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ANAEMIA IN POOR CLASS WOMEN WITH SPECIAL REFERENCE TO PREGNANCY AND MENSTRUATION

BY

HAROLD W. FULLERTON, M.A., M.B., Ch.B.

BEIT MEMORIAL RESEARCH FELLOW

(From the Department of Medicine, University of Aberdeen)

About four years ago it was decided by Professor L. S. P. Davidson of the Department of Medicine, Aberdeen University, that a large-scale investigation into the incidence, aetiology, and treatment of anaemia among the poor classes should be carried out in Aberdeen. This work has entailed estimation of the haemoglobin levels of more

a fair average of the poorest classes in Aberdeen. In many families the wage-earner was unemployed. The average income for the entire group was roughly 11s. weekly per "man-value." In this communication the anaemia of adult women will be discussed with special reference to pregnancy and menstruation.

FIG. 1.

than 3,000 individuals of both sexes and of all ages, from infancy onwards. It is important to emphasize that the subjects included in this survey considered themselves to be in normal general health; they were not selected because anaemia was suspected. Indeed, every precaution was taken to ensure that they formed a representative cross-section of the poor classes in Aberdeen. Many of them were volunteers obtained at dispensaries for the poor and at clubs for the unemployed. In other cases—for example, at ante-natal clinics—a haemoglobin estimation formed part of the routine examination of every woman who attended. The economic status of the different groups naturally varied, but it is on the whole

Effect of Age

In Fig. 1 the average haemoglobin levels of 1,534 women of different age groups are presented. The group of 715 non-pregnant women contained no nulliparae; the remaining 819 women were pregnant at the time of examination, and of these 40 per cent. were nulliparae. Haldane haemoglobinometers were used for all haemoglobin estimations, and their accuracy was repeatedly checked; the haemoglobin standard, therefore, is such that 100 per cent. corresponds to 13.8 grams of haemoglobin per 100 c.cm. of blood. The figures at each point on the curves in this and in subsequent charts represent the number of individuals examined.

The main conclusions drawn from these curves have already been published,¹ and may be summarized here as follows:

1. The haemoglobin percentage curve for non-pregnant women falls gradually throughout reproductive life and lies well below the normal standard for women—98 per cent., according to Price-Jones.

concentration. Of pregnant women 49.5 per cent. had haemoglobin percentages of less than 80; 17.5 per cent. were below 70; but only 1.5 per cent. showed less than half the normal level. Thus there is a greater incidence of anaemia in pregnant than in non-pregnant women, but the percentage of cases of very severe anaemia (haemoglobin less than 50 per cent.) is less.

FIG. 2.

2. After the menopause there is a marked rise in the average haemoglobin level.

3. The curve for pregnant women shows a striking parallelism to that for non-pregnant women, and lies about 5 per cent. below it for all age groups.

The effect of age on the incidence of anaemia is shown graphically in Fig. 2. It is seen that the percentage of non-pregnant women with less than 70 per cent. haemoglobin increases markedly with age, rising from 10.5 per cent. for the age group 15 to 19 years to 28.6 per cent. at the menopause. Thereafter the incidence falls gradually to zero for the over 65 age group. The incidence of haemoglobin levels of less than 70 per cent. in pregnant women is greater for all age groups and shows the same rise with increase in age.

Fig. 3 shows the distribution of haemoglobin levels in pregnant and non-pregnant women aged 15 to 44. The abscissa represents decimal ranges of haemoglobin and the ordinate the percentage of subjects whose haemoglobins fell into each decimal range. The chart for non-pregnant women shows that 30 per cent. had haemoglobins less than 80; 16 per cent. were below 70; and as many as 6 per cent. had less than half the normal haemoglobin

Iron Intake

Complete blood examinations and treatment by iron of several hundreds of these women have shown clearly that the anaemia is due to iron deficiency. Therefore, the majority of women of this class are presumably in negative iron balance throughout reproductive life; menstrual blood loss and repeated pregnancies apparently constitute demands which are inadequately met by the dietary intake of iron. The diet of this class of the population is strictly limited by income, consists largely of iron-poor carbohydrate foods, and is low in iron-rich foods such as animal protein and green vegetables. The calculated iron intakes of forty-nine poor families in Aberdeen have been previously reported in detail.² The average iron intake per day was 10.71 mg. per "man-value,"

FIG. 3.

and intakes of 5 and 6 mg. were not uncommon. Cathcart's³ standards of relative food requirements were used in computing the "man-value" of each family. On this basis a woman is reckoned as 0.8 of a man. Hence the average daily intake of iron was 8.57 mg. in the case of women. In these calculations no allowance was made for waste in cooking. If the recom-

mended deduction of 10 per cent. be allowed for wastage, the daily intake of iron of poor women in this city is approximately 7.71 mg. Widdowson and McCance⁴ did not make these deductions in comparing our figures with their findings in the series of women of the middle classes whom they investigated. However, direct estimations of the total and "available" iron contents of the dietaries of poor women in Aberdeen are to be carried out, and will give more definite information on this important point. A further modification of the above figures is necessary in view of the fact that the iron content of "golden syrup," which is consumed often in large quantities by the poor families in this city, was erroneously taken to be the same as that of molasses, which actually has a much higher iron content. Correction for this error reduces the average daily iron intake to 7.3 mg. for women. From published reports^{4 5 6 7} of the availability of iron in foodstuffs, it appears that probably about 75 per cent. of the total iron content of the diets of poor women is "available." It can be assumed that approximately one-half of this amount may be absorbed.⁸ Thus in the class of women under consideration an average of about 5 mg. of "available" iron is ingested daily and approximately 2.5 mg. of iron may be absorbed.

Thus the majority of women of the poor classes are restricted to an iron intake which is very much less than the generally accepted standard figure of 15 mg. per "man-value" given by Sherman.⁹ It is interesting to observe, however, that the haemoglobin curve of women who have passed the menopause shows a marked rise (Fig. 1), indicating that, when the demands of pregnancy and menstruation have ceased, this low iron intake permits of considerable haemoglobin regeneration. This fact becomes still more striking when it is realized that absorption of iron is less efficient in older women, since the incidence of achlorhydria increases with age.^{10 11 12 13 14 15} Iron balance studies have indicated that adult males can maintain iron equilibrium on very low iron intakes,^{16 17} and it therefore becomes evident that no standard figure for optimal iron intake can be recommended without consideration of the factors of age and sex.

Relation to Income

In my opinion iron-deficiency anaemia is much more common among women of the poor classes than the middle and upper classes, but it has not been found possible to obtain a series of the latter type for comparison. Throughout our investigations, however, details of the income and number of dependants were obtained where possible from the women who volunteered for blood examination. The average weekly income was then calculated on the "man-value" basis, and the correlation between this figure and the haemoglobin level was investigated.

TABLE I.—Haemoglobin Levels according to Incomes

	Weekly Income	Number of Cases	Average Hb.	Average Age	Hb. less than 70 %
332 pregnant women	Less than 15/-	164	73.1	24.3	32 = 19.5 %
	15/- or more	168	79.6	24.8	24 = 14.3 %
140 non-pregnant women	Less than 15/-	97	83.2	24.6	13 = 13.4 %
	15/- or more	43	86.3	24.4	5 = 11.6 %

The results presented in Table I show that both in pregnant and in non-pregnant women the average haemoglobin level is lower and the incidence of anaemia is higher in the groups with incomes of less than 15s. weekly per "man-value." Since there is a difference in the inci-

dence of anaemia between the groups of women whose income is below and above 15s. a week—the latter group averaging £1 a week with very few individuals reaching an income of 30s.—it is not unreasonable to assume that the difference would be more marked if data regarding women of higher income groups were available. This supports our view that in the middle and upper classes, where the diet is not restricted by economic circumstances, the incidence of anaemia is probably much less. Further evidence in favour of this deduction is provided by the investigations of Price-Jones,¹⁸ Williamson,¹⁹ and others, which have shown high haemoglobin levels in women of the middle classes.

Number of Pregnancies

It is not the purpose of this paper to consider in detail the aetiology of the hypochromic anaemia which is so common in women of the poor classes. Our attention will be confined to the two factors which represent the greatest demands for iron—namely, menstruation and child-bearing. It is often held that repeated pregnancies constitute the most frequent cause of the hypochromic anaemia of women. This belief is due to the fact that this form of anaemia occurs especially during the latter part of reproductive life in poor women, many of whom give a history of repeated child-bearing. It has already been shown that women of the older age groups have a greater incidence of anaemia than younger women. Also, it is apparent that on the whole the older women show a greater degree of parity than the younger women. It is therefore obvious that the average haemoglobin levels of women with many previous pregnancies will be lower than those of women with few previous pregnancies, since the average age of the former group will be greater than that of the latter. Thus in a group of 242 non-pregnant women aged from 15 to 44 the average haemoglobin level of those with five or more previous pregnancies was 79 per cent. and of those with none to two previous pregnancies 85.7 per cent. The average age of the former group was 33.5 years and of the latter 25. A similar finding held for pregnant women. The average haemoglobin of women who had had five or more pregnancies was 74.6 per cent., and of those who had had two or less pregnancies 79.2 per cent., the average ages being 34.1 and 23.7 respectively. It is clear, however, that this does not prove that repeated pregnancies constitute a greater iron drain than menstruation, unless the correlation between parity and anaemia can be shown for women of the same age groups. Accordingly an analysis has been made of the haemoglobin levels of women arranged in age groups and divided into those with three or less, and those with four or more, previous pregnancies. The results are shown in Table II, and the average haemoglobin

TABLE II.—Haemoglobin Levels and Incidence of Anaemia according to Parity

Age Group					25-29		30-34		35-39		40-44	
					0-3	4+	0-3	4+	0-3	4+	0-3	4+
Previous Pregnancies												
143 non-pregnant women	{	Number of cases	...	...	51	17	19	23	5	22	—	6
		Average Hb	...	...	86.8	82.4	83.9	82.5	80.8	82.0	—	76.3
		Percentage of cases with Hb. less than 70 per cent.			9.8	11.8	15.8	13.0	20.0	18.2	—	33.3
376 pregnant women	{	Number of cases	...	...	160	26	76	39	23	37	5	10
		Average Hb.	...	...	79.0	76.9	73.7	81.1	69.4	78.0	69.4	78.7
		Percentage of cases with Hb. less than 70 per cent.			17.5	23.1	27.6	15.4	43.5	21.6	60.0	20.0

levels of the different groups are presented graphically in Fig. 4.

It is seen that for 143 non-pregnant women no correlation exists between average haemoglobin levels and the degree of parity, while for 376 pregnant women the haemoglobin levels are on the whole higher in women with four or more previous pregnancies than in women with three or less previous pregnancies. Table II shows that the incidence of haemoglobin levels of less than 70 per cent. is unaffected by parity in the group of non-pregnant women, and is on the whole less in the groups of pregnant women who had had four or more pregnancies.

It may be deduced, then, that both pregnancies and menstruation cause in poor women demands for iron which are not compensated by the amounts which can be utilized from the diet. The cumulative effect of this

FIG. 4.

negative balance is shown by the fall in haemoglobin level during reproductive life, and evidence has been presented which suggests that in a large group of women the average demands for iron resulting from pregnancy do not exceed and may even be less than the average iron loss resulting from menstruation.

Quantitative Iron Estimations

A consideration of these iron demands on a quantitative basis supports this view and throws much light on the general problem of iron-deficiency anaemia in women. The demands for iron during reproductive life depend in ordinary circumstances on the following factors:

1. Blood loss during menstruation.
2. The supply of iron to the foetus, uterus, and placenta during pregnancy.
3. Iron supply during pregnancy for the increase in maternal tissues other than the uterus and its contents.
4. Blood loss at parturition.
5. Iron content of the milk during lactation.

MENSTRUAL BLOOD LOSS

Several investigations have recently been made into the iron lost in the menstrual flow.^{20 21 22} It is a matter of common knowledge that even in women who consider themselves to be quite normal in this respect the amount of blood loss varies greatly. On the other hand, many women who lose only moderate amounts of blood consider the loss excessive. It is therefore unlikely that a woman's estimate of the extent of this blood loss is of much value except in extreme cases. It has been found on analysis of our data that the average haemoglobin levels of women giving a history of excessive menstrual loss are practically the same as those for the entire group of women. The unreliability of the menstrual history has been clearly shown by Fowler and Barer,²² who found that in a group of women the amount of iron lost at each period varied from 3.5 to 450 mg., and the average figure for ten anaemic women was approximately 120 mg. All of these women considered themselves to have normal menses. In a similar investigation of fifty women, mostly members of a hospital staff, they found that the iron loss at each period varied from 3.84 to 78.4 mg.²¹ No woman with a haemoglobin percentage of less than 75 was included in this series, and all gave a normal menstrual history. Estimations of the iron loss during menstruation are being carried out in Aberdeen, but the results at present available are too few to be of value.

It is evident, then, that the degree of menstrual loss varies within very wide limits, and when severe obviously cannot be compensated by absorption of dietary iron. If we regard 2.5 mg. as the maximum daily retention of iron which can occur in women taking the average diet of the poor classes, then the total retention over twenty-eight days is 70 mg. Hence, if the menstrual loss exceeds 70 mg., a negative iron balance which will continue to the menopause is produced by this cause alone. Women taking a diet containing 3 to 4 mg. of iron daily could compensate for a monthly loss of iron amounting only to 30 or 40 mg. These calculations do not take into account the high incidence of achlorhydria and hypochlorhydria, which considerably reduce iron absorption.

We can conclude, then, that menstruation of a degree considered to be normal may produce iron deficiency in many women of the poor classes. Conversely, it may be calculated that only profuse menstruation can by itself be responsible for iron deficiency in women of the middle and upper classes. Widdowson and McCance⁴ found that the average intake of "available" iron in middle-class women whose diets were not restricted by income was 7.9 mg. daily. If half of this amount were retained, menstruation would not produce a negative iron balance unless the blood loss exceeded the equivalent of 110 mg. of iron at each period.

IRON LOSS IN PREGNANCY

The iron content of the foetus at term depends on several factors, especially the body weight, the haemoglobin level, and the blood volume. The committee of the White House Conference on Child Health and Protection²³ quote the figures of Hugounenq and Camerer and Söldner for the total of iron contents of eight newborn infants. The average is 341.6 mg., with a minimum of 268 mg. and a maximum of 392 mg. They select the figure of 375 mg. on which to base their calculations of foetal iron reserve. Coons *et al.*,²⁴ summarizing nine published analyses of the human foetus, find an average total iron content of 395 mg., and Macy and Hunscher²⁵ state that the foetus has accumulated 246 mg. of iron

at term. It appears, therefore, that 400 mg. can be taken to represent roughly the foetal iron content at term.

Quantitative estimations of the iron content of the placenta have not been found in the literature. Since the placenta weighs as a rule 1 lb.,²⁸ it is probable that its iron content does not exceed 100 mg.

The uterus at term weighs about 2 lb.²⁶ and contains, therefore, 50 mg. of iron if 5 mg. per cent. be taken as the iron content of skeletal muscle.²³ It is probable that during involution of the uterus part of its iron content is released and conserved by the maternal organism. If this be so, then 50 mg. should not be regarded wholly as maternal iron loss. The quantity, however, is comparatively small, and in the absence of exact knowledge of its fate shall be taken as part of the iron loss due to pregnancy. Therefore 550 mg. may be considered to represent the total iron supplied to the uterus and its contents during gestation.

IRON IN THE TISSUES

Several authors^{25 27 28} have presumed that an additional supply of iron is needed by the mother during pregnancy owing to the gain in weight which occurs over and above that due to the uterus and its contents. Thus, Coons²⁸ has taken 21 lb. as the average weight gain, excluding the weight of the foetus, and has calculated its iron content by applying the average figure (0.006 per cent.) for iron in the adult body, on the assumption that the lack of iron in the amniotic fluid is compensated by the large proportion of blood in the placenta. She deduces, therefore, that 500 mg. of iron is necessary for this purpose. This deduction is warranted only if such weight gain occurs in equal degree in all the body tissues, particularly those rich in iron—namely, blood and muscle. It is well established that the weight gain is attributable to an increased water content of the tissues and blood, and a diffuse deposition of fat, which disappear to a large extent shortly after delivery.^{29 30 31} Therefore extra demands for iron due to this cause may be neglected.

The iron balance studies of Coons,^{24 28} in pregnant women having an average dietary intake of about 15.7 mg. iron, have shown that over the whole period of gestation 799 mg. of iron may be retained. This should not be taken to mean that the maternal iron content will be reduced if the retention is less than this amount. Dieckmann and Wegner³² have shown that there may be an increase in the total circulating haemoglobin during pregnancy. It is probable that such a gain in haemoglobin occurs only in cases where the iron intake is high, and the amount of iron retained over and above that necessary for the uterus and its contents is presumably utilized for this purpose. Increased haemoglobin formation by the maternal organism is likely in cases where there is such a "surplus" iron retention in the presence of a pre-existing iron-deficiency anaemia, or when blood dilution due to physiological hydraemia is marked. Since we are here concerned only with the effects of pregnancy in reducing the maternal iron content, the iron utilized in some cases for new haemoglobin formation need not therefore be considered.

BLOOD LOSS AT PARTURITION

The degree of haemorrhage which occurs after delivery varies within very wide limits, and will be referred to in more detail later. Williams³³ measured the blood lost in 1,000 full-term labours and found that the average loss was 343 c.cm. Similar figures were recorded by Dieckmann and Wegner,³¹ Galloway,³⁴ and Richter, Meyer and Bennett.³⁵ Thus an average of approximately 175 mg. of iron is lost at parturition.

IRON CONTENT OF MILK

Published data regarding the iron content of human milk show marked variations. Wallgren found an average of 0.044 mg. per cent., and the Committee of the White House Conference²³ quote the figures of several investigators, the average of which is 0.13 mg. per cent. Garry and Stiven²⁷ take 0.044 mg. per cent. as the mean figure. It is probable that there is an inverse ratio between the quantity of milk secreted and its percentage mineral content. It was found by Schoedel³⁶ that healthy infants consumed daily 520 grams of human milk in the first month and 885 grams in the fifth month. Macy and Hunscher²⁵ found an increase in consumption from 640 grams daily in the first to 860 grams in the fifth month. Garry and Stiven²⁷ consider that the average is an increase from 500 grams to 1 litre daily. This represents an average of 750 grams over the period of lactation. Taking 0.13 mg. per cent. as the iron content and 750 grams as the average daily consumption, we find that the maternal organism loses just under 1 mg. of iron daily by lactation. This is probably a high average figure for the class of women we are considering, since mothers of a poor social class have a milk flow which is 100 grams less than the figures quoted.²⁷ That it is approximately correct, however, is borne out by the finding of Langstein and Edelstein³⁷ that normal babies fed with human milk had an iron intake of 0.65 mg. during the fifth month.

Discussion

Hence the iron lost by the mother during pregnancy and the six months after delivery is represented by the sum of 550 mg. (uterus and its contents), 175 mg. (blood lost at parturition), and 180 mg. (iron loss during six months' lactation)—that is, a total of 905 mg. Since sixteen menstrual periods are missed during this time, the total drain of iron resulting from pregnancy and lactation is equivalent to a monthly loss of 57 mg. of iron by menstruation. Moreover, the total drain of 905 mg. of iron occurs over a period of 460 days, and represents therefore a daily loss of just under 2 mg. Hence a woman needs to achieve a positive balance of 2 mg. daily in order to supply the demands of pregnancy and lactation. When the figures for total and "available" iron intake of women of the poor classes in Aberdeen are considered it becomes evident that in many cases such a positive balance cannot be attained, and repeated pregnancies will therefore cause the gradual development of an iron-deficiency anaemia. Also, a quantitative consideration of the loss of iron resulting from pregnancy and menstruation has made it clear that in many cases menstruation constitutes a greater demand than pregnancy, thus explaining our finding that no positive correlation between the degree of parity and the haemoglobin levels or incidence of anaemia can be shown in women of the same age group.

It must, however, be borne in mind that repeated pregnancies may contribute to the production of iron deficiency in ways other than that considered. It has been shown by Strauss and Castle,³⁸ and Davies and Shelley³⁹ that the gastric secretion of hydrochloric acid is depressed during pregnancy. Our own results have confirmed this finding. It is therefore not unreasonable to suppose that repeated pregnancies may in many cases cause a permanent achlorhydria or hypochlorhydria, which, by reducing the amount of iron absorbed from the diet, will increase the liability to hypochromic anaemia. Moreover, with an increase in the number of children the income available for food, particularly the expensive iron-rich foods, becomes reduced, and hence the mother is more liable to the development of iron deficiency.

Conclusions

1. Anaemia due to iron deficiency is of very frequent occurrence in women of the poor classes in Aberdeen.
2. The iron deficiency is due to a combination of factors, of which a diet poor in iron and loss of iron during reproductive life are of great importance.
3. Evidence has been presented to show that in the group of 1,534 adult women investigated menstruation constitutes an iron loss at least as great as that due to pregnancy and lactation.
4. A quantitative study of the loss of iron due to menstruation and pregnancy has made it clear that the diets of poor women are very frequently inadequate to compensate for the iron demands of reproductive life.

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The Archives of the Academy of Sciences of the U.S.S.R. in Leningrad have received the first batch of papers belonging to the late Professor I. P. Pavlov. The papers, which were presented to the Academy by Pavlov's widow, comprise some 2,500 letters from scientists in Russia and foreign countries. Most of them relate to the years following the revolution. Among those received before the revolution are several from Metchnikov.

ANAEMIA AND TOXAEMIA OF
PREGNANCY*

BY

JOCELYN MOORE, M.B., B.S., F.R.C.S.

AND

E. M. PILLMAN-WILLIAMS, M.B., B.S.

The aetiology of toxæmia of pregnancy is at the present time so much under discussion that it is of interest to review any possible bearing that anaemia may have on either its aetiology or its development. It is also of value to consider the relationship of anaemia to the clinical and to certain biochemical findings in patients with well-established toxæmia.

Recent Literature

The references in the literature dealing with the haematological findings are singularly lacking. The majority of writers, however, agree that the anaemia, if present, is in this country of the hypochromic or microcytic type. This anaemia is probably a deficiency state due to lack of iron, and therefore improvement takes place when iron therapy is instituted. In India there is an entirely different state of affairs, as the anaemia is of the hyperchromic or macrocytic type, and is due to some deficiency in the vitamin B complex in the diet. Only occasional cases of macrocytic anaemia are seen in this country, therefore in this paper we shall confine ourselves to the consideration of the hypochromic (microcytic) type of anaemia.

O'Sullivan, in his investigations of pregnant women with albuminuria, either due to toxæmia or associated with urinary infections, found that in the former or toxic group fifteen patients out of nineteen suffered from hypochromic anaemia. In the "pyelitis" group twenty-one out of thirty-two patients who were given iron in addition to the usual treatment for the albuminuria, either of toxic or infective origin, looked and felt better after iron treatment. This improvement was also shown by a diminution in the amount of albumin present and by the rise of the haemoglobin content of the blood and the red cell count. On the other hand, Boycott, in his investigations on anaemia associated with pregnancy, did not find any connexion between anaemia and toxæmia.

A consideration of toxæmia in patients in whom there is pre-existing renal disease such as chronic nephritis led Whitby and Britton to form the opinion that anaemia of the hypochromic type is almost always associated with chronic nephritis. In these patients there is probably a disordered or diminished blood production, and it is not known whether this is due to a nutritional deficiency or to a toxic disorder. The haemoglobin value is usually about 60 per cent. or less if the disease is progressive. Robscheit-Robbins and Whipple, in their recent publication, suggest that anaemia in infective and toxic states in animals is due to a disturbance of the internal metabolism inhibiting the haemoglobin-building powers of the body, and not to a defective absorption or defective formation. They believe that this same factor is often of importance in human disease. Moore, in his series of haemoglobin percentages and blood count estimations amongst pregnant women, found that the lowest average readings occurred in the group of patients suffering from chronic nephritis complicating pregnancy. Stieglitz found that the presence of renal disease hindered the treatment of anaemia in pregnant women, and advised that energetic measures should be taken to combat this anaemia.

* Read in opening a discussion in the Section of Obstetrics and Gynaecology at the Annual Meeting of the British Medical Association, Oxford, 1936.