13. Absorption of Haemoglobin Iron

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In studying nitrogen metabolism after alimentary bleeding, we have used the iron content of the faeces as a rough measure of the amount of blood effused into the bowel [Black & Leese, 1940]. This involved the assumption that a negligible quantity of haemoglobin iron is absorbed by the human intestine, and such appears to be the generally accepted view [Hahn, 1937; Shohl, 1939]. The published evidence for this opinion is, however, based mainly on animal work, is slight in amount, and some of the observations recorded are in conflict with the conclusions drawn. Cloetta [1896] gave blood to dogs, and analysed the alimentary contents 2 days after ingestion, before any faeces had been passed; no absorption of iron was detected. Lintzell [1931] found in one experiment on man that practically all the iron of ingested haemoglobin could be recovered in the stool. On the other hand, Elvehjem [1932] observed some increase in blood haemoglobin in anaemic rats after feeding haematin and copper salts. Moreover, Bing *et al.* [1936] found that only about 10% of ingested crystalline haemin could be recovered in the stools; in one patient, a slightly negative iron balance became positive after haemin was given, so it appears that the haemin iron was absorbed and retained. It was decided to approach the problem of haemoglobin iron absorption directly, in man, by determining the increase in the iron content of the faeces after the ingestion of a known amount of haemoglobin iron, so large that day-to-day fluctuations in the basal faecal iron could be neglected.

METHODS

Observations were made only on patients whose stools were free from occult blood (benzidine and pyramidone tests); a diet containing about 8 mg. of iron per day was used throughout the experiment. The stools were collected over 3-day periods in porcelain vessels. After a control period of 6–9 days, blood was administered by duodenal tube; 5–8 hr. were taken to run in a litre of blood, and an injection of codeine and atropine was given before the blood drip was started. The stool collection was continued until 6 days after the faeces were again free from occult blood. Iron analyses on the ingested blood and on the faeces were made by the titanous chloride method [Klumpp, 1934]. In view of the large sampling error with fresh stool, the samples for iron estimation were taken after deflagrating the 3-day stool [Brock & Hunter, 1937]; with this technique duplicate samples of normal stools agreed within 2%.

RESULTS

The experiment was carried out on two patients with iron-deficiency anaemia, and on one normal subject (see Table 1). Within 24 hr. of giving the blood, the stool was tarry, and blood was obvious in the stool for 3–4 days, while tests for occult blood remained positive for 5–6 days. The detailed results are given in the table; the amount of iron absorbed varied from 10 to 25% of the iron in the blood given. Blood was also given by mouth to a third anaemic patient, whose faeces could not be satisfactorily collected; of the three anaemic patients two showed a definite reticulocytosis and rise in blood haemoglobin after the giving of blood by mouth; the third (patient 2, who absorbed only 10% of the iron given) showed a slight increase in the reticulocyte count, but no haemoglobin response.

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Table 1

Patient 1. ♀. Hypochromic iron-deficiency anaemia. Hb=32% (Haldane).

3-day period	1	2	3	4	5	6	7
Iron in stool (mg. per period)	12.5	24.6	39.5	201.2	114.5	32.6	14.1
	Amount of blood given			1 l.			
	Iron content of blood given			334 mg.			
	Excess iron recovered in stool			267 mg.			
	Percentage of iron absorbed			20			

Patient 2. ♀. Hypochromic iron-deficiency anaemia. Hb=42% (Haldane).

3-day period	1	2	3	4	5	6
Iron in stool (mg. per period)	15.3	22.5	342.2	23.2	20.9	9.6
	Amount of blood given			970 ml.		
	Iron content of blood given			359 mg.		
	Excess iron recovered in stool			324 mg.		
	Percentage of iron absorbed			10		

Patient 3. ♂. Normal.

3-day period	1	2	3	4	5	6	7
Iron in stool (mg. per period)	39.4	42.3	26.2	115.0	178.8	20.5	17.9
	Amount of blood given			950 ml.			
	Iron content of blood given			313 mg.			
	'Easily split-off iron' in blood			26.6 mg.			
	Excess iron recovered in stool			235 mg.			
	Percentage of iron absorbed			25			

Note. In the first and third patients blood was given by mouth after the third period; in the second patient blood was given after the second period.

DISCUSSION

Of the iron contained in blood, about 5–10% is detachable from organic combination by incubation with 0.8% HCl—the so-called 'easily split-off iron' [Barkan, 1927]; the inorganic iron in the serum does not exceed 2 mg./l., and may be neglected for the present purpose. It is plain from the results that a larger portion of the iron is absorbed than can be accounted for as easily split-off iron; in the third patient an estimation of the easily split-off iron in the blood given showed it to be 26.6 mg., or 8.5% of the total iron, whereas no less than 25% of the total iron was absorbed.

Our type of experiment cannot exclude the possibility that some iron is absorbed and re-excreted, but that such a process happens to any significant degree is very unlikely [McCance & Widdowson, 1937]. It is of interest, in view of the demonstration by Hahn *et al.* [1939], that anaemic dogs absorb iron much more readily than normal dogs, that our anaemic patients seemed to absorb less iron than the normal subject; the explanation may lie in the fact that the anaemic patients had complete achlorhydria, whereas the control subject had rather high figures for free and total gastric acidity.

The absorption of iron from haemoglobin is not likely to occur unless the haemoglobin has suffered some degree of breakdown in the alimentary tract. It is known that absorption of the organically combined iron in meat is increased by the changes brought about in cooking [Oldham, 1941], and it seems at least possible that digestive or putrefactive processes may cause similar changes in ingested blood. Bing *et al.* [1936] have shown that of the alimentary secretions only gastric juice would break down haemin *in vitro*; on the other hand, faecal bacteria readily destroyed haemin under similar conditions. It may be significant that in our second patient, in whom only 10% of the haemoglobin iron was absorbed, there was definite intestinal hurry, with complete evacuation of the blood inside a single 3-day period; in the other two subjects, the more gradual evacuation of the bowel must have afforded a greater opportunity for the bacterial breakdown of haemoglobin.

SUMMARY

A litre of blood was given by mouth to one normal and two anaemic patients, and the faecal iron determined. It was found that 10–25 % of the ingested iron was absorbed.

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