A STUDY OF THE BLOOD PICTURE IN SCARLATINA

WITH REFERENCE TO ITS VALUE IN DIAGNOSIS

by

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I N D E X

INTRODUCTION

The correct diagnosis of scarlet fever is of the utmost importance. Fortunately this disease does not usually present much difficulty; for the signs and symptoms in a typical case are perfectly definite. The diagnosis of the atypical case however is a less simple matter, and one which is a constant source of worry.

The type of case met with in epidemic is frequently modified, the mild case is often very unlike scarlet fever, while many other conditions simulate the true exanthem.

Segregation in hospital, since the disease became compulsorily notifiable, has done much to lessen the mortality from scarlet fever, but at the same time it has modified the disease, probably through reducing the virulence of the virus, at any rate, atypical cases of scarlet fever are at the present time more frequently encountered than they were in the days before the vast majority were nursed in hospital.

A definite diagnosis cannot be made invariably, and yet the question of diagnosis is a vital one, for on the one hand there is the risk of contagion in the home and elsewhere, with consequent paralysis of the

household, while on the other hand there is the chance that the non-scarlatina patient on being sent to hospital may there contract the real disease; - a serious matter, for it is a notorious fact that hospital infected cases are frequently extremely ill. Thus to avoid any risk the medical man frequently labels an atypical case - "observation scarlet", - and sends it as such to hospital, for he may suspect the presence of the real disease from the history, or from the appearance of the patient, without being quite sure.

In hospital a more or less steady stream of such cases arrives, and there is joined by all cases suspected of suffering from scarlet fever without clinical signs sufficient to warrant a definite diagnosis. Under this heading are cases sent to hospital as Scarlet Fever without any sign of the disease on arrival, and cases with some other infectious disease, suspected of scarlet fever from the presence of a rash or other sign.

These observation cases receive special care and attention in hospital. They must be rigorously isolated, for on the one hand they may become infected, and on the other they may disseminate infection. They must be closely studied with a view to establishing a definite diagnosis one way or the other. In fact they are a constant source of tribulation.

Usually they are retained in isolation until

some complication or sign of Scarlet Fever is developed, when they are placed in a scarlet fever ward, or until they are discharged because they show no sign of disease, and in either case they have taken up much valuable time and space.

Enough has been said to indicate the importance of diagnosis in this common diaease. Let us now examine the features of scarlatinal diagnosis and indicate wherein purely clinical examination may be inconclusive.

Scarlet fever may be diagnosed at any one of 3 stages. Preeruptive - during the rash - after the rash. In the observation case the diagnosis is seldom called for in the preeruptive stage, but it is commonly required in the eruptive stage and later. During the eruption the signs of the disease are many, and yet any or all of them may be absent, or present in such a slight degree as to be of no value in diagnosis. After the rash fades, apart from the appearance of the tongue, the desquamation, and the development of complications, there are no signs of the disease, and of these, the desquamation alone is typical. Other infectious diseases cause a rash followed by desquamation, and in an atypical case of scarlet fever the "peeling" may be quite atypical. Thus after the rash there is no certain aid to diagnosis.

In fact all through the illness where signs are atypical the diagnosis must be a guarded one, and often it is only after close observation that a diagnosis can be made.

A study of the literature on scarlatina reveals the fact that many observers have examined the blood of scarlet fever patients and have noted certain changes.

These changes indicate the presence of an eosinophilia during the early stages of the disease contrary to the usual rule in infectious diseases. Here then is a change which may be typical of scarlatina, which can be readily observed and checked, and which may be of great value in diagnosing the observation case. It has been said that the results of any blood test are to be interpreted only in the light of the fullest possible clinical information, and these observation cases, so closely observed clinically, are ideal subjects for a blood examination.

Moreover a differential count is easily carried out and is not liable to great error, so that it could be readily utilised as an aid to diagnosis in scarlatina. Gulland and Goodall (1914), express the opinion that it may be of value to investigate the the eosinophil count in mild cases of scarlatina, and other writers agree with them, though Tileston and Locke (1905) decided that the study of the blood in scarlatina was of no advantage in diagnosis.

The literature gives many reports of blood examinations in scarlet fever, carried out in various countries, at various times, and doubtless on various types of patient, so that though there is a certain uniformity in the findings, one encounters a wide range of variation in details.

It was therefore decided to take blood counts in typical scarlet fever cases in hospital, and at the same time to take counts in all observation cases - Thus standards for the normal case could be established which would act as a control for the observation cases in hospital at the same time and probably suffering from the same type of disease.

The work was arranged under the following headings.

1. The differential blood count in normal people.
2. Changes observed by others in the differential blood counts in the course of scarlet fever.
3. Personal observations on the changes in the blood picture of scarlatina cases in the first ten days of the disease.
4. Summary of results of blood counts in scarlatina cases.
5. The blood picture in other diseases and conditions which may be mistaken for scarlatina.
6. Differential Blood counts in observation scarlatina cases.
7. General Summary and Conclusions.

I. The Differential Blood Count in Normal People.

Since the differential count may occupy an important position in the diagnosis of scarlatina, it is clear that a standard for comparison between counts in scarlet fever patients, and in normal people, must be set up.

A brief study reveals the fact that hardly two observers agree upon the percentage number of cells present in a normal person.

We give some of the figures on Page 7.

Others give the following figures for eosinophils -

Hayem	7%	Canon	1-3%	Weishsel-baum	5%
Gabritchewsky	1-3%	Von Limbeck	2-8%		
Muller & Reider	1-4%	Oskor	6%		
		Zappert	.67-11%		

	Polymorpho-nuclear leucocytes	Lympho-cytes	Monoun-clear	Transi-tional	Eosino-phil	Large lympho-cytes & trans-itional	Most cells	Basi-phil cells
Pappenheim	70-75	20-22	2	6	2-4		0-1	
Cabot	60-70	20-40	1	10	5.4		. 1-.5	
Bunting	50-60	30-40	.6-2	6-8	.8-4		. 4-1,5	
Miller	64	22	8	3	2.5		. 6-33	
Warfield	50-60	20-30	5-10	5-9	2-8		. 4-2	
Erlich	70-72	22-25			2-4	2-4		
Gulland & Goodall	70	25				4		1

These results show conclusively that there is considerable divergance of opinion upon the normal percentage composition of the white blood cells.

In the case of eosinophils the highest limit is 11%, but a general average figure from the lists shows that eosinophil cells are rarely found over 4%.

Gulland and Goodall regard 4% as the maximum for an eosinophil count, while Ewing states that since the eosinophil cells may be increased many times without passing the limits established as physiological, it is obvious that none but considerable changes can have any distinct pathological significance, yet the observations on eosinophilia have referred quite as much to a persistently high or low average count within physiological variations, as to distinct increase or decrease, and a certain pathological signifance has been shown to go with these lesser variations. One is thus justified in regarding as an eosinophilia, a percentage over 4% while an average over 4% in a large number of cases, would indicate an eosinophilia in these cases.

In children the percentage is about 1% higher according to Zappert, though other authorities have not found this so, in any case an average over 4% would be an indication of an eosinophil increase even in children.

The eosinophil cells have been termed the finest re-agents for detection of foreign organismal poison in the blood, and they show no changes uniform to age, sex, or digestion.

The polymorphonuclear leucocytes and the lymphocytes show wide variations also, and the working figures for these seems to be 65% - 70% for polymorphs and 25% - 35% for lymphocytes, including as lymphocytes all mononuclear cells.

In children a higher percentage of lymphocytes is normal, and one expects to find up to 45%.

Thus one establishes the following standard as normal.

Polymorphonuclear	Lymphocyte	Eosinophil
65 - 70%	25% - 35%	4%
	45%(in children)	

These figures agree more or less with these generally accepted in the district in which the series of counts in scarlet fever patients was taken.

II.

Changes observed by others in the differential Blood counts in the course of Scarlatina

The literature on Scarlatina blood counts is manifold. It is noteworthy that in 1919 Turk (Monatschrift fur Kinderheilkunde 15 p156) in a paper on the behaviour of the white blood corpuscles in the blood picture of scarlet fever in early childhood states that in spite of numerous researches on the blood of scarlatina the views are still divided on this question. Most of the work carried out has been done on an insufficient number of cases, and faulty methods have been employed. Thus in spite of many reports of blood examinations no definite law has been established, nor is this to be wondered at when one considers the great variation which the disease can manifest.

A brief historical sketch of the work done on the differential blood count in scarlatinal is of interest.

The chief authorities quoted are:-

BOWIE (1902) Thesis "The Leucocytosis of Scarlatina".

TILESTON & LOCKE (1905) "Journal of Infectious Diseases".

O.KLOTZ (1904) "Journal of Infectious Diseases".

EWING "Clinical Pathology of the Blood".

TURK (1918 - 1919) Monatschrift fur Kinderheilkunde 15 p 156.

Kotschetkow (1891) made the first systematic study in 20 cases which he arranged in groups of severity according to the total leucocyte count. He found in moderately severe, and in mild cases, that the eosinophil cells were normal or subnormal at the onset of the disease, and they rose gradually in number to a maximum of 8 to 15% in the 2nd and 3rd week. In very severe cases the eosinophils remained low and rapidly sank to zero. He found the neutrophil leococytes high at first but they fell rapidly, while the lymphocytes were low at first and rose later. He stated that the changes were so constant as to be of considerable prognostic importance.

Rille in 1892 reported on the blood in three cases. In two of these the blood picture was unaltered, while in the third case which ended fatally, the eosinophilswere increased (5.31% - 7.7%).

Felsenthal in 1892 gave results in six mild cases of scarlet fever in children where he found the eosinophil cells slightly increased at the time the rash appeared (11% in one case) and in a few days they were fewer in number.

Zappert in 1893 reported an eosinophilia during or just after the febrile stage (maximum 7.7%). In three cases he reported:-

(1) Eosinophilsscanty during the fever.
(2) Eosinophils2% with the rash.
(3) A moderate eosinophilia.

Van den Berg in 1898 gave counts in 16 cases and during the fever the differential count was:-

Polymorphonuclear	68% - 82%
Lymphocytes	16% - 28%
Eosinophils	1.3% - 8%

Turk in 1898 stated that the eosinophilia was definite. In two adult cases he found the eosinophils decreased at the onset of the disease but they later increased during desquamation.

Cabot in 1900 noted that the polymorphounclear cells were high at first, but soon fell, while the eosinophils were high during the fever and remained numerous until the 6th week.

Reckzeh in 1902 found an indefinite eosinophilia in ten children (1 - 12.5%), with maximum on the 8th day.

Sacquepee in 1902 studied 14 cases and found that the percentage of polymorphounclear cells was very high for the first few days (up to 90%), later falling to normal, while the lymphocytes followed an exactly opposite course and the eosinophil cells were increased reaching a maximum on the 4th or 5th day (13%).

Brown (1903) showed an eosinophilia in the second week of the disease in 3 cases.

Bowie (1902) while mainly concerned with the total leucocyte count gave numerous differential blood counts in the large number of cases which he examined. He found an increase in the percentage

number of eosinophil cells following a preliminary diminution at the onset of the disease. This increase went on rapidly until the fever had passed its height in simple favourable cases, then the eosinophils diminished in number and came to normal some time after the total leucocytosis was over. The more severe the case the longer were the eosinophils in rising in number. In fatal cases they never increased at all.

Polymorphounclear cells were relatively increased at first, but they fell to normal while the lymphocytes followed an inverse course. In simple cases the cycle of blood changes was over in three weeks.

He arranged his cases in three groups:-

(1) Scarlatina simplex.
(2) Scarlatina anginosa.
(3) Fatal cases.

The simple scarlets showed an eosinophilia with a maximum of 10% between the 3rd and 7th days of disease. Anginose cases showed very few eosinophilsin the early stages of the disease, and fatal cases showed a complete absence of eosinophil cells.

In detail he gave counts in individual cases all of which showed an increase in eosinophils in the first week of the disease. Bowie thought the blood changes might be useful in the diagnosis of scarlatina especially from mild tonsillitis.

Klotz (1904) studied fourteen cases with ages ranging from 2½ to 14 years. He arranged these into groups:-

(1) Very mild

(2) Moderately severe (a) complicated (b) uncomplicated

(3) Very severe or malignant

The very mild cases showed a normal differential count with very slight variations.

The moderate cases with complicationswere similar to these without complications and the results of eosinophil percentages were:-

2nd	- 4th day	1.1%
4th	- 10th day	3.7%
10th	- 16th day	6.8%

The severe cases showed an entire absence of eosinophil cells. In his summary he stated that in a favourable moderately severe case with good resistance the eosinophil cells were at their highest before the 10th day but his absolutely highest percentage was 19. 3% in the second week. He thought that the eosinophils as a rule were few in number until the 5th day, thereafter they increased till the 21st day.

Tileston & Locke (1905) Made a thorough study of 34 cases in hospital with a view to establishing the blood changes in scarlet fever.

They made the following age divisions:-

(1)	under 2 years	- 1 case
(2)	2 to 10 years	- 28 cases
(3)	11 to 23 years	- 5 cases

All their cases were under a constant regime of diet and treatment and showed unmistakable signs of the disease. No medication was used. The blood for

examination was taken at 9.30 a.m. and at 4 p.m.

They made no grouping according to the severity of the disease as did Bowie and Klotz but preferred to establish a standard for the average case noting exceptions where the disease was very mild or severe, and recording all complications. At first they studied their cases in groups for each year, but as they found no significant variations they adopted the grouping given above.

As lymphocytes they grouped together all mononuclear cells. They concluded that there was considerable variation in the course of the disease, in the conduct of the leucocytes in a few cases, but on the whole the cases conformed to a uniform type.

The polymorphonuclear cells were relatively much increased for the first few days reaching 80 or 90% on the 2nd to 8th days to fall abruptly thereafter then more gradually to normal in the 3rd to 6th week.

The lymphocytes followed an inverse course falling at first to below normal - in some cases to 5% on the 2nd to 4th day then rising to normal in the first week and increasing (to over 50% in some cases) till the 6th week. Convalscents showed a lymphocytosis for many weeks.

The eosinophilswere low at first but soon rose to normal and above, and often were 5% or 6% on the 4th and 5th day.

Examining the figures in detail one finds an increase in the percentage of eosinophils in every moderately severe case during the first week. The mild cases show a wider range of variation 12% on the 6th day in one case and 2% in another case on the 7th day - on the whole however even the mild cases conform to the general rule and show an increase in the percentage of eosinophil cells during the first week of the disease.

The severe cases invariably showed a low eosinophil count.

Ewing expressed the opinion that in scarlet fever the polymorphonuclear cells in all cases were much increased from 80% to 90% according to the intensity of the disease. The maximum for these cells was on the 2nd day of the exanthem. Thereafter they slowly decreased in number. He reported no such fall in severe cases. "The eosinophil cells may show characteristic changes". In all but the very severe cases they were normal or subnormal at first steadily increasing after the second or third day, and reaching their maximum of 8 to 15% in the 2nd or 3rd weeks. One case reported showed no eosinophils at the height of the exanthem.

Turk (1918 - 1919) made a very exhaustive study, and carried out 465 counts in 58 cases between the ages of 2 and 5 years.

This observer pointed out that complications are the exception rather than the rule in fever hospitals, and concentrated on the average case. Other cases were counted but the number of severe cases and cases with complications were very small, so that 48 typical scarlets were examined in great detail.

In these simple uncomplicated scarlets Turk obtained the following figures from the blood counts.

Day of Disease	No.of cases	Lymph.	Poly.	Eosin.
1	4	16.5	79.4	1.8
2	28	19.5	71.7	4.8
3	38	22.8	70.3	6.2
4	39	25.9	66.6	6.5
5	41	31	60.6	7.4
6	37	34	58.6	6.3
7	41	34	49.7	6
8	33	37.2	55.3	5.9
9	36	35.6	58 2	5.5
10	38	36.2	57.3	5.7
11	36	38.2	55.1	5.9
12	34	34.3	59.5	5.2
13	26	34.4	60	4.9
14	26	37.7	52.2	4.5

These figures he regarded as typical of simple scarlatina and they undoubtedly indicate a marked type of change.

The polymorphs are relatively increased in the first two days of the disease. They are normal on the third day and thereafter fall until the seventh day. Subsequently the polymorphs remain low for some time. In individual cases the polymorphs were 90% on the first day in one case and 60% in another. The lymphocytes are low at first and gradually increase in number till they reach their normal figure between the 4th and 5th day, steadily increasing thereafter and maintaining a relatively high percentage for some time. The eosinophil cells show very characteristic changes. They are few in number on the first day but they rapidly increase showing a figure over the normal on the 2nd day and reaching a maximum of 7.4% on the 5th day. The eosinophilia is maintained throughout the first two weeks. According to Turk the outset of the eosinophilia is just at the height of the rash and the cells are highest proportionally and absolutely on the 5th day, on which day one case showed 23%.

These figures are in complete agreement with those of Sasquepee, Besancon, Lable and Weil.

In complicated and severe cases of which Turk examined a small number the eosinophilia is later in developing and in children with the exudative diathesis very large numbers of eosinophil were found in simple cases.

Summary of reported results:-

The various blood examinations reported above, cover a wide field. Figures are obtained from various widely separated areas, and it is only natural that they show some degree of variation coming as they do from America, Germany, England and elsewhere. Various factors influence the disease in different countries, such as the prevalence of epidemics, the isolation methods adopted, and the resistance to disease of the patients, to mention but a few.

Taking such facts into consideration one notes that over all there is a wonderful uniformity in the results.

In the first place there is a perfectly definite blood change in scarlet fever. This takes the form of an initial increase in the proportion of polymorphonuclear cells with a corresponding reduction in lymphocytes and eosinophil cells. This early increase is not maintained for many days and as it passes off the other blood cells return to normal. As in all blood examinations no hard and fast rules can be laid down. The changes are there, but various writers disagree as to the actual times at which they occur. In the course of the disease the polymorphs having come to normal in the first few days fall below that figure, while the lymphocytes steadily increase and the eosinophil rapidly multiply till at some time during the later part of the first and the earlier part of the second week the blood picture shows a low percentage of polymorphonuclear cells and a high percentage of lymphocytes and eosinophils. This change, or rather this series of changes seems to be found in scarlet fever alone of all the infectious diseases, and if it is invariably present it would be an extremely useful aid to diagnosis. However exceptions are reported not only in typical scarlet fever cases but more especially in very mild and in very severe cases. Indeed in the former class no very definite results are available, but in the latter type the general rule is certainly not followed and in fact the eosinophil increase is entirely absent.

Can the figures given be accepted for comparison with those found in observation cases in hospital at the present time. One is chary of accepting figures of others when one has no check upon the nature of the disease and upon the other factors which might alter the blood picture. Turk's results are the most comprehensive, but he shows no results for children under 2 years of age, nor for adults.

In the end one is forced to the conclusion that for a comparative study of the blood changes in observation scarlet cases, a comprehensive study of a series of scarlet fever cases in the same hospital at the same time is necessary. In the very mild cases the blood changes must be established, for these are the cases which most often lead to difficulty in diagnosis. In severe cases, and these one presumes are the toxic and septic scarlet cases of the present time, it cannot be hoped that the blood will give any assistance in diagnosis.

III

Personal observations on the changes in the blood picture of scarlatina cases in the first ten days of the disease.

It now remained to establish, if possible, a typical change in the blood of all scarlet fever patients.

With this end in view all available cases were examined, some frequently, others on one or two occasions.

The routine methods for collecting the blood, and making and staining the film were employed. In every case the blood was taken from the ear, and samples were collected in all cases between the hours of 11.30 a.m. and 12 noon or at about 4 p.m.

The stain employed in the first place was Leishman's, and this did admirably. Later Jenner's stain was employed and gave excellent results also, in particular the granular elements of the various cells were clearer than with the other stain.

Never less than 300 white blood corpuscles were counted, and on occasion when a low or high count was obtained from a count of 300 cells a further 300 were enumerated. "As a rule the counting of 300 cells gives an accurate index of the condition of the blood". (Gulland and Goodall).

In every case the results were given in round figures. It was felt that if the blood changes were so slight that they had to depend upon a decimal to show an increase or decrease, then they were not sufficiently definite to warrant a further stody, therefore no decimals were given but the figure nearest was tabulated as the actual number present.

All the cases examined were in scarlet fever wards in hospital undergoing a strict regime of diet and treatment.

They may fairly be claimed as typical examples of the type of case presently encountered in hospital and in private practice. No epidemic occurred during the time these counts were done, nor was there a run of very mild or very severe cases. In the vast majority of cases the patient was suffering from scarlatina simplex and few developed complications. Where complications occurred we have noted them. We have also earmarked the very mild cases and included them in the general list. Four toxic cases were examined and three septic cases, more as a matter of general interest than from the hope of finding a blood change of value in diagnosis. In one or two cases in children, worms were reported and these counts were excluded, not because they showed any untoward changes, but because one had to exclude the possible effects of the parasites upon the blood picture.

The necessity for subdivisions in results

AGE:-

Age has a definite influence upon the percentage of blood cells in a normal individual, and even more so in disease is there a variation. Any sub-division into age groups must be arbitrary. Tileston and Locke decided that over two years of age the percentage of cells present does not vary sufficiently to justify a sub-division, but a preliminary study showed that the changes in adults were rather different from those in children under 10 years of age in this series, while under two a similar difference was noted. It was therefore decided to arrange the cases in 3 groups according to age.

(1) under 2 years
(2) 2 to 10 years
(3) over 10 years

Sex seems to have no influence upon the blood picture, but the sex was noted in every case to make comparison possible.

Bowie, Klotz and Turk have arranged their cases in groups according to the severity of the disease.

Bowie (1) Scarlatina Simplex (1) without complications
(2) with complications

(2) Scarlatina Anginosa.

(3) Fatal cases.

Klotz (a) Very mild cases

(b) Moderately severe (1) complicated
(11) uncomplicated

(c) Very severe or malignant cases.

Turk Concentrated on the average slight or moderately severe case and had four sub-groups.

(1) Moderate scarlatina with adenitis.

(2) Severe scarlatina with adenitis.

(3) Scarlatina with otitis.

(4) Scarlatina in children with exudative diathesis.

As stated above we hoped to establish a uniform change in all scarlatina cases, very mild, mild, moderately severe with or without complications, making an exception in the case of very severe cases (i.e. Toxic and Septic cases) which are a small group and the results from which one merely included for their interest. The cases were therefore arranged in 3 large groups according to age. Very mild cases and cases with complications were noted and were included in their groups.

In the first place 4 cases were examined in each age group with the idea of finding out if possible the days between which the blood changes were most extreme, and as this time could reasonably be expected before the 10th day of the disease no counts were done beyond that day. One hoped to find characteristic changes in these 12 cases, all of which were perfectly definite cases of scarlatina of the moderately severe type with-

out complications. As the cases were examined in hospital it was not possible to have counts before the third day, moreover the day of disease is estimated from the history given by the patient or a close relation, and is liable to error on that account, but such error cannot be avoided. In a few cases in hospital, the signs of disease were such as to indicate that the day of disease was far in advance of the actual estimated day, and such cases were excluded from the lists.

THE AVERAGE CASE

GROUP A. (under 2 years of age)

Polymorphonuclear cells

Case	Day 3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%
I	69	46	46	42	40	40	56	58
II	84	82	70	71	58	53		
III		71	50	52	47	49	54	
IV		66	60	44	53	54	53	54
Average	76.5	66	56.5	52.5	49.5	49	54	56

Lymphocytes

Case	Day 3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%
I	29	51	50	51	48	49	38	40
II	14	12	25	19	39	41		
III		25	44	41	49	47	43	
IV		30	30	42	35	41	42	44
Average	21.5	29.5	37.5	38	43	44.5	41	42

Eosinophils

Case	Day 3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%
I	2	3	3	7	12	11	6	2
II	2	6	5	10	3	6		
III		4	6	7	4	4	3	
IV		4	10	14	12	5	5	2
Average	2	4	6	9.5	7.5	6.5	5	2

THE AVERAGE CASE

GROUP B.(Aged 2 to 10 years)

Polymorphonuclear cells

Case	Day 3 %	4 %	5 %	6 %	7 %	8 %	9 %	10 %
I	82	84	87	79	74	74	73	74
II	87	87	71	63	61	56	73	72
III	76	70	69	58	56	56	60	
IV		73	58	43	48	52	72	
Average	82	78.5	71	60.5	60	60	69.5	73

Lymphocytes

Case	Day 3 %	4 %	5 %	6 %	7 %	8 %	9 %	10 %
I	10	9	8	16	20	20	24	25
II	8	5	19	27	32	37	25	26
III	19	24	22	35	34	38	36	
IV		22	36	51	49	46	25	
Average	12	15	21.5	32.5	34	35	27.5	24.5

Eosinophils

Case	Day 3 %	4 %	5 %	6 %	7 %	8 %	9 %	10 %
I	8	7	5	5	6	6	3	3
II	5	8	10	10	7	7	2	2
III	5	6	9	7	10	6	4	
IV		5	6	6	3	2	3	
Average	6	6.5	7.5	7	6	5	3	2.5

THE AVERAGE CASE

GROUP C. (Over 10 years)

Polymorphonuclear cells

Case	Day 3 %	4 %	5 %	6 %	7 %	8 %	9 %	10 %
I	75	70	69	56	83	89	87	
II	73	80	76	74	83	82	88	80
III		91	84	75	61	63	62	68
IV		86	84	60	56	52	50	63
Average	74	82	78	66	70	71.5	72	70.5

Lymphocytes

Case	Day 3 %	4 %	5 %	6 %	7 %	8 %	9 %	10 %
I	24	26	25	39	13	9	12	
II	24	15	18	23	15	15	10	18
III		7	13	20	34	34	36	29
IV		10	12	37	40	41	46	33
Average	24	14.5	17	30	26	24.5	26	26.5

Eosinophils

Case	Day 3 %	4 %	5 %	6 %	7 %	8 %	9 %	10 %
I	1	4	6	5	4	2	1	
II	3	5	6	3	2	3	2	2
III		2	3	5	5	3	2	3
IV		4	4	3	4	7	4	4
Average	2	3.5	5	4	4	4	2	3

Taking the averages side by side for comparison we get the following Tables, page 29.

One must admit at once that the individual cases show very wide variations. There is also a marked difference between the average counts in each age group.

	Polymorphonuclear				Lymphocytes				Eosinophils			
Day of Disease	Group A	Group B	Group C	Average All cases	Group A	Group B	Group C	Average All cases	Group A	Group B	Group C	Average All cases
	%	%	%	%	%	%	%	%	%	%	%	%
3	76.5	82	74	77.5	21.5	12	24	19.2	2	6	2	3.3
4	66	78.5	82	75.5	29.5	15	14.5	19.9	4	6.5	3.5	4.6
5	56.5	71	78	68.5	37.5	21.5	17	25.3	6	7.5	5.5	6.2
6	52.5	60.5	66	59.7	38	32.5	30	33.5	9.5	7	4	6.8
7	49.5	60	70	59.8	43	34	26	34.4	7.5	6	4	5.8
8	49	60	71.5	60.3	44.5	35	24.5	34.5	6.5	5	4	5.2
9	54	69.5	72	65.2	41	27.5	26	31.5	5	3	2	3.3
10	56	73	70.5	66.5	42	24.5	26.5	31	2	2.5	3	2.5

One must admit at once that the individual cases show very wide variations. There is also a marked difference between the average counts in each age group.

As was anticipated the most marked changes occur in GROUP A. Here the changes described by others are at once obvious and though the changes are by no means quite uniform in each of the 4 cases yet they all conform to the same general type. The polymorphs are at their lowest on the 7th and 8th days. The lymphocytes rise from below normal to normal and above, attaining a maximum on the 7th and 8th day - a course exactly opposed to that of the polymorphs. The eosinophils show a definite increase on the 5th day and reach their maximum on the 6th or 7th day.

GROUP B. In this the general changes follow the same course as in GROUP A, except that the lymphocytes show a less definite absolute increase though they increase in proportion just as rapidly. The eosinophils attain their maximum here somewhat earlier, namely on the 5th day while the polymorphs are never under 60%. This last feature being due to one case which maintained a relatively high percentage of polymorphs throughout.

GROUP C. Here the changes are very slight but they bear out the general findings nevertheless, if one excepts cases 1 and 2 which while following the general rules up till the 6th day suddenly became a law unto themselves. The change which they showed suggested some fresh influence on the blood, but there was no

sign of anything clinically to account for the change, and unless it was due to something surreptitiously ingested it cannot be explained.

From these results then one could reasonably expect to find a typical picture between the 5th and 8th days in a moderately severe case of scarlet fever.

To establish these typical changes 114 cases were examined.

Under Group	A	.....	10 cases
"	B	.....	60 "
"	C	.....	44 "

Some of these cases were examined once, others were examined two and three times and several were examined many times.

Altogether 232 counts were made of which the vast majority were done between the 5th and 8th days.

The method generally adopted was to take a specimen of the blood on the 4th, 5th, or 6th day, and in the event of this not showing a characteristic change a subsequent count was done and in some cases repeated, in the hope that some degree of change could be noted. If an eosinophilia was found no further counts were made, provided the other cells conformed to the number associated with scarlatina on the day of examination.

G R O U P A

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
4th	1	F	82	12	6	
	2	M	69	28	3	Mild case
	3	F	46	51	3	
	4	F	71	25	4	
	5	F	66	30	4	
	6	M	73	22	5	Mild case
Average			68	28	4	
Day						
5th	1	F	70	25	5	
	2	M	58	37	5	Mild case
	3	F	46	51	3	
	4	F	50	44	6	
	5	F	60	30	10	Mild case
	6	M	67	23	10	
	7	M	65	32	3	
	10	F	36	58	6	
Average			56.5	37.5	6	
Day						
6th	1	F	71	19	10	
	2	M	53	41	6	Mild case
	3	F	42	51	7	
	4	F	52	41	7	
	5	F	42	44	14	Mild case
	6	M	44	42	14	
	7	M	58	36	6	
Average			52	39	9	

GROUP A (Contd.)

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
7th	1	F	58	39	3	
	2	M	56	40	4	Mild case
	3	F	40	48	12	
	4	F	47	49	4	
	5	F	53	35	12	Mild case
Average			51	42	7	
Day						
8th	1	F	53	41	6	
	2	M	59	38	3	Mild case
	3	F	40	49	11	
	4	F	49	46	5	
	5	F	54	41	5	Mild case
	8	M	55	40	5	
	9	M	32	59	9	
	10	F	40	57	3	
Average			47	47	6	

G R O U P B

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
4th	I	M	73	19	8	
	II	M	70	26	4	
	III	M	58	33	9	
	IV	M	87	7	6	
	V	F	71	25	4	
	VI	F	83	16	1	Mild case
	VII	M	66	32	2	
	VIII	F	72	27	1	
	IX	M	58	32	10	
	X	M	75	16	9	
	XI	F	82	17	1	
	XII	F	77	20	3	
	XIII	M	82	10	8	Mild case
Average			73	22	5	
Day 5th	I	M	69	21	10	
	II	M	70	26	4	
	III	M	57	35	8	
	IV	M	71	20	9	
	V	F	44	50	6	
	VII	M	56	40	4	
	VIII	F	70	26	4	
	X	M	70	24	6	
	XI	F	66	28	6	

GROUP B (Contd.)

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
5th	XII	F	63	31	6	
	XIII	M	82	10	8	Mild case
	XIV	M	63	30	7	
	XV	M	80	20	0	moderately severe
	XVI	F	52	40	8	
	XVII	F	59	38	3	
	XVIII	F	55	40	5	
	XIX	F	70	25	5	
	XX	M	65	31	4	
	XXI	M	58	38	4	Very mild
	XXII	F	50	45	5	
	XXIII	F	68	30	2	
	XXIV	F	58	41	1	
	XXV	F	70	27	3	
Average			64	31	5	
Day						
6th	I	M	58	32	10	
	III	M	60	31	9	
	IV	M	63	30	7	
	V	F	52	41	7	
	VI	F	62	34	4	Mild case
	VII	M	50	47	3	
	XI	F	63	31	6	
	XIII	M	79	16	5	Mild case
	XIV	M	43	52	5	

GROUP B (Contd.)

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
6th	XV	M	73	25	2	
	XVI	F	48	48	6	
	XVIII	F	46	50	4	
	XX	M	63	31	6	
	XXV	F	58	37	5	
	XXVI	M	68	27	5	
	XXVII	F	69	23	8	
	XXVIII	M	65	32	3	
	XXIX	M	66	25	9	
	XXX	F	60	36	4	
	XXXI	F	74	24	2	
	XXXII	M	70	25	5	
	XXXIII	M	57	37	6	
	XXXIV	M	62	32	6	
	XXXV	F	80	16	4	Otitis media later.
	XXXVI	F	52	44	4	
	XXXVII	F	42	54	4	
	XXXVIII	M	75	21	4	
	XXXIX	F	54	41	5	
	XL	F	80	13	7	
	XLI	F	77	19	4	
	XLII	F	72	23	5	
	XLIII	M	41	52	7	
Average			60.5	33	5.5	

GROUP B (Contd.)

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
7th	I	M	55	38	7	
	IV	M	61	29	10	
	V	F	58	39	3	
	XIII	M	79	14	7	Mild
	XVII	F	61	36	3	
	XXVII	F	60	37	3	
	XXVIII	M	69	28	3	
	XXXI	F	74	21	5	
	XXXIV	M	57	38	5	
	XXXV	F	67	30	3	Otitis media
	XLVIII	M	48	44	8	
	XLIV	F	51	44	5	
	XLV	M	57	42	1	
	XLVI	M	78	19	3	
	XLVII	F	77	22	1	
	XLVIII	M	50	44	6	
	XLIX	M	55	38	7	
	L	M	60	36	4	
	LI	M	61	36	3	
	LII	F	33	58	9	
Average			60.5	34.7	4.8	

GROUP B (Contd.)

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
8th	I	M	55	39	6	
	IV	M	71	24	5	
	IX	M	60	33	7	
	XIII	M	74	20	6	Mild
	XXI	M	55	41	4	Very mild
	XXVII	F	74	24	2	
	XXVIII	M	68	31	1	
	XLIII	M	52	40	8	
	LII	F	57	28	15	
	LIII	F	61	32	7	
	LIV	F	59	34	7	
	LV	M	58	38	4	
	LVI	M	71	29	0	
	LVII	M	50	45	5	
	LVIII	M	65	34	1	Adenitis
Average			62	33	5	
Day 9th	VI	F	65	32	3	Mild
	XIII	M	72	24	4	Mild
	XLIII	M	62	29	9	
	XLIV	F	61	38	1	
	XLV	M	53	43	4	
	XXIV	F	48	47	5	
	XXI	M	56	39	5	Very mild
	XXVII	F	70	27	3	
	LVIII	M	71	26	3	Adenitis
	LIX	M	64	32	4	
	LX	F	58	38	4	
Average			62	34	4	

G R O U P C

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
4th	I	M	91	6	3	
	II	M	88	8	4	
	III	M	86	10	4	
	IV	M	83	14	3	
	V	M	79	17	4	
	VI	F	78	16	6	
	VII	F	89	9	2	
	VIII	M	84	12	4	Mild case
	IX	F	87	12	1	
	X	M	80	14	6	
	XI	M	71	25	4	
Average			83.3	13	3.7	
Day						
5th	I	M	84	9	7	
	II	M	87	10	3	
	III	M	84	12	4	
	IV	M	75	19	6	
	VI	F	75	19	6	
	VII	F	88	10	2	
	VIII	M	78	17	5	Mild
	IX	F	82	15	3	
	X	M	83	12	5	
	XI	M	69	25	6	
	XII	F	77	22	1	
	XIII	F	73	23	4	
	XIV	M	74	23	3	
	XV	F	61	30	9	

GROUP C (Contd.)

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
5th	XVI	F	79	18	3	
	XVII	M	71	23	6	
	XVIII	F	79	17	4	
	XIX	M	75	19	6	
	XX	F	70	26	4	
	XXI	F	67	24	9	
	XXII	M	62	32	6	
	XXIII	M	77	20	3	
Average			76	19.3	4.7	
Day 6th	I	M	75	22	3	
	II	M	86	11	3	
	III	M	60	37	3	
	IV	M	70	23	7	
	XI	M	56	39	5	
	XII	F	70	27	3	
	XIV	M	60	34	6	
	XVI	F	68	24	8	
	XVIII	F	71	23	6	
	XX	F	66	28	6	
	XXIII	M	76	21	3	Adenitis
	XXIV	M	45	51	4	
	XXV	M	69	31	0	Very mild case
	XXVI	F	80	18	2	Mild case
	XXVII	M	61	35	4	
	XXVIII	M	60	35	5	

GROUP C (Contd.)

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
6th	XXIX	M	80	11	9	
	XXX	M	66	30	4	
Average			68.5	27	4.5	
Day						
7th	I	M	61	34	5	
	III	M	56	41	3	
	XI	M	56	39	5	
	XXV	M	62	34	4	Very mild case
	XXXI	F	48	48	4	
	XXXII	F	68	29	3	
	XXVIII	M	60	35	5	
	XXXIII	F	70	28	2	
	XXXIV	F	72	22	6	
	XXXV	F	65	30	5	
	XXXVI	M	38	57	5	
	XXXVII	M	83	15	2	
Average			62	34	4	

GROUP C (Contd.)

Day	Case	Sex	Poly. %	Lymph. %	Eosin. %	Remarks
8th	I	M	63	32	5	
	III	M	52	41	7	
	VII	F	76	23	1	
	XVII	M	57	36	7	
	XXXVIII	M	64	30	6	
	XXXIX	F	52	46	2	
	XL	F	62	34	4	
	XLI	M	56	40	4	
	XLII	M	78	17	5	
	XLIII	F	74	21	5	
	XLIV	M	60	37	3	
	XXXVII	M	82	15	3	
	XI	M	79	20	1	
Average			66	30	4	
Day						
9th	I	M	62	35	3	
	XVII	M	60	32	8	
	XI	M	80	19	1	
	XXXVII	M	80	18	2	
	XXXVIII	M	53	45	2	
Average			67	30	3	

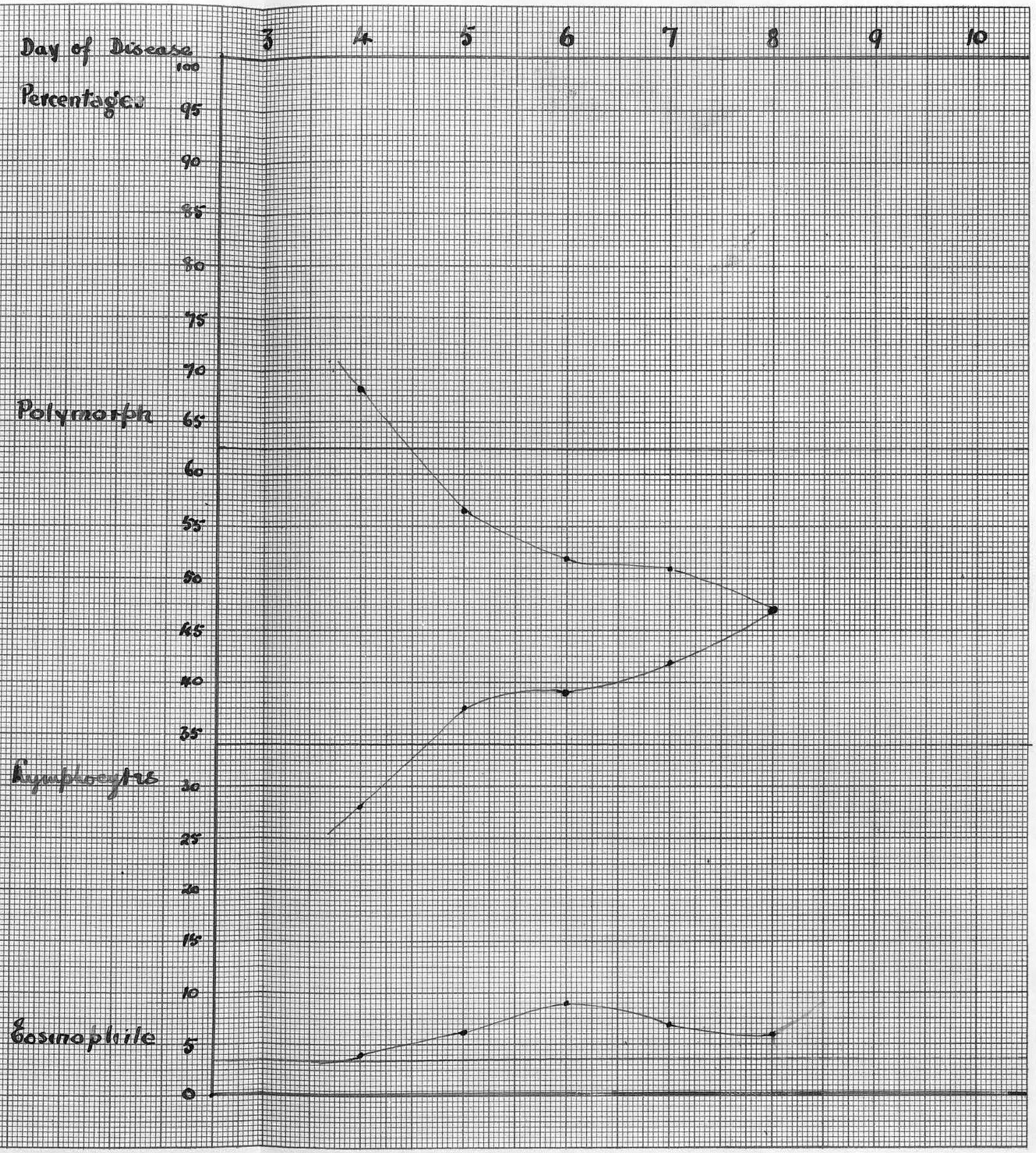
Arranging these averages side by side for comparison we find:-

GRAPHIA.

Group A.

Cases of Scarlatina

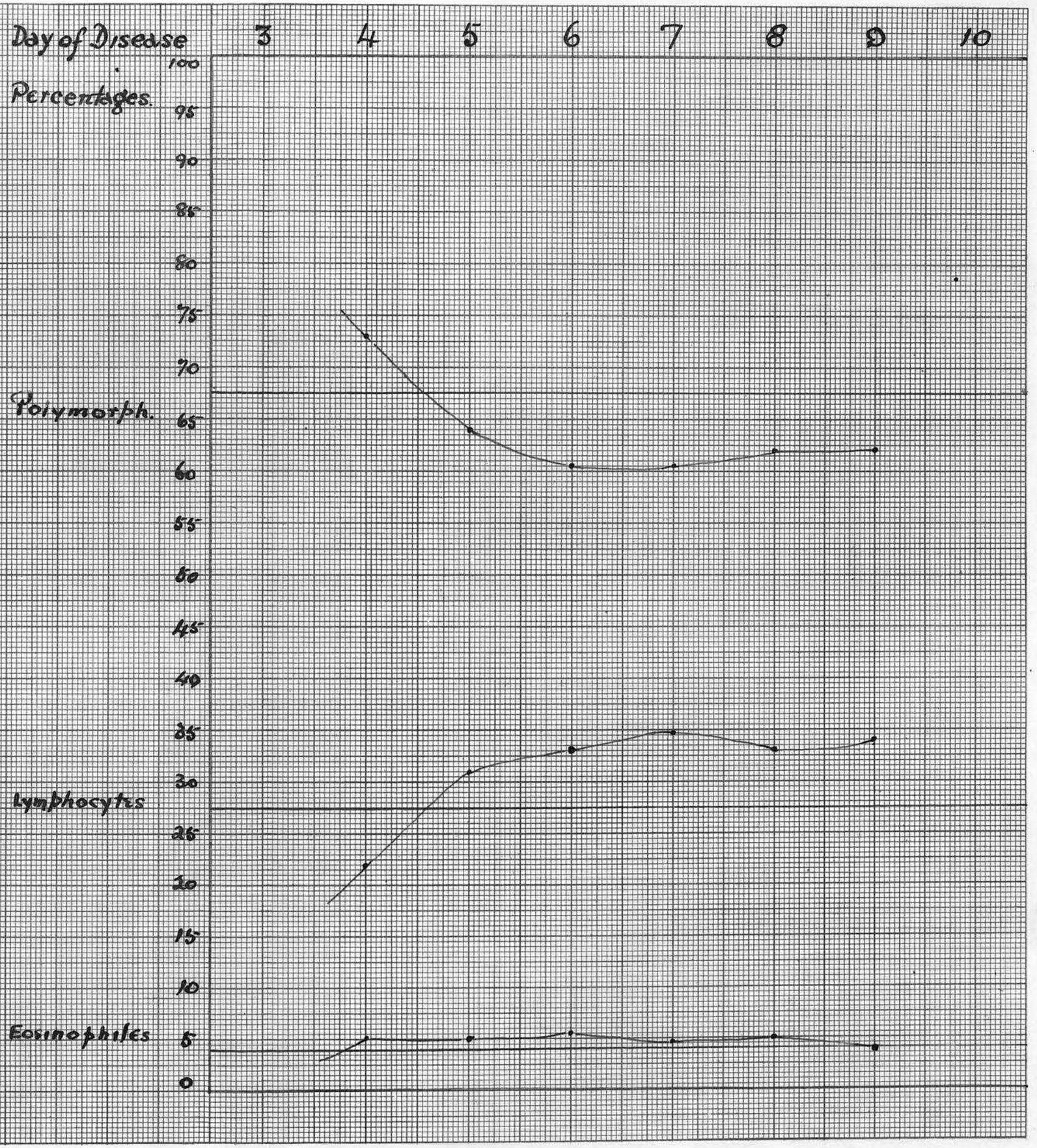
under two years of age.



	Polymorphonuclear				Lymphocytes				Eosinophils			
Day of Disease	Group A	Group B	Group C	Gen. Average	Group A	Group B	Group C	Gen. Average	Group A	Group B	Group C	Gen. Average
	%	%	%	%	%	%	%	%	%	%	%	%
4	68	73	83.3	74.8	28	22	13	21	4	5	3.7	4.2
5	56.5	64	76	65.5	37.5	31	19.3	29.5	6	5	4.7	5.2
6	52	60.5	68.5	60.3	39	33	27	33.3	9	5.5	4.5	6.3
7	51	60.5	62	57.8	42	34.7	34	36.9	7	4.8	4	5.3
8	47	62	66	56.3	47	33	30	38.7	6	5	4	5
9		62	67	64.5		34	30	32		4	3	3.5

Graph 1 B.

Cases of Scarlatina aged 2-10 years.



The figures have been plotted to facilitate comparison.

The physiological ~~limits~~ averages are indicated in red ink and they clearly indicate the degree of variation in the various cell counts.

These figures and graphs show the necessity for sub-divisions according to age for the typical changes are seen in a marked degree in the cases under two years.

GROUP A

These cases have the polymorphs relatively high on the 4th day, but they have fallen to below normal by the 8th day - the lymphocytes relatively few on the 4th day rise to normal and above by the 8th day.

The eosinophils are normal in number on the 4th day but rapidly rise to their maximum on the 6th day.

GROUP B

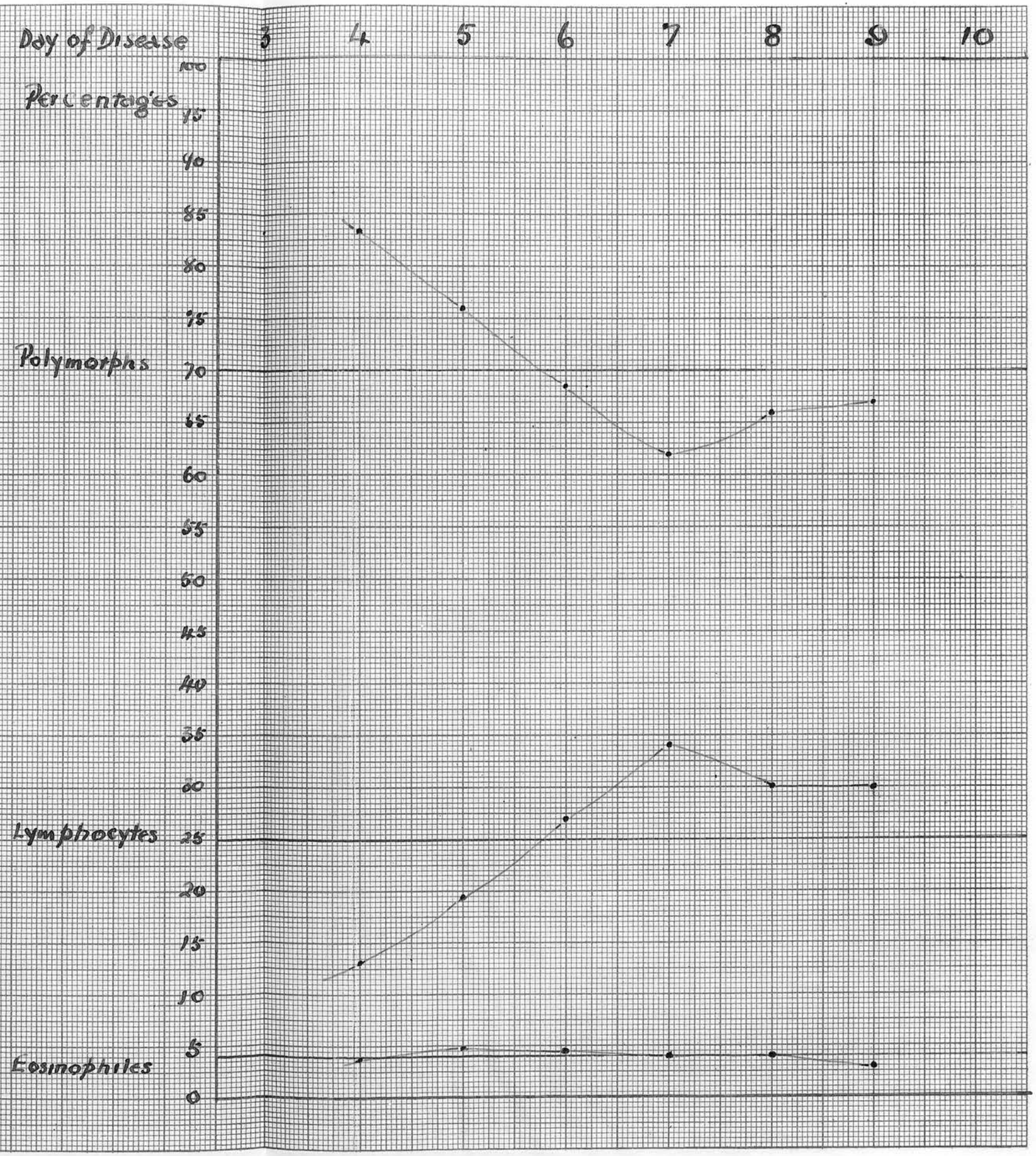
In cases between the ages 2 and 10 years similar changes are noted but in a less marked degree for the polymorphs though higher on the 4th day never fall below 60% while the lymphocytes show a subnormal number on the 4th day and rise to a maximum on the 7th day.

GROUP C

In the cases over 10 the blood cells seem to endeavour to maintain their relative numbers with greater tenacity for the polymorphonuclear count is 62% on the 7th day - the maximum lymphocytes 34% on the same day while the maximum eosinophilia is on the 5th and 6th days.

Graph 1C

Cases of Scarlatina over 10 years of age.



After a study of the general results then we are still pretty much where we were before.

The results in individual cases are now scrutinised, for the tables teem with apparently exceptional cases. These upon detailed examination in most cases conform to the general type.

In GROUP A

On the 6th day every case showed a well marked eosinophilia from 6% to 14%. Cases 8 and 9 which were not examined until the 8th day showed a definite eosinophil increase on that day. The highest polymorph percentage and the lowest lymphocyte counts were found on the 4th day (82% and 12%). The mild cases of which there were two showed the same variations as did the moderately severe cases.

In GROUP B

Though the maximum average eosinophilia occurs on the 6th day, many cases show normal and sub-normal figures for that day. Thus case 6, a mild case shows but 4%; however, it had 1% on the 4th day, therefore the cells are obeying the usual law.

Case 7 showed an eosinophil increase from 2 to 4% between the 4th and 5th days but only 3% on the 6th day.

Case 8 increased the percentage eosinophils from 1% on the 4th day to 4% on the 5th day.

Case 15 a moderately severe scarlatina case showed no eosinophils on the 5th day increasing to 2% on the 6th day.

Cases 24, 25, & 31 all showed low counts of eosinophils followed by an increase on 6th or 7th days.

Case 28 alone showed 3% on the sixth day declining to 1% on the eighth day and it was probably in reality a case of longer standing than was believed from an examination of the history.

The mild and very mild cases noted are in no way exceptional, nor are the cases with complications. GROUP B cases then conform in every respect to the changes seen in GROUP A, but the variations are less marked.

In some cases a high polymorphonuclear percentage is maintained beyond the 6th day, though in every case it is decreased below the 4th day count. The various exceptions noted above indicate the necessity for an examination of blood counts in Group B cases being made from the 4th day onwards in order to appreciate the alteration in the proportion of the various white blood cells as the disease runs its course.

GROUP C cases

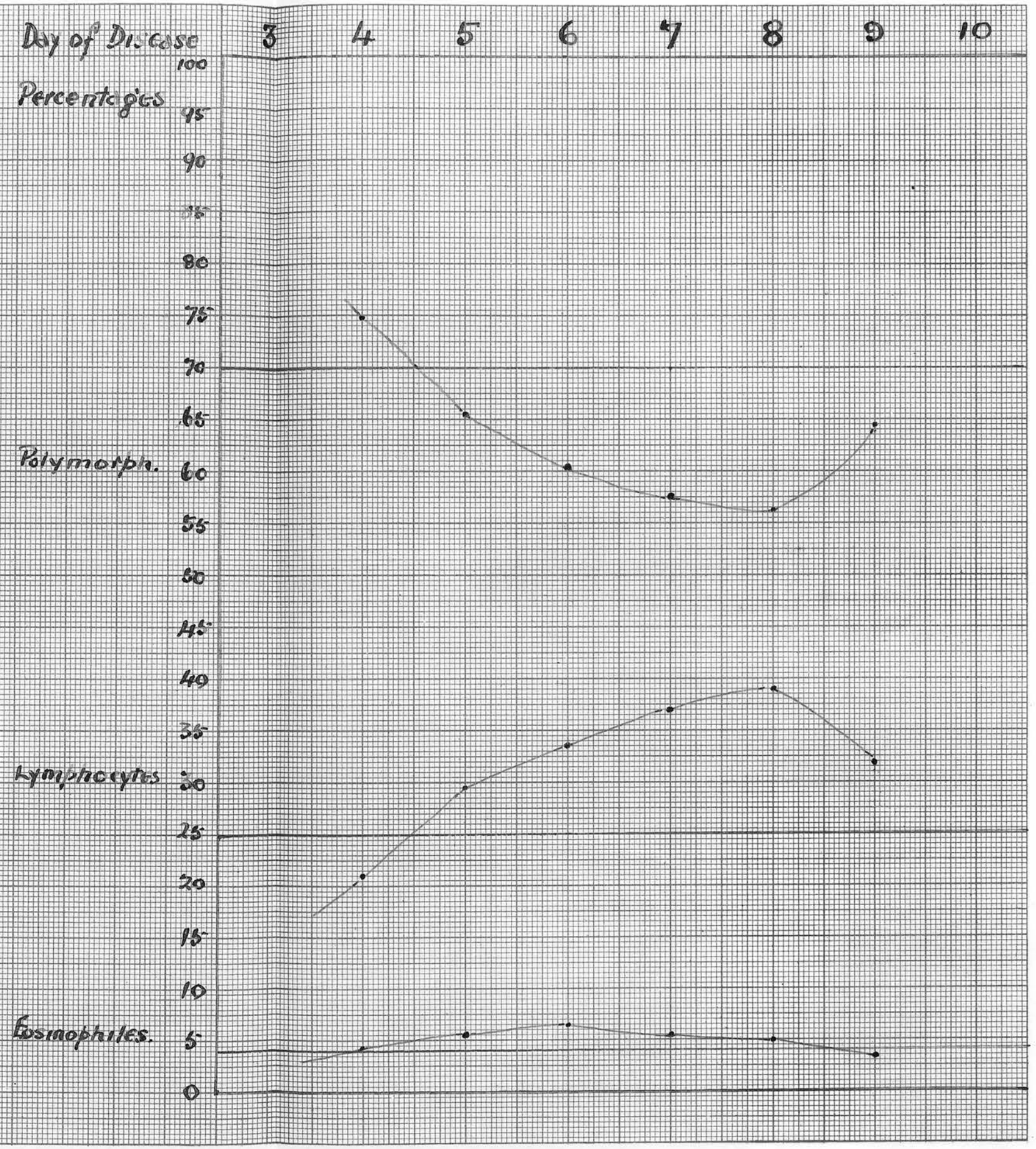
An eosinophilia giving the modest percentage 4.5 on the 5th day and 4.7 on the 6th day shows that over 10 years of age blood changes are very much modified in scarlet fever. Actually the highest count was 9% on the 5th day.

Polymorphs are higher at first than in either of the other groups and they never fall much below normal, that is if we remember 65% is the minimum polymorph count normally.

On the 7th day polymorphs are at their minimum and lymphocytes are at their maximum, but on this day

Graph 10.

Curves representing the percentages of various blood cells found in all scarlatina cases examined.



the average count might well be a normal count. Again one realises the importance of daily examination in these cases - as examples case 12 with 1% eosinophils on the 5th day shows 3% on the 6th day, while case 28 with no eosinophils on the 6th day shows 4% on the 7th day.

The very mild, mild and complicated cases under this group show no characteristic features.

SEVERE SCARLATINA

SEPTIC CASES

Case	Age	Day	Poly. %	Lymph. %	Eos. %	Remarks
I	5	6	87	21	1	
II	4	6	91	7	2	
III	17	5	89	10	1	
		6	84	14	2	
		7	83	15	2	

TOXIC CASES

Case	Age	Day	Poly. %	Lymph. %	Eos. %	Remarks
I	11	4	90	8	2	
		5	86	14	0	
		6	86	12	2	
		7	68	30	2	
		8	64	35	1	
II	17	4	92	7	1	Died
		6	88	12	0	
III	1	6	70	29	1	
IV	6	6	67	31	2	

IV. Summary of results in Scarlet Fever blood counts

What facts are established by the foregoing figures?

I There is undoubtly a characteristic change in the blood picture in the course of the disease.

II This change is uniform for all cases but varies in degree according to age and the severity of the disease.

III There are apparently exceptional cases.

IV No hard and fast rule can be laid down as to the probable date of the blood alterations, but these occur within certain fairly definite periods.

V No reliable assistance in diagnosis can be expected from a single blood examination made on a particular day of the disease, as a routine measure.

What changes are found in the blood picture in Scarlet Fever?

Studying each type of cell individually we find:-

(a) The polymorphonuclear cells invariably show a fairly high percentage on the fourth day - all but one case and that a child under 2 showed this feature. These cells rapidly diminish in number in every case and are sub-normal on the sixth day. It is noted that cases with a very high percentage on the 4th day may show a per-

sistently relatively high percentage even on the 6th day though on that day its figure is much decreased as compared with the 4th day figure. It seems probable that in the first two or three days the percentage of polymorphs is very high and it falls rapidly after the 4th day on which day in some cases the decrease has already begun. In any case the change in the polymorphs is accomplished in every case on the seventh day with very few exceptions, and low percentage counts are found until the 9th day. This sequence of changes in the polymorph count has been shown by several observers and by Turk in particular, and is quite definitely characteristic of Scarlatina in all cases.

(b) The lymphocytes are proportionally low in number in all cases on the 4th day. With an occasional exception in young children the per centage figure is well be low normal. They rapidly increase in number until there is a definite lymphocytosis on the 6th day and in all cases before the 8th day. This increase persists until the 10th day at least. The same rule applies as in the case of polymorphonuclear cells, viz. that cases which show an abnormally high or low count on the 4th day maintain a relatively high or low count

throughout, but such counts follow the general rules as to variation from day to day.

These findings agree in general with the reports in the literature. The polymorph decrease and the lymphocyte increase is as nearly as possible coincident.

(c) The eosinophil cells naturally call for most attention. They show a characteristic line of conduct. They are in the vast majority of cases under 4% on the 4th day. Some cases do show a percentage higher than this but they are few and could be included in the type of case which normally has a high eosinophil percentage. The eosinophils have increased on the 5th day to round about 4% and on the 6th day to over that figure. In the great majority of cases the percentage eosinophilia does not rise after the 6th day. The maximum is on the 5th and 6th day, but a definite eosin. increase persists until the 8th day and a few cases have their maximum count on the 7th and 8th days. Again one must note that the change is one of type rather than of degree, and no figure can be laid down as the characteristic per centage of eosinophils on any one specified day, rather do the number of eosinophils present vary with the individual patient.

These findings agree in general with those of other writers, but they differ somewhat in detail.

A graphical representation of what one believes to be the typical blood change in scarlatina from the 3rd to the 10th day has been given. The various features can be rapidly appreciated and the curves can be compared.with these given from the figures of blood counts made in observation cases later on.

How are the blood changes modified by the age of the patient?

By arranging the results in GROUPS A, B, and C, they can be readily compared and a glance at the average tables and graphs shows the main variations due to age.

Infants show the most marked and most rapid fall in the number of polymorphs and a lymphocytosis is very commonly establised on the 6th or 7th days for the mononuclear cells increase just as rapidly in number as the other cells decline. They also give the best examples of the eosinophil changes, developing a high percentage on the 6th and 7th days. In the case of infants one would state that the changes are uniform and definite in all cases.

Children between 2 and 10 years of age furnish many cases which agree in detail with the infants. The polymorphs are slower to fall in number and the lymphocytes to increase - nor are the changes so extreme when they do begin. Thus in very few cases the lymphocytes out number the polymorphs on the 7th day though they are commonly much increased. The eosinophils too show less extreme changes and are liable to wider

variations, while they rise and fall before the 9th day having attained their maximum before the day on which the infants attained it. However this group of cases too show perfectly characteristic changes though these are not so definite as in the younger group.

Patients over 10 years of age show even less definite variations.

The polymorphs are certainly high at first, - relative to the other groups they are very high on the 4th day; and they fall, but never very far below normal, to their minimum on the 6th day. The lymphocytes are very few in number at first, and rapidly increase, but the lymphocytosis is only maintained for a very brief spell on the 6th day. The eosinophils follow the usual course but show very slight increase over normal, and this fairly early on.

How does the severity of the disease modify the blood picture?

As far as one can judge from the small number of very mild scarlet cases, and from the few mild cases, the blood changes follow the general course laid down for the average moderately severe case. It may be that the change is seen a trifle earlier in such cases, and certainly in the very mild cases it is less marked, but the same general changes are there in the first week of the disease.

The severe cases show much the same changes whether they be of the toxic, or septic type. The polymorphonuclear cells are much increased in number with lymph-

ocytes reduced and eosinophils absent - this type of blood picture is found throughout the first week. In some cases a few eosinophils were noted. If anything, the septic cases showed higher polymorphonuclear leucocytoses than did the toxic cases. In severe cases the study of the blood picture is of no value in diagnosis.

Complicated cases show no apparent variation from noncomplicated moderately severe cases.

During what days are the blood changes found?

One has no data relative to the blood picture in the first three days of the disease. On the fourth day when the rash in most cases is just beginning to fade and when the temperature has passed its maximum the blood picture is typical - High polymorphonuclear count - Low lymphocyte count and very few eosinophils, but, just as the time for the appearance and commencement of fading of the rash, and the day of maximum temperature varies, so doubtless does the blood picture vary. Thus in some cases the 4th day changes are found on the 3rd day or 5th day. In the same way the characteristic changes which produce in about 3 days an entirely different blood picture viz, low polymorphonuclear count, high percentage lymphocyte count, and an eosinophilia, may occur at a slightly earlier or later date. However, the changes noted have certainly occured in all but the severe cases before the 8th day.

The complete change then, in all but exceptional cases can be confidently expected between the 4th and the 8th days.

Exceptional Cases

There are exceptional cases. Such cases are found in all diseases, and no law in relation to blood changes in disease however comprehensive could cover every case.

As has been shown at some length elsewhere the vast majority of the apparently exceptional cases do conform to the general laws though in some instances in rather a modified manner. The real out and out exceptions are extremely rare, sufficiently so to be ignored, or treated as freaks.

Can the blood examination be of aid in diagnosis?

A single blood count in some cases will give on the 5th, 6th or 7th days such figures that the observer can state that the disease is probably Scarlet Fever. In most cases however a series of counts are required commencing on the 4th day and continued daily until the 8th day. Only then can the characteristic changes be observed in their entirity, and we venture to suggest that such a series would be of real value in diagnosis, for as we shall show later such a series of changes is characteristic of Scarlet Fever and of no other disease. Thus one is brought to the conclusion that a blood count performed on a suspected case of scarlatina can alone have no value, but aseries of counts on such a case

might give valuable information, while instead of studying the number of a certain type of cells on a particular day one would study the relative percentages of the cells for some 4 day. Such an arrangement would include all cases which though apparently never showing variations in percentages of the white blood cells beyond the physiological limits, yet show a perfectly definite series of blood changes quite typical of Scarlatina, and would show these variations and indicate their pathological significance.

V. DIFFERENTIAL COUNTS IN OTHER DISEASES

The blood picture in other diseases and conditions which may be mistaken for Scarlatina.

According to C.B.Ker (Manual of Fevers 1921) the conditions with which Scarlet Fever may be confused are:-

Measles
Diphtheria
Rubella
Prodromal rashes in Measles
Smallpox and chickenpox

Various erythemata:-
Drug rashes - copaiba, quinine, belladonna etc.
Serum rashes:-
Enema rashes and similar conditions
Food rashes

Septic rashes
Burns
Tonsillitis (Acute)

A search was made for reports on the blood counts typical of these conditions of which the following is an epitome. The authorities are quoted in most cases.

MEASLES:- Absence of eosinophils throughout the illness:- (Tileston and Locke, Ewing, Zappert, Cabot, Felsenthal, Brown, Gulland and Goodall)

DIPHTHERIA:- Eosinophil cells usually low in number and hard to find - polymorphs relatively increased (Ewing)
Eosinophils unaltered (Gulland & Goodall)

RUBELLA:- No blood changes reported at length - but eosinophils unaltered in a few cases with relative increase in number of lymphocytes.

Prodromal rashes:- These do not as a rule coincide with a blood change. In any case they cannot be confused with Scarlet Fever when the eruption develops, and it is not till then that the blood examination is of any value in diagnosis.

DRUG RASHES:- These are apparently unaccompanied by blood changes in so far as the percentage of the various white blood cells is concerned.

Copaiba is said to be the commonest offender and in Gonorrhoea in some cases an eosinophilia has been noted.

ENEMA RASHES:- Never differentiated by blood changes.

SEPTIC RASHES:- In septic cases eosinophils are always very low and polymorphonuclear cells are high. (Cabot, Ewing, Reider, Gulland & Goodall).

BURNS:- No alteration in the blood picture.

TONSILLITIS:- Polymorphonuclear cells said to be increased and eosinophil cells few in number.

In addition to such conditions there are of course many which might give rise to a suspicion of Scarlet Fever but all these are usually easily differentiated.

PHEUMONIA:- gives high percentage polymorphs and few eosinophils throughout.

TYPHOID:- very few eosinophils during the fever (Gulland and Goodall)

INFLUENZA:- the blood picture is unaltered in the absence of complications.

The changes described under Scarlet Fever are confined to that disease alone. No other infectious disease shows an eosinophilia in the earlier stages except malaria and rheumatic fever. In the latter the eosinophils are slightly increased, while in the former they are increased to some degree during the febrile stages. The most typical differentiating feature of the Scarlet Fever blood counts is the increase of eosinophils just after the fever while the polymorphon-

uclear cells are yet increased above normal.

Other diseases which cause an eosinophilia are not at all likely to be confused with scarlatina. They are chiefly - True spasmodic, asthma, skin diseases (with gross lesions in all cases), uraemia with fits, various blood diseases, intestinal parasites, etc.

It seems possible that the factors which govern the production of serum rashes in diphtheria also have an influence on the blood.

They lead to an eosinophilia in some cases for a period of some 5 days after the appearance of the rash. Since these cases with such a rash are suffering from diphtheria also it may be that the blood picture is modified and may in fact resemble that of scarlatina.

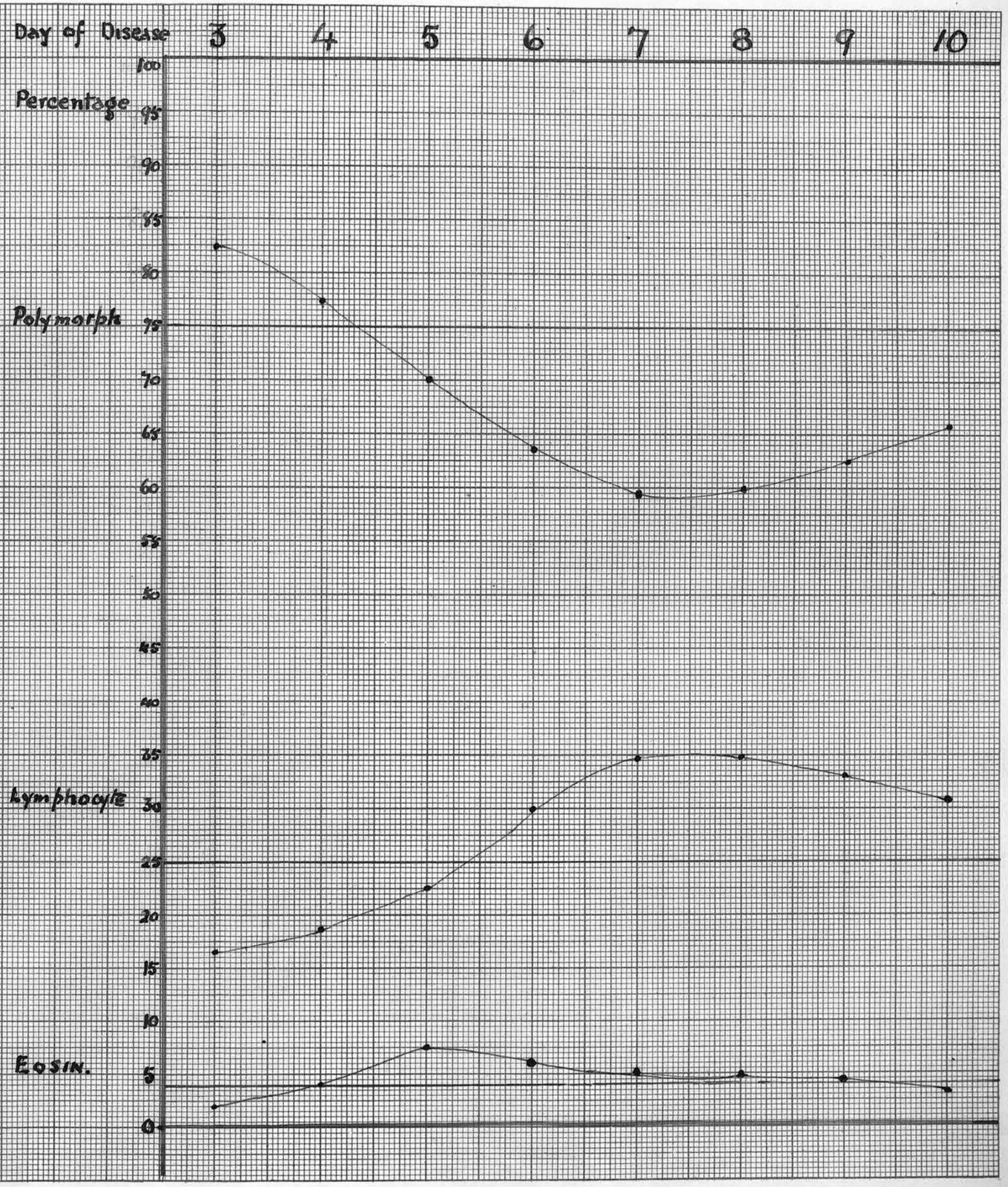
A drug rash associated with gonorrhoea may give blood counts resembling scarlatina counts but in a series of cases the typical scarlatina changes would not be manifest.

With these exceptions then the blood picture which has been examined in detail heretofore can be taken as characteristic of Scarlet Fever alone.

GRAPH 1.

The various cell counts.

in a typical case of Scarlatina.



VI

Differential blood counts in Observation Scarlet Fever Cases

In this series of cases we have included all observation cases in hospital, whether sent in as such, classified as such on arrival or already in hospital with another infectious disease showing signs arousing a suspicion of scarlet fever. Altogether 40 different cases were examined with ages ranging from one year to 44 years. All were in isolation in hospital undergoing the routine regime of diet and treatment - no medication was used in any case.

Of these 18 were ultimately diagnosed as cases of scarlatina, and the remaining 22 were found to be suffering from disease other than scarlatina. The cases have been arranged therefore in two groups according to the ultimate diagnosis which was made clinically in every case. In each group the cases are arranged according to age. There are three under two years, 17 between two and ten years, and the remaining 20 over ten years. 115 counts were made. An effort was made to collect a blood sample on the 4th and 5th days and on a subsequent occasion. In many cases 3 counts were done between the 4th and 8th day, in others 4 counts were done. While some cases showed characteristic changes in 2 counts others did so in one count. Thus an effort was made to study rather the series of blood changes in these cases than the blood picture on any one day, for the study of the blood in scarlet fever

and led one to the conclusion that the characteristics of the blood changes could best be studied in a series of counts made between certain days, viz, between the 4th and the 8th days of the disease.

In the second group the ultimate diagnosis is given in every case, scarlatina having been excluded after close observation.

GROUP I

Cases ultimately diagnosed as scarlet fever.
18 cases - 46 counts

Case No.	Age	Supposed day of disease	Poly-morphs.	Lymph-ocytes	Eosin-ophils
			%	%	%
I	1	4	58	38	4
		6	56	38	6
		7	54	37	9
II	4	5	81	18	1
		6	70	27	3
		7	68	28	4
III	4	5	70	29	1
		7	64	33	3
IV	4	6	69	29	2
		7	65	38	2
		8	60	37	3
V	6	5	50	45	5
		6	40	52	8
VI	7	4	84	13	3
		5	78	17	5
		6	70	23	7

GROUP I (Contd.)

Case No.	Age	Supposed day of disease	Poly-morphs	Lympho-cytes	Eosin-ophils
			%	%	%
VII	9	4	59	40	1
		5	50	46	4
		6	54	39	7
VIII	10	7	54	41	5
IX	10	5	69	26	5
		8	68	28	4
X	11	6	63	29	8
		8	58	23	19
XI	12	5	48	47	5
		6	40	47	13
XII	12	5	85	11	4
		7	73	23	4
XIII	13	6	77	21	2
		7	69	27	4
		8	73	24	3
XIV	13	6	70	26	4
		9	72	25	3
-X- XV	18	5	65	30	5
		6	62	30	8
		7	69	26	5
		8	60	36	4
XVI	22	6	68	26	6
		7	70	25	5
XVII	42	6	74	20	6
		7	73	24	3
XVIII	44	5	78	20	2
		6	69	26	5
		7	62	31	7

-X- Diphtheria case, developed Scarlet Fever

GROUP II

Cases intimately diagnosed as not suffering from scarlatina

22 cases - 69 counts

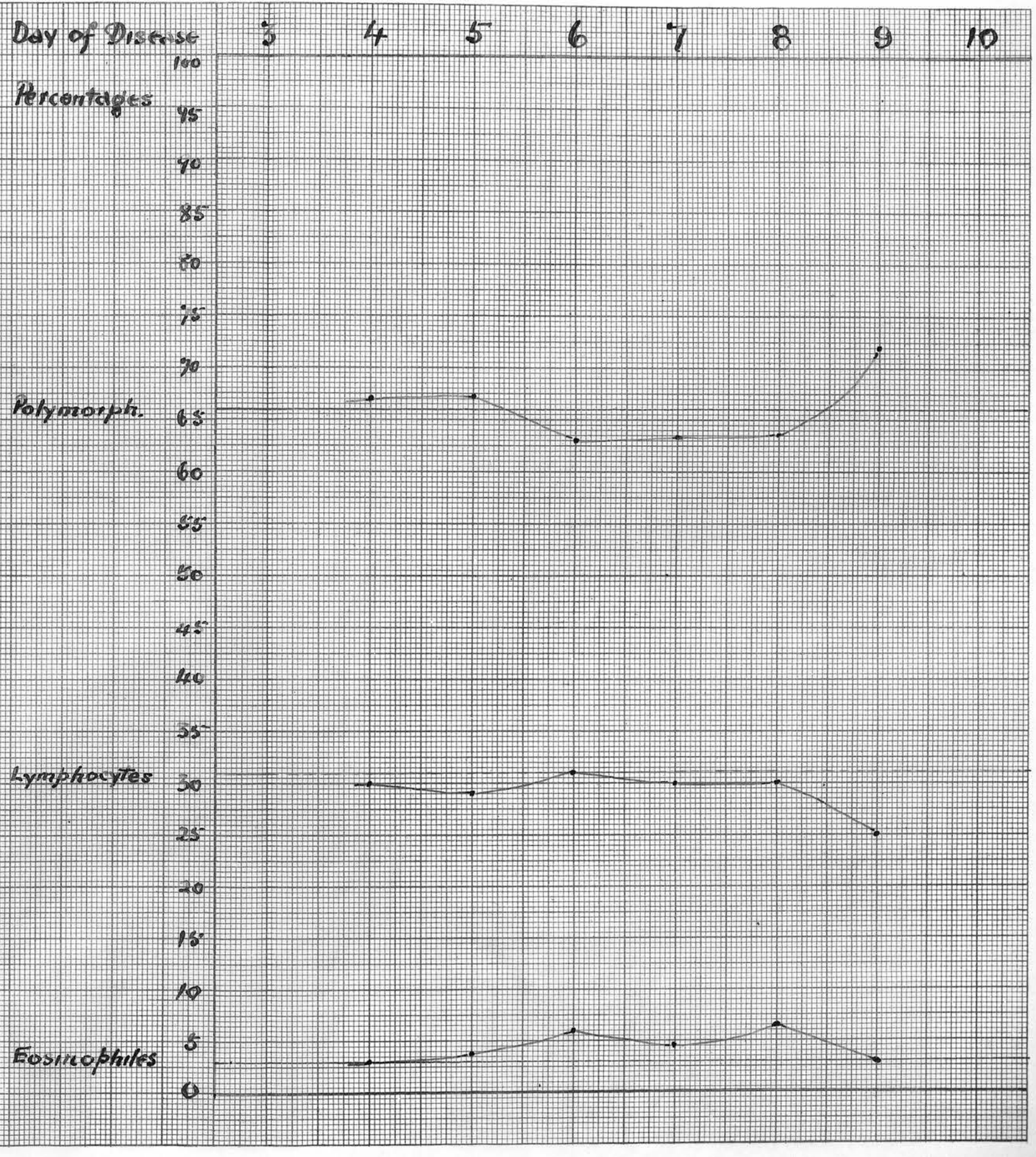
Case No.	Age	Day of Disease	Polymor. %	Lymphocytes %	Eosinophils %	Ultimate Diag. / Remarks
I	1-3/12	6	43	46	1	Convalesc. dip. Red-throat ? tongue Nil.
		7	38	61	1	
II	1½	4	48	50	2	
		5	48	49	3	Nil
		6	52	47	1	
		7	48	52	0	
III	2½	4	50	49	1	Erythema
		7	56	42	2	
IV	2½	6	32	63	5	Tonsillitis
		7	44	43	3	
		8	36	60	4	
V	3½	5	75	23	2	Nil
		7	78	20	2	
VI	3½	6	70	28	2	
		7	68	27	5	Nil
		9	79	18	3	
VII	4	4	80	16	4	Tonsillitis
		5	83	12	5	
		6	78	20	2	
		7	73	22	5	

GROUP II (Contd.)

Case No.	Age	Day of Disease	Polymor. %	Lymphocytes %	Eosinophils %	Remarks
VIII	5	6	76	23	1	Contracted S.F. in hospital later on.
		7	83	15	2	
		8	78	18	4	
IX	5	4	62	36	2	
		6	58	38	4	Diphtheria with Scarlatina form (? serum) rash
		7	53	40	7	
X	5	4	51	46	3	
		5	48	50	2	Erythema
		6	54	43	3	
		9	59	40	1	
XI	6	4	69	28	3	Erythema
		6	74	20	6	
XII	8	5	73	22	5	
		6	70	23	7	Erythema
		7	63	32	5	
		8	68	30	2	
XIII	9	5	41	58	3	
		6	51	47	2	Diphtheria with Scarlatina form (? serum) rash & rise of temperature
		7	50	47	3	
		8	57	36	7	
XIV	12	4	68	21	11	
		5	63	32	5	Nil
		6	70	25	5	

Graph II.

Cases of observation scarlatina ultimately diagnosed as scarlatina.

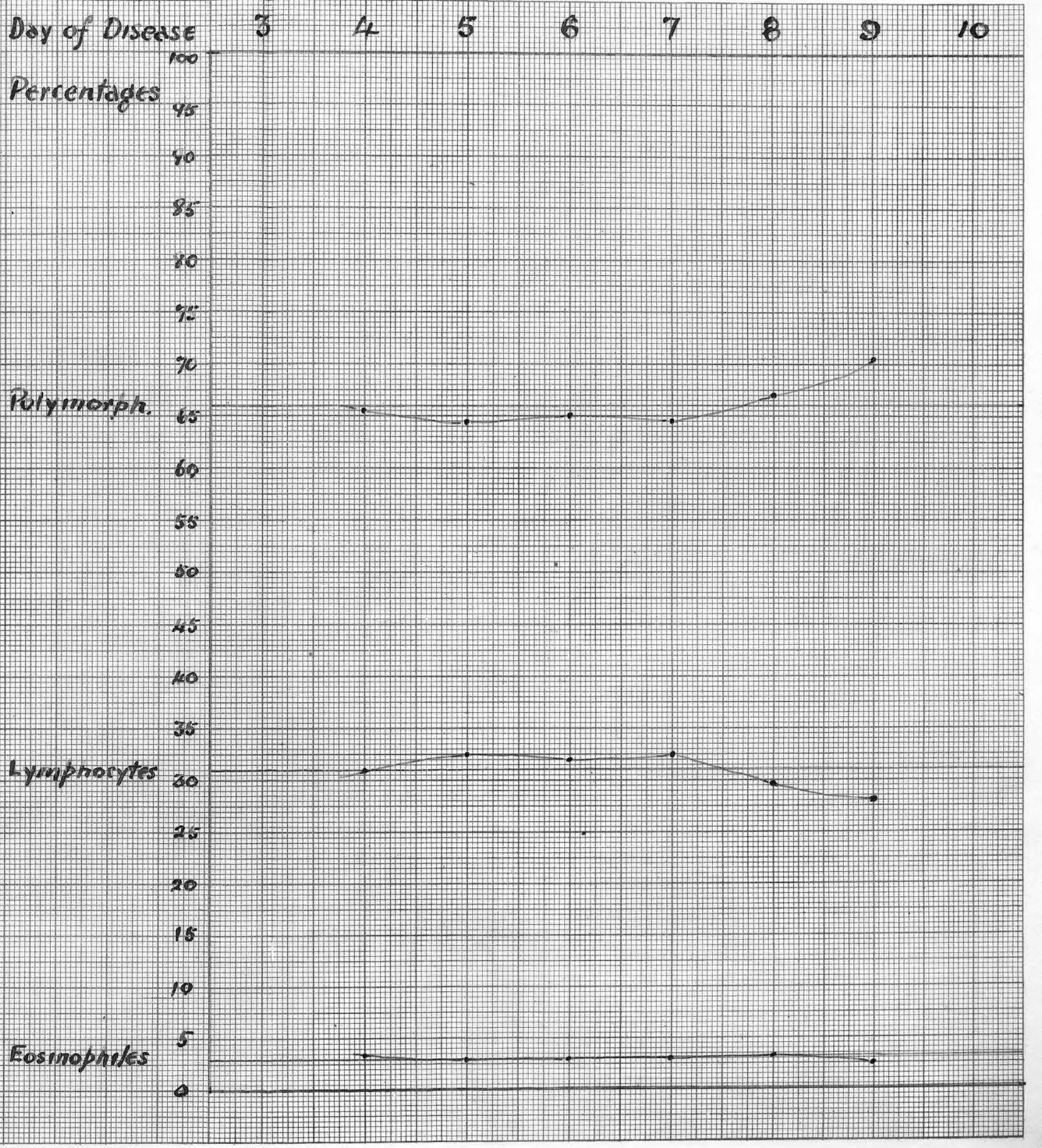


GROUP II (Contd.)

Case No.	Age	Day of Disease	Polymor. %	Lymphocytes %	Eosinophils %	Remarks
XV	14	6	76	23	1	Nil
		8	79	20	1	
XVI	14	4	74	22	4	Tonsillitis
		6	77	20	3	
XVII	15	6	63	34	3	
		8	69	30	1	Erythema
		9	70	26	4	
XVIII	17	3	78	20	2	
		4	82	17	1	
		5	72	25	3	Tonsillitis
		6	74	24	2	
		7	80	20	0	
		9	79	20	1	
XIX	17	8	70	27	3	Erythema
		9	68	30	2	
XX	19	5	66	31	3	Nil
		6	70	26	4	
		5	70	29	1	3rd week in hospital
		6	75	23	2	sore throat- rise of
		7	78	22	0	temperature Diagnosis- nil
XXI	23	6	73	27	0	
		7	77	20	3	Tonsillitis
		8	79	20	1	
		10	70	27	3	
XXII	30	5	73	25	2	Nil
		8	78	19	3	

Graph III

Cases of observation scarlatina ultimately diagnosed as not scarlatina



An examination of the figures shows at once a difference between the two groups. The vast majority of cases diagnosed as scarlet fever show figures corresponding to these found in typical cases of scarlet fever, while the other group almost without exception show no such uniform changes.

GROUP I Case I Polymorphs slightly decreased, lymphocytes unchanged and eosinophils increased between the 4th and 8th days. The typical scarlet change modified. Case II Closely resembles several scarlet fever counts.

Case III Typical change but in slight degree.
Case IV Very slight changes tending to the scarlatinal type but poorly developed.

Case V Typical scarlet fever counts.
Case VI As V but percentage polymorphs remains relatively high.

Case VII Very similar to Case I - modified scarlet change.

Case VIII Typical count for moderate scarlatina case on the 7th day.

Case IX Blood counts of no value here - might well be normal counts but eosinophils are slightly increased.

Case X The highest eosinophil count in the whole series - the changes conform to S.F. type roughly.

Case XI Like scarlet fever counts.

Case XII To some extent like scarlet counts with low eosinophil count.

Case XIII As XII.

Case XIV Might well be a normal blood count.

Case XV Resembles counts found in scarlatina.

Cases XVI, XVII & XVIII Show changes characteristic of scarlatina.

In analysing these results then one finds in ten cases changes such as were found in cases of scarlet fever. In 6 cases the counts showed changes resembling scarlatina changes, some in a slight degree only. In 2 cases in which the blood was examined on 2 occasions in each, there was no change typical of scarlatina - probably because the counts were made at unsuitable times. One might here boldly state that in all of these cases the blood examination would have been an aid to diagnosis, not per se, but in relation to the clinical findings.

A study of the graph might be misleading in the absence of an analysis of the individual cases.

One notes throughout the low percentages of polymorphonuclears due to the influence of age and to extreme cases, also the small amount of the various changes - showing that just as the symptoms and signs were poorly developed in these cases so were the blood changes modified.

The average curves of course give no definite information. At the same time it will be seen that they tend to the formation of the scarlatina blood curves.

On comparing these curves with those of the other group of observation cases which were diagnosed as non-scarlatina we note at once that the path followed by the various blood cells and more particularly by the eosinophils is suggestive of the difference between the two groups for the non scarlet group gives curves which do not approximate to these of scarlatina.

GROUP II Case IV shows an eosinophilia and lymphocytosis on the 6th day but subsequent counts show no changes. This case closely resembles the blood picture in some cases of scarlatina.

Case VI Shows 5% eosinophils on the 7th day but there is no lymphocytosis. It also has some resemblance to scarlatina cases.

Case VII In the same way shows an eosinophilia on the 5th and 7th days but no lymphocytic increase and a high percentage of polymorphs is found on the 6th and 7th days.

Case IX Reproduces changes as found in scarlatina.

Case XI Though showing 6% eosins on the 6th day shows also an increased number of polymorps - a change quite unlike scarlatina.

Case XII Might well be a case of scarlatina. The counts are not unlike many found in scarlet cases.

Case XIII Shows an eosin. increase to 7% on the 8th day, but the other cells do not behave as in scarlatina.

Case XIV Though showing 11% eosinophils in one unit, shows changes unlike scarlet fever, for the polymorphs do not decrease.

None of the other cases examined show changes which resemble those of scarlet fever.

Thus in this series (Group II) there are 3 cases out of 22 which are more or less indistinguishable from scarlatina in so far as the blood counts are concerned, while there are five cases which have some points resembling those found in scarlatina.

Altogether then the clinical diagnosis is roughly born out by the findings from blood examination.

The diagnosis resting as it did upon pure observation of the symptoms and signs in the cases might be questioned, but the clinical experience of the person

making the diagnosis was such that one could accept his decision as being as accurate as the available methods would allow.

One notes that in cases of diphtheria with a serum rash the blood picture is in some respects very like that seen in scarlatina. In tonsillitis cases the polymorp percentage is not invariably high though it tends to be above normal, and in one case diagnosed as such, the blood picture was not unlike scarlatina.

With these exceptions the study of the blood in these non-scarlatina patients showed no uniform feature or change.

What then do these counts show?

They show that as a general rule the blood picture in observation scarlets is of value in diagnosis.

Unfortunately the changes are not invariable, possibly on account of faulty methods employed. Moreover there is always the possibility that the diagnosis was not accurate and this might account for the few exceptions. On the whole the changes typical of scarlatina are seen in the vast majority of cases which can be clinically diagnosed as scarlatina, and are absent in observation cases which are diagnosed as something else.

A study of the blood picture must be made daily from the 4th day to the 8th day. This is very necessary, for the changes may be slight or modified in such a manner, that a count done on any one day is of

very little value, and may in fact lead to an erroneous conclusion. The study of cases with a scarlatiniform rash in diphtheria is of no value unless it be that the two cases cited above were in reality suffering from scarlet fever - a very remote possibility, and one which could hardly have passed unobserved.

One has wandered far from the original idea of the blood count as the mainstay in diagnosis of scarlet fever in observation cases. Many observation cases do not reach hospital until the 5th day or later, and in such the blood count would be of little or no real value. Even when a series of counts in any one case ranging from the 4th to the 8th day is made, except where changes are perfectly definite, one could not put too much faith in the results, and in any case the blood count could never be anything but an aid to diagnosis, a point for or against the disease, never a decisive factor in itself.

Given a case which might be a mild case of scarlatina, then a series of blood counts showing an early polymorphonuclear increase during the fever, with a low percentage of lymphocytes and few eosinophils, later revealing the changes found in scarlatina though in a slight degree, one thinks that the blood examination would clinch the diagnosis. On the other hand in a case with no sign of scarlatina, and blood changes resembling those found in that disease, one would be

chary of basing the diagnosis on the blood counts alone. Between those two extremes come a vast number of cases of all sorts and conditions, and in these the application of blood examination will one thinks be of definite value in every case, but will never over rule the findings made clinically.

GENERAL SUMMARY

AND

VII CONCLUSIONS

The object of the study of the differential blood count in scarlatina was to establish a law in relation to the conduct of the white blood cells in that disease and having established such a law to apply it in the diagnosis of scarlet fever, more particularly in these cases described as observation cases.

Numerous observers have made similar studies and some have formulated a law which governs the conduct of white blood cells in scarlatina, but hitherto the application of such a law in diagnosis has not been made.

In addition many of the earlier reports deal with a small number of cases and apply to a limited class of patients, or to a particular type of the disease.

In this work an effort was made to establish one common feature or series of features characteristic of all cases of scarlatina. With this end in view patients with scarlatina of every type, and at all ages were examined, though naturally the majority were average cases between the ages of 5 and 15 years.

The results of the blood examination of these patients has been given in detail and from them the following features have been established as typical.

At the beginning of an attack of scarlet fever the polymorphonuclear cells are much increased in

number. They number in some cases as many as 90%. For the first four days of the disease (i.e.usually until the rash has begun to fade) they remain relatively increased so that a blood count on the fourth day gives in practically all cases a high proportion of polymorphonuclear cells. From the 4th day onwards these cells decrease in number till the end of the first week when they are nearly always under the normal figure. The count remains relatively low for some days thereafter.

Thus in a series of counts made in scarlatina patients from the 4th to the 7th or 8th days a high percentage of polymorphonuclear cells on the 4th day is converted rapidly into a low percentage count on the 7th or 8th day.

While the polymorphs are increased at first the lymphocytes are few in number - commonly about 15%. Until the 4th day they remain low but rapidly increase to normal and above. They are normal on the 5th or 6th days and definitely above normal before the 8th day. The increase persists for some days thereafter. As with the polymorphs a series of counts would show the changes from the 4th to the 8th days.

The eosinophils are below normal at the outset of the disease and for three or four days thereafter. On the fourth day they are commonly under 4%. On the fifth day they are normal in number or just above

normal but they increase on the 6th day and remain above normal until the 7th or 8th days.

The abive statement then is the law in relation to the conduct of the white blood cells in scarlatina in its early days.

Elsewhere the factors which modify the law have been enumerated.

Briefly put they are:-

(1) The age of the patient.

(2) The severity of the disease.

Under 2 years of age extreme changes were commonly noted. Between 2 and 10 years the changes though well marked were not so obvious, while over 10 years of age the degree of the changes was very limited, in many cases the variation in the relative proportion of cells present being well within the physiological limits. In spite of these modifications however the law holds for all cases, since high or low counts persisting in disease though within physiological limits have a certain significance. Very severe cases of scarlatina do not conform to the law. The polymorphonuclear cells are high and remain high certainly during the whole of the first week and very few eosinophils are found in these cases.

Very mild cases, mild cases, and cases with complications show the same features as do the average case of moderate severity.

The literature shows that the above findings are

similar to those of others.

The eosinophil increase has received most attention and is variously reported as occuring on the second day and on to the 21st day. Kotschetkow found the eosinophils low at the outset of the disease and increasing to a maximum on the 2nd or 3rd week. Felsenthal found them slightly increased at the time the rash appeared (? 2nd day). Zappert though the eosinophilia could be found during or just after the rash. Turk (1898) stated that the eosinophil cells increased during desquamation. Bowie found the eosinophils increased until the fever had passed its height, with maximum between 3rd and 7th days. Klotz noted the eosinophil cells were below normal until the 5th day but they increased usually before the 10th day to above normal. Tileston and Locke reported an eosinophil increase commonly on the 5th day.

Turk (1919) showed that the eosinophil cells were over normal on the 2nd or 3rd day and reached a maximum on the 5th day. The increase therefore began just at the height of the rash. Sacquepee, Besancon, Lable and Weil agree with Turk. The eosinophilia occuring just after the height of the rash and appearing while the temperature is yet raised is the characteristic feature of the blood in scarlet fever. In actual practice no day can be laid down as the day upon which the eosinophil cells begin to increase. The various

opinions quoted above show that clearly, but in every case a characteristic scarlatina change can be noted sometime during the first eight days and usually between the 4th and the 8th days.

In conjunction with the eosinophil cells the other white blood cells show a definite line of conduct no less characteristic. Again various opinions are held as to the day upon which changes commence. Tileston and Locke found polymorphs high and lymphocytes few until the 2nd to the 8th days after which the former fell rapidly while the latter increased in number. Turk found that the fall of the polymorphs began on the 4th day (they were normal on the 3rd) while the lymphocytes increased to their normal figure on the 4th or 5th days. It is clear that it is extremely difficult to state that the change occurs in any particular day. Just as thethe duration of the symptoms and signs varies from case to case so doubtless do the blood changes, yet in all but very severe and exceptional cases (which are very rare) they follow the general law.

These typical changes apply to the cases examined on this occasion. Doubtless epidemics and various other modifying factors have an influence on the disease so that just as symptoms vary in intensity so does the blood picture vary, and thus the facts stated above may not be universal for all types of scarlatina. However they are certainly established in the series of cases examined.

It is difficult to give definite figures for each cell count. The normal proportions of various white blood cells are variable in health quite apart from such influences as digestion etc., and what might be regarded as a normal count in one case, may in fact be abnormal, yet showing no variation beyond physiological limits. Thus one must rather look to the type of change than to the degree of variation in the proportions of the various cells.

When one applies the law to observation scarlets one must exclude the possibility of other diseases causing a similar blood change. From examination of the literature and from personal observations one finds that malaria, more particularly the chronic forms, acute rheumatism during the febrile stage, diphtheria cases with a serum rash, and possibly gonorrhoea with an associated copaiba rash are the sole diseases which might be confused with scarlatina, which show an eosinophilia.

In actual practice malaria is never confused with scarlatina, nor is acute rheumatism, though scarlet cases with early arthritis may look like rheomatic cases.

Diphtheria with a scarlatina-form serum rash is often very like scarlatina, but there are usually distinguishing features - more especially the appearance of the tongue.

Drug rashes may closely simulate scarlatina rashes but they are seldom associated with other symptoms.

All other acute infectious diseases from which scarlet fever has to be diagnosed in atypical cases show no blood changes at all like those associated with scarlatina.

Parasites causing blood changes must always be excluded.

Actually in the series of observation scarlets studied, the diagnosis was made from a close clinical examination of the patient quite apart from the blood examination.

It is interesting to note that the law for scarlatina cases holds good in the majority of cases diagnosed as scarlatina while it is contradicted in most of the cases diagnosed as suffering from some other conditions, not scarlatina.

The ultimate diagnosis in these cases is of course but a matter of opinion. He would be a bold man indeed who could guarantee his diagnosis of scarlatina in every case, and thus the results cannot be taken as absolutely incontroversible in every case.

Nevertheless one has to accept the diagnosis in these cases for lack of any certain exclusive test for scarlatina, and one has to admit that they are as accurate as is possible while diagnosis rests upon present methods.

As has been shown the series of blood changes in scarlatina is typical for all cases except very severe cases and in the diagnosis of scarlet fever from other

conditions simulating it the study of the blood is of value in most cases. The study however must be carried out over a certain number of days, viz, from the 4th to the 8th day, before a typical blood picture is established. The presence of such a typical blood picture with the distinguishing features of scarlet fever is a very strong point for a diagnosis of scarlatina except in cases of diphtheria with a serum rash possibly in a few of the drug rashes associated with gonorrhoea. On the other hand the absence of a typical blood picture over a series of counts while not absolutely excluding the possibility that one is dealing with scarlatina, is strong presumptive evidence against that disease. The study of the blood therefore in observation scarlet fever cases is of value as an aid to diagnosis. In itself the blood count or series of blood counts is not sufficient to make a diagnosis, but as in all diseases, excepting always the pure diseases of the blood itself, the blood count or series of counts must be backed up by clinical evidence before it can be accepted as factor to clinch the diagnosis.

There the matter must rest. Over a large series of cases and at other times results might show some variation from those which have been set down in this work, nevertheless the findings in scarlatina cases and in observation cases were based upon blood examinations made at the same time in the same hospital under similar conditions and the one ventures to suggest is a point

of some value, so that no apology is required for the presence in this work of a number of statistics more or less identical with those of other observers.

In conclusion we might very briefly tabulate the results of our investigation.

(1) There is a definite alteration in the percentage numbers of white blood cells in scarlatina.

(2) The polymorphonuclear cells are much increased at first and remain over normal in number until the fourth day when they begin to fall and rapidly decrease in number until the end of the first week. In most cases the fall carries the number of cells well below the normal figure but in others the figure reached may be at or about the lower physiological level.

The lymphocytes are always few in number at first. They begin to increase as the polymorphonuclear cells decrease and are found increased from the 6th to the 8th or 10th days.
The increase may be of such a degree as to cause a definite lymphocytosis but more usually the lymphocyte cells do not increase more than 10 - 15% above their normal high physiological figure while occasionally they are not more numerous than normally.

The eosinophils are few in number until the 4th day. Then they begin to increase rapidly attaining a maximum on the 5th, 6th or 7th days and remaining increased until the 9th day at least.

(3) The changes are most readily observed in a series of counts carried out from the 4th to the 8th days.

(4) Under two years of age the series of changes are very marked, but over that age are less obvious becoming increasingly less extreme as the age increases.

(5) All cases of scarlatina except the very severe (toxic and septic) cases show the same type of blood changes.

(6) In observation cases diagnosed in hospital as scarlatina practically every case showed the characteristic scarlatina blood changes, while with one or two exceptions the cases diagnosed as non scarlatinal did not show such changes.

(7) The blood examination is of value in diagnosis of observation scarlets, for no other diseases except diphtheria with serum rash, and possibly gonorrhoea with a drug rash, show changes resembling those of scarlatina.

(8) There are exceptional cases, occasionally encountered which do not follow the usual laws in relation to blood changes in scarlatina, so that the blood examination cannot be taken as a perfectly conclusive clinical feature.

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