A study of the blood after splenectomy following trauma / Jerome Meyers.

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A STUDY OF THE BLOOD AFTER SPLENECTOMY FOLLOWING TRAUMA

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The aim of this paper is not to enter exhaustively on the proved or problematic relations of the spleen to the various blood elements either during embryologic life or during extrauterine existence under normal or pathologic hemic conditions; but rather to point out as concisely as possible the variation, or lack of variation, from normal, as found in a series of twenty-six complete blood examinations in a case of splenectomy following traumatic rupture of that organ. The cause for the splenectomy. trauma, afforded an excellent opportunity to observe what effect the removal of a spleen hitherto healthy would have on the elements of a blood unaffected by any hematopoietic disease.

The examinations, made during a busy surgical service, were made at first every day, later every other day, then every third day, each time as nearly at 8 p. m. as was possible. The patient left the hospital and the city on Sept. 3, 1907, but came back for observation on October 22 of the same year, when the last examination was made. In the estimation of the hemoglobin the Tallquist method was employed; in the differential count of the leucocytes 500 cells were examined. Wright's stain was used for microscopic examination.

For the opportunity and permission to follow the blood picture I wish to thank the attending surgeon, Dr. Albert Vander Veer.

HISTORY OF THE CASE (DR. J. N. VANDER VEER)

Patient.—J. X., aged 11, schoolboy, was brought to the Albany Hospital, July 15, 1907, at about 10 a. m. The family history and past history were negative.

Present Illness.—On the afternoon of July 11 the patient while on an outing climbed into a tree and fell about thirty feet to the ground, striking on his abdomen. Although ex-

periencing some pain at this time, he lay on the ground watching the other children play until 5 p. m., when the family returned home. The patient went with them, and seemed to experience only a slight pain in his abdomen. At 8 o'clock that evening his family physician, Dr. Troidle, was called to see him, as the boy was suffering some pain in his abdomen, in the neighborhood of the umbilicus. He had had a good bowel movement. Physical examination at this time proved absolutely negative, as there was no rigidity of the muscles whatsoever, no dulness in the flanks, and a specimen of urine showed no lesion of the genitourinary tract. A mild cathartic was ordered for the patient, and it was suggested that he stay in bed. On the following day he felt well, but on the day after this, the second day following the injury, he complained of some pain in the left flank; there was a slight rigidity of the left hypogastric region and the boy showed some signs of shock. He was seen that afternoon by the attending surgeon, and it was suggested that hot packs be applied, a blood count be made and a careful estimate of his temperature and pulse be kept until the next morning. He grew decidedly worse that night, and the third day following the accident was brought to the hospital, with a tentative diagnosis of internal hemorrhage of some form, presumably of the intestine, for he had had no further bowel movement since the day of the accident. A low enema did not bring forth any results, and percussion at this time over the flanks, especially of the left side, gave dulness. The temperature was slightly subnormal, being 97 F., and the pulse varied from 90 to 100.

Operation.—On entrance to the hospital, as soon as preparation for an abdominal section could be made, the patient was placed on the operating table. The first incision (Dr. Albert Vander Veer) began at the umbilicus and extended downward for a distance of about three inches; some free blood was encountered, and it was then surmised that there was an extensive rupture of some one of the internal organs, presumably the liver or spleen. Examination of the intestines through this incision revealed that they were intact, with no injury whatever, and there were no signs of a peritonitis at this point. The incision was then extended upward around the umbilicus to the ensiform cartilage, when more free blood was encountered, and palpation on the left side showed that there was a rupture of the spleen. The incision was then extended to the left beneath the costal margin and the spleen brought into view, showing a stellate rupture on the internal surface, not large in character, and occupying a space which could easily be covered by a silver dollar. The spleen was quite movable, and it was an easy matter to throw a chromicized catgut ligature around the pedicle and tie it off *en masse*.

BLOOD COUNT SHOWING VARIATIONS AFTER SPLENECTOMY

Date.	Red Corpuscles.	Hem. %	Color Index.	White Corpuscles.	Polynuc. Leucocytes (Neutroph.) %	Small Ly'p's. %	Large Ly'p's. %	Transitionals %	Large Monos. %	Eosinophiles. %	Eosinophiles. %	Temperature at.	Pulse.	Corrected Color Index.
July 16.....	5,250,000	70	0.66 +	28,320	86.0	8.4	3.6	1.4	0.6	..	..	101.4	140	0.93 +
July 17.....	3,030,000	70	1.1 +	23,333	87.4	6.2	4.8	0.8	0.8	..	..	100.2	100	1.58 +
July 18.....	3,460,000	70	1.0 +	18,600	81.6	12.4	4.6	1.0	..	0.4	..	100	84	1.40 +
July 19.....	3,575,000	70	0.98 +	16,500	84.0	8.4	5.8	0.2	..	1.6	..	100	90	1.34 +
July 20.....	3,560,000	70	0.98 +	17,800	71.0	16.0	8.2	..	..	3.8	..	100.6	100	1.35 +
July 21.....	3,610,000	70	0.96 +	17,600	70.2	13.0	8.4	2.8	1.8	3.8	..	100.2	88	1.32 +
July 22.....	3,705,000	70	0.93 +	19,811	63.4	25.0	6.2	1.0	0.6	3.8	..	100.2	88	1.29 +
July 24.....	3,800,000	75	0.98 +	16,200	58.4	24.6	7.8	3.4	3.4	2.4	..	99	76	1.34 +
July 26.....	3,820,000	75	0.98 +	24,100	69.2	13.0	9.6	1.6	2.6	4.0	..	99	78	1.34 +
July 28.....	2,980,000	75	1.27 +	16,600	69.4	19.2	8.2	1.0	1.6	0.6	..	100	80	1.72 +
July 30.....	3,235,000	75	1.17 +	20,800	71.0	17.2	9.2	0.6	0.6	1.4	..	100	100	1.60 +
Aug. 1.....	3,950,000	75	0.94 +	12,500	61.4	26.6	7.4	0.4	0.8	3.4	..	99.8	98	1.31 +
Aug. 3.....	4,520,000	80	0.88 +	14,600	63.6	22.4	5.4	0.8	1.4	4.4	..	99	90	1.22 +
Aug. 5.....	4,525,000	80	0.88 +	16,943	58.4	28.0	6.8	1.0	1.2	4.6	..	98.8	86	1.22 +
Aug. 7.....	5,105,000	80	0.78 +	15,600	42.0	43.6	9.6	0.4	2.6	1.8	..	98.6	86	1.08 +
Aug. 9.....	4,520,000	80	0.88 +	11,000	55.6	31.6	4.2	1.2	1.8	5.6	..	99.4	76	1.22 +
Aug. 11.....	4,860,000	80	0.82 +	15,000	57.2	30.4	4.8	1.8	0.6	5.2	..	99.4	84	1.12 +
Aug. 14.....	4,830,000	80	0.83 +	14,000	52.6	33.0	6.6	0.8	4.0	2.8	0.2	98.8	90	1.13 +
Aug. 17.....	4,850,000	85	0.86 +	20,100	65.8	22.6	6.4	1.4	1.0	2.2	0.6	99.2	78	1.19 +
Aug. 20.....	4,845,000	75	0.77 +	16,200	54.0	35.0	6.0	0.8	1.2	3.0	..	99.4	84	1.05 +
Aug. 23.....	5,840,000	75	0.64 +	10,000	48.6	31.4	10.4	0.4	4.2	4.4	0.6	98.6	84	0.87 +
Aug. 26.....	4,590,000	75	0.81 +	15,200	45.4	43.8	3.4	0.8	2.8	3.6	0.2	98.8	82	1.12 +
Aug. 29.....	5,450,000	75	0.68 +	18,000	49.0	42.6	4.6	0.2	1.8	1.4	0.4	98.8	92	0.93 +
Sept. 1.....	4,290,000	75	0.87 +	12,400	34.2	61.0	3.0	1.2	0.4	0.2	..	98.4	100	1.19 +
Sept. 3.....	5,190,000	75	0.72 +	28,400	78.2	18.0	2.0	0.6	0.8	0.4	..	101	120	0.98 +
Oct. 22.....	3,650,000	75	1.02 +	14,100	53.4	39.0	1.4	3.0	0.6	2.0	0.6	....	...	1.40 +

The patient recovered nicely from the operation; the drainage-tube which had been placed down on to the pedicle was removed at the end of the fifth day and a small gauze wick substituted. There were no resultant symptoms following the operation. Throughout there was a gradual recovery, save for two instances in which the boy was allowed to partake of food which had been smuggled in by overindulgent relatives. He left the hospital September 3, clinically in excellent condition, and has since (to Nov. 15, 1908) progressed as a normal boy in every respect.

The results of the examination can be seen *in toto* in the tabulations, which show the number of red blood cells; the percentage of hemoglobin; the color indices, first estimated with 100 per cent. hemoglobin and 5,000,000 red cells as a basis, then calculated with 80 per cent. hemoglobin and 5,500,000 red cells at normal for a boy of 11 years; the total number of leucocytes with the percentage of the various forms, together with the pulse and temperature at the time of the examination.

The first count, taken on the evening of the day of the operation, showed a red-cell count of 5,250,000; the next day it had fallen over 2,000,000. The count then gradually rose until July 28, when there was again a sudden decrease of about 1,000,000 red cells. And so further there were rises and falls of 500,000 to 1,000,000 red cells in two or three days. On August 23 the count reached 5,840,000, the highest noted, only to drop to 4,590,000 on August 26; then it rose and fell with each successive count until, on the last estimation, October 22, the reds numbered only 3,650,000 cells. We have then a lessened number of red corpuscles, with a surprising variability from day to day, a fluctuation that apparently has no connection with the degree of leucocytosis or the temperature.

Microscopically, the red corpuscles showed at no time any evidence of even a moderate anemia. A few poikilocytes were found, but no nucleated forms were seen during the entire period.

In estimating the color index I took at first the normal number of red corpuscles in 1 c.mm. as 5,000,000 and the normal percentage of hemoglobin as 100 per cent. But in a child of 11 the number of red cells is normally higher, 5,500,000, and the percentage of hem-

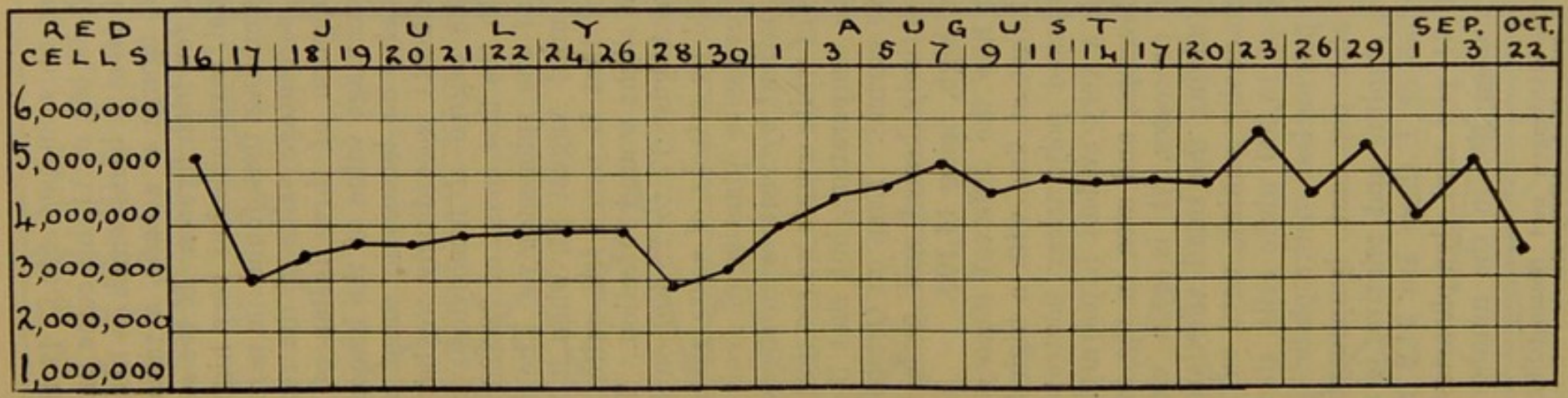

Chart 1.—Showing the great variability in the number of red corpuscles.

oglobin lower, only 80 per cent.[1] If the later figures are normal for a boy of 11, his color index should then be calculated from a basis which is his normal. Even with the first figures as a basis, a variable color index is seen with a few high figures. If the second figures are used as normal, a variable but very high color index is obtained, resembling that found in pernicious anemia; for here the percentage value of the red cells remains, with the exception of three instances, constantly far below the percentage value of the hemoglobin.

Unfortunately, no leucocytic count was made soon after the accident; accordingly we have no means of comparing the degree of leucocytosis previous to the operation with the first count of 28,320 on the evening of the day of the splenectomy. The leucocytosis remained high until August 23, when it was 10,000; it will be noted that it never fell quite to normal, the cause being a slight wound infection. The sudden rise to 20,000 on August 17 to 28,400 on September 3 is to be explained by attacks of acute gastritis due to the eating of an excessive quantity of fruit surreptitiously given to the patient by visitors on the ward. Examining the series of white counts we see that we have variations with the temperature, but that the count is persistently above normal. Even on October 22, when the wound was entirely healed and perfectly closed, the count was yet high, being 14,100.

Examining now the different leucocytic elements, it will be noted that at first with a high leucocyte count there is a marked polynuclear neutrophilic hyperleucocytosis with a very evident hypolymphocytosis. But as the case develops, and even in the face of ordinary inflammatory processes, it is seen clearly that the lymphocytes (adding the small and large varieties together) are gradually gaining, until on August 7, with a total count of 15,600 white cells, there are only 42 per cent. of polynuclear neutrophilic leucocytes contrasted with 53.2 per cent. lymphocytes. A hyperlymphocytosis, absolute and relative, is surely developing; on September 1 there are 34.2 per cent. polynuclears and 64 per cent. lymphocytes. Still, when there was a sudden rise in the number of leucocytes,

1. Blutkörperchenzählungen und Hæmoglobinbestimmungen bei Kindern, Arch. f. klin. Med., 1889, xlv.

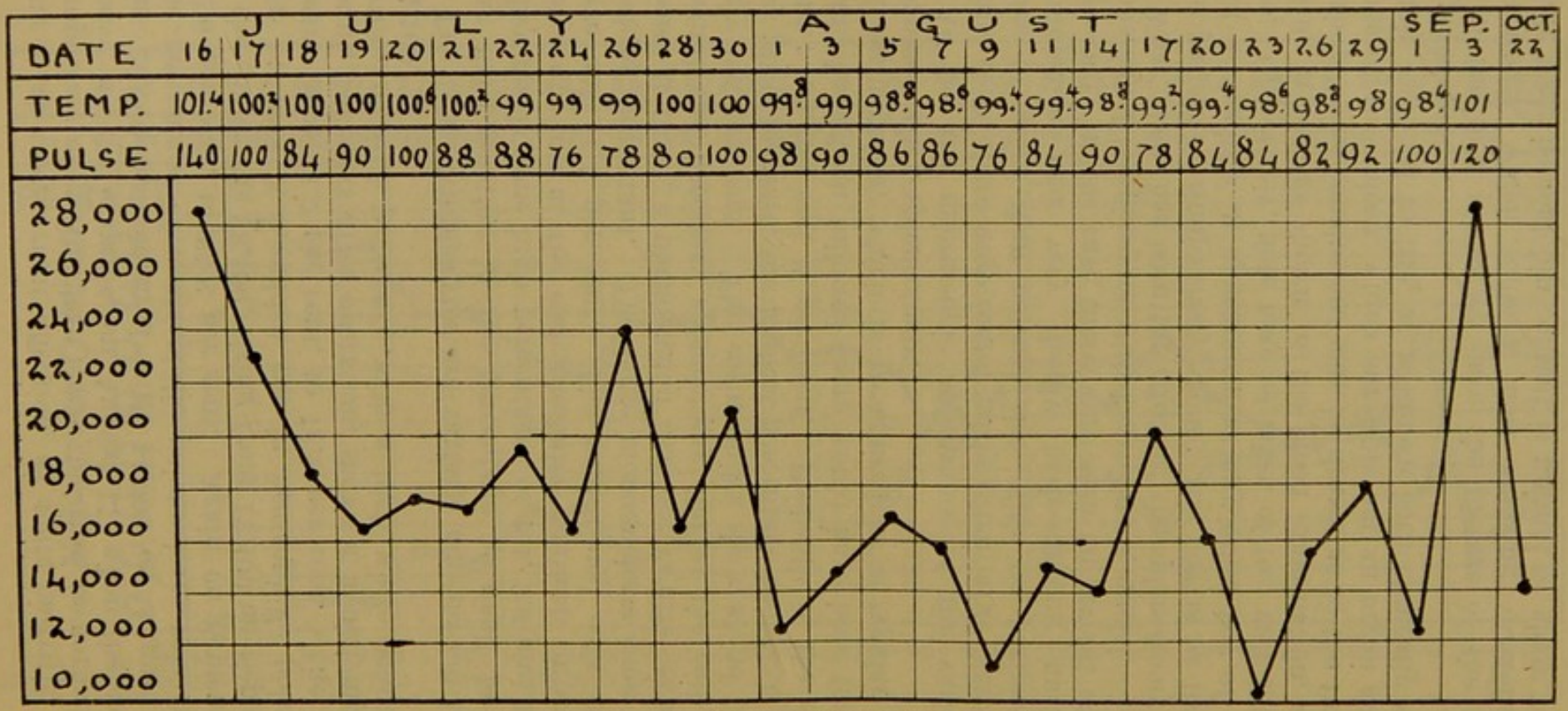

Chart 2.—Showing the variation of the leucocytes.

due to an intercurrent affection, as acute gastritis, the proportion of polynuclear leucocytes rises to normal or above, as, for example, on August 17, when the count was 20,000 as compared with 14,000 on August 14, the percentage of neutrophilic polynuclears rose from 52.6 per cent. to 65.8 per cent. Again on September 3 the count was 28,400, rising from 12,400 on September 1; here is a sudden rise in neutrophilic polynuclears from 34.2 per cent. to 78.2 per cent. The last count, 102 days after operation, shows a hyperlymphocytosis of 40.4 per cent., with a high white count of 14,100.

The large lymphocytes are variable and do not bear any fixed relation to the percentage of small forms. They reach some high percentages of 8.4, 9.6 and 10.4 per cent., but at the end gradually diminish until we have only 1.4 per cent. The transitional cells show nothing important. The large mononuclears show increase at times, a phenomenon that occurs after experimental and necessary splenectomy, but at the end are only 0.6 per cent. The eosinophiles show at no time any great increase, the highest percentage being 5.6 per cent.; at the end 2 per cent. Probably if the case could have been followed there would have been found an eosinophilia, which is recognized as a regular occurrence after splenectomy.

As for the microscopic appearance of the various white cells, there were found fairly often large lymphocytes of more than normal size, with no peripheral protoplasm and very deeply basic-staining nuclei; also early in the case there were seen on several occasions small lymphocytes with karyokinetic nuclei.

What, then, has been the effect of the splenectomy on the patient? Subjectively, none; the boy is as lively and as healthy in appearance as any other boy of his age. Objectively, note may be taken of two very interesting results as shown in the blood examination, and perhaps some conclusions may be drawn as to the functions of the spleen, which surely is not an organ absolutely essential to life, as is known both clinically and experimentally.

In the first place, we have the picture of the red corpuscles, which show a most amazing variability, while their hemoglobin content is normal or above nor-

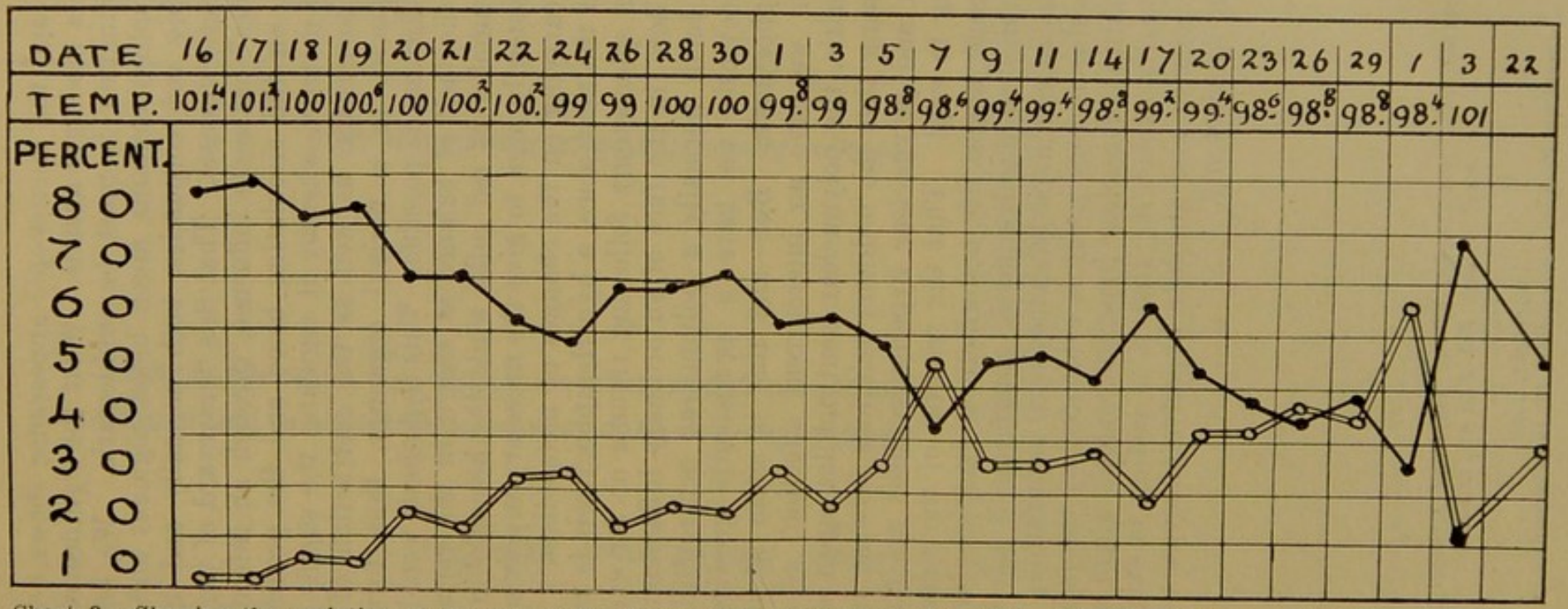

Chart 3.—Showing the variation of the polynuclear neutrophilic leucocytes and of the lymphocytes, and the gradual rise of the latter. Heavy line = polynuclear leucocytes; double line = lymphocytes.

mal, and the microscopic appearance shows no sign of even a moderate anemia. What the significance of this combination is must be problematic. We know that the spleen contains much blood pigment and disintegrating red corpuscles, both normally and in hematopoietic diseases. That this "graveyard of the red corpuscles" has some influence, through an internal secretion, on the circulating blood and the producing red bone marrow, whereby it regulates the supply of fresh red corpuscles, as well as the destruction of the old corpuscles in a normal organism, thus forming an equilibrium, is possible. This hypothesis would account for the lack of balance as shown in the variability of the number of red cells, while the hemoglobin remains consistently high to give the necessary supply of oxygen for carrying on the changes of metabolism.

In the next place, a hyperlymphocytosis is recognized after splenectomy following trauma or for experiment, but here, in the face of an ordinary inflammation, calling forth normally a polynuclear neutrophilic hyperleucocytosis, we have a persistently growing hyperlymphocytosis. But—and this is again of interest—when we have an intercurrent affection, as an acute gastritis, the polynuclear neutrophiles again dominate, showing that the ordinary relations between inflammation and polynuclear hyperleucocytosis are still struggling to exist. That the removal of the spleen, which in embryologic life manufactures lymphocytes, gives a stimulus to the lymphatic apparatus of the body and thus causes a hyperlymphocytosis, is probable; that this stimulus is very great is evidenced by the lack of neutrophilic polynuclear hyperleucocytosis where we should naturally expect it; that it is lasting is evidenced by the relative and absolute hyperlymphocytosis seen late after splenectomy.

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