CCLXIV. THE SUGAR AND TOTAL KETONE CONTENT OF THE BLOOD OF EWES AND OF THEIR NEW-BORN LAMBS

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IN many animals it has been found that the maternal blood at term contains a higher percentage of sugar than the foetal blood. Needham [1931] cites data illustrating this point and gives figures obtained in human subjects by 18 investigators, from which the following averages have been calculated: maternal blood 118 mg., foetal blood 94 mg. sugar per 100 ml. Aron [1924] records even wider differences for the dog (maternal 110 mg., foetal 65 mg. per 100 ml.) and for the guinea pig (maternal 107 mg., foetal 60 mg. per 100 ml.). On the other hand he gives data for the cow (maternal 100 mg., foetal 110 mg.) and for the pig (maternal 100 mg., foetal 139 mg.) which suggest that the reverse is true for these species. Passmore & Schlossman [1938] record a similar relation for sheep and goats.

In the course of a study on the occurrence of ketonaemia in pregnant ewes the opportunity was taken to determine the sugar and total ketones present in the blood of ewes (both normal and ketonaemic) at the time of parturition and in that of their new born lambs. A number of ewes were available which, for some weeks during the latter half of pregnancy, had shown progressively increasing ketonaemia accompanied by marked hypoglycaemia. The lambs from these ewes were small and weak and it was of interest to see whether this weakness could be correlated with a low blood sugar level and/or the passage of ketones from the maternal to the foetal blood stream. As controls a number of healthy ewes with their vigorous new-born lambs were also examined.

METHODS

Blood sugar: Somogyi's modification of the Shaffer-Hartmann method [Peters & Van Slyke, 1931].

Total ketone bodies in the blood: Gravimetric method using Denigès' reagent [Peters & Van Slyke, 1931].

RESULTS

All the ewes were bled a day or more prior to parturition and as soon after lambing as possible, the new-born lambs being bled at the latter time. The analytical data are recorded in Table I with the times before and after lambing at which the samples were taken. They serve to show the changes which occur in the blood of the ewe at about the time of labour as well as the differences between the blood of the new-born lamb and its dam with respect to sugar and ketone bodies.

Blood sugar. In the normal healthy ewe at parturition there is a marked rise in the blood sugar level, but the figures cited suggest that *post partum* there is a fairly rapid return to the normal level. Thus, although the ewes bled up to within

Table I. *The sugar and total ketone bodies in the blood of ewes at parturition and in that of their new-born lambs: mg. per 100 ml.*

Ewe no.	Days before lambing	Ewe						Interval between lambing and bleeding
		Before lambing		After lambing		Lamb		
		Sugar	Ketones	Sugar	Ketones	Sugar	Ketones	
		Healthy ewes						
40	1	52	0	145	0	163	0	10 min.
65	6	56	0	112	0	156	0	30 „
68	2	60	0	83	0	109	0	2½ hr.
44	1	56	0	72	0	94	0	3 „
79	3	50	0	50	0	97	0	14 „
Ewes showing ketonaemia								
81	3	18	48	62	25	62	0	5 min.
48	1	40	36	55	16	65	0	5 „
41	8	32	41	—	44	—	0	5 „
4	1	31	83	67	60	124	0	15 „
89	4	38	12	46	12	64	0	15 „
37	6 hr.	39	28	37	24	92	0	30 „
98	6	28	48	64	32	93	0	60 „
11	8	28	53	53	33	68	0	60 „

3 hr. after lambing showed this rise, in the case of ewe no. 79 which was not bled until 14 hr. after lambing, the blood sugar was at the same level as it had been 3 days before lambing. A similar rise in blood sugar level at term has been reported in the case of human subjects by Ketteringham & Austin [1938] who found that at the first stage of labour (1–8 hr. before delivery) 28 mothers had an average blood sugar of 93 mg. per 100 ml. and at delivery the average value was 122 mg. per 100 ml. In the ewes suffering from ketonaemia and having a low blood sugar level before lambing the rise was also shown but the level reached was by no means as high as in the healthy ewes.

In the case of the lambs it is shown that at birth, or shortly after, their blood contained a higher percentage of sugar than did that of the mother. This difference is pronounced in the case of the healthy ewes and their progeny, but is less marked for the lambs from some of the ketonaemic ewes. It is probable that, following birth, the blood sugar levels of the lamb may change with rapidity over a fairly wide range. Thus Passmore & Schlossman [1938] found a rise in the blood sugar from 128 to 142 mg. per 100 ml. in the 15 min. following the delivery of an experimental lamb which had been treated with insulin. They suggest a *post partum* mobilization of liver glycogen as a result of the exposure of the new-born lamb to a cold atmosphere. If this elevation is general the rather low blood sugar levels obtained 5 min. after birth could be explained and the rather higher values obtained soon after might be expected. Ketteringham & Austin [1938] found that 3–6 hr. after birth the blood sugar of human babies dropped to the normal infant range. The results shown for the lambs from normal ewes suggested that an analogous change could be demonstrated in the lamb. The smaller differences between the blood sugar levels of the ketonaemic ewes and their lambs and the smaller changes in the blood sugar level of these lambs at the longer intervals from the time of birth are in all probability attributable to the hypoglycaemic condition of the ewe during the latter stages of pregnancy.

Blood ketones. An interesting finding of this investigation is the complete absence of ketone bodies from the blood of the new-born lambs from ewes which had been showing signs of severe ketonaemia for periods up to 6 weeks prior to and immediately after lambing. One might expect that molecules of the size

and nature of β -hydroxybutyric acid (the chief ketone present in the blood of the ketonaemic ewe) would pass readily through the placental membrane. Many investigators have shown that in most mammals gases and crystalloid substances with small molecules pass readily through the placenta. Thus Anselmino [1929] found that 50 min. after injecting dihydroxyacetone into the blood stream of the pregnant rabbit, the foetal and maternal bloods contained the same concentration of this added material. Needham [1931] discusses the variation in permeability shown by different types of chorion and gives as an illustration the fact that sodium salicylate will pass readily through the placenta of the cat or the guinea-pig but not through that of the cow or ewe. It seems that the placenta of the ewe likewise prevents the passage of ketone bodies to the foetus.

It is possible that the foetal lamb possesses some mechanism facilitating the oxidation or removal of ketone bodies from the system, but this does not seem probable. It is generally accepted that young animals develop ketosis more readily than adults and suffer more severely from its effects. This does not suggest the existence of any special protective mechanism in the young.

SUMMARY

1. The sugar and total ketones in the blood of normal and ketonaemic ewes prior to and shortly after lambing are recorded along with the corresponding figures for the blood of the lamb, drawn shortly after birth.
2. At parturition there is a marked rise in the blood sugar levels of both normal and hypoglycaemic ewes.
3. The blood of the new-born lamb contains a higher percentage of sugar than that of its dam bled at the same time.
4. Hypoglycaemia in the pregnant ewe is reflected in a much lower blood sugar level at parturition and a relatively low blood sugar level in the new-born lamb.
5. The blood of new-born lambs from ewes showing marked ketonaemia was quite free from ketone bodies.

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