HAEMOGLOBIN AND RED CELLS IN THE HUMAN FOETUS

II.—THE RED CELLS

BY

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In a previous paper (Walker and Turnbull, 1953) we have demonstrated the haemoglobin levels and red cell count in the cord blood of the human foetus throughout pregnancy.

From the 10th week to the 24th week the red cell count doubles (from 1,500,000 to 3,000,000), but the haemoglobin rises only from 9 to 15 g. After the 24th week, the red cell count continues to rise till at 40 weeks, in the well oxygenated foetus, it is just under 4,000,000 per c.mm., but the haemoglobin level is unchanged at 15 g. These findings suggest that throughout pregnancy the red cells must be becoming progressively smaller.

If at 40 weeks extra red cells have been produced under the stimulus of anoxia, the haemoglobin level may be 20 g. and the red cell count 5,000,000, the haemoglobin rising by 30%, but the red cell count by only 25% over the levels found at 40 weeks in the well oxygenated foetus (15 g. and 4,000,000). These unequal rises in haemoglobin and red cells under conditions of anoxia suggested therefore that the extra cells produced are somewhat larger or contain more haemoglobin than those normally present in the blood at that time.

Very little information is, however, available from other authors with regard to the characteristics of the red cells in the human foetus during pregnancy. Wintrobe and Shumacker (1935, 1936) studied 12 foetuses, obtained at hysterectomy, and three premature infants, all live born, at intervals from the 76th to the 252nd day of pregnancy. Their findings suggest that the packed cell volume increases gradually as pregnancy advances and that the red cell size and the number of immature red cells steadily diminish.

Many investigators have, however, studied the red cells in the cord blood of the infant at birth (presumably at or near full-term) and some of the results are shown in Table 1. It is seen that, while the mean readings of packed cell volume vary from 50·8 to 56% the range covered (40-60%) is very similar in each series. There is reasonable agreement amongst the authors that the mean cell volume and mean cell haemoglobin are, at birth, above

TABLE 1

PACKED CELL VOLUME, MEAN CELL HAEMOGLOBIN, MEAN CELL VOLUME, MEAN CELL HAEMOGLOBIN CONCENTRATION AND RETICULOCYTE LEVELS IN HUMAN CORD BLOOD AT BIRTH

Reference	No. of Cases	Packed Cell Volume (%)		Mean Cell Haemoglobin (γγ.)		Mean Cell Volume (c.μ)		Mean Cell Haemoglobin Concentration (%)		Reticulocytes (%)	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Mugrage and Andresen (1936)	40	53·18	(42-62)*	35·1	(30-40)*	108·9	(99-120)*	32·2	(30-35)*		
Guest *et al.* (1938)	34			37·5		113	(90-124)				
Waugh *et al.* (1939)	41									2·7	(0·2-5·0)
	51	51·3	(41-61)								
De Marsh *et al.* (1941)	16	51·0	(38-59)								
Findlay (1946)	17										0 -6·0
	11	50·8	(40-61)								
Gairdner *et al.* (1952)	12	56		33·7		107		31·8		3·5	

* Calculated from author's data.

normal adult levels and that there is a high reticulocyte count, suggesting that the cells are larger than adult cells, and that there are still a number of immature cells in the blood.

In this paper the behaviour of the red cells is studied throughout pregnancy, with reference to the packed cell volume, the reticulocyte count, the mean cell diameters (which have been measured) and the calculated absolute values of red cell characteristics (mean cell haemoglobin, mean cell volume, mean cell haemoglobin concentration). We have also studied the features of the extra cells produced in response to anoxia. As in our previous paper the samples were taken at birth from the cord vessels of live-born foetuses and infants in the Aberdeen Maternity Hospital. The methods of selection of cases and of classification into clinical groups is similar to that detailed previously.

Techniques

Packed Cell Volume. At delivery at least 1 ml. of blood was withdrawn from the umbilical vein into a clean dry syringe and placed in a test-tube in which 2 drops of Wintrobe solution had been evaporated to dryness. Wintrobe haematocrit tubes were used and 0·7 ml. of blood was centrifuged at 3,000 r.p.m. for 30 min. The packed cell volume (excluding white cell layer) was read without correction for trapped plasma.

Mean Cell Diameter. A photographic technique (Adams, 1954) was employed. The image of a thinly spread blood film stained with Leishman's stain was projected from a horizontally placed microscope downwards on to Kodak bromide foil card photographic paper. The height of the microscope was adjusted so that the image of the cells was magnified exactly 1,000 times. This type of paper has a high dimensional stability and can be developed without shrinkage or distortion. Two or three suitable fields were selected from each film and photographed. The diameter of the red cells was measured using an accurately calibrated 8-cm. square glass grid with a centimetre/millimetre scale. If a cell was ovoid, the average of the greatest and smallest diameters was taken. Crenated or badly distorted cells were not measured nor were those at the periphery of the film to avoid errors due to spherical aberration. In each case 500 cells were measured to the nearest 0·5 μ.

Reticulocytes. The reticulocyte preparations were vitally stained using brilliant cresyl blue and counterstained with dilute Leishman's stain. The number of reticulocytes was then enumerated in 1,000 red blood cells.

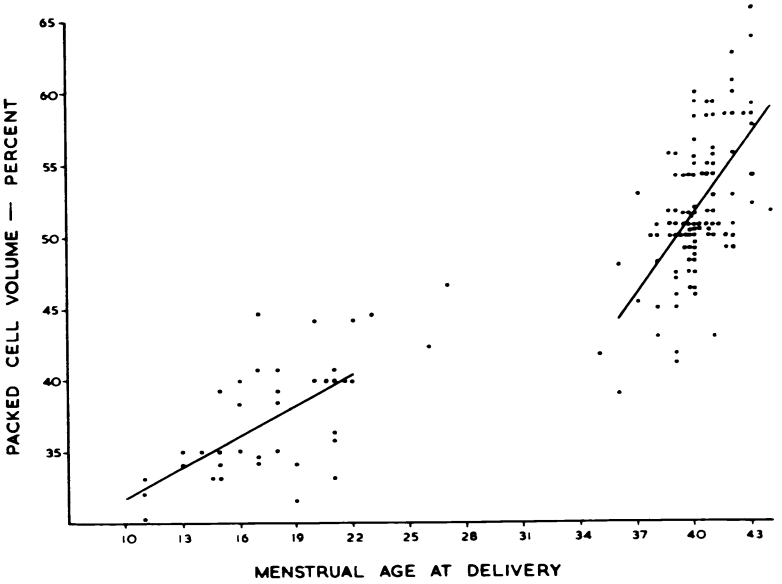
Absolute Values. The mean cell volume, mean cell haemoglobin and mean cell haemoglobin concentration were calculated by means of the usual formulae (Whitby and Britton, 1950).

Findings

Packed Cell Volume. Readings of the packed cell volume in 143 cases of clinically normal pregnancy are shown in Fig. 1. There is a wide scatter in the readings, especially in early pregnancy, resembling the scatter in the red cell counts at this time. Regression lines have, however, been calculated for the periods 1 to 22 and 36 to 43 weeks to show mean values.

The packed cell volume rises from a mean value of 31·6% at the tenth week to reach 40·5% at the 22nd week (probably 42 to 45% by the 23rd to 25th weeks). There are very few readings from then until the 36th week, but the results suggest that there is little, if any, rise in the packed cell volume over this period. From the 36th week onwards the results spread out. While many remain within the

FIG. 1.—Packed cell volume levels in cord blood of the human foetus in normal pregnancy.



range of 42 to 45% the majority are much higher and the mean value rises steadily. If pregnancy continues after the 41st week the mean values continue to rise and readings within the normal adult range (42 to 47%) are no longer found (Table 2). At the 43rd week one reading of 66% (haemoglobin 19·5 g. and red cell count 5,320,000) was found.

TABLE 2
PACKED CELL VOLUME LEVELS IN CORD BLOOD OF THE FOETUS IN NORMAL LATE PREGNANCY

Menstrual Age	Packed Cell Volume (%)	
	Mean	Range
38	47·8	43 – 51
39	49·4	41·5– 56
40	51·3	46 – 60
41	53·4	43 – 59
42	54·9	49 – 63
43	58·6	52·5– 66

When the pregnancy was complicated by pre-eclampsia, where abortion had threatened earlier, or foetal distress was manifest the readings were, in most cases, higher than readings in normal cases at the same stage of gestation. This is only to be expected, since such cases have, as we have shown previously, higher red cell counts than normal cases. In Fig. 2, for example, the readings in 42 cases of pre-eclampsia are seen. In cases of placenta praevia the readings for the packed cell volume were within normal limits.

Mean Cell Volume. Estimations in 143 cases of clinically normal pregnancy are seen in Fig. 3. Regression lines have been calculated to demonstrate the mean values. At the 10th week a mean value of 191 c.μ was found, but by the 22nd week the mean value was 141·3 c.μ. After this time insufficient cases are recorded, but it would appear that there is a slow fall in the mean cell volume until about the 36th week when the mean value was 116·8 c.μ. At each week after the 36th the mean varied only from 115 to 118 c.μ and this level was maintained till the 43rd week. The regression line from the 36th to 43rd week is level at 116·8 c.μ and there does not appear to be any fall in the mean cell volume over this period.

When mean cell volume estimations were performed in cases complicated by pre-eclampsia, threatened abortion earlier in the pregnancy, or foetal dis-

FIG. 3.—Mean cell volume readings in cord blood of the human foetus in normal pregnancy.

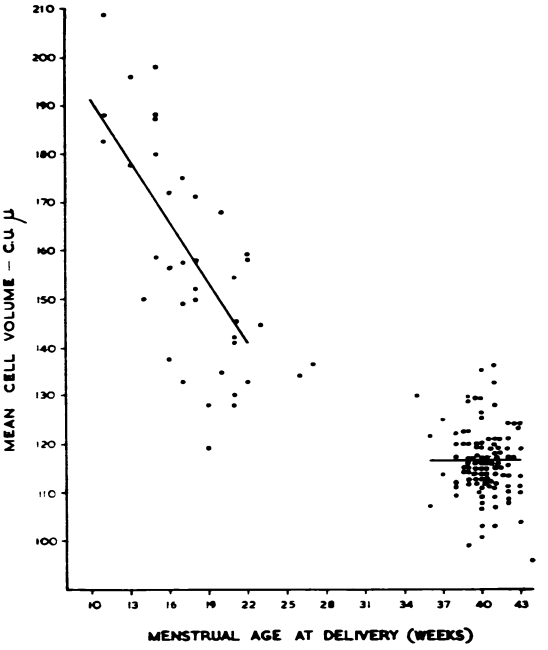


FIG. 2.—Packed cell volume levels in cord blood in pre-eclampsia.

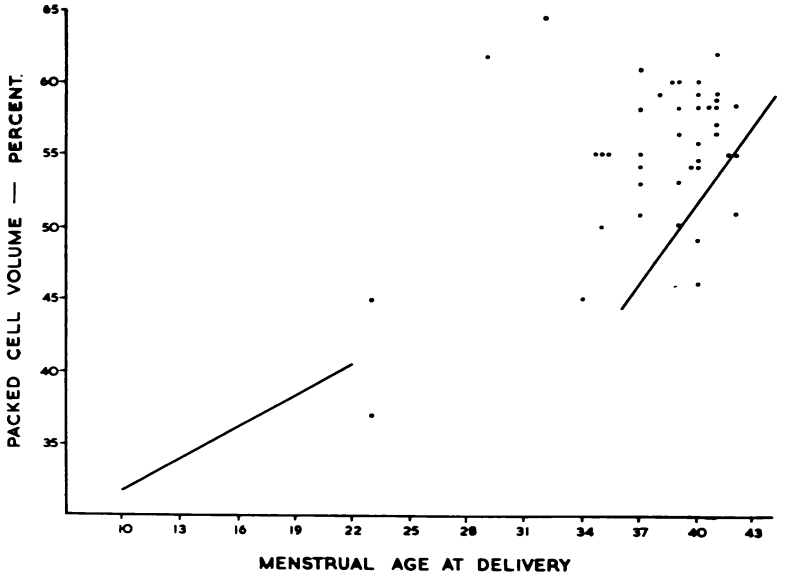
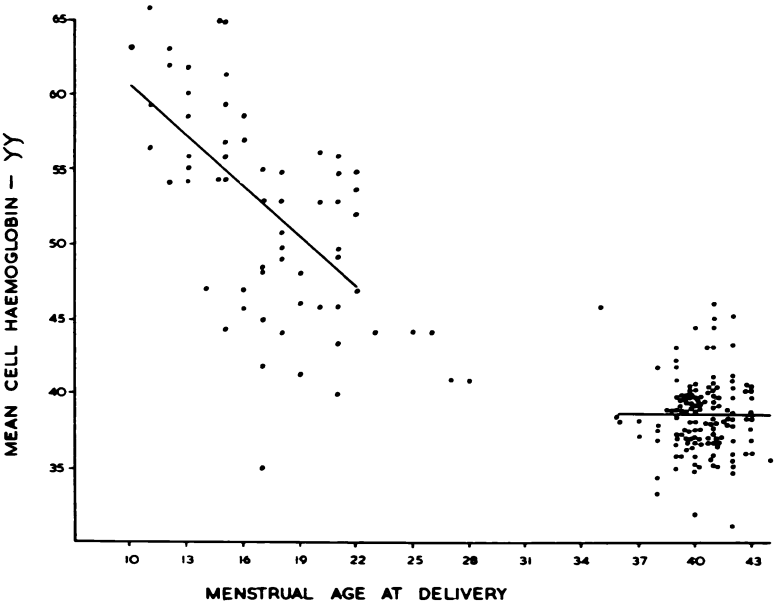


FIG. 4.—Mean cell haemoglobin readings in cord blood of the human foetus in normal pregnancy.



tress, no difference could be demonstrated from the findings in normal cases. The readings were grouped round the regression lines as were the normal readings and the mean values at each week for normal and abnormal cases were very similar.

Mean Cell Haemoglobin. The findings in a series of 200 cases of normal pregnancy are shown in Fig. 4. There is quite a marked scatter among the readings, but nevertheless, a fairly clear pattern can be seen. The calculated regression lines show that the mean cell haemoglobin falls rapidly from a level of 60·5 γγ at the 10th week to reach 47·0 γγ at the 22nd week. In this period from 22 to 36 weeks there are only six readings recorded, but from these it appears that the mean cell haemoglobin continues to fall rapidly at first and gradually later. During the last few weeks of pregnancy there is considerable variation among the findings, but the mean value at each week till the 43rd week varies only between 37 and 39 γγ (regression line at 38·6 γγ). The distribution of the findings in cases of pre-eclampsia, previous threatened abortion and foetal distress was again similar to that seen in the normal cases. The mean readings in the abnormal cases after the 36th week varied also from 37 to 39 γγ.

No statistical difference was found to exist between the readings from normal and abnormal cases with regard to mean cell volume and mean cell haemoglobin levels.

Mean Cell Haemoglobin Concentration. The findings in 143 normal cases are seen in Fig. 5. Unlike the estimations already studied, it appears that the mean cell haemoglobin concentration changes little throughout pregnancy, although there is some variation in individual cases at each stage. From the 10th to the 25th week and 36th to 43rd week 90%

FIG. 5.—Mean cell haemoglobin concentration levels in cord blood of the human foetus in normal pregnancy.

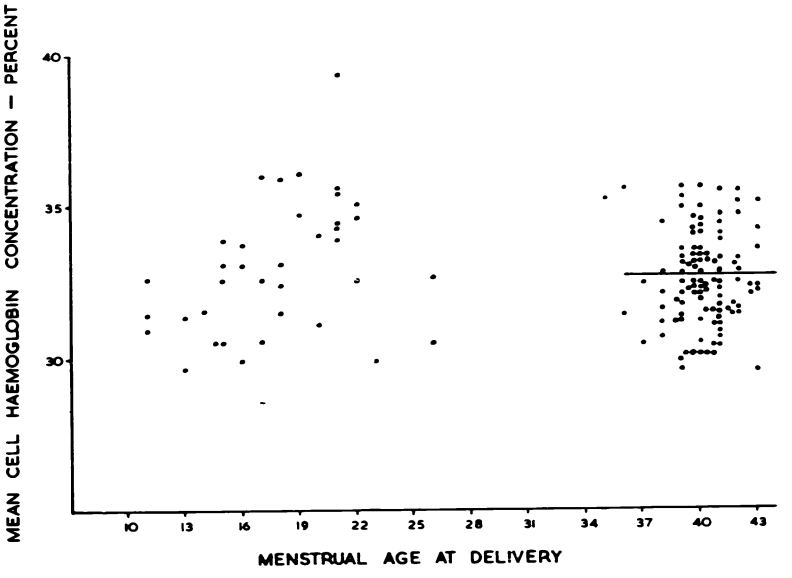


FIG. 6.—Reticulocyte levels in the cord blood of the human foetus in normal and abnormal pregnancy.

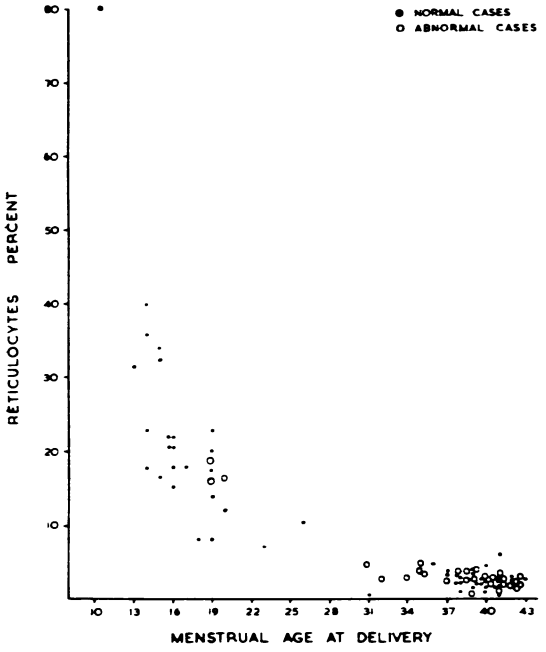
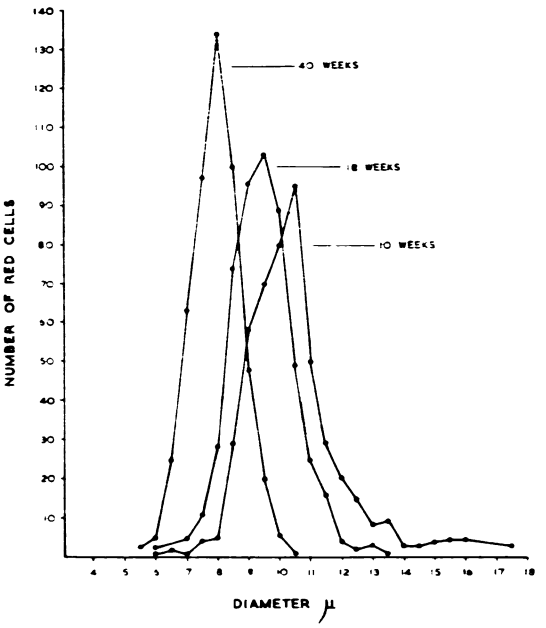


FIG. 7.—Red cell distribution curves in three foetuses of 10, 18 and 40 weeks gestation.



of the readings lie between 30 and 35%. In cases of abnormal pregnancy the values obtained were also between 30 and 35%.

Reticulocytes. In Fig. 6 the findings in 82 cases (54 normal and 28 abnormal) are shown. At 10 weeks only one estimation was performed but 80% of the cells were reticulocytes. At the 14th week readings vary between 20 and 40%, but by the 25th week the average appears to be 10%. There is then a slower fall, until by the 36th week only 2 to 3% of the cells were reticulocytes and this value was maintained until the 43rd week (the range after the 36th week is 0·7 to 5·7%). It can be seen that in abnormal cases (complicated by pre-eclampsia, previous threatened abortion or foetal distress) no variation in the reticulocyte readings was found. We could find no correlation in the later weeks between the haemoglobin level, the red cell count and the reticulocyte values.

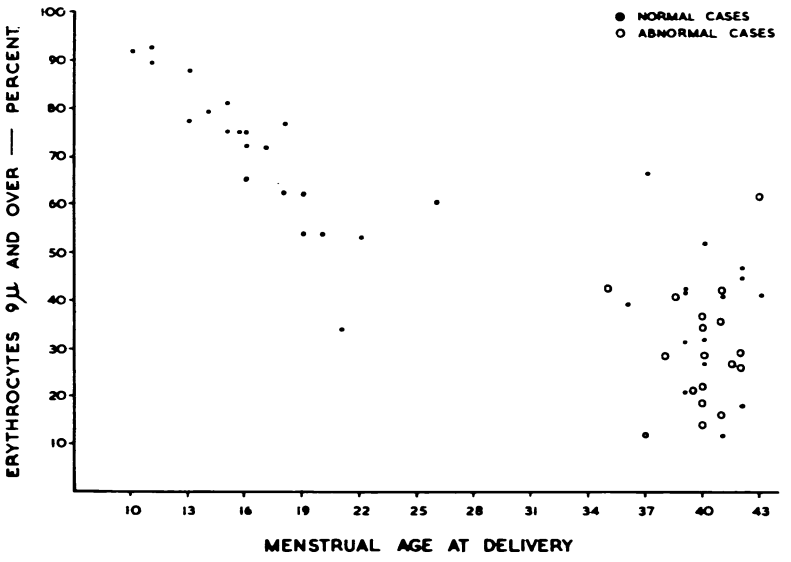
Mean Cell Diameter. The mean cell diameter from the 10th to the 43rd week is seen in Table 3. At the 10th to 11th weeks the mean is high and the range is wide. There is a steady fall till about the 20th week and very large cells (over 12·5 μ) are, by

TABLE 3

RED CELL DIAMETER FINDINGS IN CORD BLOOD OF THE FOETUS THROUGHOUT PREGNANCY

Menstrual Age	No. of Cases	Red Cell Diameter (μ)		Menstrual Age	No. of Cases	Red Cell Diameter (μ)	
		Mean	Range			Mean	Range
10	1	10·5	6 –17·5	22	1	8·8	6 –11·5
11	2	10·2	6 –16	26	1	8·9	6·5–11·5
13	2	9·8	6·5–15·5	35	1	8·6	5·5–12
14	1	9·5	7 –12·5	36	1	8·5	5·5–12
15	2	9·5	6 –13	37	2	8·5	5·5–12
16	4	9·3	6 –13	38	1	8·3	5·5–10·5
17	1	9·2	7 –11·5	39	5	8·5	5·5–11·5
18	2	9·3	6 –13·5	40	10	8·3	5 –11·5
19	2	8·9	6·5–11·5	41	5	8·3	5 –11
20	1	8·8	5·5–11	42	6	8·4	5 –11
21	1	8·4	6 –10·5	43	2	8·8	4 –12

FIG. 8.—Proportion of red cells 9 μ and over in the cord blood of the human foetus in normal and abnormal pregnancy.



that time, no longer seen. There is after that time very little change in the mean cell diameter or in the range of cell size. The changing pattern is illustrated in Fig. 7 where curves have been drawn of the results in three foetuses in the 10th, 18th and 40th weeks of pregnancy. At 10 weeks the base of the curve is wide and the peak is at 10·5 μ. As pregnancy progresses the base narrows, the peak becomes higher, and the whole curve shifts to the left. The mean diameter gradually diminishes as the proportion and number of small cells increase.

Cell Size. At the 10th to 11th weeks the cells vary from 6 to 17·5 μ but 90% are at least 9 μ in diameter (Fig. 8). The wide range of cell size lessens as pregnancy progresses and by the 20th to 22nd week cells over 13 μ are no longer seen, 50% are 9 μ or more, and the majority of the remainder are 8 or 8·5 μ. At this stage only 10% of the cells are 7·5 μ or less (Fig. 9). No cases have been examined from then till the 36th week. From the 36th to 43rd week there is a great variation in the size of cells in the blood of different foetuses. While about 50% of the cells are 8 to 8·5 μ in diameter (Fig. 10) the remainder may be composed of any mixture of large and small cells.

Throughout pregnancy the red cell count increases steadily and we have constructed Fig. 11 from the mean figures for cell size at 10, 22 and 40 weeks to show the number of cells of each size in 1 c.mm. of blood (the mean readings for red cell count are taken from Walker and Turnbull, 1953). It will be seen that there is a steady rise in the total number of cells less than 9 μ in size but that the number of large cells falls only slightly from 1,430,000 to 1,230,000. In the late weeks of pregnancy there may be, however, as we have shown, great variation in the numbers of large and small cells in the blood of individual foetuses and in Fig. 12 is seen the possible

FIG. 9.—Proportion of red cells 7·5 μ and less in the cord blood of the human foetus in normal and abnormal pregnancy.

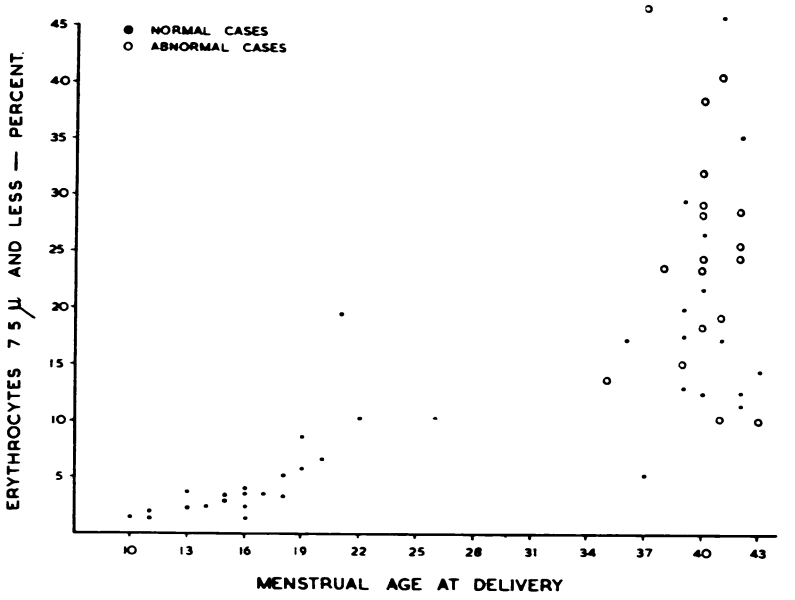


FIG. 10.—Proportion of red cells 8-8·5 μ in the cord blood of the human foetus in normal and abnormal pregnancy.

variation in number of cells of each size. In 10 cases at 39 to 43 weeks, with less than 20% of small cells, there was an average of 0·73 million small and 2·12 million large cells. In five cases, with more than 30% small cells there was, on average, 1·79 million small and 0·76 million large cells. The medium-size cells (8 and 8·5 μ) remained unchanged in both series at 2·09 million.

Discussion

During intra-uterine life red cell production is influenced mainly by the normal process of growth and maturation but a fall in the oxygen supply to the foetus will stimulate the production of extra cells.

Growth and Maturation. At the 10th to 11th week the red cell count is about 1,500,000 and 80% of the cells are reticulocytes. The cells are large, the mean cell volume 190 c.μ and the mean cell diameter 10·5 μ. While over 90% of the cells were 9 μ or over in diameter, there was a wide range of sizes (6 to 17·5). As the cells are few in number, but large, the mean cell haemoglobin is high, 65 γγ.

From the 10th to the 22nd/23rd week the red cell count rises to about 3,000,000 and the haemoglobin to normal adult levels. The red cell count doubles in this period, but the packed cell volume rises by only about one-third (31·6% to 40-42%) since the increase in the count is due to smaller cells, the number of cells over 9 μ remaining unaltered. The influx of smaller cells and the disappearance of cells over 13·5 μ in size causes the fall in the mean cell volume to 140 c.μ and the mean cell diameter to under 9 μ. The increasing maturity is seen in the disappearance of the very large cells and by the fall in the reticulocyte count to 10%. The fall in the mean cell haemoglobin is explained by the decrease in cell size as the mean cell haemoglobin concentration is little altered.

In the late weeks of pregnancy changes due to maturation of the cells are greatly modified by the superimposed effects of anoxia.

The Red Cells in the Later Weeks. We have shown (Walker and Turnbull, 1953) that in the second half of pregnancy the haemoglobin level in

FIG. 11.—Mean distribution of erythrocytes at 10, 22 and 40 weeks.

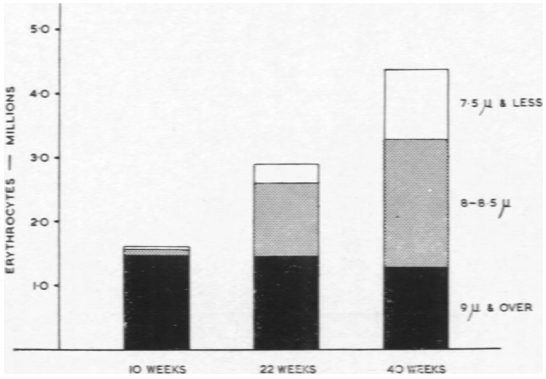
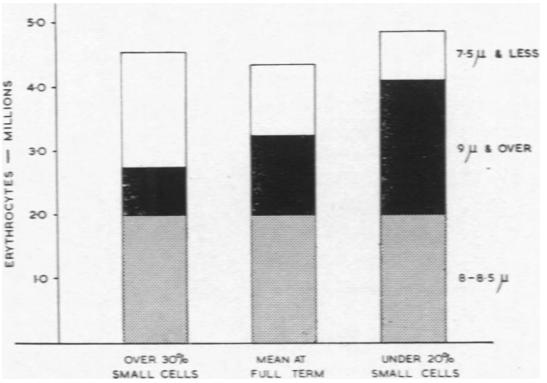


FIG. 12.—Distribution of erythrocytes at full term where over 30 per cent. and under 20 per cent. of cells are 7·5 μ or less.



the cord blood is an index of the efficiency of the oxygen supply. When the oxygen supply is good the haemoglobin level remains at 14·8 to 15 g. but the red cell count as a normal 'growth' process rises steadily to reach about 4,000,000 at 40 weeks. When the oxygen supply is less good the haemoglobin may be 20 g. and the red cell count 5,000,000.

We have shown earlier in this paper that except for the packed cell volume, the findings in the blood of infants in the later weeks from cases of pre-eclampsia, or foetal distress, or where abortion had threatened earlier, cannot be shown to be different from the findings in clinically normal pregnancies. In our first paper we demonstrated that such clinical groupings were useful to distinguish infants likely to have suffered intra-uterine anoxia. Such a clinical grouping is, however, of limited value in the present study since in both abnormal and apparently normal cases a deficiency of oxygen is indicated by a high haemoglobin level and red cell count. The haemoglobin level in the cord blood of the foetus is, therefore, a clearer indication of efficiency of oxygen supply, in the individual case, than the clinical features of the pregnancy.

By using the haemoglobin level as an index of oxygen supply it is possible to distinguish the normal growth and maturation changes in the later weeks from the superimposed changes due to anoxia.

The Packed Cell Volume. Table 4 shows the relation between the haemoglobin level, the red cell count, the packed cell volume and the absolute characteristics of the red cells. It will be seen that there is a close correlation between the haemoglobin level, red cell count and packed cell volume. Where the oxygen supply to the foetus is good and the haemoglobin remains below 16 g. the packed cell volume is 46·5 (±0·7), which is within normal adult levels, although this is achieved by a smaller number of somewhat larger cells than in the adult. When, however, the haemoglobin level is raised in response to anoxia the red cell count and packed cell volume rise. It will be seen from Fig. 1 that in some cases in the 39th to 41st weeks the packed cell volume is no higher than in others at the 22nd to 24th weeks. In such cases the increase in the red cell count (to 4,000,000) has been achieved by the addition of very many small cells and a marked fall in the number of cells over 9 μ in size, the haemoglobin remaining at 14·8 g. In such bloods the mean cell volume at 40 weeks is at or about 100 c.μ (Fig. 3).

The Mean Cell Volume. The findings in Fig. 3 suggest that there is no fall in the mean cell volume as the foetus becomes older after the 36th week, but we would have expected that, as a normal growth change, the mean cell volume would fall steadily and that especially after the 41st week much lower values would be found. Our results were, therefore, submitted to statistical analysis on the theory that anoxia (manifest by a high haemoglobin reading) might be masking the normal maturation pattern. Analysis* has shown that, provided the readings of mean cell volume are adjusted to a standard haemoglobin reading, there is a slight but not significant fall from the 39th to the 41st week, and a significant fall thereafter. What is even more important is that the high mean cell volumes over this period are in most cases associated with high haemoglobin readings and low with low.

* See page 110.

TABLE 4

RELATION BETWEEN HAEMOGLOBIN LEVEL, RED CELL COUNT, PACKED CELL VOLUME, AND ABSOLUTE VALUES OF THE RED CELL CHARACTERISTICS BY WEEKS' GESTATION AND HAEMOGLOBIN LEVEL

No. of Cases (Normals – Abnormals)	Weeks' Gestation	Haemoglobin (g.)		Red Cell Count (c.mm.)	Packed Cell Volume (%)	Mean Cell Haemoglobin (γγ)	Mean Cell Volume (c.μ)	Mean Cell Haemoglobin Concentration (%)
		Range	Mean					
22	39–41	14·8–16·1	15·4	4·15 ±0·06	46·5 ±0·7	37·19 ±0·44	112·4 ±1·6	33·15 ±0·34
56	39–41	16·3–17·6	17·0	4·45 ±0·04	52·2 ±0·4	38·25 ±0·27	117·5 ±1·0	32·60 ±0·21
57	39–41	17·8 and over	18·8	4·89 ±0·04	57·5 ±0·4	38·50 ±0·27	117·9 ±1·0	32·71 ±0·21
11	42	16·3–17·6	16·7	4·34 ±0·08	50·3 ±1·0	38·64 ±0·62	115·4 ±2·2	33·54 ±0·48
18	42	17·8 and over	18·5	4·89 ±0·06	56·4 ±0·8	37·87 ±0·48	115·3 ±1·7	32·90 ±0·37
11	43–44	17·8 and over	19·2	5·15 ±1·0	58·5 ±1·0	37·50 ±0·62	113·5 ±2·2	33·16 ±0·48

It appears, therefore, that, as a normal growth process, the mean cell volume falls steadily as the foetus grows older. In many foetuses in late pregnancy, however, a deficiency of oxygen supply forces the production of red cells, which are on the whole larger than the mean size in the blood at that time, so that in the cord blood at birth in many cases mean cell volumes over 116 c.μ will be found in association with red cell counts of about 5,000,000.

Cell Size. We had hoped, on the evidence of the mean cell volume, to demonstrate clearly that the extreme variation in cell sizes in individual bloods in late pregnancy would be clearly related to the haemoglobin level. Our figures show that, on average, bloods with the highest red cell counts have the greatest number of cells over 9 μ in size, but there is a marked individual variation and the correlation, though present, is not statistically significant. It will be noted, however, from a study of Figs. 11 and 12 that in the blood of some infants there are many more cells over 9 μ in size (in each unit volume) at 40 weeks than are found at 22 weeks. These large cells are rarely seen in the blood of the normal infant after the sixth week (van Creveld, 1932) and must represent a foetal type of haemopoiesis and the large numbers found in some bloods in the late weeks may represent extra cells produced in response to anoxia.

At birth at the 39th to the 43rd week the cord blood will show red counts varying from 4,000,000 to 5,000,000, packed cell volume varying from 41·5 to 66%, and a mean cell volume varying from 100 to 130 c.μ, the higher levels in each case being found in association with high haemoglobin levels and due to the superimposed effect of anoxia on the normal growth pattern. Although large cells over 12·5 μ in diameter are no longer seen, some 10 to 60% of the cells measure more than 9 μ in diameter. The reticulocyte count varies from 0·7 to 5·7%, but we are unable to explain the scatter and found no correlation between the reticulocyte count and the red cell count.

Summary

The red cells in the cord blood of the human foetus have been studied from the 10th to the 43rd weeks of pregnancy. The packed cell volume, the mean cell diameter and the reticulocyte count have been measured and the absolute values of the red cell characteristics calculated.

As pregnancy progresses the red cells as a whole become more mature. The Price-Jones curve shifts to the left, the base narrows and the peak becomes higher.

Three groups of cells have been studied in detail; 9 μ and over, 8 and 8·5 μ, 7·5 μ and under. It is shown that as pregnancy progresses the number of cells less than 9 μ in size in each unit volume of blood gradually increases, while the numbers which are 9 μ and over remain nearly unchanged. There is, however, in the later weeks a wide variation in the number of large and small cells in the blood of different infants.

Deficiency of oxygen supply to the foetus in the later weeks of pregnancy alters the red cell pattern from that seen under normal conditions of growth and maturation. Variation in the oxygen supply *in utero* of the individual foetuses is responsible for the scatter in readings of packed cell volume and mean cell volume in the cord blood at birth and possibly for much of the variations in number and proportion of cells of various sizes.

We are greatly indebted to Dr. F. H. C. Marriott for all statistical analyses reported in this paper.

* The mean cell volume (M.C.V.), haemoglobin (Hb), and menstrual age in weeks (W.) were given for 175 infants. Normal pregnancies and others were considered together without distinction.

The regression of M.C.V. on W. and Hb was calculated.

$$\text{M.C.V.} = \underset{\pm 0\cdot53}{-1\cdot13\,\text{W.}} \quad \underset{\pm 0\cdot06}{+0\cdot19\,\text{Hb.}} \quad +139\cdot6$$

The coefficient of W. is significant ($P<0\cdot05$) and that of Hb highly significant ($P<0\cdot01$).

The equation is in agreement with the suggestion that high mean cell volume readings are associated with high haemoglobin readings, but that the mean cell volume tends to decrease with increasing menstrual age.

Table 5 shows the mean values of M.C.V. and haemoglobin for each week of menstrual age from 39 to 44, and the mean M.C.V. adjusted to Hb 120 (a convenient value close to the overall mean of 119·3). The adjusted value is obtained by calculating M.C.V. $-0\cdot19$ (Hb -120).

The differences between the adjusted values for 39, 40 and 41 weeks are not significant, but there are significant differences between weeks 41 and 42 ($P<0\cdot05$) and 42 and 43 ($P<0\cdot01$).

TABLE 5
RELATION BETWEEN MEAN CELL VOLUME AND MENSTRUAL AGE

Weeks' Gestation	No. of Cases	Mean Haemoglobin (%)	Mean of Mean Cell Volume (c.μ)	Adjusted Mean of Mean Cell Volume (c.μ)
39	30	116·0	116·7	117·4
40	62	116·6	116·8	117·4
41	43	121·8	117·1	116·7
42	29	120·4	115·3	115·2
43+	11	130·5	113·5	111·5

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