XXIV. THE AMINO-ACID CONTENT OF THE BLOOD OF CHILDREN IN HEALTH AND IN DISEASE.

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THE majority of the results in the following paper were obtained in the course of a research, still in progress, on the blood picture of rheumatism in childhood. Together with these, estimations were carried out upon other hospital cases of various kinds, and a series of controls upon normal children was later made.

The only previous work on this subject which we have found is given in a paper by Hoeffel and Moriarty [1924] giving the amino-acid-nitrogen content of the blood for normal infants and children. The figures there quoted are, for infants up to 22 months, 5.57 mg. per 100 cc.; for children of 2 years to 15 years, 5.28, and for adults, 7.04.

In our work blood samples were drawn, from the basilic vein, into oxalated tubes, and a tungstic acid filtrate prepared by the Folin-Wu method. The estimations were carried out by Folin's volumetric method [1922] as were those of Hoeffel and Moriarty.

EFFECT OF FASTING.

The question of the possible increase of the amino-acid-nitrogen during protein ingestion has been debated by various workers. Hammett [1920] definitely denies that any difference can be found between blood specimens taken fasting and 3 hours after a meal. Folin and Berglund [1922], on the contrary, obtain a definite increase after a meal, and are supported by several other investigators. For some time our samples were taken at any convenient hour, and were therefore for the most part non-fasting. It was then decided to take all future specimens definitely fasting, *i.e.* before breakfast.

It must be remembered in studying the figures given below, that the amino-acids disappear rapidly from the blood, owing firstly to deamination by the liver, and secondly to absorption by the muscles. Our readings show that in spite of this, the blood figures are altered by a meal.

A number of results are given in Table I fasting and non-fasting. Though the limited number of figures for which there is here space is insufficient to

yield a fair average, a mean of the total estimations carried out in the research is given for each set of figures.

Table I.

Specimen	Age	Sex	Diagnosis	Amino-acid-N mg. %
<i>Fasting:</i>				
C. A.	11	F.	Chorea	7.37
B. L.	5	F.	"	9.09
V. W.	12	M.	"	8.48
N. P.	10	F.	Rheum. carditis	7.63
R. B.	5½	M.	"	8.08
J. M.	12	F.	Ac. rheum. + carditis	8.46
H. M.	9	M.	"	9.21
E. F.	3	F.	Pyelitis	9.00
W. H.	5	M.	Ac. nephritis	7.70
R. L.	9	M.	"	6.55
L. B.	10	F.	Renal rickets	8.00
C. Y.	10	F.	"	6.25
B. O.	12	F.	Coeliac rickets	6.09
I. D.	10	M.	Jaundice	9.66
G. T.	12	F.	Diabetes	7.70
<i>Non-fasting:</i>				
J. L.	7	F.	Chorea	10.00
M. M.	5½	F.	"	10.66
F. D.	8	F.	"	6.74
V. G.	11	M.	Rheum. carditis	9.60
F. T.	12	M.	"	10.40
A. T.	7	F.	"	9.67
L. W.	11	F.	Chr. pyelitis	10.17
G. J.	11	F.	Rickets	9.48
T. S.	7½	M.	Tetany	8.70
J. P.	10	M.	Chr. nephritis	7.35
K. S.	4	F.	Ac. nephritis	7.73
I. H.	12	F.	Exophthalmic goitre	11.50
E. D.	11	F.	Acholuric jaundice	10.80
J. B.	7	F.	Coeliac rickets	8.07
N. P.	6	F.	Renal rickets	9.03
Mean of 40 non-fasting bloods				8.97
Mean of 77 fasting bloods				8.23

Where a considerable variation exists, as in the above series of results, it is more illuminating to record the proportion in which the readings are distributed in the scale of results. This is done in Figs. 1 and 2 which explain themselves. The number of results lying between each pair of limits 7 to 8, 8 to 9, and 9 to 10 mg. and the total number above and below the extreme limits, are represented, as percentages of the total obtained, by the height of the columns.

It is evident at once that the effect of protein digestion is to raise the amino-acid-nitrogen. In the non-fasting bloods the greatest number of results lie above 10 mg. (mainly between 10 and 11), the next greatest between 8 and 9, and the least below 7. For the fasting bloods, the greatest number lie between 8 and 9, the next greatest between 7 and 8, and the least above 10.

Nearly 48 % of the non-fasting bloods, but only 29 % of the fasting bloods, lie above 10 mg.

Conclusions drawn from a large range of results such as these seem to us of more value than isolated experiments involving the estimation of amino-nitrogen before and after protein feeding to selected cases, the method on which previous statements have mainly been based.

In order to obtain a conception of the difference in results attributable to digestion, it is preferable to take a less diversified series of cases. The ideal desideratum, namely, two series of normals, fasting and non-fasting, was unobtainable. For our purpose we have taken two series of results from cases of rheumatism and chorea, in which, as we shall show later, the amino-acid-nitrogen is normal.

Fig. 1. Non-fasting.

Fig. 2. Fasting.

The fasting figures lie between 6.75 mg. and 10.0, the non-fasting between 6.85 and 10.65. Of the fasting specimens 38.8 % lie above and 61.1 % below 8.5, while of the non-fasting specimens, 61.1 % lie above and 38.8 % below.

To procure reliable controls for the examination of these results, it was decided to utilise perfectly healthy children in preference to convalescent or "surgical" hospital cases.

Volunteers were obtained from school children of both sexes, attending at an elementary school in the neighbourhood, by the assistance of Dr G. A. Auden, school medical officer for Birmingham, to whom the author wishes to express his considerable indebtedness for the help given and interest taken in this matter.

The children attended at the hospital before breakfast and a blood sample was taken in the usual manner. Table II shows the results obtained.

It will be seen that these results are all higher than those given by Hoeffel and Moriarty, and, indeed, higher than any adult amino-acid-nitrogen figures given in the literature. This matter was investigated, and led to a separate research into the principles of the method employed, the results of which

Table II. *Normal children (fasting).*

	Age	Sex	Amino-acid-N mg. %
M. Bh.	11	F.	9.52
E. Ws.	10	F.	9.21
J. B.	13	M.	8.97
A. N.	11½	M.	8.91
J. M.	11	M.	8.86
P. H.	10	F.	8.70
J. T.	10	M.	8.58
A. C.	11	M.	8.43
E. M.	11½	M.	8.33
F. R.	11	M.	8.09
P. P.	10	M.	8.09
E. Wd.	11	F.	8.09
M. Bs.	11	F.	8.00
F. C.	11	M.	7.65
P. E.	11	M.	7.60
E. B.	10	F.	6.08
Mean (16 estimations)	...	...	8.32

appear in the preceding paper [1928]. It is there suggested that although Folin's method may not be reliable as an absolute measurement of the amino-acids in a given sample of blood, a series of results are not rendered nugatory provided they are carried out under the same conditions, and preferably by the same worker. If these precautions are taken, figures in such a series, considered relatively, are quite trustworthy.

Since our own experiments fulfilled these conditions, a comparison of the amino-acid-nitrogen results for the chief diseases investigated can now be undertaken.

BLOOD-AMINO-ACID IN DISEASE.

Rheumatic carditis, chorea, etc.

The total estimations carried out upon rheumatic carditis with and without chorea, on chorea itself, and on acute rheumatism number 52. Of these, 32 were taken fasting, the remainder non-fasting.

The mean of the fasting results was 8.21 mg. %. This, compared with the fasting normal of 8.32, does not differ sufficiently to be of importance. The non-fasting mean was 9.15 mg. %.

We therefore consider that the amino-acid-content of rheumatic bloods is normal.

Nephritis.

Twenty-five cases of nephritis were examined. Of these, 21 were taken fasting and 4 non-fasting.

Only 8 separate patients were examined of the fasting group, some of them yielding several samples. On the whole the results were normal, tending if anything to become slightly raised for acute haemorrhagic nephritis, of which several cases were examined. An exception was R. L., a boy of 10 years, suffering from a severe mixed nephritis, who yielded 8 specimens. The highest of the figures was 8.14 mg. %, the lowest 5.13, and the mean 6.58.

Renal infantilism and coeliac infantilism.

Cases of these less common diseases were examined from time to time. Although the chief interest in their blood chemistry centres around the calcium and phosphorus content, it will be seen that the amino-acids are also abnormal.

Seventeen cases of renal infantilism and 6 coeliac cases were examined. The mean of the renals was 7.06 and of the coeliacs 7.28 mg. %.

In Table III are summarised the "fasting" results discussed above.

Table III.

Diagnosis	No. of estimations	Amino-acid-N mg. %		
		Max.	Min.	Mean
Normal	16	9.52	6.08	8.32
Rheumatism, etc.	32	10.07	5.69	8.21
Nephritis:				
(a) Ac. haemorrhagic	11	10.20	7.65	8.48
(b) Mixed (R.L.)	8	8.14	5.13	6.58
(c) Chronic	1	—	—	8.48
(d) Pyelo-nephritis	1	—	—	8.70
Renal infantilism	17	9.52	5.02	7.06
Coeliac infantilism	6	8.07	6.09	7.28

SUMMARY.

Estimations of the blood amino-acid-nitrogen in normal children and in those in various pathological conditions, both fasting and non-fasting, are reported.

The amino-acid-nitrogen has consistently been found to be lower in fasting bloods than in non-fasting, and the mean difference due to this influence is estimated.

The blood amino-acid-nitrogen for normal healthy children has been determined, and by comparison with this figure it has been shown that:

- (a) in rheumatism and chorea with or without carditis no change is found;
- (b) in nephritis there is a lowering of the amino-nitrogen;
- (c) in renal and coeliac infantilism this lowering is still more marked.

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REFERENCES.

- Edgar (1928). *Biochem. J.* **23**, 132.
- Folin (1922). *J. Biol. Chem.* **51**, 377.
- Folin and Berglund (1922). *J. Biol. Chem.* **51**, 395.
- Hammett (1920). *J. Biol. Chem.* **41**, 599.
- Hoeffel and Moriarty (1924). *Amer. J. Dis. Child.* **27**, 64.