AMERICAN GYNECOLOGY

VOL. I. OCTOBER, 1902. No. 4.

PRELIMINARY REPORT OF SOME OBSERVATIONS ON THE BLOOD OF PREGNANCY AND THE PUERPERIUM.*

BY GEORGE R. PRAY, M.D.,
First Assistant in Gynecology and Obstetrics, University of Michigan, Ann Arbor.

In a study of the literature one is impressed by the lack of uniformity concerning the condition of the blood during pregnancy. Even prior to the perfection of instruments of precision for estimating blood states it was the prevalent opinion that the blood was changed during pregnancy. The pregnant woman was thought to have a much increased blood production, giving rise to a plethoric condition. As opposed to this view may be cited Ramsbotham[1], who spoke against the practice of letting blood indiscriminately simply because the woman was pregnant, as was almost universally practised at that time. However, no very definite work was done toward the solution of the question till Nasse[2], in 1853, published the results of some very careful and exhaustive researches upon thirty-nine cases of blood letting in pregnant women. In 1876 he published a more complete paper containing the blood findings in bitches examined before, during and after pregnancy. The examinations included a study of the specific gravity of the blood, the fibrin, the water of the blood, and the salts, including iron. He found that during pregnancy the salts and the specific gravity were diminished, while the water and fibrin were increased. A day after labor the specific gravity was increased and the water diminished, while from eighteen to twenty days later they reached the normal. The increase of fibrin lasted longer. Chemical investigations are of value in that they may throw more light on a blood state than the counting of red cells. These investigations showed the condition of the blood to be one more of anemia

*Read at the meeting of the Michigan State Medical Society, Port Huron, June 27, 1902.

than of plethora. Andral and Gavart[3] by less extensive investigations had arrived previously at similar conclusions. Acting on the same hypothesis, Cazeaux and Scanzoni, observing cessation of symptoms such as vertigo, tinnitus aurium and headache, after increasing the quantity and quality of the food of the pregnant woman and after the administration of iron, propounded their view of a chloroanemia. Willcocks[4] more recently has pointed out that this view is not correct, as the hemoglobin of the individual cell is not lessened. Spiegelberg and Gschleiden[5] have shown experimentally that the amount of blood in pregnant bitches is increased volumetrically to fill the dilated vessels of the pelvis. In general the weight increases during pregnancy, as has been shown by several observers. This increase is not dependent entirely on the growth of the uterus and its contents and enlargement of the mammary glands, as Nasse has proved by experimentation. The fatty tissue is increased particularly, the muscles not participating in the change. Mencanti[6] more recently found in pregnancy with a constant hemoglobin index a falling specific gravity.

Because of these findings, the increased circulatory area, the increased nutritive demand by reason of the hypertrophied organs and the fetus, the chemical findings and a constant hemoglobin index with a fall of specific gravity, we are forced to believe that the condition is one of serous hydremia. This presupposes a constant number of red cells and no loss of functional value of the given cell by reason of this dilution. Cabot[7], speaking of the red cells, says normal pregnancy does not affect the blood count. He admits that dilatation of the vessels by drugs causes a condition of serous dilution of the blood but says this is only temporary. Stengel and Stanton found the blood pressure to be the same during pregnancy as before. Taking into consideration the greatly increased circulating area of the blood. we see that there must be a volumetric increase of the blood to cause this.

Evidence of increased fibrin in the blood of pregnant women is furnished not only by fresh specimens examined microscopically but by the deposits found on the inner table of the skull and on the pelvic bones, wrongly called by Rokitansky osteophytes. The increase in fibrin is greatest near labor and clinically is shown by the increased coagulability at this time. Peckelharing[8] has shown the source of the fibrin to be a nucleoproteid due to the disintegration of white blood cells and blood plates. The increase of fibrin is not surprising when we consider the greatly increased metabolism which Nasse proved by estimating the nitrogenous output of the urine and feces.

Fehling[9] found increased hemoglobin in the earlier months of preg-

nancy and ascribed it to better hygienic surroundings incident to the state. His average for red cells during pregnancy was 3,500,000 and for hemoglobin 93 per cent, a very high percentage for the number of cells present. After labor 47 of the 83 cases dropped correspondingly in red cells and hemoglobin, 26 increased slightly and 10 remained constant.

Meyer[10] examined 37 cases on three different occasions—once early in pregnancy, once the day after labor and finally after the patient got up. The difference between the average of his first examinations and an average obtained for non-pregnant women was 7,000 red cells and 7.8 per cent hemoglobin in favor of the non-pregnant woman. He found both markedly decreased after labor and also ascertained that the hemoglobin had risen in two weeks to a point above that found at his first examination. This led him to believe in the chlorotic anemia view.

Reial[11] observed an increase in red blood cells and hemoglobin in anemic cases in the maternity hospital. He concluded that this change was due to improved conditions of living and believed that if anemia occurred in pregnancy it was due to the ordinary causes of anemia and progressed similarly to that in the unimpregnated woman.

Dubner[12] found in 20 cases, 19 to 36 years of age, married and of the working class, an average decrease of about 6 per cent of hemoglobin and 275,000 red blood cells during pregnancy. He claimed that by securing better hygienic surroundings the blood could be brought to normal. The diminution of red blood cells and hemoglobin was in proportion to the amount of blood lost. Eight days after labor the condition present before labor was re-established.

Schroeder[13] found that of 34 cases examined during pregnancy hemoglobin increased 12.92 per cent in 25 and in 9 it decreased by the same amount. He examined 42 cases after labor and found that 33 showed a decrease of 10.2 per cent in hemoglobin, 7 cases an increase of 6.8 per cent and 2 showed no change. Twenty-five cases regained 7.6 per cent during the lying-in period, leaving them 2.75 per cent behind the average for pregnancy. The normal amount was not reached for some time.

Bernhard[14] found the average for red cells and hemoglobin practically the same in pregnant and non-pregnant women. He claimed that pregnancy was apt to produce anemia in weak persons, while in strong persons an improved condition of the blood often resulted.

Wild[15] found a small increase of hemoglobin and red cells in the last few weeks of pregnancy and a well-marked increase in white cells. After labor the hemoglobin and red cells sank, the first in a more marked

degree. Whites were most numerous shortly after labor, sinking gradually during the lying-in period.

Elder and Hutchison[16] found the average of hemoglobin in 7 cases at term to be 72 per cent. The reds were below normal in practically all cases. These observers studied the relation of the child's and the mother's blood and found that the condition of the former was always much better than that of the latter. The hemoglobin varied in the mother from 60 to 83 per cent, which was about two-thirds that found in the child, the latter being 95-115 per cent. The average number of white cells at term was 14,522 per cubic millimeter.

Henderson[18] made observations on fresh blood, fibrin, hemoglobin, red and white cells. The only change in the fresh specimen in normal cases was the increased fibrin. The day following delivery the hemoglobin averaged 68.2 per cent. He observed an increase of 5 per cent during the lying-in period. Red cells at term were 3,975,348. There is a decrease of red cells for two days after labor, then a gradual rise till the ninth day, when a second fall occurs, which lasts for some time and probably to some extent throughout lactation. The white cells averaged 21,365 at term. (These counts were mostly taken during the progress of labor, thereby giving too large a number for a correct average at term.) The average was practically the same in primiparous and multiparous patients. White cells decreased in number steadily after confinement but some leucocytosis persisted as long as the patients remained under observation.

The following observations were made on 12 patients admitted to the obstetric service of the University of Michigan Hospital from March 12 to June 1, 1902. The observations include 104 examinations and counts of red cells, white cells, hemoglobin, and 25 differential counts of leucocytes. Examinations prior to delivery were necessarily omitted in two emergency cases, one a Cesarean section and one a case of puerperal eclampsia. Eight of these 12 patients were primiparæ. The ages varied from 16 to 41 years. By occupation the subjects were: one school-girl, one waitress, one factory operator, one actress (puerperal eclampsia), three housewives and three housemaids. Their average stay in the hospital before delivery, excluding the two emergency cases, was $42^{6}/_{10}$ days, which is a longer period than most observers have had their cases under continuous observation. While in the hospital these patients received the ordinary house fare, a generous mixed diet. They took but little exercise although urged to do so. The technic of the blood examinations was as follows: Before confinement the blood was counted and spreads were prepared every four or five days. The

first day after confinement and every succeeding second day counts were made and spreads prepared. The blood was taken from the second finger without pressure. The Thoma-Zeiss apparatus was used for counting cells. The red cells were diluted one hundred times with Toison's solution. The white cells were diluted forty times with one-third per cent solution of glacial acetic acid. The hemoglobin was estimated with Tallquist's chart. While not quite so accurate as Fleischl's instrument, in a large series of observations the results will vary only a trifle. For the reds the five larger squares (one in each corner and one in the center) were counted, giving 160 of the smaller squares on the two specimens counted. The whites were counted after the method of Thoma (*Virchow's Archiv*, 1882), in which the blood is diluted 1-40 and a field of just such size found that it exactly touches the corner of the Thoma-Zeiss rulings. All the leucocytes in five or ten of these fields are counted and averaged and reference to a table gives the number per cubic millimeter. The spreads were prepared by drawing a slide over a small drop of blood on a well-cleansed coverglass. Four coverglasses were prepared at each examination. These were air dried and stained for two minutes in Delafields hematoxylin, washed, stained for thirty seconds in a 1 per cent aqueous solution of fuchsin, dried on filter papers and mounted in Canada balsam. The differential counts were made with a mechanical stage, a Bausch and Lomb microscope (objective 7, eye piece 1) being used.

Hemoglobin.—The results are based on 104 examinations, 55 before and 49 after labor. Six different averages have been obtained for this, the same having been done for red and for white cells. The average for the first examination was 77.7 per cent of hemoglobin and for the last before labor 78.5 per cent. The average found at the first examination after labor was 68 per cent and that for the last examination made before the discharge of the patient was 72.6 per cent. An average of all counts before labor and of all counts after labor gives an average before delivery of 78.5 per cent and after labor of 72.9 per cent. The highest recorded percentage was 95 and the lowest 50. The average at term is 9.6 per cent above that of Henderson.[18] Blackwell's[19] average of all examinations before labor gives only 54.2 per cent. This result was obtained from 163 examinations of New York servants who were under poor hygienic surroundings. On the other hand, Bernhard's average of 82.9 for the last count before delivery and Finkelman's of 94.1 for the hemoglobin of all observations during pregnancy are noticeably higher than in this series. That German women in general are "fuller blooded" than American is a matter of common observation

and rarely do we find one of our women coming up to the 100 per cent of the Fleischl scale. Of the 10 cases observed before delivery 6 showed a small increase, 3 a small loss and one no change. The color index shows a lack of only .03; so each cell is practically normal.

Red Cells.—Average of all examinations before labor, 3,713,363 per cubic millimeter.

Average of all examinations after labor, 3,559,466 per cubic millimeter.

Average of first examinations, 3,722,900.

Average of last examinations before labor, 3,642,857.

Average of first examinations after labor, 3,211,571.

Average of last examinations before discharge, 3,706,375.

It will be seen from this that there is a decrease of 80,000 red cells with an increase of 2.9 per cent of hemoglobin during the period between admission and labor. It is also observed that at the last examination red cells are only 7,188 behind the first observation while the hemoglobin is 5.1 per cent less. This is considerably greater than in the case of red cells, but red cells are regenerated more quickly after labor than is hemoglobin. Red cells and hemoglobin sank to their lowest points three days after labor, then steadily rose as long as under observation.

White Cells.—The averages of white cells are somewhat lower than are those generally recorded.

Average of all examinations before labor, 10,354 per cubic millimeter.

Average of all examinations after labor, 15,359 per cubic millimeter.

Average of first examinations made, 9,500.

Average of last examinations before labor, 12,229.

Average of first examinations after labor, 17,129.

Average of last examinations before discharge, 12,472.

In the series no fall was noticed about the ninth day with a subsequent rise, as Cabot and Henderson have observed. Comparing this with a normal 7,500 per cubic millimeter gives an increase of 4,279 for the leucocytosis at term.

Stained Preparations.—In counting leucocytes Cabot's outline was

adopted; this divides them into large and small lymphocytes, polymorphonuclear neutrophiles and eosinophiles.

Cabot's findings in normal blood.		*Writer's findings in the blood of pregnant women.*	
		Before labor.	After labor.
Small lymphocytes,	20—30 per cent.	13.9	13.45
Large lymphocytes,	4— 8 per cent.	11.1	11.01
Polymorphonuclears,	62—70 per cent.	74.4	73.71
Eosinophiles,	½— 4 per cent.	1.28	1.81

Henderson is the only other observer reviewed who has done any work in the differential counting. His values are as follows for 32 cases after labor.

Small lymphocytes	10.8 per cent.
Large lymphocytes	8.8 per cent.
Polymorphonuclears	78.7 per cent.
Eosinophiles	1.7 per cent.

It will be seen that polymorphonuclear cells and large lymphocytes are increased. Small mononuclear cells are rather below normal, and eosinophiles are slightly above the usual limit, since 4 per cent is not often reached without some cause. The values obtained were from 25 counts taken at random from the specimens, 12 before labor and 13 after. This was done to ascertain if any changes took place in the proportion of leucocytes shortly after labor. The counts before and after labor show very slight differences.

From a more detailed study of the individual cases I am led to believe that the blood is only slightly altered as regards the value of red blood cells and hemoglobin in the average pregnancy. In the woman of low vitality, unable to supply the demand for increased nourishment and keep up with the increased metabolism, the generation of these two blood constituents is not rapid enough to keep pace with the increase of the vascular area and a subsequent decrease in these blood constituents takes place. In a woman of good vitality, free from constipation (a potent cause of anemia in pregnancy), taking sufficient nourishment and assimilating the same, the stimulus caused by the constantly increased metabolism may result in a relatively high value of these blood constituents. In cases in which these constituents are low there is a serous dilution of the blood. The dilution is of the serum and not of the cell body, as the high color index of the given cell shows, as well as the microscopic examination of red cells, which shows no hydropic degeneration or other pathological change. According to Nasse, the

muscular tissue of pregnant dogs contains less water than that of unimpregnated animals. This may be the source of the increased fluid in the blood. The argument that a physiologic process should not alter the blood condition does not hold good, for puberty and menstruation are physiological; yet the blood of male and female children is identical till after puberty[17], when the normal count in the male becomes 5,000,000 red cells per cubic millimeter and in the female 4,500,000.

That the dilution of the blood is largely mechanical is substantiated partially by the fact that there is an increase of blood constituents during the suppression of the menstrual periods in the first three months of pregnancy, then often a gradual fall as the vascular area grows greater. This often goes on till the later months, when the growth of the uterus is overshadowed by the relatively greater growth of the fetus.

As to leucocytosis, it is fair to assume that this is due to the increased metabolism and is of toxic origin. In my cases there was no particular difference between the number of leucocytes in primiparous and multiparous cases. I have seen no confirmation of the statement that leucocytosis is absent in a large proportion of multiparous patients.[20] The majority of reported cases do not seem to bear this out. That leucocytosis of pregnancy is not a prolonged digestion leucocytosis, as is believed by some, is shown by the fact that in pregnancy eosinophile cells are relatively increased while in the digestion leucocytosis they are decreased. Reider also finds in the last months of pregnancy a decrease of leucocytes after food is taken.

After delivery the blood constituents in the majority of cases rapidly regenerate. When the loss of blood has not been excessive the restoration is almost completely accomplished in eight or ten days. The red cells and hemoglobin do not increase side by side here because of the more rapid regeneration of the red cells. In the series of cases reported the hemoglobin increased about 5 per cent and the red cells 500,000 between labor and the discharge of the patients. This shows about twice as great a regeneration of the red cells as of the hemoglobin. The fall that takes place at labor is 10.5 per cent of hemoglobin and 431,286 of the red blood cells. I believe the rapid regeneration of the blood is due not only to the formation of new cells but also to the lessening of the vascular area by the contraction of the emptied uterus and the subsequent transudation of the fluids of the blood. In favor of this is the fact that when the child was nursed, the rise in the constituents of the blood became most noticeable at the time the milk appeared in the breasts, the reflex connection between the breast and uterus causing by

the irritation of the breast a still farther contraction of the uterus and its blood spaces.

The fall of the leucocytes is due in a large measure to lochial discharge. The interior of the uterus is simply a large wound area which discharges a great number of white cells. That the leucocytes do not return to normal during observation is due to the fact that they are intimately connected with the process of involution which goes on in the pelvic organs. In the majority of the cases reported the mothers did not nurse their infants, so the breasts were bandaged, and leucocytes in these cases had to aid in the involution of the breasts. After every hemorrhage there is a leucocytosis, so the fall of the leucocytes after delivery is undoubtedly masked somewhat by this. That the leucocytosis present after delivery is not all due to hemorrhage is shown by the fact that a post-hemorrhagic leucocytosis disappears long before the red cells reach their previous height, while here the red cells reach the point of the last count before delivery and the leucocytes are increased.

Conclusions.—I. Where blood generation fails to keep pace with the increased vascular area a serous dilution of the blood takes place.

II. In the majority of cases this is not serious and can be overcome by simple hygienic measures—fresh air, good food and the overcoming of constipation. Cases in which the vitality is overtaxed by the increased demand for nutrition may call for iron or other hematinic treatment.

III. The regeneration of the blood is partly effected by the lessening of the vascular area after labor and subsequent transudation of fluids of the blood into the tissues.

IV. The leucocytosis is due to increased action of enlarged lymph glands of the pelvis, and in part to increased metabolism which causes a somewhat toxic condition. Its decrease is caused by the lochial discharge. Its persistence is accounted for by the fact that the involution of the hypertrophied pelvic organs and breasts is accomplished in a great measure by the leucocytes.

V. A study of the blood of a woman delivered by the Cesarean operation shows the same general behavior of the blood constituents as does that of women after normal labors.

BIBLIOGRAPHY.

1. Ramsbotham, F. H., Process of Parturition, Philadelphia, 1845, p. 448.

2. Nasse, H. Das Blut den Schwängeren. Archiv f. Gynäk., 1876, Bd. 10, S. 315.

3. Andral and Gavarrett. Untersuchungen über die Veranderungen des Faserstoffes, der Blutkügelchen, etc. Nordlinger, 1842. Translation by A. Walter, 1842.

4. Willcocks, F., Lancet, 1881. Vol. 2, p. 944.

5. Spiegelberg and Gscheidlen. Untersuchungen über die Blutmengen trachtiger Hunde. Archiv f. Gynäk., 1872, Bd. iv, S. 112.

6. Memcanti. Deut. Archiv f. klin. Med.

7. Cabot, Richard, Clinical Examination of the Blood, New York, 1900, p. 56.

8. Peckelharing. Untersuchungen über das Fibrinferment. Amsterdam, 1892. Quoted in Am. Text-Book of Phy., 1897, p. 355.

9. Fehling. Verhandel der deutschen Gesellsch. f. Gynäk., 1886, S. 51.

10. Meyer, P. J. Untersuchungen über die Veranderungen des Blutes in der Schwangerschaft. Archiv f. Gynäk., 1887, Bd. 31, S. 145.

11. C. Reinl. Beitrag. zur Geburtsh. u. Gynäk. Festschrift f. Hegar, 1889.

12. Dubner. Untersuchungen über die Hoemoglobingehalt des Blutes in den letzten Monaten der Gravidität und in Wochenbette. Münch. med. Woch., 1890. Bd. xxxvii, S. 517.

13. Richard Schroeder. Untersuchungen über die Berschaffenheit des Blutes von Schwängeren und Wöchnerinnen, u. s. w. Archiv f. Gynäk., 1891, Bd. 39, S. 306.

14. Leopold Bernhard. Untersuchungen über Hämoglobingehalt und Blutkörperchenzahlen in der letzten Zeit der Schwangerschaft und im Wochenbett. Münch. med. Woch., 1892, Bd. xxxix, S. 197.

15. Max Wild. Untersuchungen über den Hämoglobingehalt und die Anzahl der rothen und weissen Blutkörperschen bei Schwängeren und Wochnerinnen. Archiv f. Gynäk., 1897, Bd. 53, S. 363.

16. Elder and Hutchison. Obst. Trans. Edinburgh, Vol. XX.

17. Ewing, Jas. Clinical Pathology of the Blood, Phila., 1901, p. 90.

18. Henderson. Observations on the Maternal Blood at Term and During the Puerperium. J. Obst. and Gynecol. of the Brit. Emp., 1902, p. 168.

19. Ethel Blackwell. Tests of the Hemoglobin of Pregnant Women. N. Y. Md. Journal, 1895, Vol. 61, p. 776.

20. Hubbard and White. Jour. Exper. Med., 1898, p. 639.

21. Ingersley. Uber die Menge der rothen Blukörperchen bei Schwängeren. Centrallblat, 1879, S. 635.