Observations

ON

NUTRITION IN RELATION TO ANAEMIA

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Recent advances in haematology clearly indicate that nutrition may play an important part in the production of anaemia. The evidence on which this statement is based is obtained from experimental work on animals and from clinical investigations in human beings. Thus Waddell, Hart, Steenbock, and Elvehjem¹ have shown that when rats are fed for some weeks on milk alone a hypochromic anaemia invariably develops, while the rate of growth of the animals is seriously reduced. So constant is this effect that anaemia produced in this way is regularly used for the assay of therapeutic agents. That the anaemia is nutritional in origin is shown by the fact that the addition of iron and traces of copper to the diet will prevent the occurrence of the anaemia, or, if it is already present, will rapidly effect a cure. A similar type of hypochromic anaemia has been shown by Helen Mackay² to be present in many infants of the poorer classes who are fed exclusively and over prolonged periods on cow's milk. Prevention and cure are readily obtained by the addition to the diet of a few grains of iron and ammonium citrate daily. While it is admitted, therefore, that milk is probably the nearest approach to a complete food that we have, it is certainly deficient in its blood-building qualities.

Evidence on the importance of iron in relation to anaemia and general health has also been obtained in the case of the larger domestic animals. McGowan and Crichton³ found that, unless given access to iron-rich food, sucking-pigs develop anaemia, which can be cured or prevented by iron salts. This condition appears to be common. Professor Knox of Guelph, Canada, in a recent personal communication to one of us, states that in Ontario the death rate of young pigs was very high until iron feeding was instituted, since when the mortality has been reduced to normal. A condition of acute anaemia also occurs in various parts of the world in cattle grazing on a special type of pasture which, according to Aston,⁴ is poor in iron. This anaemia can also be prevented or cured by iron salts (Aston,⁴ Orr and others⁵). It is well recognized that after famines, especially in tropical countries, anaemia, defective growth, poor resistance to infection, etc., are widespread; a similar condition of affairs was observed in Central Europe after the war. In view of the gross quantitative and qualitative deficiencies in a diet during times of famine, it would be difficult to allocate these ill effects to individual defects in the dietary.

These anaemias may be classified as direct deficiency diseases resulting from a definite deficit of iron in the dietary, but in human beings recent researches indicate that some very important types of anaemia should be classed as *conditioned* or *virtual* deficiency diseases.

Pernicious anaemia is probably the best example. Minot and Murphy⁶ have shown that this anaemia develops as a result of the deficiency of a substance (the specific anti-anaemic factor) which is found in liver, and which has been shown to be necessary for normal blood formation. Castle⁷ and others have shown that this factor is elaborated in the stomach as the result of an interaction of an enzyme-like substance (the intrinsic factor) secreted by the stomach with the protein of foodstuffs (the extrinsic factor). If the intrinsic factor is totally lacking, normal or even excessive quantities of protein are of no value in preventing the development of anaemia. For this reason pernicious anaemia is classified as a conditioned deficiency disease. Simple achlorhydric anaemia,⁸ in which the blood picture is of the hypochromic type, indicating iron deficiency, may be similarly classified. The cause is attributed to defective iron absorption from the gut consequent on alteration of the hydrogen-ion content secondary to achlorhydria. This form of anaemia develops on a diet with a normal iron content, and continues until large amounts of iron are given therapeutically. The deficiency, therefore, is a virtual one.

From what has been said it is clear that anaemia can be occasioned, either directly or indirectly, by dietary deficiency, and no modern classification of the anaemias would be acceptable which did not attempt to define this aspect. In a recent paper on the classification and treatment of anaemia,⁹ nutrition as an aetiological factor has been fully discussed.

A problem of immediate and practical importance, however, still remains to be considered. The world crisis, with its dislocation of trade and consequent widespread unemployment, has produced a marked lowering of the standard of living of the working classes. In this country, thanks to unemployment funds and organized relief, no person need approach the stage of starvation. Nevertheless, the unemployed man with a family must be dangerously near the lowest economic level at which satisfactory growth and health can be maintained. The problem of the relation of this lowered standard of living to the health of the future generation has assumed the greatest importance. In this paper, however, it is proposed to deal solely with one aspect—namely, the relation of nutrition to anaemia. An investigation was undertaken with the object of ascertaining whether anaemia was prevalent among the poor, and if so whether: (1) its origin lay primarily in dietary deficiency; (2) such factors as menstruation, pregnancy, and infection, etc., were of major importance; (3) the anaemia responded successfully to iron therapy; and also to ascertain the measures to be adopted for its prevention.

INCIDENCE OF ANAEMIA

Through the courtesy of the directors of the Aberdeen Dispensary, which is attended by those unable to pay for private medical attendance and who are not qualified to enrol under the panel system, an opportunity was given of examining a large number of poor persons under suitable conditions, and with the willing assistance of the medical officers of the dispensary. The majority of the cases investigated belonged to families in which the wage earner was unemployed.

Methods.—A clinical history was obtained from those who volunteered to have a blood examination. The great majority of these were apparently healthy individuals, and had presented themselves at the institution not for medical attention, but as escorts to their children or friends for whom advice was sought. In the case of women detailed information concerning menstruation, pregnancies, and parturition was recorded. Five hundred

persons were examined, of whom 455 were women and forty-five men. In addition, 100 children from families in the same class of the community were examined, the children being taken equally from families in which the mothers were anaemic and non-anaemic. Lastly, 650 children were investigated by Dr. Sutherland of Peterhead as part of an experiment which is being undertaken by him in conjunction with the department of medicine with reference to vitamin A as a prophylactic agent in regard to infection. While no blood tests were performed, Dr. Sutherland carefully examined on two occasions the skin and mucous membranes of every child for clinical evidence of anaemia.

Haemoglobinometer and Standard.—The standard haemoglobinometer used was the Haldane carboxyhaemoglobinometer, calibrated so that a reading of 100 per cent. was equivalent to an oxygen-carrying capacity of 18.5 per cent., or 13.8 grams haemoglobin per 100 c.cm. of blood. This is the standard used by Price-Jones in his observations on normal people. The instrument was carefully examined by him and found to give accurate readings when compared with those obtained by the van Slyke method. The normal figures obtained by Price-Jones by this method of haemoglobin estimation were, in 100 men, 105 per cent., and in a similar number of women, 95 per cent. These figures were therefore accepted as standards of normality.

Arrangement of Results.—Cases with haemoglobin values of 85 per cent. or over were placed in Group I; those with 70 to 84 per cent. in Group II, which may be held to constitute mild anaemia cases; and those under 70 per cent. in Group III. In this last group many severe cases of anaemia were present, and members were advised to attend Professor Davidson's department at the Aberdeen Royal Infirmary, where they underwent full physical and blood examination, as well as gastric analysis by fractional test meals whenever possible. Additional data were thus made available concerning them.

TABLE I*

	Total	Group I	Group II	Group III
A. Children ...	100	98%	2%	0
	650	99%	1% (approx.)	0
B. Adult males ...	45	88.9%	6.7%	4.4%
† C. Adult females	455	53.2%	33.0%	13.8%

* All cases of anaemia found in this investigation were of the microcytic hypochromic type.

† Degrees of Anaemia in Decimal Ranges of Haemoglobin

Haemoglobin	85 and over	84-75	74-65	64-55	54-45	44-35	34-25	24-15	Total
No. of cases	242	118	45	19	14	9	7	1	455

Of the forty-five adult males only five were found to be anaemic. Three had haemoglobin levels between 70 and 85 per cent., while two were below 70 per cent. At the time of blood investigation one was suffering from a bleeding duodenal ulcer, another from a recent haemoptysis, while a third was 69 years old, with arteriosclerosis and chronic bronchitis. Of the 455 adult females, mainly between the ages of 18 and 55, 213 (46.8 per cent.) had haemoglobin values below 85 per cent., and of these sixty-three (13.8 per cent.) were below 70 per cent. haemoglobin. Only two of the 100 children from poor families were found to have a haemo-

globin percentage below 85, and of the 650 children in Peterhead only six were found to be anaemic in the first examination and eight in the second.

This part of the investigation indicates that anaemia is relatively uncommon in children between the ages of 5 and 14 years and in adult males, but that it is very prevalent among women of child-bearing age of the poorest classes, since it was found to be present in nearly half the cases examined.

DIETARY SURVEY

An attempt was then made to ascertain whether this incidence of anaemia could be correlated with the iron content of the diet. Information was collected concerning the food consumption over a period of fifteen days of forty-nine families in Aberdeen, of which twenty-five mothers were anaemic and twenty-four had a normal blood level. In addition, a similar investigation among sixty-six families from the poorest classes in Peterhead was undertaken; it was from these latter that a considerable proportion of the 650 children mentioned above was drawn. The method used was similar to that employed by Orr and Clark,¹⁰ except that the period was fifteen days instead of one week. In the calculations no allowance was made for waste in cooking. The figures given in the table, therefore, show the amount of food entering the home, and not the amount actually consumed. In accordance with the estimate of the Food Committee of the Royal Society¹¹ of allowance for waste, 10 per cent. should be deducted from the figures given below.

Cathcart's¹² standards of relative food requirements were used in computing the man value of each family, and no account was taken of occupation. In this method each individual of the family is assessed according to age and sex in terms of one man as a unit; thus a child of 2 is reckoned as 0.4 of a man. The average food consumption per man value per day for iron and for other important constituents, as well as the income and milk consumption, are shown in the following table. For the sake of comparison the results obtained in the Aberdeen and Peterhead surveys during 1926-7 are included.

TABLE II.—Average Consumption per Man Value per Day

	Aberdeen		Peterhead		
	Present Survey		Previous Survey	Present Survey	Previous Survey
	Anaemic	Non-Anaemic			
Calories ...	2584.0	2375.0	3531.0	2229.0	4120.0
Protein (grams) ...	84.1	75.4	107.9	80.5	125.1
Carbohydrate (grams) ...	395.3	377.6	561.0	431.9	685.7
Fat (grams) ...	65.8	55.7	84.8	56.9	85.2
Calcium (grams) ...	0.712	0.703	0.97	0.683	1.19
Phosphorus (grams) ...	1.313	1.197	1.75	1.282	2.14
Iron (grams) ...	0.0114	0.0100	0.015	0.0115	0.020
Copper (milligrams) ...	3.21	2.88	—	3.43	—
Milk per man value per day (pint)	0.51	0.44	0.57	0.36	0.56
Income (shillings) ...	1.49	1.41	1.80	1.18	1.52

It is interesting to note that the intake of all the constituents is lower in the present investigation than it was in the corresponding dietaries surveyed in 1926-7. With the increase in industrial depression since 1926 the dietary of the poorer classes of the community has become

definitely worse. The lack of employment, as indicated by the lowering of the income per man value, has resulted in a lower purchasing power, which is reflected in the food intake. In both towns there is a fall of about 22 per cent. in the average total income per man value and a fall of 26 to 30 per cent. in each of the individual constituents of the diet. If the income were assessed as per person and not as per man value, the figure would be even lower, and for Aberdeen would average 1.1 shillings per day. While it is true that there has been a fall in the cost of food, it is apparent that this has not been sufficient to counterbalance the fall in income. This is probably due to the fact that expenditure on other items, such as rent, clothing, fuel, and amusement, has not fallen proportionately. The average diet of the families with cases of anaemia is very similar to that of families with no cases of anaemia. The differences appearing in the above table between the two classes can be regarded as within the limits of experimental error in this method of survey, although it is interesting to note that, on the whole, the anaemic families were taking a slightly better dietary than the non-anaemic. Both diets are poor, the caloric intake and each individual constituent being in most cases below or on the borderline of the following generally accepted standards: calories, 3,000 to 3,500; protein, 100 grams; calcium (Sherman), 0.68 gram; phosphorus (Sherman¹³), 1.32 grams; iron, 0.015 gram per man value per day.

It is obviously impossible to assess the vitamin content with any degree of accuracy. It must, however, have been comparatively low, since the bulk of the dietary in nearly all cases consisted of white bread and other wheat flour foods, potatoes, and sugar, with some meat and fish. The intake of fresh fruit, green vegetables, and milk was low, the consumption of milk per man value being barely half a pint per day.

More detailed information with regard to the diet in the anaemic and non-anaemic families of the Aberdeen survey is given in the following distribution tables. Table III gives the energy-yielding constituents and Table IV the mineral content. The results for the Peterhead survey are not set out in this manner, as they show a very similar distribution, and the figures would accordingly be redundant.

TABLE III

Calories	Protein		Carbohydrate	Fat	
	Anaemic	Non-anaemic		Anaemic	Non-anaemic
1,500-1,750	2	2	grams 40-50	—	1
1,750-2,000	1	5	50-60	2	6
2,000-2,250	4	6	60-70	3	4
2,250-2,500	3	2	70-80	8	3
2,500-2,750	7	3	80-90	3	5
2,750-3,000	3	4	90-100	5	3
3,000-3,250	2	—	100-110	2	1
3,250-3,500	2	—	110-120	1	—
3,500-3,750	—	1	120-130	—	1
3,750-4,000	—	1	130-140	1	—
4,000-4,250	1	—			
	25	24		25	24

TABLE IV

Calcium	Phosphorus		Iron	Copper	
	Anaemic	Non-anaemic		Anaemic	Non-anaemic
grams			mgms. 5.3-6.0	0	4
			6.0-7.5	4	4
			7.5-9.0	3	2
			9.0-10.5	5	6
0.150-0.300	—	2	10.5-12.0	4	2
0.300-0.450	4	2	12.0-13.5	2	2
0.450-0.600	7	6	13.5-15.0	2	2
0.600-0.750	6	5	15.0-16.5	1	—
0.750-0.900	1	4	16.5-18.0	3	1
0.900-1.050	4	1	18.0-19.5	—	—
1.050-1.200	1	2	19.5-21.0	—	—
1.200-1.350	1	2	21.0-22.5	1	—
1.350-1.500	—	—	22.5-23.2	—	1
1.500-1.650	1	—			
	25	24		25	24

An examination of the tables shows that there is no correlation between the incidence of anaemia and any of the dietary constituents. In particular it should be noted that there is no correlation between the iron content of the diet and the haemoglobin content of the blood. The lowest iron intake, between 5 and 6 mg. per man value per day, was found in four families in which there was no anaemia. One family of five had normal haemoglobin values with a daily intake of less than 6 mg. From experimental data on iron elimination, it has been suggested that 15 mg. per day should be taken as a safe standard of the requirement of iron. It is obvious from the results of the present investigation that a normal blood picture can be maintained at a much lower level.

Although there is no information in the literature as to the copper requirements of human beings, it is of interest, in view of the possible connexion between copper supply and iron metabolism, that the copper intake of the two groups of the Aberdeen families and of the Peterhead families was at approximately the same level. These results show that on dietaries of this type the copper intake averages about 3 mg. per man value per day, and a normal blood level may be maintained on a lower intake than this.

IMPORTANCE OF FACTORS, OTHER THAN DIETARY, IN CAUSATION OF ANAEMIA

The distribution of the 455 women examined in the dispensary is recorded in three groups in Table I. The different groups will now be considered in regard to the question of "disability." This term is intended to indicate possible factors other than diet in the causation of the anaemia.

Menorrhagia.—This "disability" is based entirely on the history elicited from the case. An attempt to differentiate between slight, moderate, and heavy menorrhagia was found to be so arbitrary as to be of little value. Nevertheless it appeared that heavy menorrhagia was most frequent in Group III and least frequent in Group I.

Pregnancy and Childbirth.—A patient was considered to be associated with this "disability" when she was pregnant at the time of examination or had had a child or miscarriage within a year previous to examination.

"Infection."—This term is taken to indicate a heterogeneous group of conditions such as syphilis, bronchitis, pharyngitis, cystitis, pneumonia, tuberculosis, etc. For convenience, recent operations, kidney disease, haemorrhage other than uterine, etc., are also included under this heading.

It must be pointed out that such symptoms as pallor, weakness, and breathlessness on exertion, which might be due to anaemia, are not included under the term "disability." Practically all the cases in Group III complained of such symptoms on being questioned. The role of achlorhydria as a causal factor is considered separately. The relation of "disability" to the three groups is summarized in Table V. From a study of Table V it

TABLE V

Group	Haemoglobin per cent.	Number of Cases	History of "Disability"	*Menorrhagia	Pregnancy or Childbirth		"Infection"	Average Number of Pregnancies	Average Weekly Income per Person
					Recent	Present			
I	85 and over	242	50 (20.7%)	21	10	3	16	4.6	7s. 8½d.
II	70-84	150	84 (56%)	31	18	10	25	4.9	7s. 10d.
III	Less than 70	63	47 (74.6%)	26	10	6	5	5.9	7s. 1½d.

* In Group I five of the thirty-four cases of menorrhagia and pregnancy were associated with "infection" in addition; in Group II the figures were five out of fifty-nine; and in Group III four out of forty-two.

will be seen that the proportion of disabilities is lowest in Group I (20.7 per cent.) and highest in Group III (74.6 per cent.). Menorrhagia and pregnancy or recent childbirth are the factors which appear to bear the most direct relation to the degree of anaemia. Fourteen per cent. of cases in Group I are associated with these conditions, 39 per cent. in Group II, and 67 per cent. in Group III. Since "infection" is a factor common to children and adult males as well as females, and since it is less frequent in cases of severe anaemia than it is in cases having no anaemia or only a mild form, we are of opinion that the role of "infection" in the production of the anaemia is only of subsidiary importance.

ACHLORHYDRIA

In addition to the disabilities discussed above, the role of gastric secretion (in relation to anaemia) was investigated whenever possible. Test meals were performed in twenty-eight cases belonging to Group III. Of these, twenty-five showed achlorhydria in the fasting-juice, and, out of these twenty-five, seventeen maintained achlorhydria in response to the gruel, including thirteen which remained achlorhydric even after histamine injection. The remaining eight of these twenty-five cases showed definite hypo-acidity. Of the other three cases two showed a normal curve and one had hyperacidity. It is interesting to note that these last three gave histories of recent blood loss. One had had severe menorrhagia with periods lasting for fourteen days; another had a history of menorrhagia and had had a child two months previously; while the third dated all symptoms of anaemia from excessive blood loss at the birth of a child two weeks previously. As a control experiment test meals were performed on nine women who had a haemoglobin value of not less than 80 per cent. None of these cases gave

a history suggestive of a gastric lesion. One case showed complete achlorhydria even after histamine injection. The remaining eight responded to gruel, the lowest maximum figure for free hydrochloric acid being 16.

It is thus seen that over 89 per cent. of women of the anaemic group on whom gastric analysis was performed had achlorhydria or hypochlorhydria, as compared with 11 per cent. of non-anaemic women. If defective gastric secretion is considered along with menorrhagia, pregnancy, and "infection" under the term "disability," over 90 per cent. of the women in the severely anaemic group give a history of "disability" as opposed to 20.7 per cent. in the non-anaemic group. The importance of the role of achlorhydria in the production of hypochromic anaemia is now generally admitted, but it is a moot point, and one which we do not propose to discuss in this paper, whether the achlorhydria (through its effect in decreasing iron absorption) leads to anaemia, or whether anaemia by itself causes achlorhydria consequent on the poor blood supply to the gastric glands.

RESULTS OF ADMINISTRATION OF IRON SALTS TO ANAEMIC SUBJECTS

Table VI shows the results obtained by administration in twenty cases of Group III of 30 grains of iron and ammonium citrate three times a day. (For a full report of fifty cases see *Proceedings of the Royal Society of Medicine*, March, 1933.)¹⁴

TABLE VI

	Initial Blood Count		Duration of Treatment in Days	Subsequent Blood Count	
	Haemoglobin %	R.B.C. 10 ⁵ per c.mm.		Haemoglobin %	R.B.C. 10 ⁶ per c.mm.
1	19	2.23	44	80	4.40
2	24	3.13	27	70	4.42
3	31	4.01	60	80	4.68
4	30	3.52	34	65	4.13
5	45	3.87	35	72	5.23
6	45	3.58	40	75	3.89
7	45	2.65	83	92	4.60
8	47	3.00	14	70	4.24
9	30	2.50	96	85	4.34
10	26	3.50	49	70	4.59
11	45	3.52	64	88	4.57
12	55	4.64	28	83	5.05
13	32	3.25	21	85	4.60
14	35	3.13	51	100	5.50
15	32	2.14	50	100	5.02
16	35	3.47	60	92	4.74
17	40	5.09	54	80	4.23
18	38	3.72	16	74	4.15
19	50	3.68	30	76	5.67
20	43	3.57	97	80	5.09

DISCUSSION

The figures generally accepted for the iron content of an average diet are based on the studies made by Sherman of 150 American dietaries. The iron content was found to vary from 14 to 20 mg. of iron per man value daily. From his metabolic studies he concludes that an adult requires from 6 to 16 mg. of iron daily. McLester¹⁵ rightly points out that this investigation does not take into consideration all contingencies. For instance, the iron-sparing qualities of calcium are of practical impor-

tance ; it is definitely known that a normal blood level can be maintained on a diet rich in calcium and moderate in iron, but that anaemia will occur on the same iron intake if the calcium is reduced. Again, women need more iron than men to meet the demands of menstruation, pregnancy, and lactation. For these reasons it is generally agreed that the food ingested daily should contain at least 15 mg. of iron.

The dietary survey of 115 families of the poorest classes in Aberdeen and Peterhead indicates that the daily iron intake is markedly below this figure, since an average of 11 mg. of iron daily was ingested. Nevertheless, many persons were found to be in good health, with normal blood levels, on a daily intake of iron of 6, 7, or 8 mg. In short, provided no demands for additional iron were present (such as are discussed in the following paragraph), no person was found to be taking a diet so poor in iron that an anaemia could be attributed to direct iron deficiency. The minimum iron requirement therefore must lie below 6 mg. daily. The figure is all the more surprising since the average calcium intake was low, so that the absence of anaemia could not be explained on the grounds of the iron-sparing properties of calcium.

At first sight, then, since there appears to be no correlation between the incidence of anaemia and direct iron deficiency in diet, it might be presumed that diet plays little or no part in the prevention or production of anaemia. A consideration of additional information at our disposal, however, places the problem in a different light. In this investigation the subjects could be divided into two groups: (1) 750 children between the ages of 5 and 14 years, and forty-five adult males ; (2) 455 adult females, mainly between the ages of 18 and 55. In Group I anaemia was conspicuous by its relative absence, while in Group II nearly half the individuals were anaemic. It is obvious, therefore, that some function of womanhood must be the deciding factor in the production of the anaemia, and the data we have already discussed makes it abundantly clear that blood loss during menstruation and following pregnancy, and the increased demands for iron for the foetus during pregnancy, and for the mother during lactation, together with defective iron absorption secondary to achlorhydria, are the deciding factors in the production of anaemia in women. If the iron content of the dietary were adequate to meet these hazards anaemia would be relatively infrequent, except where the degree of blood loss was so excessive and continuous that no diet could reasonably be expected to make good the haemoglobin deficiency. It appears to us not unreasonable that a higher iron intake in the diet would probably raise the majority of the slightly anaemic women in Group II to normal levels. That the anaemia is due to iron deficiency, and, further, that the diet cannot adequately supply the deficiency, is abundantly clear from the dramatic effects which are produced by the treatment of these individuals with large doses of iron and ammonium citrate without any alteration in the diet. (Vide Table VI.)

With regard to the children between the ages of 5 and 14 years, it was found that the iron required for haemoglobin formation and growth was adequately met by the daily iron intake in the food. The figure, therefore, for the iron requirements of growing children is much smaller than was formerly believed to be necessary. We are unable to express any definite views about the body's reserve stores of iron in children and adult males, since increased demands for iron to meet eventualities were seldom seen in these classes in this investigation. Information could be obtained only by studying the rate of blood regeneration in persons suffering from anaemia secondary to blood loss, such as occurs in peptic ulcer, who belonged to groups drawn from the poorest class of the community and from

a class having good economic status. Similarly, for the experiment in women to be complete we should have to compare the blood condition of 500 women of the poorest classes with that of a similar number of women from a better economic level, where the iron intake would be approximately 20 mg. daily. No figures are available, but we are unable to believe from our clinical experience that 46 per cent. of women in the upper classes between the ages of 18 and 55 are anaemic.

In conclusion, we may say that dietaries containing from one-third to one-half the usually accepted iron content will suffice to maintain a normal blood level, provided, as is usually the case in children and adult males, there are no additional demands for haemoglobin. In all nutritional studies it is necessary to distinguish minimal from optimal dietaries. The latter should be adequate for the maintenance of health and to meet periodic and increased demands consequent on the hazards of life. It is certain that for women the dietaries in this investigation were iron-deficient, as judged by the high percentage of anaemic persons and by the response of the anaemia to iron administration. The iron requirement for women is obviously tidal ; it corresponds with certain functions of womanhood already discussed, and at such times may be very much higher than normal.

Lastly, certain extremely important aspects of preventive medicine must be considered. If the percentage of anaemic women found in Aberdeen is present in the industrial areas of the South (and we believe that anaemia may be even more severe there, since economic conditions are worse and the cost of living higher), then the loss of economic efficiency of the working-class mothers of this country must be enormous. It is true that most of the women investigated complained of few if any symptoms of ill-health, but this was due to the fact that they had become accustomed to living subnormal lives for years and had really forgotten the joy of good health. They invariably admitted that this was so, when, after efficient treatment, their blood level had been restored to normal. It is also certain that anaemic persons are more liable to infection and other forms of illness than persons with a normal blood level, as has been shown by the researches of Helen Mackay.² For the maintenance of health during infancy the natural stores of iron must be adequate, since the infant makes his blood from the rich iron deposit in the liver stocked during gestation. A liver poor in iron allows anaemia to develop rapidly in an infant on a milk diet. On the grounds of economic efficiency and of health the prevention of anaemia in working-class women and infants has become a major problem, and one which demands immediate attention. It is suggested that a glass of milk (half a pint, which would supply 0.34 gram of calcium and 0.28 gram of phosphorus) and a pennyworth of iron and ammonium citrate, without any additional change in the diet of pregnant women of the poorest classes, would produce remarkably beneficial results to mother and infant. This is at present being investigated in Aberdeen.

SUMMARY

1. Anaemia is prevalent among nearly half the women of the poorest classes in Aberdeen, but is not common among men or school children.
2. The anaemia appears to be mainly due to increased demands for iron as a result of (a) frequent pregnancies ; (b) excessive blood loss during menstruation and at parturition.
3. This anaemia cannot be directly correlated with the iron content of the diet.
4. The dietaries investigated are minimal, not optimal, since they are incapable of meeting the iron requirements under the conditions referred to above (No. 2).

5. The anaemia can be rapidly cured, with marked improvement of general health, by the administration of iron salts.

6. The relation of these findings to preventive medicine is discussed.

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EXPERIMENTAL SHOCK

WITH SPECIAL REFERENCE TO ANAESTHESIA *

BY

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The problem of why persons subjected to physical trauma should pass into a condition of shock is one which has long been of interest to surgeons. Nowadays, indeed, shock rivals sepsis in its importance in surgical operations.

During the war the study of the subject received a great deal of attention, and many valuable conclusions were reached, but there still remains, especially on the clinical side, a state of great confusion. The present state may, I think, be indicated by the fact that the College last year divided one of its valuable prizes between two surgeons whose views on the treatment of so-called surgical shock were a direct contradiction one of the other.

Now it happens that shock can be produced with great ease in laboratory animals, and in the time at my disposal I propose to put forward evidence to you which will emphasize that shock is not a single entity, but may be produced experimentally and clinically from a variety of causes, and that any single remedy used without understanding of the case in hand is bound to give most contrary results.

DEFINITION OF SHOCK

We may define shock in an animal as the state which results from a fall of arterial blood pressure, which, if severe, may lead to death from oxygen want. Its onset may, however, be preceded by a compensated or even over-compensated stage in which the body succeeds in maintaining the blood pressure against the forces which would cause it to fall.

From our knowledge of the circulation, then, we must consider that shock may occur from cardiac failure, from loss of blood, from increased capacity of the circulation—that is, from an undue opening-up of vessels which are normally closed—or from a reduction of the peripheral resistance to the flow of blood from the arterial system. From the point of view of surgery, however, it is probably best to group the various experimental procedures under

headings which are indicative of the cause. In dealing with the detail I shall deliberately omit a large number of minor points, because I feel that if there was a clearer understanding of the principles involved the literature would not be in the confused state that we find it in to-day, for I am convinced that much of the excellent clinical literature appears discordant purely because those concerned are writing about a variety of different conditions, but all under the same title of "surgical shock." There is evidence which indicates that the patient who dies from gross tissue damage such as burning, the patient who dies from minor mechanical injuries, and those who die after prolonged surgical operations, may be deaths from distinctly different states. I hope you do not think I dwell too much on patients who die—many recover—but there are still thousands who die annually who might be saved if the subject was more systematically studied.

SHOCK FROM HAEMORRHAGE

I do not propose to spend much time in discussing this variety of shock, as its cause is obvious. I should, however, like to emphasize that many of the mechanisms by which the body attempts to compensate for haemorrhage are nervous and depend on the carriage of afferent impulses to the vasomotor centres, which in turn send out impulses to constrict the spleen and blood vessels generally. What is particularly important from a surgical point of view is that, being nervous, these mechanisms can be relatively easily anaesthetized, and the effect of the haemorrhage therefore becomes enhanced, and there is abundant evidence that a low blood pressure, say of 60 mm. of mercury, if allowed to persist for half an hour, is liable to bring about permanent changes, which may be fatal. Every attempt should therefore be made to restore the blood pressure before administering an anaesthetic.

DIRECT ACTION OF TOXINS ON PERIPHERAL VESSELS

Histamine or Toxic Shock.—Great attention has, since the war, been focused on this variety of shock since the discovery of the dramatic phenomenon of histamine shock by Dale and Laidlaw. By some it has been hailed as the complete solution of the shock problem, but it is only fair to say that the authors themselves have never made this claim. On the other hand, no one will deny that toxæmia is a most important factor in shock, and probably the most important factor when the onset of the shock is delayed.

The special importance of histamine lies in the fact that it is present in watery extracts of practically all tissues, as it is a simple derivative of the amino-acid histidine, and its effect when injected in minute quantities into the circulation of anaesthetized cats and dogs produces in a few minutes a condition of shock. The shock produced is comparable with that variety of shock in man in which the onset of the symptoms may have been delayed and have apparently depended on the absorption of toxins from damaged tissues.

The skin has been shown to contain relatively large amounts of histamine or its precursor; indeed, there is reason from the work of Lewis to believe that the production of this or a similar substance is a physiological method by which the skin is flushed subsequent to minor injuries. The delayed shock of severe burns is probably produced by the absorption of such a substance.

Dale and Richards showed that histamine acts by dilating the capillaries, and this has been since confirmed by many others. As a result of the capillary dilatation there is a relative insufficiency of blood—the animal, as it were, bleeding into its own capillaries, which have become opened up. The state is like that of haemorrhage, only the animal bleeds into its own vessels. But the

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