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Contributors

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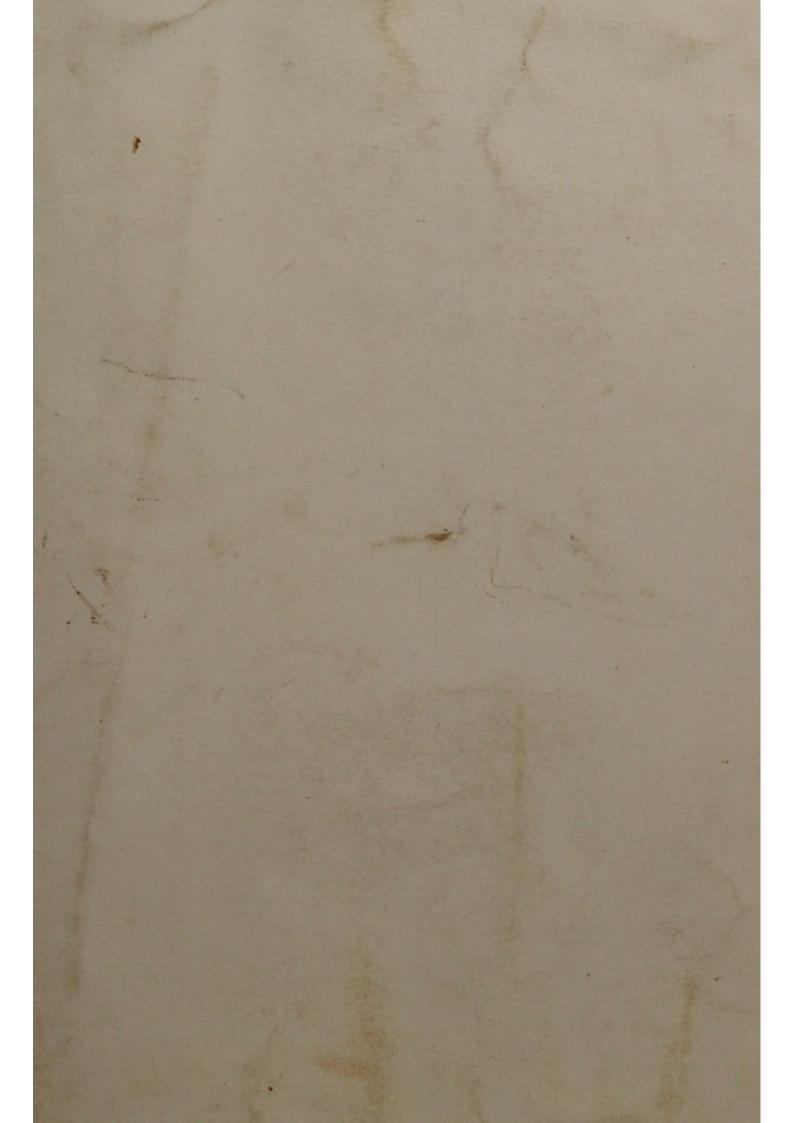
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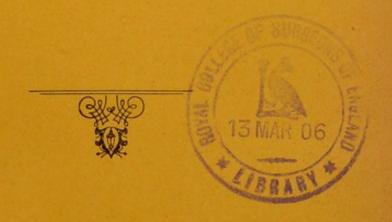
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BRUSSELS

Personally I rely very little on the thermometer in appendicitis, peritonitis, and other abdominal inflammations, for I have seen an appendical abscess containing a pint of pus (1) and a peritoneum full of pus with a normal temperature in both cases. The X Rays have very frequently been a source of error. Yet no surgeon would hesitate to admit the value of these and other similar means of examination, nor would he decline the aid that they might give him. His attitude would be twofold : on the one hand he would insist that methods should be improved so that sources of error could be eliminated ; and, on the other, that the information derived from any one of these methods of examination should never be allowed to stand alone, but should be correlated with all the other clinical evidence which would throw any light on the case.

Examination of the blood, I believe, stands on precisely the same basis. Tuffier has well said of hematology : « It has won the right to be included among our anatomico-pathological means of investigation », and again that it is to be employed « on the sole condition that the examination shall be made and repeated with care and by a competent observer, and interpreted solely in conjunction with the symptoms and a complete clinical investigation » (2).

Those who are optimistic and enthusiastic as to the results from examination of the blood, who possess what Tuffier has well described as a « robust faith », and speak sometimes of the « exact nature of leucocytosis » and again as to the value of the leucocyte-count in surgery, « that the question is no longer sub judice », are quite as much in error in my opinion as those who are so pessimistic regarding the value of hematological investigations as practically to place no dependence upon them.

My own feeling is that many and possibly all of the many different examinations of the blood and its components are either of definite value or before long will become so. Upon some we can depend as yet but little. In fact, as to some, our knowledge is still crude and imperfect. Upon others we can depend more, but must accept their conclusions with caution, and if they are in contradiction with the results from other well-established long-known methods of investigation, our skepticism should be increased ; that others are assuming a definite positive value ; but that no one of the results of hematology has yet won such an assured position of certainty that we can always depend upon it for diagnosis, prognosis, and especially for treatment when a human life is at stake.

Hematology is fighting its way to the front. In spite of its very recent

appearance on the field of diagnosis and prognosis, it has won important victories and to a certain extent has established its position. All our efforts should be bent not toward discouraging such researches by rejecting them as useless, but toward giving every facility for the further prosecution of the work, being well assured that as time goes on most of these methods of investigation will give us more and more positive and reliable aid, while probably a few will have to be discarded as useless and may even be misleading. My message, therefore, is one of hope and encouragement rather than a record of unquestioned reliable achievement.

The subject assigned to me is quite too large to cover it with any approximate degree of thoroughness in a paper which must from the circumstances of the case be more or less brief. I can, therefore, only touch lightly on some of the topics included under the title « Examination of the Blood » ; treat of others a little more fully, but still very inadequately ; and discuss a very few in somewhat more of detail.

Examinations of the blood, naturally, are divided into three different categories.

I. — *The physical examination of the blood as a whole.*

This includes blood pressure, spectrum analysis, the coagulation time, and the freezing point. Blood pressure and spectrum analysis I shall entirely omit, and can only briefly consider the other two topics.

II. — *The chemical examination of the blood.*

The chemistry and the physiology of the blood are so inextricably intermingled that it is difficult if not impossible to separate them. It is not only true of hematology, but of all surgery, that while surgical pathology has made great advances especially in the last forty years since the days of the elder Gross (3) in America, and Rokitansky (4) in Europe, it is only within a very few years that surgical physiology and surgical chemistry, if I may be allowed to use these terms, have assumed any importance whatever.

Among the chemical investigations are included specific gravity ; osmosis ; alkalinity of the blood, and a number of other investigations which as yet have only a slight application to surgery. Vaughan and his pupils in the University of Michigan and a few of the younger investigators both in Europe and America are doing excellent work in this

direction. On the other hand, the alleged presence of sugar in carcinoma may prove an important means of diagnosis between carcinoma and sarcoma, and may have possibly other as yet unthought of values.

Only very recently has the presence of acetone in the blood along with acetone and diacetic acid in the urine been thought to be of any importance in surgery, but the admirable papers of Brewer (5) and of Kelley (6) and others have distinctly aroused the attention of surgeons and emphasized the great occasional importance of such an investigation. As yet we do not know what causes this new danger after anesthesia and in certain diseases, and, of course, we know nothing of the means of curing it, nor the best means of avoiding its grave dangers. All of these subjects I merely mention, but must pass them by for want of time.

The presence of glycogen in the blood and its iodine reaction (iodophilia) will be considered later, though briefly, as also will the determination of the percentage of hemoglobin, both of which are important chemical investigations.

III. — *The third method of investigating the blood is by the microscope.*

The investigation of the normal elements of the blood is important. As yet our investigations of the erythrocytes, not only their number, but their form, degeneration and alteration are exceedingly imperfect. The recent studies of Kullmann (7) on the hemolytic action of a carcinoma extract point significantly to its possible importance. These investigations, one may say, are both microscopical and chemical. The extract from cancer of the breast and that from cancer of the uterus were passed through a Pukall filter (Tonkerze) and in from three to ten hours completely destroyed the red corpuscles both of man, the rabbit, the calf, and the pig. This action, it is believed, may possibly explain the cachexia which sooner or later follows malignant disease, even when it affects organs which do not directly involve the nutrition of the body, such as the breast, the uterus, the extremities, etc.

The chief microscopical investigations thus far have had to do with the leucocytes, especially as shown in leucocytosis, in iodophilia, and in eosinophilia, which I shall consider later.

How little we know of the blood plates, we are only too painfully conscious of. Yet these same blood plates probably have a most important influence on the production of gangrene as a result of intravascular thromboses in typhoid fever, a coagulation wholly different

from the formation of a blood clot outside of the body. Moreover, as pointed out by Cabot (8), « this may be of the utmost importance in connection with the use of gelatine injections to favor thrombosis in aneurysms ».

Another normal morphological constituent of the blood to which Müller (9) has directed attention is hemoconia or blood dust, the smallest colorless granulations of the size of the finer fat drops. What is their function and what is their diagnostic or prognostic value is as yet wholly unknown. It may not be too much to hope that both as to these particles and other formed constituents of the blood that the recently discovered method of ultra microscopical investigations may afford us most important future knowledge.

As to the blood serum, its role in diagnosis, in therapeutics and in the vast subject of immunity I can simply mention it as one element in a systematic statement of the manifold means and methods of examination of the blood. Not only in its microscopical relations (especially possibly the ultra-microscopical) but in its chemical and its physical relations is it of great importance.

But beside these normal microscopical elements which are to be investigated, there are also certain pathological elements which are frequently found in the blood. Our means of recognizing and examining these have only recently assumed any serious value. Much is to be expected from improved methods in the future. In 1898, when my book on the Surgical Complications and Sequels of Typhoid Fever was published, I could only collect a very few observations demonstrating the presence of the typhoid bacilli in the blood. Since then with improved methods, it is certain that in at least 80 % of the cases of typhoid, and in the first week in even 93 % the bacilli may be found. This has added a new means of very early diagnosis of great importance. It anticipates the eruption; it anticipates the Widal reaction; is one of the very earliest means of diagnosis and, of course, when positively present is conclusive.

The earlier researches of Adami (10) and the more recent investigations of Nichols (11) and Ford (12) have an important bearing upon this bacterial invasion. They seem to show that bacteria are constantly passing into the interior of the organism from epithelial and mucous surfaces and lodging in the lymph glands and the mesentery even in health, and probably, therefore, all the more in disease, when the bacteria are far more virulent.

Not only, however, are typhoid bacilli found, but the bacillus of anthrax, pneumonia, tetanus or glanders, the streptococcus, the sta-

phylococcus, the meningococcus, and the colon bacillus have all been found in the blood. Jochmann (13) has shown that reversing the ordinary surgical importance of the staphylococcus and the streptococcus, the latter is much less dangerous as a secondary infection in the blood then the former, and also requires a different treatment (*).

So constant is the presence of the staphylococcus albus in blood cultures that its presence always suggests the possibility of an accidental infection from the skin itself.

The presence of the pneumococcus in the blood in pneumonia and possibly in peritonitis of similar origin means a grave but not necessarily a hopeless prognosis. Even the gonococcus has been found in the blood in several gonorrhoeal infections (**).

In addition to the discovery of these various bacteria in the blood, however, it is probable that other methods of cyto-diagnosis will assume a much larger importance in the near future. Finally the presence of pigment in the leucocytes and also in the free serum may be of pathological importance.

I shall now consider briefly the value of the coagulation time (hematopexis) and the freezing point (cryoscopy), iodophilia, leucocytosis, and eosinophilia, and then the value of these investigations in a few diseases, such as appendicitis, typhoid fever, intestinal obstruction, carcinoma, and sarcoma. Time compels me to omit the rest, including a number of interesting observations, such as a case of purpura in which staphylococci were found in the blood and two examinations howed respectively a hemoglobin of 74 % and 101 %, erythrocyte counts of 6,010,000 and 7,420,000 and a leucocytosis of 19,800 and 10,400; three cases of typhoid abscess and gangrene with a mixed

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(*) Opsonins.

Within the last two years Wright and Douglas of England have discovered and identified the opsonins in the blood, certain substances which by their action on the bacteria appear to prepare them for the destructive action of the phagocites. Especially do they seem to protect the blood against a staphylococcus infection. They are apparently a new and simple anti-body whose influence may be of great importance.

(**) At the meeting of the Association of American Physicians in Washington in May 1905, Thayer (Med. News, May 20th, 1905, 958) reported a number of cases of gonorrhoeal ulcerative endocarditis. One of them simulated typhoid in the temperature chart and the symptoms to such an extent that « on the 21st day, when it had been about decided that the case must be one of typhoid fever, the gonococcus was found in pure culture in the blood », thus revealing its true character.

infection, and yet a leucocyte count of only 7,800, 8,200 and 9,000, while another case of typhoid osteomyelitis showed 14,000, etc.

The tables appended I owe to the labors of Drs. John C. Da Costa, Junior, the author of the well-known worck on « Clinical Hematology », Frederick J. Kalteyer, Aller G. Ellis, William Warren and J. Bernhard Mencke, who have not only given me the results in the Jefferson Medical College Hospital, but also at the German Hospital through the courtesy of Drs. James C. Wilson, John B. Deaver and A. O. J. Kelly. To all of these gentlemen I express my hearty thanks for their kindness.

Coagulation time.

It seemed to me desirable to employ a concrete term or name for the coagulation time. Accordingly, I consulted my old professor of Greek at Brown University, whose name is familiar to all Greek scholars, Professor Albert Harkness, who suggested : « Haematopexis », and added « Pexis used of a solid means to fix in position (e. g. nephropexy), but used of a liquid, it means to freeze or to coagulate. Hippocrates used it in this same sense ».

We must distinguish between coagulation of the blood into a thrombus within the blood-vessels, which is in intimate relation with the blood-plates and other formed elements of the blood, and coagulation of the blood out-side of the body, which is in relation to the amount of fibrin, yet the two seem to have some distinct interrelation as yet not fully understood. By coagulation time or *Hematopexis* is meant the time required for clotting outside of the body.

As to intra-vascular thrombosis, it is of great importance in connection with typhoid fever and its surgical results, especially typhoid gangrene. The coagulation of the blood outside the body in typhoid is distinctly prolonged in the early stages of typhoid, but during convalescence, the blood clots in a very much shorter time than is normal and, presumably, may explain the characteristic of gangrene, which, as I have pointed out elsewhere (14), is especially a complication or sequel occurring late in the fever or distinctly during convalescence.

Wright and Knapp have suggested that this increased coagulability is due to the increase in the amount of the calcium salts during convalescence, and that this is due principally to the quantity of calcium salts given to the patient in milk, which constitutes his principal diet. They advise as a preventive measure against such thrombosis, partial decalcification of the milk by adding sodium citrate to it ; but

that this shall not be done so long as there is danger of intestinal hemorrhage. While there seems to be, therefore, some relation between the extra-somatic and the intra-vascular coagulability of the blood, though they depend upon different causes, yet the distinction above alluded to must be borne in mind.

The extra-somatic coagulation time is of special importance in cases of jaundice. The normal coagulation time is usually from three to four minutes (*), up to seven or occasionally ten minutes.

A prolongation of the coagulation time to 10 or even 12 minutes, however, is not always indicative of such serious danger as to deter us from operating. In several cases I have had such a prolongation when I have operated for gall-stones and yet I had no trouble with hemorrhage except in case 36 in the table. It is to be observed, however, that these have been cases in which the jaundice was of comparatively recent origin and of moderate severity. I well remember the first case that I ever operated on for gall stones (15) in which the patient had suffered for only six weeks from jaundice but was of a deep olive color. The jaundice was so intense that her vision was affected to such an extent that a white shirt-bosom looked green to her. She bled to death from the cut edges of a moderately thickened gall-bladder. In three years at the Jefferson Medical College Hospital, four patients suffering from jaundice, the result of malignant disease, have bled to death after operation.

In the appended table I have given the recorded hematopexis in 38 cases. In none of them was there any unusual hemorrhage at operation, although in 7 the time was prolonged to from 10 to 14 minutes excepting case 36. In this case the patient died from constant slow oozing of blood and at the necropsy the blood in the peritoneal cavity was entirely liquid. She had been given chloride of calcium for three days up to 30 grains a day before operation.

The apparent influence of jaundice is seen upon taking the average of the cases (a) with jaundice and (b) with « slight » or « no » jaundice. Omitting cases 31 and 32 in which the presence or absence of jaundice is uncertain, there remain 36 cases, of which 18 fall into each category. In case 36 I have taken the mean of the three tests. Of the 18 cases with

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(*) I cannot understand the statement of Tuffier (2, p. 5) that the normal coagulation time is 20 minutes and that a delay of 20 to 45 minutes is pathological. Every time that an operation is done, one sees the blood coagulate in a very few minutes, far less than 20.

jaundice more or less marked, the average hematopexis was 8 minutes and 11 seconds. Of the 18 cases with slight or no jaundice, the average was 5 minutes and 24 seconds.

Coagulation time of the blood in 38 cases of cholelithiasis.

N°	Hg.	Erythrocytes.	Leucocytes.	Coag.	Time.	
1.	92	4,860,000	7,200	6′	30″	Jaundice.
2.	—	—	—	8	31	Jaundice.
3.	—	—	—	7	0	Jaundice.
4.	—	—	—	10	0	Very slight jaundice.
5.	90	—	7,000	9	0	Jaundice.
6.	60	3,610,000	5,000	14	0	Jaundice (very deep)
7.	75	4,040,000	8,000	12	0	Decided jaundice.
8.	—	—	—	13	0	Jaundice.
9.	—	—	—	12	0	Jaundice; g.-bl. cancer.
10.	78	4,060,000	11,000	6	30	Slight jaundice.
11.	—	—	—	6	0	No jaundice.
12.	95	4,350,000	5,000	7	0	Jaundice 2 weeks before.
13.	—	—	—	7	0	Marked jaundice.
14.	—	—	—	6	20	Jaundice.
15.	49	2,300,000	9,800	10	30	Lemon-yellow conjunctivæ.
16.	—	—	—	8	30	No jaundice.
17.	89	4,430,000	7,800	5	30	No jaundice.
18.	65	3,940,000	16,400	5	30	Jaundice.
19.	82	5,150,000	7,700	3	0	No jaundice.
20.	75	4,150,000	19,400	5	0	Jaundice.
21.	94	4,100,000	7,200	6	15	Jaundice.
22.	75	4,640,000	14,000	4	30	Marked jaundice.
23.	73	3,530,000	4,800	4	0	No jaundice.
24.	97	5,310,000	9,000	2	15?	No jaundice.
25.	98	5,110,000	6,500	4	10	Jaundice.
26.	90	4,450,000	5,600	4	15	Very slight jaundice.
27.	83	4,670,000	12,040	5	30	No jaundice.
28.	70	4,100,000	7,920	4	15	No jaundice.
29.	102	5,850,000	8,200	5	30	No jaundice.
30.	—	—	—	5	0	No jaundice.
31.	—	—	—	7	9	?

No	Hg.	Erythrocytes.	Leucocytes.	Coag.	Time	
32.	70	4,080,000	5,900	5	30	?
33.	88	4,000,000	7,000	5	0	No jaundice.
34.	—	—	—	7	0	No jaundice.
35.	78	3,970,000	3,600	6	0	Jaundice.
36.	84	4,500,000	16,000	9 / 12 / 10	35 / 10 / 30	Jaundice; fatal hemorrhage after operation.
37.	75	5,130,000	13,200	4	30	Slight jaundice; no bleeding at operation.
38.	85	5,120,000	4,800	3	30	No jaundice; no iodophilia.

In none of there 38 cases was there any hemorrhage at operation except in no 36 a woman who bled to death after operation.

The use of thyroid extract internally in hemophilia.

My friend, Dr Wm. J. Taylor has given me notes of the following cases, showing the value of thyroid extract in hemophilia. This should be tested by other surgeons to determine definitely its influence in this serious condition.

Preparatory to an operation for nephrorrhaphy, a woman, age 38 years, a bleeder, whose coagulation time was eleven and a half minutes, was given thyroid extract at intervals for a couple of months, for periods not longer than one week at a time. At the end of this time the coagulation time had fallen to two minutes and six seconds. The operation was now done. The wound was unusually dry, and there was less than the usual amount of post-operative oozing.

A boy of 18, a bleeder, who had been operated upon for necrosis of the fibula, did not do well. The wound oozed for weeks and did not heal. After thyroid extract was administered for one week, the wound ceased to bleed and the general condition of the patient improved remarkably.

A woman of 45 years, who had bled for several days after the extraction of a tooth three years before, was given thyroid extract for three days before the extraction of two teeth. The amount of bleeding was very slight, and she had no after bleeding.

Cryoscopy.

Cryoscopy both of the blood and of the urine is not, I think, as yet generally accepted as a definite indication deciding positively for or against nephrectomy; yet, on the other hand, it is, I think, distinctly winning its way as a means of examination which is destined in the future to play a much larger role than it does at present. Kümmell is its chief advocate in Europe. Tinker (16) has published a very excellent paper in America in which he confirms to a large extent the results claimed by Kümmell. Normal blood coagulates at $0°57 \pm 1$ %, and is indicated by the Greek delta Δ. Kümmell asserts that a freezing point above $0°58$ or certainly $0°60$, it is a distinct contra-indication to a nephrectomy.

Rumpel, in a number of prostatics, in whom he found a high volume for Δ states that the necropsy showed the lesions of pyelonephritis, although the symptoms did not arouse any suspicions.

We must, however, remember that in anemic and cachectic states there may be a normal Δ with renal insufficiency.

While at the present time we may not be willing to accept definitely the cryoscopic test as a contra-indication to nephrectomy, an elevated Δ should always make the surgeon cautious. Further studies upon this important indication are much to be desired.

Iodophilia.

That the presence of glycogen in the leucocytes as shown by the iodine stain is an absolutely reliable indication of suppuration, even the most ardent advocates of the value of hematological examinations will scarcely assert. There are too many exceptions. On the other hand, there is no question, I think, of the great value of iodophilia in certain cases as an addition to our other means of investigation, which will even materially aid us in diagnosis and sometimes prevent serious error.

Many surgeons in common with myself have seen a considerable number of cases of osteo-myelitis, which have been treated for months as rheumatism, some of them progressing to such an extent as to allow of spontaneous fracture of the femur. Inasmuch as in acute rheumatism the iodophilic reaction is absent and in the majority of cases of acute osteo-myelitis and epiphysitis it is distinctly present, this reaction in the

differential diagnosis of these conditions may be of the greatest service. (See case 15 of the first iodophilia table.)

Again, when we are in doubt whether an abscess is tuberculous or suppurative, the iodophilic reaction will often assist us since there is none in turberculous processes, but it is very frequently, though not invariably present in suppurative abscesses. That the degree of iodophilia does not accurately correspond to the degree of danger; that is to say, that severe sepsis will always produce an intense iodophilic reaction and a mild sepsis a mild reaction is certainly not true. One may obtain even from a case suffering from a furuncle the same degree of iodophilia as from a case of severe sepsis.

In intestinal obstruction, there is as a rule a more or less marked reaction, but the intensity of the reaction is not a guide to the presence of gangrene, though Locke seems always to have obtained a reaction in gangrene, and when the reaction was absent the later results proved that there had been no gangrene of the bowel.

In prognosis, however, the value of iodophilia is admitted even by those who like Reich (17) are rather pessimistic as to its diagnostic value. Persistence of the iodophilia, especially if the reaction becomes more marked, is usually an indication either of some suppurative complication that has arisen de novo, or of retention of pus, or of extension of the suppurative process. While we can hardly agree with Schnitzler that iodophilia is an absolutely proof of pus in intra-abdominal suppuration, it at least raises a strong suspicion of suppuration and thus makes us cautious and leads us to investigate the other clinical symptoms with all the more care.

In fatal cases of peritonitis, iodophilia as a general rule increases, while, as we would expect, the leucocyte count falls. The iodophilic action, therefore, is of distinct value in the prognosis of peritonitis. If we have a rising leucocytosis and a falling iodophilia, the prognosis is likely to be good, and, vice versa, if the leucocytosis in falling and the iodophilia becoming more marked, the prognosis is distinctly unfavorable.

In surgical tuberculosis, Reich was the first to show that in all its forms the iodophilic reaction is absent even if there be a distinct tuberculous « abscess », but that in mixed infections iodophilia is obtained. If, therefore, after operation upon a tuberculous lesion, there is fever and an iodophilic reaction, we may infer a mixed infection, but if we have no iodophilic reaction, we may infer that there is no infection other than the tuberculous, in spite of a high temperature. Recently I have had a very obscure case of tuberculous spinal caries followed by death from tuberculous ulceration in the small intestine causing severe

and repeated hemorrhages, in which the absence of iodophilia and the low leucocytosis were very marked proofs of the tuberculous nature of the disease and aided much in the diagnosis. The symptoms were very analogous to an appendicitis, and he had a continuous temperature of 102° to 103°, and occasionally 104°, but there was no iodophilia and the leucocytosis was only 3,400 to 7,800. A careful bacteriological examination of the contents of the tissues after operation showed an absolutely pure tuberculous infection.

So too after an aseptic operation, if there is a marked febrile reaction but iodophilia is negative, and especially if with this the leucocytosis does not show any increase, we may feel quite confident that there is no pyogenic infection and need not disturb the dressing. If after opening an abscess the intensity of the iodophilic reaction diminishes, we may be confident that the evacuation of the pus has been effective and the case is progressing favorably. If, however, the intensity of the reaction does not fall, or, if having fallen, it becomes mor pronounced, we may be fairly certain that there is retention of pus or an extension of the suppurative process. In all of these, however, it is of the utmost importance that we exclude any complication capable of producing an iodophilia.

In the appended 59 cases, some of the reactions would have been sorely misleading had we depended upon this test alone. But in conjunction with other hematological findings and with the symptoms and physical signs it was of value. I have already called attention to case 15 in the first iodophilia table. In case 14, the faint reaction confirmed the low leucocyte finding. Cases 22, 23, 24 and 28 with the low leucocytosis pointed to the correct diagnosis. But on the other hand, cases 9, 10 and 31, and in case 6 of the second table, it was distinctly misleading. In other cases it will be seen that the iodophilic reaction was more reliable than the leucocyte count.

Iodophilia (42 cases) :

DIAGNOSIS.	Leucocyte count.	Character of reaction.
1. Sup. appendicitis; gen. peritonitis	13,000	P Mkd D
2. Sup. appendicitis	12,900	P Mkd D G
3. Sup. appendicitis	7,400	P Ft D
4. Croup. pneumonia	11,200	P Mod D
5. Sup. appendicitis . . . . . — . 1	13,200	P Mod D G
6. Sup. and gangr. appendicitis	16,100	P Mod D

	DIAGNOSIS.	Leucocyte count.	Character of reaction.
7.	Sup. appendicitis	14,000	P Mod D G
8.	Pyosalpinx	19,200	P Mkd D
9.	Sup. appendicitis	10,200	N
10.	Sup. appendicitis	11,400	P Ft D
11.	Sepsis	»	P Mod D
12.	Sup. appendicitis	6,200	P Mod D
13.	Phthisis	5,800	P Mkd D G
14.	Catharrhal appendicitis	6,400	P VFt D G
15.	Rheumatic fever (vs. Gon. arthritis).	12,000	N
16.	Pyosalpinx	16,800	P Mkd D
17.	Sup. appendicitis	15,000	P Mod D
18.	Sup. appendicitis	24,600	P Mkd D G
19.	Croup. pneumonia.	22,000	P Mod D G
20.	Sup. appendicitis	10,000	P Mkd D G
21.	Sepsis (endometritis)	17,500	P Mod D
22.	Nephroptosis (vs. appendicitis)	8,900	N
23.	Enteric fever	4,200	N
24.	Catarrhal appendicitis.	8,000	N
25.	Sup. appendicitis	22,000	P Mkd D
26.	Pyosalpinx	17,800	P Mod D G
27.	Croup. pneumonia.	39,500	P Mkd D G
28.	Cholelithiasis (180 calculi; no pus)	6,000	N
29.	Croup. pneumonia.	12,500	P Vft D
30.	Enteric fever	5,600	P Mod
31.	Subphrenic abscess	10,200	P Ft D
32.	Pernicious anemia	2,800	P Mod
33.	Carcinoma (gastric)	7,000	N
34.	Sup. and gangr. appendicitis	14,000	P Mod D G
35.	Sup. appendicitis	17,000	P Mkd D G
36.	Gangr. appendicitis	7,900	P Mkd D G
37.	Sup. appendicitis; ulc. cholecystitis; peritonitis; multiple hepatic abscesses; phlebitis. . . .	18,000	P Mkd D G
38.	Croup. Pneumonia	14,600	P Mkd D
39.	Sup. appendicitis	26,000	P Mkd D

DIAGNOSIS.	Leucocyte count.	Character of reaction.
40. Intestinal obstruction (gangrene)	28,000	P Mod D G
41. Sup. appendicitis	9,000	P Mod D
42. Sepsis (puerperal)	8,400	P Mkd D

Key to abreviations :

P : Positive reaction.
N : Negative reaction.
Mod : Moderate reaction.
Mkd : Marked reaction.
Ft : Faint reaction.
VFt : Very faint reaction.
D : Diffuse staining.
G : Granular staining.

Iodophilia, positive in 17 out of 99 cases :

	Leucocytes.	Reaction.
1. Sarcoma of liver.	13,600	Very faint.
2. Sarcoma of abdominal wall.	18,500	—
3. Tubal abortion with adhesions	8,760	Moderate.
4. Tuberculous arthritis of knee	4,800	—
5. Carcinoma of testicle	10,160	—
6. Pelvic abscess. . . . . . :	12,440	Very faint.
7. Carcinoma of pancreas	11,200	Moderate.
8. Sarcoma of liver	20,400	Extracellular.
9. Pelvic abscess.	8,840	Moderate.
10. Post-operative peritonitis, after chronic appendicitis	14,480	Marked.
11. Pelvic cellulitis	19,440	—
12. Heart disease	7,800	Moderate.
13. Purulent cystitis	20,140	—
14. Polyp in external auditory meatus.	8,800	—
15. Criminal abortion, retained placenta	11,000	Very faint.
16. Gunshot wound of abdomen, 7 perforations of intestine	16,120	Moderate.
17. Urinary retention.	9,840	Marked.

Hemoglobin.

The chief surgical interest of hemoglobin, and along with it the color index, is in connection with anesthesia. Both chloroform and ether distinctly diminish absolutely the amount of hemoglobin and though there is an apparent increase in some cases, the color index shows that this is only apparent and not real, as has been shown particularly by Da Costa and Kalteyer (18). When, therefore, an operation has to be done, it is of great importance to know the percentage of the hemoglobin, for if the percentage is too low, the blood may carry a dangerously small amount of oxygen especially to the respiratory centre. If then the hemoglobin, already at a low level, is still further diminished by the anesthetic, it is very possible that death on the table may readily occur without any perceptible lesion to account for it.

The facts above stated are generally admitted. The only difference of opinion among surgeons is as to what percentage of hemoglobin should contra-indicate a general anesthetic. Von Mikulicz fixes the percentage at 30. Below this he thought a general anesthetic was absolutety contra-indicated. Others have fixed it as high as 50 %.

Personnally, I agree with Da Costa and Kalteyer, and Fish (19), in recommending that first, if the percentage of hemoglobin is less than 50, great care should be used in the administration of the anesthetic, especially if chloroform be used. Second, if the percentage is below 40 %, it is desirable, if possible, to substitute local for general anesthesia. Since the introduction, especially by Crile and Matas, of the method of producing complete and prolonged anesthesia by neural infiltration in suitable cases, the substitution of a local for a general anesthetic has received a marked impetus. Third, if the percentage falls below 30 %, I should be still more loath to give a general anesthetic, and would only consent to do so under the stress of an imperious necessity. In a number of emergencies such as are produced by accident, by appendicitis, by typhoid perforation (*), by cholelithiasis, etc. Sometimes an operation *must* be done and done without delay in order to save life. In such cases one has to take the chances of a low

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(*) Thayer has shown that there is a progressive diminution in the percentage of hemoglobin from 76 % in the first week to 50 % in the seventh week of typhoid In operating on a case of typhoid perforation, this should be remembered .

hemoglobin. If the operation in such that a local anesthetic can be used, it certainly ought to be employed. On the other hand, if a local anesthetic cannot be used, then we must proceed with general anesthesia in spite of the low hemogobin.

It is a great encouragement to know that in a number of these cases a much lower percentage than 40 or even than 30 has existed and yet success has crowned the attempt. Thus Moynihan (20) records five cases in which the percentage of hemoglobin was 18, 22, 25, 28 and 33. Da Costa and Kalteyer record cases of 30 and 24 %. Deaver records two cases of 30 and 22 %; Tuffier, 20 %; Silhol, 20 %; Herrick, 18 %,

A number of other cases in which the percentage of hemoglobin ranged from 15 to 30 % have been operated on successfully by Girvin, Shober, Le Conte, Noble, Baldy, J. C. Da Costa, and others (21). Such exceptions, however, only prove the rule as above quoted.

In addition to this we must remember that J. Chalmers Da Costa (22) in an earlier paper showed that « prolonged anesthesia profoundly deteriorates the blood and strongly militates against recovery, hence rapidity of operation is most desirable », a conclusion too often overlooked by many of us in the painless security of modern anesthesia. Moreover, the anesthetic should be administered only by an experienced man who will be able to anesthetize the patient with the minimum amount. Oxygen should always be at hand and often should be administered with the anesthetic.

Comparing the hemoglobin in the appended tables of carcinoma, sarcoma, goitre, ulcer, and cholelithiasis, in all of which prolonged anesthesia may be required, we are struck with these facts. In 48 cases of gastric ulcer, the lowest average percentage of hemoglobin occurred, and that 17 or 35.4 % showed a hemoglobin of from 50 to 20 %. In 181 cases of carcinoma, 35 or 19.4 % showed a hemoglobin of from 50 to 10 %. In 19 cases of sarcoma, only 2 or 10.5 % showed a hemoglobin of from 50 to 30 %. In 144 cases of cholelithiasis, 13 or 9 % showed a hemoglobin of 50 to 10 %.

In other words, we should be especially careful to observe the percentage of hemoglobin before operating on gastric ulcer since over one case in three will show a low percentage of hemoglobin, and in carcinoma, since one case in five will show the same condition.

Leucocytosis.

It is of great importance to remember that there is a physiological leucocytosis and that any blood count which is of value to the surgeon

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must, if possible, be made at such a time and under such conditions as to avoid any misleading enumeration. The most important of these conditions is digestion, during which, sometimes, there is an increase up to 25 %; hence no leucocyte count for diagnostic purposes should be made during the process of digestion, but after it has been completed. Again, violent exercise, massage, cold baths, etc. have the same effect and an enumeration immediately after them should be avoided. So, too, there is a leucocytosis of pregnancy and in infancy, for which, however, allowance must be made inasmuch as in some cases we cannot escape making our count during such periods.

There is a pathological leucocytosis, however, which must be looked at from two points of view.

1. It is distinctly a sign of infection and in many cases of suppuration. Richardson (23) of Boston was the first to impress upon surgeons in America the value of the leucocyte count especially in appendicitis. Curschmann (24) did a similar service two years later on the continent. Since then we have learned that there are certain precautions which must be used in interpreting the degree of leucocytosis. In a general way, however, one may say that if the infection is of minor importance, there will be only a small increase in the number of leucocytes. Again, if there be an abscess which is well encapsulated, there will be only a moderate rise in the number of the leucocytes, for, as Mc Caskey (25) in a thoughtful article on the diagnostic value of leucocytosis says, « in order that these chemotactic influences may be manifested it is necessary for the chemotactic substances to gain an entrance into the circulation — a point which is absolutely vital in the whole question of the diagnostic bearing of leucocytosis. Especially is this true in its bearing upon the absence or presence of suppuration in some part of the body ». « A thick impervious, pyogenic, non-absorbing membrane », as he points out, may « wall in the pus from the circulation » and « prevent the entrance into the circulation of the bacterial toxins which probably constitute the chemotactic substance in cases of suppuration ». « If the anatomical conditions are such that the toxins cannot to any great extent enter the circulation, a leucocytosis of diagnostic significance may be entirely absent. »

2) But instead of a slight infection or a delimited abscess producing a slight leucocytosis, the sepsis or the morbid process may be so intense as to overwhelm the resisting power of the patient, and so produce either a small or even no leucocytosis. Even in a walled in abscess, however, an increase in the percentage of polynuclear leucocytes to 80 or 85 % may assist us to a correct diagnosis. If his resisting

power or power of reaction is low, even a moderate infection may overwhelm the patient and a severe infection surely will. In this case we shall have little or no leucocytosis. Hence if a patient is severely ill and the degree of leucocytosis is low, or there be no leucocytosis, the prognosis is extremely bad. On the other hand, the patient being ill and even severely ill, if the leucocyte count is high, it shows that his resisting power is good and the outcome of the battle may be at last in favor of the patient rather than the disease.

The percentage of the polynuclear leucocytes is of especial importance, so that a differential count should always be made. As already indicated, an increased number of leucocytes, especially if with this there is an increased percentage of polynuclears above, say 70 % make us suspicious of the existence of pus. By the kidness of Dr. M. Allen Starr of New York, I am permitted to quote a very interesting case in which the diagnosis between abscess of the brain and cerebral softening was finally decided largely by the leucocytosis and the high percentage of the polynuclear neutrophiles. A woman, aet. 48, was operated upon for mastoid disease on March 3rd, 1905, and apparently recovered entirely though the wound had not completely healed. On April 7th, she had a slight rise of temperature and some general malaise for a few days. On April 12th, suddenly she became paraphasic and talked jargon, and on the following day was dull and listless. The head was tender on the left side, there was headache, normal temperature, pupils equal, discs clear, reflexes normal and no trace of paralysis or anesthesia. The blood count showed a rising leucocytosis and a high percentage of polynuclears.

	Leucocytes.	Polynuclears
April 12th.	11,400	84 %
— 15th.	14,400	85
— 16th.	14,800	79
— 19th.	15,400	85
— 22nd	15,000	80

By April 22nd, she had become much worse, had a chill, a temperature of 104.5°F; pulse 108; was speechless; knee jerks much increased with slight paresis of the right arm and choked discs. Operation the next day, evacuated an ounce of pus from the third frontal convolution. She died 36 hours later.

In the differential diagnosis of tumor of the brain and abscess of

the brain, the leucocytosis of abscess and its absence in tumor is of great use. But in cerebral hemorrhage, there is usually a high leucocytosis, which will not, therefore, aid us in distinguishing this condition from abscess, though the other symptoms may.

Just what degree of leucocytosis is a distinct or fairly distinct evidence of pus is a much mooted point. Varying numbers from 18,000 to 25,000 or 30,000 have been proposed. I do not think that any definite mathematical limit can be assigned, but that we must take into account not only the number of the leucocytes, but also the general condition of the patient. In some with a relatively low power of resistance, a count of 18,000 may readily indicate a beginning suppuration. In others with high resistance, suppuration may not even set in until the higher counts mentioned have been reached.

In the annexed table of 277 cases of abscess, if we assume any count of over 10,000 as a pathological increase and therefore to be deemed a distinct though low leucocytosis, it is to be noted that in 203 cases (73.3 %) the leucocytosis was above 10,000 and only in 74 cases (26.7 %) was it below 10,000. Moreover the average range of the leucocytosis in the different form of abscess was never below 10,000, the lowest average being 11,428 and the highest 18,891.

Moreover, we must remember that the absence of leucocytosis in some diseases and especially in typhoid is very significant and may be diagnostic. The differential diagnosis especially between typhoid and appendicitis in the early stages of the two diseases is often of the utmost importance and often of the utmost difficulty and has been already alluded to.

If there be no leucocytosis, especially if there be a leukopenia, so that the leucocytes fall to 7,000 at 5,000 or even below, the diagnosis is distinctly in favor of typhoid and against appendicitis. But again we must remember that in such a case, though it be typhoid, if there be any other suppurative lesion, even so slight as a furuncle, we may have very appreciable leucocytosis. We must, therefore, carefully guard against being misled by such a complication.

In estimating the value of the leucocyte count in any disorder, we must recognize from the outset that a single count, just as a single observation of the temperature though of some value, is of very little value as contrasted with a *chart* of the temperature or of the leucocytosis derived from regular, daily, and in some cases, frequent observation. To state such a comparison is sufficient. It needs no argument. The surgeon when first called to a case of appendicitis will always take the temperature and give the observation due weight, but if he has

repeated accurate observations the evidence is of far greater value. He should do the same with the leucocyte count.

There are surgeons who regard the examination of the blood as « often of no practical value » and that it « may often misguide the surgeon ». They decry the alleged modern tendency « to replace the bedside by the laboratory as the point from which to make the diagnosis » ; they regard the substitution of « the highly magnified but extremely limited field of the microscope for the broader view of the eye of the physician » as mischievous, for « in the majority of instances the diagnosis must be made at the bedside without the aid of the microscopist, and any man who has no confidence in diagnosis made without the aid of the laboratory, limits his usefulness. The blood count theoretically promises the surgeon more perhaps than any other of the lines of laboratory investigation and is certainly of great practical value, yet the information thus obtained is open to many fallacies, and the surgeon who depends on this means alone to decide for or against operation in any condition is often acting to the detriment of his patient ». (Deaver)(26- Very true! But what surgeon, in making a decision for or against opetion, *would* depend on this means alone? Or on the temperature alone? Or on unilateral abdominal rigidity in appendicitis alone? No wise surgeon will trust to *any* one sign or symptom, valuable as it may be. He will always correlate *all* the symptoms and *all* the signs rather than depend upon any one. « *When such a choice* (i. e. between the laboratory and the bedside) *must be made* », says Cabot most aptly « sensible men will generally agree with Deaver that the bedside is the point of vantage», but such a choice should rarely be necessary, for « the microscope should be a « laboratory » instrument no more than the thermometer ».

The present estimate of the value of leucocytosis in appendicitis is well stated by an editorial writer in the *Medical Record* (27) as follows : « The consensus of opinion among most observers is that a positive result (i. e. a leucocytosis) affords a more certain indication of the presence of suppuration than any one other clinical sign. » Valuable as it is, however, it must be used only in conjunction with all our other means of investigation. Da Costa (28), perhaps, states it as well as any other author; « the clinical inferences to be drawn are of value chiefly as corroborative of other well-known physical signs, but are obviously untrustworthy when considered apart from the latter. A marked leucocytosis indicates simply an intense infection in a person whose resisting powers are normaly developed and actively exerted against the disease, but it is of no prognostic value in itself, for it conveys no idea of the final outcome of the conflict between the disease and the organism. Absence

of leucocytosis or a slight increase may be either of very favorable or of very grave significance, inasmuch as these signs occur both in trivial and in overwhelming infections. If the absence is associated with clinical manifestations which point to a severe infection, the sign may be depended upon as being of grave prognosis. »

ABSCESS.

Hemoglobin (166 cases).

Average	61.5 %	
Highest	98.0 —	
Lowest	20.0 —	
Range in 6 cases	90–100 %	
— 22 —	80–90 —	
— 34 —	70–80 —	
— 25 —	60–70 —	
— 26 —	50–60 —	
— 30 —	40–50 —	
— 16 —	30–40 —	
— 7 —	20–30 —	

Erythrocytes (166 cases).

Average	3,827,540 per cb. mm.
Highest	5,970,000 —
Lowest	1,320,000 —
Range in 15 cases	above 5,000,000 per cb. mm.
— 49 —	4,000,000 to 5,000,000 per cb. mm.
— 84 —	3,000,000 to 4,000,000 —
— 10 —	2,000,000 to 3,000,000 —
— 8 —	1,000,000 to 2,000,000 —

Leucocytes (277 cases).

Of 180 pelvic abscesses . . .	122	showed leucocyte counts in excess of 10,000
— 30 renal — . . .	26	— — —
— 32 superficial abscesses . ,	25	— — —
— 10 empyemata (thorax) . .	10	— — —
— 9 — (gall-bl.) . .	8	— — —
— 8 hepatic	6	— — —
— 8 cerebral	6	— — —

Range of leucocytes in 277 cases of different forms of abscess.

	Pelvic.	Renal.	Supfl.	Thorax.	G. Blad.	Hepatic.	Cerebral.
Average.	15,634	13,924	13,600	17,180	18,891	14,922	11,428
Highest.	48,200	33,800	17,850	31,800	21,200	23,400	18,500
Lowest.	550	6,000	4,800	11,200	9,500	9,300	6,800

CHOLELITHIASIS (summary of 144 cases).

Hemoglobin.

Average. . . . . 73.3 %

Highest . . . . 102.0 —

Lowest . . . . 15.0 —

Range in 1 case . . . . above 100 %

—   13 cases. . . . . 90–100 %

—   32 — . . . . 80–90 —

—   50 — . . . . 70–80 —

—   24 — . . . . 60–70 —

—   11 — . . . . 50–60 —

—   6 — . . . . 40–50 —

—   1 — . . . . 30–40 —

—   5 — . . . . 20–30 —

—   1 — . . . . below 20 %

Erythrocytes.

Average. . . . . 4,360,024 per cb. mm.

Highest. 5,850,000   —

Lowest 1,040,000   —

Range in 17 cases. . . . . . above 5,000,000 per cb. mm.

—   69 — . . . . . . 4,000,000–5,000,000 per cb. mm.

—   41 — 3,000,000–4,000,000   —

—   14 — 2,000,000–3,000,000   —

—   3 — 1,000,000–2,000,000   —

Leucocytes.

Average.	9,470 per cb. mm.
Highest	26,000 —
Lowest	2,600 —

Range in 6 cases.	20,000–30,000 per cb. mm.
— 12 —	15,000–20,000 —
— 22 —	10,000–15,000 —
— 90 —	5,000–10,000 —
— 14 —	below 5,000 —

Eosinophilia.

The normal percentage of the eosinophilic cells is by no means well settled. Various authors estimate from 3 % (Tuffier), 4 % (Zappert), up to 6 or 8 % (Wolff) as the normal, and any amount over these percentages as pathological. Hence, at present, it is difficult to fix any absolutely definite percentage beyond which a pathological condition may be considered as present. In some very marked cases, the percentage may rise to 40 % and even to 72 %. I have myself had no opportunity of testing the eosinophilia in cases of intestinal parasites in which it is always marked. Most of these cases, of course, are medical, but some cases of trichinosis may easily come under the care of the surgeon, especially where the diagnosis is doubtful and the possible diseases from which the patient may be suffering so many. Brown (29) states that « the diagnosis of trichinosis can now be made even in the most sporadic and atypical of cases by the remarkable increase in the eosinophile cells in this disease ». Of course when so made, it can be confirmed by an examination of the muscles at a later period of the disease.

This marked eosinophilia in trichinosis and its diagnostic value has been confirmed by a number of writers, references to whose papers can be found in the article already referred to and also in the various text-books on hematology.

It is important, however, to note that while this eosinophilia in trichinosis is very true in *recent* infections by the trichina, in *old* infections eosinophilia may be absent, i. e. there is established a tolerance of the individual or an acquired immunity toward the chemotactic poisons influencing eosinophilia.

Again, as has been pointed out, particularly by Sabrazes in 1899, and Mimmi in 1901, and Tuffier (2 p. 67), eosinophilia is a presumptive though not an absolutely certain evidence of hydatid disease. Its presence should always cause us to investigate by clinical symptoms the possibility of hydatid disease, of intestinal parasites, and of sarcoma, which sometimes is attended with a marked eosinophilia. Among other surgical diseases of importance attended by eosinophilia may be named also syphilis, chylous effusions, osteo-malacia, and multiple periostitis.

Appendicitis.

It is most unfortunate that appendicitis should have been the earliest and that even now it is the principal battle-field as to the value of the examination of the blood and especially of leucocytosis. In the early stages of appendicitis, the very stage when prompt diagnosis and in the very large majority of cases prompt operation is necessary, the information given by the blood-count must of necessity be much less valuable than at a later period, when we can have the larger information derived from a series of examinations. As already stated a single leucocyte count stands in the same relation to a series of daily counts that a single observation of the temperature does to a similar temperature chart.

Not only in appendicitis, but in other diseases in addition to our present charts showing the temperature, pulse and respiration, there should be a similar chart recording the daily or, if possible, multiple daily observations of the blood count. For my own part, excepting occasionally, the record of the respiration gives me but little positive help saving in a few disorders. Its chief value is the assurance that there is no pulmonary complication. In the majority of surgical cases it is a negligible observation. A morning and evening leucocyte count in the majority of surgical disorders, especially the acute ones, in my opinion would be far more desirable and more instructive. In fact it may be laid down, I think, as a rule that *until we record the daily fluctuation of the leucocytosis taken at least once a day and still better, two or three times a day, just as now we record the temperature, the pulse, and the respiration, we shall not be in a position to determine the real value of leucocytosis.* Tuffier relies more on the degree of leucocytosis than on the temperature, and Wassermann goes so far as to place more reliance on the leucocytosis than upon both the pulse and the temperature.

2.

What are the questions in appendicitis which we may ask the leuco-cyte count to enable us to solve?

1. In diagnosis, is the patient suffering from appendicitis, or some other disease which it is difficult to distinguish from it? Among these are various diseases of the female generative organs, such as a suppurating ovarian cyst, ovarian abscess, pyosalpinx, ectopic pregnancy, certain diseases of the kidney, such as perinephric abscess or pyonephrosis, empyema of the gall-bladder, thrombosis of the mesenteric vessels and malignant disease of the cecum. In all of these, as pointed out by Da Costa (28, p. 370), there is, as a rule, a leucocytosis, and iodophilia also is present, excepting perhaps in ectopic pregnancy. Leucocytosis, therefore, does not aid as much as we should hope in the differential diagnosis of these diseases from appendicitis, especially at the onset when we most need aid. A marked leucocytosis would exclude simple colic with or without constipation (Cabot). If, however, there is hepatic or renal colic which has any inflammatory and especially any suppurative complication, then the leucocytosis would not distinguish between the two. In various abdominal neuralgias, there would be no leucocytosis, nor in a movable kidney with a possible kink in the ureter. As Da Costa (28, p. 371) well says, « the simple fact of the presence or absence of a leucocytosis is more often misleading than useful in the diagnosis of appendicitis ».

We must remember, however, that it is only a little over five years since Richardson first urged the usefulness of the leucocyte count as a surgical guide in appendicitis. That there should have been many hundreds, and even thousands of cases so faithfully studied in this short time is greatly to the credit of the many surgeons and hematologists who have taken part in this matter; but we must remember also that but few cases have been followed in the systematic way which I advocate and that the data to be derived from the examination of the blood are as yet very imperfect. Five years after the introduction of the thermometer, it hardly lent us as much assistance as does the examination of the blood to-day.

2. Does the leucocyte count give us valuable information as to the character and the progress of the disease ; that is to say, is the disease simply catarrhal; has an abscess formed; is there gangrene, perforation, or general peritonitis? In these conditions the leucocyte count is of much greater value. While there is not always a marked leucocytosis in a case of appendicitis with a localized abscess and while in gangrene, perforation, or general peritonis, the system may be overwhelmed in a few cases by the intense sepsis, yet, as a rule, the catarrhal form of

appendicitis shows only a moderate leucocyte count, so that, as Da Costa again has well stated, as a rule « the *average* count in purulent and gangrenous appendicitis is higher than the *maximum* count in the catarrhal form of the affection ». (Cf. Table.)

The annexed table of the leucocyte count in 275 cases of purulent and non-purulent appendicitis is most instructive. In 86 non-purulent cases, the highest count was 17,100; 81 (94 %) were below, and 5 (6 %) above 15,00, and 49 (57 %) below 10,000; while in 189 purulent cases the highest count was 58,500, 77 (40.7 %) were below and 112 (59.3 %) above 15,000, and only 24 (12.7 %) were below 10,000, or in tabular form.

		86 non-purulent cases.	%	189 purulent cases	%
Highest count		17,100	—	58,500	—
Above . . .	15,000	5 cases.	6	112 cases.	59.3
Below . . .		81 »	94	77 »	40.7
Below . . .	10,000 .	49 »	57	24 »	12.7

While, therefore, a high or a low leucocytosis in any individual case of appendicitis may not be a positive indication that it is a purulent or a non-purulent case, yet the probabilities will point strongly in the one or the other direction and may aid us greatly in interpreting the other clinical signs. Unless the leucocyte count is above 20,000, the probability of its having reached a purulent stage is very slight, and, conversely, if it is above 20,000, there is a strong probability of its being a purulent case. Here even a single count will be of value, though a series will be of far more value. Between 10,000 and 20,000, the higher figures will incline us to believe it to be purulent, the lower towards the belief that it is non-purulent. The diagnosis in theses cases must depend largely on the clinical signs in correlation with the blood count. (I use the terms purulent and non-purulent here in the sense employed in the table.)

3. Will the leucocyte count indicate the time for operation, i. e. whether it should be promptly done or postponed to a later period? Here we can obtain some help, though by no means as much as we could wish. As long ago as 1899, Richardson (23) made what is even now a fair statement of the value of a blood count : « In doubtful cases an unnecessary operation may be avoided by a blood-count made at this time. A leucocytosis often adds the necessary evidence upon which to decide in favor of operation. » A high leucocyte count with severe

clinical symptoms would be an indication for immediate operation, provided the other symptoms also indicate operation or at least are not contra-indications, since the body resistance is good and there is, presumably, no tendency to the encapsulation of any existing abscess. Says Federmann (30) « all our cases of peritonitis with low leucocytosis or none, and severe clinical symptoms who were operated upon died; all those with a high leucocytosis even with severe clinical symptoms recovered; hence we believe that the leucocyte count before the operation is of the greatest prognostic value ».

Moreover, there is a general consensus of opinion that if a case has run on for a week or more and shows a leucocytosis of 20,000 or still more of 25,000 or over, this is good evidence of a more or less well-recognized and delimited abscess. If, however, there is a high and especially increasing leucocytosis with severe clinical symptoms, it indicates a rapidly increasing suppuration and demands immediate operation. No case, however, should be allowed to run on so long without operation unless the symptoms are distinctly improving.

In the last (3rd edition, 1904) edition of his work on « Appendicitis », Deaver takes a very much more encouraging view of the value of leucocytosis than he did in his paper before the American Surgical Association, four years ago, in which its very title (*) indicated grave doubt as to the practical value of the blood count. Beyond estimating the resisting power of the patient, as a fair indication of the probable extent of the lesion, leucocytosis he thinks is worthless as a reliable indication for operation with one valuable exception. « When a spreading peritonitis is diagnosticated from the clinical evidence, the leucocyte count is of great value as an indication of the patient's resistance. Operation upon a patient with a swollen tympanitic abdomen, fever, increased pulse, etc. and a *low leucocyte count*, is but to court disaster. » With this I fully agree, and I know no means by which the resistance of the patient to infection can be so well gauged as by the degree of leucocytosis.

4. As a case of appendicitis continues with or without operation, can we judge whether it is progressing favorably or unfavorably? Of course, the pulse, the temperature, and the local signs are of great value in estimating the progress of the case favorably or unfavorably, but we can obtain also important aid from a leucocyte chart. If the leucocytosis

(*) « The examination of the blood in relation to surgery of scientific but often of no practical value, and may misguide the surgeon. »

falls, together with an increase in severity of the general symptoms, the prognosis should be very unfavorable. If the leucocyte count, having fallen after operation, begins to rise, it is almost a certain indication of retention of pus and sometimes an indication for another operation. Especially if operation is postponed (which he recognizes now is sometimes wise), Deaver advises frequent blood counts. If the fever and the leucocytosis both increase it is an evidence of a spreading infection; if the leucocytosis reaches 25,000 and remains there after subsidence of the temperature, an abscess may be diagnosticated. If the leucocyte count subsides, the patient may be regarded as recovering, provided the general symptoms and abdominal condition also point in the same way. But if the leucocyte count falls and the general condition becomes worse, then there is probably a spreading peritonitis without resistance on the part of the patient.

Along with the leucocytosis, the iodophilia is of similar value, since the two usually go hand in hand. « The intensity of staining is usually in direct relation with the degree of toxemia (Warren). »

APPENDICITIS (summary of 275 cases).

Leucocyte count in non-purulent (*) and in purulent (†) forms of appendicitis.

Range in 0 non-purulent and in 1 purulent cases, above 50,000 per cb. mm.

—	0	—	0	—	40,000–50,000	—
—	0	—	2	—	35,000–40,000	—
—	0	—	3	—	30,000–35,000	—
—	0	—	6	—	25,000–30,000	—
—	0	—	29	—	20,000–25,000	—
—	5	—	71	—	15,000–20,000	—
—	32	—	53	—	10,000–15,000	—
—	43	—	23	—	5,000–10,000	—
—	6	—	1	—	below 5,000	—
	86		189			

Average. . . 9,360 for 86 non-purulent and 16,618 for 189 purulent cases.
Highest . . . 17,100 — 86   —   58,500 — 189   —
Lowest . . . 1,600 — 86   —   4,200 — 189   —

(*) Including catarrhal and interstitial forms; obliterative appendicitis; fecal and other concretions, etc.
(†) Including cases with abscess, gangrene, perforation, peritonitis, sepsis, etc.

Typhoid Fever.

Although this is a medical rather than a surgical disease, yet it is frequently important to be able to diagnosticate between appendicitis and typhoid, The surgical complications and sequels of typhoid also are assuming more and more importance in surgery, as their frequency and gravity are understood. A leucocytosis above 12,000, as pointed out by Kast and Gütig (31), almost certainly rules out typhoid, whereas 7,000 and below, and especially 5,000 and below makes the probability of typhoid very great.

The leukopenia of typhoid is very striking and enables us with considerable certainty to diagnosticate typhoid not only from appendicitis, but from other abdominal suppurative diseases, such as ovarian cyst, pyosalpinx, etc. Thus Grawitz (2, p. 51), in a case in which a diagnosis of typhoid fever was made in consequence of the general condition and hypertrophy of the spleen, a leucocytosis of 30,000 with 80 % of poly-nuclear cells, led to a puncture of the spleen in which a large abscess was found.

During the first week of typhoid, however, there is apt to be a slight and fluctuating leucocytosis, which may obscure the diagnosis. But at that time we have the additional advantage that in 93 % of the cases in the first week, as shown by Coleman and Buxton (32) the bacilli of typhoid can be demonstrated in the blood.

Most of the surgical complications of typhoid fever also produce a well-recognized leucocytosis, as is well shown by Cabot (7, pp. 203-204). If perforation takes place, and, for want of adhesions, is followed by general peritonitis, there will almost always be a rise in the leucocyte count, though it may not be prompt enough to act as a reliable guide to operation. If the resistance of the patient is good, there will be pro-bably a considerable increase in the number of leucocytes followed pretty rapidly by a diminution in their number as the sepsis increases. We must, of course, correlate this with all the other symptoms, and while we cannot say positively from the leucocytosis alone that there has been a perforation, yet such a sudden rise or a sudden rise followed by a fall is very significant. In one respect the leucocyte count may be of great aid; namely, it may *disprove* a supposed typhoid perforation by showing that from the moment of the supposed perforation there has been no rise and later fall of the leucocytosis. To determine this fact, Tuffier advises that there shall be even hourly examinations in cases of suspected typhoid perforation.

He (2, pp. 58-59) gives an excellent illustration of the value of the leucocyte count in a case in which in the third week of typhoid there was spontaneous pain over the whole abdomen, distention and tenderness of the belly, rapid pulse and a sudden fall of the temperature below 37° C. This would certainly produce a grave suspicion of perforation; but two examinations the same morning showed a leucocytosis of 3,800 and 4,100, with only 49 % of polynuclears, and the patient recovered without operation, confirming the diagnosis of false perforation.

Of course in all cases suggesting perforation, in which there is a leucocytosis, great care must be used to see that it is not due to any other inflammatory complication. When the patient's resistance is so poor that there is no leucocytosis in spite of the existence of a perforation and peritonitis, the presence of a marked iodophilia may materially aid in the diagnosis.

So far as the prognosis of operation in cases of perforation is concerned, those with a high leucocyte count are much more favorable, of course, than those with a very low one, as this is indicative of intense sepsis. Sometimes the perforation causes an increase in the percentage of polynuclear cells without any increase in the total number of leucocytes.

Intestinal obstruction.

In intestinal obstruction, as a rule the leucocytosis is of greater value in prognosis than in diagnosis. Bloodgood (33) has observed that within twelve hours the leucocyte count may rise as high as 20,000, especially if the obstruction is complete. If the same high count or even a higher exists on the 3rd or 4th day, the outlook is favorable for the patient in view of the high leucocyte count being an evidence of good vital resistance.

In strangulated hernia, after reduction has been accomplished, if the leucocyte count falls, we may be fairly sure that there has been no reduction en masse. This, of course, presupposes that the other symptoms are favorable. If markedly unfavorable, there may have been reduction en masse with a low reactive power on the part of the patient which would produce a low leucocyte count. The correlation of the symptoms is of the utmost importance. When gangrene has set in, the leucocyte count will be low, especially if the patient's power of reaction is slight.

Carcinoma.

« Surprisingly little work has been done on the blood in malignant disease » says Cabot, « such cases usually being under the charge of surgeons who rarely value such investigations ». This charge was justified undoubtedly in the past, but I believe that surgeons are more and more coming to value such investigations. Indeed the discussion of the subject at the present Congress and at the recent French Surgical Congress show that surgeons are no longer liable to such an imputation. That the near future will clarify our ideas as to the light thrown upon the malignant disease by hematology and impress its importance upon us I firmly believe.

Especially do I hope that this may be the case in the chemical and microscopical examination of the blood. Too little has been done in determining whether in carcinoma there is an increased amount of sugar in the blood so as to enable us to distinguish it from sarcoma, in which there is no such increase in the amount of sugar. Loeper and Louste have found sarcoma cells in the blood but few other observers have confirmed this finding. From the microscopical structure of sarcoma, the blood vessels being bounded with no limiting membrane but only by the sarcoma cells themselves, it would be probable, a priori, that such cells should be found in the blood in sarcoma rather than in carcinoma. As our means of investigating the blood microscopically have been improved much that formerly was impossible has become every day knowledge. It is, therefore, of the utmost importance that the investigation of the value of cyto-diagnosis should be more zealously prosecuted in order to determine its real value.

I have myself recently had eight cases of sarcoma carefully investigated, but in no one of them were the cells of sarcoma found in the blood. Here again, possibly, the ultra microscope may soon be of more or less value in the diagnosis.

While the percentage of hemoglobin and the number of erythrocytes cannot be used in any individual case for a diagnosis between carcinoma and sarcoma, so far as these tables go, they show that the average percentage of hemoglobin in carcinoma is 65.9 %, while in sarcoma it is almost 14 % higher, 79.6 %; the erythrocytes in sarcoma outnumber by more than 570,000 per cb. mm. the number in carcinoma, though both of them are much below the normal.

In cancer there is frequently a leucocytosis, but this is so irregular that it is of little value from the diagnostic point of view. At the same

time, as will be seen by the annexed table of 155 cases in which the seat of the tumor is noted, a leucocyte count of over 10,000 is by far most frequent in cancer of the liver where this figure was exceeded in 80 % of the cases, followed closely by cancer of the intestine with 71.4 %. Cancer of the uterus showed 52 %, while in cancer of the breast, stomach, and rectum, the percentage varied from 25 to 33.3 %. The number of cases of cancer of the pancreas — 4 — is too small to be a reliable test.

Usually also the eosinophiles persist in carcinoma. Tuffier has found as many as 9.3 % in two cases of cancer of the uterus. Vaquez and Laubry have investigated the correspondence between leucocytosis and generalization of the cancerous infection, as Hayem (34) in 1889 did its value as a means of determining recurrence. After operation upon any cancer, there is no question that there is, as a rule, a diminished leucocytosis, as was shown by Hayem. Preceding recurrence, there is, he asserts an increase in the leucocyte count which should serve as a warning. Vaquez and Laubry assert that (in the absence of ulceration, which, of course, would produce a leucocytosis) if the leucocyte count rises above 12,000, there is probably a generalization or else marked extension of the growth. Unfortunately, however, again, the number of exceptions to this rule is large, so that though such a leucocytosis may put us on our guard, its presence or absence is not a positive sign for or against such a result.

One of the means of differential diagnosis between ulcer and cancer of the stomach, from which much has been hoped is the presence or absence of a digestion leucocytosis. The distinction between malignant disease of the stomach and simple ulcer, especially in the early stages is so vitally important and at the same time often so difficult of determination that every possible help is welcomed by every surgeon.

It has been asserted that in ulcer, in which the disease is local and limited, there is a distinct leucocytosis attending digestion, whereas, in carcinoma of the stomach, which gradually invades more and more of the mucous membrane, there is no such digestion leucocytosis. Da Costa, in the last edition of his book (p. 477) has tabulated 144 cases of carcinoma of the stomach from nine different authors, which show that there was no digestion leucocytosis in 119 cases, but that it was present in 25; in other words the digestion leucocytosis was absent in 82.6 %. Futcher (35) states that « practically all observers agree that there is a digestion leucocytosis in gastric ulcer », and that « most authorities agree that the occurrence of the digestion leucocytosis is a point of considerable diagnostic value » in differentiating gastric ulcer

and gastric carcinoma. Cabot (p. 436), on the contrary, concludes that « on the whole, we get, I think, very little information of any diagnostic value from blood counts in gastric cancer », and says (agreeing with Osler and Mc Crae), that « the presence or absence of digestion leucocytosis is too uncertain to be of much assistance in diagnosis ». My own personal conviction is that a larger and more extended experience will probably show that in the large majority of the cases we shall be aided more or less by the leucocytosis, and that it will prove in the long run to be of no little value in the differential diagnosis between these conditions.

CARCINOMA.

Hemoglobin (181 cases).

Average	65.9 %
Highest	94.0 —
Lowest	12.0 —

Range in	10	cases	90–100 %
—	35	—	80– 90 —
—	39	—	70– 80 —
—	32	—	60– 70 —
—	23	—	50– 60 —
—	18	—	40– 50 —
—	11	—	30– 40 —
—	4	—	20– 30 —
—	2	—	10– 20 —

Erythrocytes (174 cases).

Average	3,307,477 per cb. mm.
Highest	5,900,000 —
Lowest.	1,100,000 —

Range in	16	cases	above 5,000,000 per cb. mm.
—	75	—	4,000,000 – 5,000,000 —
—	48	—	3,000,000 – 4,000,000 —
—	25	—	2,000,000 – 3,000,000 —
—	10	—	1,000,000 – 2,000,000 —

Leucocytes (174 cases).

Average . . . . . 11,695 per cb. mm.
Highest . . . . . 40,800 —
Lowest . . . . . 1,000 —

Range of the leucocytes in different forms of cancer (155 cases)
(i. e. above 10,000 per cub. mm.).

Seat of tumor.		Av.	Max.	Min.	Nº with leucocytosis.	
Stomach . . . 75 cases	7,785	23,400	1,000	19 cases	25.3 %
Uterus . . . 25 —	11,150	24,000	3,200	13 —	52.0 —
Rectum . . . 16 —	8,921	16,000	6,000	4 —	25.0 —
Breast . . . 18 —	10,163	31,500	5,200	6 —	33.3 —
Liver . . . 10 —	17,549	40,800	8,000	8 —	80.0 —
Intestine . . . 7 —	11,185	16,300	7,000	5 —	71.4 —
Pancreas . . . 4 —	10,850	18,200	6,600	2 —	50.0 —

SARCOMA.

Hemoglobin (19 cases).

Average . . . . 79.6 %
Highest . . . . 102 —
Lowest . . . . 30 —

Range in 1 case . . . . above 100 %
— 4 — . . . . 90–100 %
— 8 — . . . . 80–90 —
— 2 — . . . . 70–80 —
— 2 — . . . . 50–60 —
— 1 — . . . . 40–50 —
— 1 — . . . . 30–40 —

Erythrocytes (16 cases).

Average . . . . 3,879,500 per cb. mm.
Highest . . . . 4,870,000 —
Lowest . . . . 1,470,000 —

Range in 10 cases . . . 4,000,000–5,000,000 per cb. mm.
— 3 — . . . . . 3,000,000–4,000,000 —
— 1 — . . . . 2,000,000–3,000,000 —
— 2 — . . . . 1.000,000–2,000,000 —

Leucocytes (19 cases).

Average . . . . 12,470 per cb. mm.
Highest . . . . 20,400 —
Lowest. . . . . 6,000 —

GASTRIC ULCER (summary of 48 cases).

Hemoglobin.

Average . . . . 56.8 %
Highest . . . . 90.0 —
Lowest . . . . 20.0 —

Range in 1 case . . . . 90–100 %
   —   8 — . . . . 80–90 —
   —   11 — . . . . 70–80 —
   —   9 — . . . . 60–70 —
   —   2 — . . . . 50–60 —
   —   7 — . . . . 40–50 —
   —   5 — . . . . 30-40 —
   —   5 — . . . . 20–30 —

Erythrocytes.

Average. . . . . 3,841,852 per cb. mm.
Highest . . . . 5,250,000 —
Lowest . . . . 1,090,000 —

Range in 3 cases . . . . . . above 5,000,000 per cb. mm.
   —   23 — . . . . . . 4,000,000–5,000,000 per cb. mm.
   —   12 — . . . . . . 3,000,000–4,000,000 —
   —   8 — . . . . . . 2,000,000-3,000,000 —
   —   2 — . . . . . . 1,000,000–2,000,000 —

Leucocytes.

Average. . . . . 8,570 per cb. mm.
Highest . . . . 29,400 —
Lowest . . . . 2,400 —

Range in 2 cases. . . . . . . above 20,000 per cb. mm.
   —   3 — . . . . . . 15,000-20,000 —
   —   8 — . . . . . . 10,000-15,000 —
   —   28 — . . . . . . 5,000-10,000 —
   —   7 — . . . . . . below 5,000 —

Illustrating the leucocyte count after perforation in one case.

Before perforation . . . . . = 10,200 per cb. mm.		
Immediately after perforation . . . = 21,600 —		
1st day after perforation . . . . = 16,600 —		
2nd day — . . . . = 29,800 —	(Gen. peritonitis.)	
3rd day — . . . . = 18,800 —		
5th day — . . . . = 25,400 —		
6th day — . . . . = 28,400 —		
10 thday — . . . . = 29,200 —	(Death.)	

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