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EFFECT OF COPPER DEFICIENCY UPON ERYTHROKINETICS IN GROWING CATTLE Preliminary results

N.A. MARCILESE,
Nuclear Atomic Energy Commission,
Buenos Aires, Argentina

Abstract

EFFECT OF COPPER DEFICIENCY UPON ERYTHROKINETICS IN GROWING CATTLE: PRELIMINARY RESULTS. To determine the role of copper upon erythrokinetics in young cattle, control and copper-deficient animals, with and without previous bleeding, were studied. Four Aberdeen Angus 14 to 18 months old, were allotted for each treatment. The erythropoiesis was stimulated in four control and four deficient animals by daily bleeding during 20 d, in this way removing about 5% of the initial red-cell mass per day. The erythrokinetic study was done by means of ^{59}Fe according to the methods described elsewhere. The time required for the maximum utilization of the tracer by the bone marrow to produce red cells and the amount of stable iron incorporated daily in the erythrocytic mass, were taken as parameters to evaluate the rate of erythropoiesis. In addition, the red-cell survival time was determined in another group of three control and three deficient animals by means of the $DF^{32}P$ method. The results showed that the rate of utilization of iron by the bone marrow of copper-deficient animals was lower than that of control animals: 0.25 mg/kg/d at day 12 and 0.58 mg/kg/d at day 7, respectively. The bone marrow of copper-deficient animals also showed a poor response after the bleeding when compared with the values registered for bled controls: the utilization of iron was 0.46 mg/kg/d at day 10 and 1.14 mg/kg/d at day 4.5, respectively. The values of red-cell life span for control and deficient animals did not differ statistically, they were 144 and 137 d, respectively. However, because of the few animals studied, further determinations are needed to obtain conclusive results. The erythrokinetic study clearly indicated that in copper-deficient animals the erythropoietic activity of bone marrow is impaired. In addition, during the bleeding period copper-deficient animals suffered a drastic loss of body weight and general condition, their recovery being very difficult and slow. This observation strongly suggests the practical importance of controlling blood losses due to gastrointestinal parasites in copper-deficient animals.

1. INTRODUCTION

Previous work in this laboratory indicated that erythrokinetics is negatively affected in copper-deficient cattle [1]. However, due to the fact that the growing rate of deficient animals is much slower than normal, it was difficult to interpret those results. Thus, it could not be established whether the lower rate of erythropoiesis observed in copper-deficient animals, was due to the deficiency in itself or to the lower growth rate. In the present work, to determine the role of copper deficiency upon erythrokinetics in young cattle, control and copper-deficient animals with and without previous bleeding, were studied.

2. MATERIAL AND METHODS

2.1. Animals

Twenty-two Aberdeen Angus of 12 to 18 months of age were studied. Eleven of them, the copper-deficient group, were selected from a herd bred on pastures that have long been known to cause conditioned copper

deficiency, owing to their high content of molybdenum and inorganic sulphate. Control and copper-deficient animals, after coproparasitological control and drug therapy, were distributed in open pens and fed alfalfa hay and water ad libitum. Parasitological controls were periodically repeated. Before starting the studies, the copper-deficient group was orally dosed daily for seven months with a water solution of ammonium molybdate and sodium sulphate equivalent to a daily intake of a pasture containing about 25 ppm of molybdenum and 0.3% of inorganic sulphate, on a dry-matter basis. A few days after starting the drenching clinical symptoms of molybdenosis such as scouring and anorexia were observed. Later on loss of condition, de-pigmentation of the hair and retarded growth, were evident. Liver samples obtained from the copper-deficient animals after the 7-month period, showed values of copper below 15 ppm on a dry-matter basis. The daily drenching of molybdenum and sulphate was continued during the period the animals were under study as described below.

To stimulate the erythropoiesis, four control and four copper-deficient animals were daily bled during 20 d, in this way removing about 5% of the initial red-cell mass per day. Two days after the bleeding was completed, the erythrokinetic study was started. At the same time this study was carried out in other group of four control and four copper-deficient animals. The red-cell survival time was determined in a third group of six animals, half of them copper deficient.

2.2. Methods

The erythrokinetic study was done by means of ^{59}Fe according to methods described before [2]. To calculate the percentage of ^{59}Fe utilized by the bone marrow of bled animals, the red-cell volume was estimated from the plasma volume value using the haematocrit value of the day at which the utilization of the tracer reached its plateau, corrected by the factor 0.904 to obtain the corporeal haematocrit [3]. The red-cell survival time was determined after injecting intravenously 300 μCi of di-isopropyl-phosphorofluoridate $-^{32}P$, according to procedures detailed elsewhere [4]. Statistical differences between mean values were analysed by means of the Student "t" test.

3. RESULTS AND DISCUSSION

The data used to calculate the erythrokinetic values are summarized in Table I, and the values obtained are shown in Table II. The results of the red-cell life-span determinations were for control animals, 160, 154 and 116 d (mean 144) and 150, 130, 131 d (mean 137) for the copper-deficient animals, respectively.

The values of plasma-iron transport rate registered in the control animals were higher than those of copper-deficient animals. This parameter of iron metabolism is directly influenced by the plasma-iron concentration and by its rate of clearance from the plasma. Copper-deficient animals had less plasma iron and its clearance was slower than in control animals. Consequently, in spite of the fact that the percentage of ^{59}Fe utilized by the bone marrow was almost similar in all groups, the transfer of stable iron from the plasma to the bone marrow was quantitatively less

TABLE I. DATA USED TO CALCULATE THE ERYTHROKINETIC VALUES

Animal No.	Body weight (kg)	Blood vol. (litres)	Plasma vol. (litres)	Red Cell vol. (litres)	Ht[a] (%)	Hb[b] (g%)	Plasma Fe (μg%)
			Control animals				
1178	178	10.60	7.07	3.53	38.0	12.1	180
1108	205	12.10	7.78	4.32	42.0	13.2	166
1069	184	12.68	8.04	4.54	41.8	12.6	150
1114	207	13.20	8.30	4.90	42.5	14.2	98
Mean	184				41.1[a]	13.5[a]	149[aa']
			Control animals (bled)				
1248	161	11.20	7.10	4.10	42.0	14.0	143
181	162	12.80	8.10	4.70	42.0	13.8	78
1188	172	9.85	6.56	3.29	38.0	14.0	188
1136	150	9.40	6.37	3.13	39.0	13.5	75
Mean	161				40.2[a]	13.8[a]	121[a]
			Deficient animals				
185	209	11.30	7.74	3.56	36.0	11.8	88
193	200	11.30	7.90	3.40	34.5	11.5	132
148	208	10.55	7.14	3.40	37.0	11.8	108
134	220	10.43	7.05	3.38	37.0	12.7	90
Mean	209				36.1[b]	11.9[b]	105[a]
			Deficient animals (bled)				
19	164	9.17	6.44	2.73	34.0	10.9	106
187	165	7.90	5.68	2.21	32.0	10.5	116
191	174	10.60	7.54	3.16	34.0	10.3	65
113	134	8.00	5.83	2.17	31.0	9.4	80
Mean	159				32.7[c]	10.2[b]	92[a]

NB. Red cell mass, haematocrit and haemoglobin values of bled animals were computed the day at which the maximum utilization of the tracer reached its plateau.

Means with different superscripts are significantly different

[a] Ht. = haematocrit
[b] Hb. = haemoglobin

TABLE II. ERYTHROKINETIC VALUES

Animal No.	T1/2 ^{59}Fe in plasma (min)	Plasma Fe transport-rate (mg/kg/d)	Utilization of ^{59}Fe by bone marrow (%)	Day	Red-Cell Fe incorp. rate (mg/kg/d)
		Control animals			
1178	83	0.86	80.0	7	0.69
1108	77	0.82	74.4	7	0.64
1069	100	0.67	81.4	7	0.55
1114	72	0.55	79.0	7	0.43
Mean	83^{a}	0.72^{a}	78.7	7^{a}	0.58$^{aa'}$
		Control animals (bled)			
1248	55	1.16	98.8	4	1.15
181	24	1.62	97.0	4	1.57
1188	62	1.16	83.7	5	0.97
1136	33	0.97	90.0	5	0.87
Mean	44^{b}	1.23^{b}	92.4	5^{b}	1.14$^{a'}$
		Deficient animals			
185	110	0.29	83.0	11	0.25
193	102	0.51	89.0	12	0.45
148	138	0.27	79.0	12	0.21
134	170	0.17	64.3	12	0.11
Mean	130^{c}	0.31^{c}	78.8	12^{c}	0.26^{b}
		Deficient animals (bled)			
19	53	0.79	76.0	7	0.58
187	90	0.47	64.3	11	0.29
191	45	0.63	95.6	7	0.59
113	60	0.58	65.0	14	0.38
Mean	62^{ab}	0.62^{a}	75.2	10^{c}	0.46^{ab}

NB. Means with different superscripts are significantly different

in copper-deficient animals. On the other hand, once iron was taken up by the erythropoietic tissue of copper-deficient animals, more time was required for its utilization in haemoglobin synthesis. If the rate of erythropoiesis is expressed as the amount of iron used to produce red cells, then from the values of the red-cell iron incorporation rate shown in Table II, it becomes evident that in copper deficiency the erythropoietic

activity is greatly impaired. This assumption is in agreement with the red-cell mass and haematocrit values registered in those animals.

The mean values of red-cell survival time obtained for both groups were almost identical; however, taking into account the few animals studied and the wide dispersion of the values registered in the control group, further determinations are needed in order to obtain conclusive results.

In addition, during the bleeding period, copper-deficient animals suffered in drastic loss of body weight and general condition, their recovery being very difficult and slow. This observation strongly suggests the practical importance of controlling blood losses, mainly due to gastrointestinal parasites in copper-deficient animals.

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