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THE SUGAR OF THE FOETAL BLOOD, THE AMNIOTIC AND ALLANTOIC FLUIDS

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These observations were made in order to obtain quantitative knowledge of the distribution of fructose and glucose in the blood and in the amniotic and allantoic fluids of the sheep foetus at different ages.

In 1854 Claud Bernard identified fructose in cow's amniotic fluid by its laevo-rotation; Gürber & Grünbaum (1904) recorded it in the fluids of the sheep, cow and goat. Paton, Watson & Kerr (1907) found sugar in the fluids of the sheep, cow, pig, cat, dog, rabbit, ferret and guinea-pig, but identified it as fructose only in the sheep and cow. Their identification rested on (*a*) Seliwanoff's reaction, (*b*) laevo-rotation, (*c*) yeast fermentation, and (*d*) osazone formation with phenyl-hydrazine. They did not discuss the presence of glucose either alone or simultaneously with the fructose. They estimated the sugar by a method unstated and express it as 'G' in their tables, never specifically stating that it was estimated as fructose (it might have been estimated as glucose), always speaking of it as 'sugar'. Takata (1922) found fructose in the amniotic fluid of the whale and Orr (1923) first thought it to be present in human foetal blood. In 1927 van Creveld described a method of estimating fructose and van Creveld & Ladenius (1928) showed the results of fructose tolerance tests in pregnant women. The blood fructose concentration never rose above 14 mg. %. Yamada (1933) found fructose in chick's amniotic fluid and in the same year Okamura discussed the question of sugars other than glucose in the blood. Four years later he determined the total blood sugar of the pregnant woman as being between 67 and 150 mg. %, of which 2·2–5·0 mg. were fructose. This was in the period between the third and tenth lunar months, but there was no relation between concentration and age of pregnancy.

All this time there had been some doubt as to the identification of the blood sugar as fructose. Bacon & Bell (1946, 1948), however, not only successfully isolated this osazone but also obtained the diacetone derivative. At the same time Cole improved Roe's method of estimating fructose, considerably increasing its accuracy (described in Bacon & Bell, 1948). Cole & Hitchcock (1946) estimated the fructose in the arterial blood of pregnant ewes and in the oxygenated and reduced umbilical bloods of the sheep foetus between the 70th and 144th days. Bacon & Bell (1948), besides providing proof of the existence of both glucose and fructose together in foetal blood, also give estimations between the ages of 107 and 141 days.

None of these workers estimated the two sugars in the amniotic and allantoic fluids nor did they correlate blood sugar values with fluid sugar values. The present work was designed to do this with particular reference to the fructose.

METHODS

Pregnant ewes of known conceptual ages were anaesthetized spinally, using 2–3 c.c. planocaine (procaine) followed by absolute alcohol (1–2 c.c.), preceded by a local injection of procaine (2 c.c.). Cannulae were inserted into the dorsalis pedis artery and vein and delivery was by Caesarean section by the usual technique (Huggett, 1927). The amniotic and allantoic fluids were collected separately. The oxygenated and reduced bloods were obtained with hypodermic needles after formalinizing the umbilical cords to prevent spasm and vasoconstriction (Barcroft, 1946). The total reducing substances were estimated by Hagedorn and Jensen's method and fructose by the original Roe method (1934). (This work was planned and executed before Cole's improved technique was available.)

Here two points should be noted. Partridge (1948) has shown inositol to be present in sheep's foetal blood. This, however, is not estimated by the Hagedorn-Jensen method and so does not rank as a reducing substance determined by this method. Secondly, Bacon & Bell (1948) demonstrated in three sheep embryos that the total reducing substances in foetal blood include not only fructose and glucose but also about 10 mg.% of non-fermentable reducing materials (mainly glutathione and uric acid).

The results reported in this series of sheep therefore include fructose and the non-fructose reducing substances of which perhaps 10 mg.% are non-fermenting and the remainder glucose. No glucose-oxidase or yeast fermentations have been performed.

RESULTS

The results of estimating the fructose in the oxygenated blood of the foetus, the amniotic and the allantoic fluids are shown in Table 1. In the maternal blood of all animals the total amount detectable was too small to be estimated.

Values for the non-fructose reducing substances were obtained by deducting the fructose figures in Table 1 from the total amount of reducing substance present. No subtraction was needed in respect of maternal blood.

It would appear (Bacon & Bell, 1948) that the glucose in the foetal blood is less than the figures in Table 2, by about 10 mg. Neither Bacon & Bell (1948) nor we (our work in this series of sheep was completed before their results were available) have systematically examined the amount of the non-fermentable reducing substances at the different ages of foetal life, and no one has estimated these substances in the amniotic and allantoic fluids.

TABLE 1. Fructose of foetal blood and fluids (mg. %)

Foetal age days	Foetal oxygenated blood	Amniotic fluid	Allantoic fluid
49	—	900	—
65	133	65	375
69	166	80	500
85	67	160	113
100	75	Left 120 Right 87	Left 100 Right —
105	67	200	107
110 MD	83	253	360
115	84	168	—
121	115	300	165
125	80	200	366
130	51	210	60
134	43	87	85
135	38	35	56
140	19	58	51

MD = Maternal parasitic disease of the lungs.

TABLE 2. Non-fructose reducing substances (mg. % glucose)

Foetal age days	Maternal arterial blood	Foetal oxygenated blood	Amniotic fluid	Allantoic fluid
49	223	—	55	—
65	70	152	90	380
69	50	29	23	452
85	57	19	1·5	91
100	90	25	Left 120 Right 128	10
105	68	6	31	104
110 MD	257	36	51	7
115	33	0	25	—
121	83	30	25	130
125	53	59	220	28
130	47	19	30	127
134	15	27	39	125
135	44	53	25	160
140	80	81	109	188

MD = Maternal parasitic disease of the lungs.

DISCUSSION

The foetal blood sugars. The blood sugar values for fructose and for the total reducing substances, including fructose, agree reasonably well with those of Cole & Hitchcock (1946) and with those of Bacon & Bell (1948). There is a tendency for sporadically high (greater than 100 mg. %) fructose values in the middle part of pregnancy, between the 60th and 120th days of foetal age, with mean values about 100 mg. %. After the 120th day the values fluctuate widely, but with mean values about 60–70 mg.

The non-fructose reducing materials of the foetal blood shown in Table 2 are probably an index of glucose values, but one would not be warranted in going further than this in view of Bacon & Bell's (1948) findings of a mean value for non-fermentable reducing materials of 6–14 mg. and of glucose (fermentable by glucose-oxidase) of 22 mg.

The sugars of the amniotic and allantoic fluids. The values for fructose and for non-fructose reducing substances are shown in Tables 1 and 2. There is no correlation at any age between the fructose values in the foetal blood and those in the two fluids, and limited correlation between its values in the two fluids at any one age. There is likewise no correlation between the values for non-fructose reducing substances (probably mainly glucose) in the foetal (or maternal) blood and in the two fluids.

Table 1 does show certain very high values for fructose in early foetal life at about the 49th–65th day. There is, however, a more generalized drift to high fructose values between the 100th and 130th day in both fluids, but no evidence that it has any metabolic significance. The figures need confirmation.

The only previous figures for the fluids of the sheep are those of Paton *et al.* (1907) who do not give their method of estimating the reducing sugar. They state that the sugar is fructose, give no consideration to the presence of any other sugar and give tables showing 'Sugar values G' and also 'G/N values'. So far as we know ours are the first recorded values for fructose and non-fructose reducing substances in amniotic and allantoic fluids.

SUMMARY

1. Estimations are recorded of the fructose and non-fructose reducing substances in the foetal and maternal bloods of the sheep and also in the amniotic and allantoic fluids.

2. There was no determinable fructose in the maternal blood.

3. The fructose values tend to exceed the values for non-fructose reducing substances. The latter are probably mainly glucose, but no evidence is advanced on this point.

4. The amniotic and allantoic fluid values for the fructose and non-fructose reducing substances are different from one another. The figures are all higher than the blood sugar values.

5. There is a suggestion of consistent rise of fructose in the amniotic and allantoic fluids from about the 100th to the 130th days of foetal age. After the 130th day the fructose values fall to about 40–50 mg. %.

6. There is no correlation between the concentrations of non-fructose reducing substances in the fluids (amniotic and allantoic) and in the foetal bloods.

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