negative correlations (P < 0.01) between the plasma level of T4 at birth and the time at which the maximal plasma concentration of IgG1 and IgM is reached.

— Positive correlations between the maximal plasma levels of IgG1 and IgM (P < 0.05), and between the time at which they are reached (P < 0.01).

— A negative correlation (P < 0.05) between the plasma level of cortisol at birth and the value of the ratio

Maximal plasma level of IgG1

Maximal plasma level of IgM

— In contrast to IgG1 (P < 0.01), there was no significant correlation between the outside temperature at birth and the maximal plasma level of IgM (r = - 0.5390, NS).

The time at which the maximal plasma level was reached was lower for IgM (30.64 ± 1.08 h) than for IgG1 (33.40 ± 1.31 h ; paired analysis : P < 0.025).

On the basis used by Mac Ewan *et al.* (1970) (estimated plasma volume : 7 % of body weight) and Penhale *et al.* (1973) (40 % IgG1

Table 2. — Plasma parameters in control and T4 treated calves.

Parameters	Treatment	
	control	thyroxine (T4)
At birth		
thyroxine (T4) (µg/100 ml)	17.04 ± 0.41 <sup>a</sup>	14.07 ± 2.26
cortisol (µg/100 ml)	6.89 ± 1.36	9.40 ± 1.58
IgG1		
maximum level (mg/ml)	23.77 ± 1.57	27.25 ± 3.00
time of maximum (h)	30.18 ± 1.01	35.87 ± 2.07*
IgM		
maximum level (mg/ml)	1.14 ± 0.25	1.30 ± 0.25
time of maximum (h)	29.22 ± 0.53	32.06 ± 2.01
Maximum level IgG1		
	23.58 ± 2.55	22.57 ± 2.40
Maximum level IgM		

a : mean ± S.E. (six animals in each group) ; \* : P = 0.05

Table 3. — Matrix of correlations observed for the 12 calves between climatic factors and blood parameters.

	Environmental factors			At birth		IgG1		IgM	
	Outside temperature	Hygrometry	Thyroxine (T4)	Cortisol	Maxi level	Time of maximum	Maxi level	Time of maximum	
<i>Environmental factors</i>									
Hygrometry	- 0.5561*								
<i>At birth</i>									
Thyroxine (T4)	0.3938	- 0.4918							
Cortisol	- 0.2839	0.2821	- 0.3618						
<i>IgG1</i>									
Maxi level	- 0.7797**	0.6596*	- 0.3057	0.2225					
Time of maximum	- 0.4498	0.4417	- 0.7374**	0.2542	0.5814*				
<i>IgM</i>									
Maxi level	- 0.539	0.4313	- 0.3178	0.5350	0.6165*				
Time of maximum	- 0.4904	0.4614	- 0.8196**	0.5447		0.6973**		0.5711*	
<i>Maximum level IgG1</i>	0.2069	- 0.0529	0.1145	- 0.5957*					
<i>Maximum level IgM</i>									

\* : P < 0.05 ; \*\* : P < 0.01

and 80 % IgM intravascular), the percentage of immunoglobulins absorbed varied from 42.68 to 91.96 % for IgG1 and from 8.52 to 33.21 % for IgM. The latter class of immunoglobulin was significantly less absorbed ( $16.79 \pm 2.35$  %) than IgG1 ( $74.83 \pm 4.72$  % ; paired analysis :  $P < 0.001$ ).

## Discussion

### 1. Hormonal and environmental effects on the absorption efficiencies of IgG1 and IgM

We have observed a negative correlation between the plasma level of T4 at birth and the time at which the maximal value of IgG1 and IgM were reached. In the newborn-rat (Malinowska *et al.*, 1974), injections of thyroxine reduce the intestinal absorption period of macromolecules ; as the length of this period influences greatly the time at which the maximal plasma level of immunoglobulins is reached, it is possible to think that, in the calf, thyroxine reduces also the intestinal absorption period of gammaglobulins. As discussed previously (Cabello and Levieux, 1978), the lack of effect of the injections of T4 at birth could be explained by the fact that they occurred too late to be effective in this respect.

We have observed a negative correlation between the plasma level of cortisol at birth and the value of the ratio :

$$\frac{\text{maximal plasma level of IgG1}}{\text{maximal plasma level of IgM}}$$

Table 3 shows that this effect is not mediated by an unfavourable effect of cortisol on the absorption of IgG1 (correlation coefficient between plasma cortisol at birth and maximal value of IgG1 = + 0.223, NS). As in the newborn pig (Patt and Eberhart, 1976) metyrapone, which decreases greatly the plasma level of cortisol, reduces the absorption of IgG1 ; it is possible to think that this corticosteroid in physiological concentrations, influences the absorption of the colostrum immunoglobulins, and particularly could increase the absorption of IgM (correlation coefficient between plasma cortisol at birth and maximal value of IgM = + 0.5350, near the limit of significance 0.553). These results are not in agreement with the observations obtained in the rat with pharmacological doses of corticosteroids (Daniels *et al.*, 1972 ; Morris and Morris, 1976).

It is difficult to explain why we have observed a negative correlation between the ambient temperature at birth and the maximal plasma level of IgG1, and no correlation between this temperature and IgM, because the stage at which this factor influences the level of IgG1 is not known.

### 2. Comparative IgG1 and IgM absorptive efficiencies of the calves

Most results published on the blood immunoglobulin concentrations of newborn calves emphasize the large individual differences. The present results have shown that the amount of ingested immunoglobulins (Mac Ewan *et al.*, 1970 ; Selman, 1973 ; Bush *et al.*, 1971), the concentration of colostrum immunoglobulins (Kruse, 1970 ; Dardillat, 1973), or the time of first administration (Kruse, 1970 ; Selman, 1973 ; Penhale *et al.*, 1973) alone cannot explain this phenomenon : in the same herd, with the same breed, and in standardized conditions for the quality of colostrum and management, the maximal levels observed can range between 13.1 and 32.3 mg/ml for IgG1 (factor 2.5), and between 0.6 and 2.4 mg/ml for IgM (factor 4).

The relative efficiencies of absorption of the IgG1 and IgM classes of immunoglobulins have been very controversial. The absorption of colostrum immunoglobulins from the intestine of the newborn has been considered to be a non selective process in the lamb (Sawyer *et al.*, 1977) and in the calf (Klaus *et al.*, 1969) or to be a selective process in the calf (Penhale *et al.*, 1973 ; Stott and Menefee, 1978).

As Penhale *et al.* (1970) in the calf or Sawyer *et al.* (1977) in the lamb, we have observed a positive correlation between the maximal levels of IgG1 and IgM, and between the times at which they were reached. However, other results are in agreement with the hypothesis of a selective absorption of immunoglobulins :

— The time at which the maximal plasma level of IgM is reached ( $30.6 \pm 1.1$  h) is shorter than for IgG1 ( $33.4 \pm 1.3$  h). The factors which are able to influence greatly this time are essentially the rate of equilibration between the extravascular and intravascular compartments, the rate of transfer, the duration of the transfer period and other factors such as the catabolism rate or the extent of proteinuria influencing probably in the same manner these

two classes of immunoglobulins. Among these factors, in view of the higher molecular weight of IgM, it is possible to think that its rate of equilibration between the extravascular and intravascular compartments is slower than that of IgG1 ; the rate of transfer has been studied by Logan *et al.* (1978) : it seems that IgG1 appears in the blood before IgM after the ingestion of colostrum. The two factors might delay the time at which the maximum plasma level of IgM is reached in comparison to IgG1 and might contribute to the reduction in the difference observed between IgM and IgG1 in this work. Therefore, it seems that the most likely explanation may involve the duration of the transfer period which would be shorter for IgM than for IgG1. Penhale *et al.* (1973) have made a similar conclusion.

— The percentage of absorption calculated on the basis of our experimental results is higher for the IgG1 ( $74.8 \pm 4.7 \%$ ) than for the IgM ( $16.8 \pm 2.4 \%$ ). Penhale *et al.* (1973) have obtained a similar result, but the difference was weaker than in our study. In their study, the calves were allowed to suckle their dams as soon as possible after birth. As the presence of the dam and a short delay between birth and the first ingestion of colostrum are factors which increase the absorptive efficiency of immunoglobulins (Selman, 1973), it is possible to think that in these conditions the difference of absorption of IgG1 and IgM is less evident than in our conditions (bottle fed calves ; first ingestion eight hours after birth).

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### Summary

Twelve Holstein  $\times$  Friesian calves, born in the same stable, and then transferred to outside individual boxes, were used in this experiment. Six animals received thyroxine (T4) injections at birth and after 24 h. All the calves received the same colostrum in the same conditions. The following results were obtained :

- The capacity of calves to acquire colostral IgG1 and IgM varies considerably between individuals.
- T4 injections do not noticeably alter IgG1 and IgM absorption, but thyroxinemia at birth, reflecting probably the fetal level, is negatively correlated with the absorption periods of IgG1 and of IgM.
- We have observed positive correlations between the maximum plasma levels of IgG1 and IgM, and between the times at which they were reached, but this time is shorter for IgM than for IgG1.
- The outside temperature at birth is negatively correlated with the maximal IgG1 concentration.
- IgM are less well absorbed by the calves than IgG1 (percentages of absorption : 17 % for IgM and 75 % for IgG1). This result suggests that the intestinal absorption of immunoglobulins could be selective in the calf.

### References

- BUSH L.J., AGUILERA M.A., ADAMS G.D., JONES E.W., 1971. Absorption of colostral immunoglobulins by newborn dairy calves. *J. Dairy Sci.*, **54**, 1547-1549.
- CABELLO G., 1976. *Evolution plasmatique de quelques paramètres biochimiques et hormonaux chez le nouveau-né. Hypothèse nouvelle concernant la pathologie néonatale du veau.* Thèse d'Université n° 50 DU, Clermont-Ferrand, 156 p.
- CABELLO G., LEVIEUX D., 1978. The effects of thyroxine and climatic factors on colostral gammaglobulin absorption in newborn calves. *Ann. Rech. Vét.*, **9**, 309-318.
- DANIELS V.G., HARDY R.N., MALINOWSKA D.W., NATHANIELSZ P.W., 1972. Adrenocortical hormones and the absorption of macromolecules by the small intestine of the young rat. *J. Endocr.*, **52**, 405-406.
- DARDILLAT J., 1973. Relations entre la yglobulinémie du veau nouveau-né et son état de santé. Influence de la composition du colostrum et de la protéinémie de la mère. *Ann. Rech. Vét.*, **4**, 197-212.

- KLAUS G.G.B., BENNETT A., JONES E.W., 1969. A quantitative study of the transfer of colostral immunoglobulins to the newborn calf. *Immunology*, **6**, 293-298.
- KRUSE V., 1970. A note on the estimation by simulation technique of the optimal colostrum dose and feeding time at first feeding after the calf's birth. *Anim. Prod.*, **12**, 661-664.
- LEVIEUX D., 1974. Immunoglobulines bovines et brucellose. 1. Purification des immunoglobulines et préparation de leurs antisérums spécifiques. *Ann. Rech. Vét.*, **5**, 329-342.
- LOGAN E.F., Mc MURRAY C.H., O'NEILL D.G., Mc PARLAND P.J., Mc RORY F.J., 1978. Absorption of colostral immunoglobulins by the neonatal calf. *Br. vet. J.*, **134**, 258-262.
- Mac EWAN A.D., FISHER E.W., SELMAN I.E., 1970. An estimation of efficiency of the absorption of immune globulins from colostrum by newborn calves. *Res. Vet. Sci.*, **11**, 239-243.
- MALINOWSKA K.W., CHAN W.S., NATHANIELSZ P.W., HARDY R.N., 1974. Plasma adrenocorticoid changes during thyroxine-induced accelerated maturation of the neonatal rat intestine. *Experientia*, **30**, 61.
- MANCINI G., CARBONARA A.O., HEREMANS J.F., 1965. Immunochemical quantitation of antigens by single radial immunodiffusion. *Immunochemistry*, **2**, 235-254.
- MORRIS B., MORRIS R., 1976. Globulin transmission by the gut in young rats and the effects of cortisone acetate. In W.A. Hemmings, *Materno-fœtal transmission of immunoglobulins*, 359-370. Cambridge University Press, Cambridge.
- PATT J.A., EBERHART R.J., 1976. Effects of metyrapone and ACTH on intestinal absorption of immunoreactive bovine IgG in cesarean-derived pigs. *Am. J. Vet. Res.*, **37**, 1409-1413.
- PENHALE W.J., CHRISTIE G., Mac EWAN A.D., FISHER E.W., SELMAN I.E., 1970. Quantitative studies on bovine immunoglobulins. II. Plasma immunoglobulin levels in market calves and their relationship to neonatal infection. *Br. Vet. J.*, **126**, 30-37.
- PENHALE W.J., LOGAN E.F., SELMAN I.E., FISHER E.W., Mac EWAN A.D., 1973. Observations on the absorption of colostral immunoglobulins by the neonatal calf and their significance in colibacillosis. *Ann. Rech. Vét.*, **4**, 223-233.
- SAWYER M., WILLADSEN C.H., OSBURN B.I., Mc GUIRE T.C., 1977. Passive transfer of colostral immunoglobulins from ewe to lamb and its influence on neonatal lamb mortality. *J. Am. Vet. Med. Ass.*, **171**, 1255-1259.
- STOTT G.H., MENEFFEE B.E., 1978. Selective absorption of immunoglobulin IgM in the newborn calf. *J. Dairy Sci.*, **61**, 461-466.