

THE COAGULABILITY OF THE BLOOD IN YELLOW FEVER.

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DUE to the high degree of perfection attained in modern pathological technique, made possible by the improved microscope, by numerous specially devised accurate instruments, and by many newly created chemical stains, medical men of the last two decades have been able to establish the correctness or erroneousness of many etiological and pathological theories accepted in the past. The great majority of these antiquated theories, which were based, for the most part, on macroscopic examination alone, have been found to be grievously wanting, and these have been replaced by scientific facts. However, some of these theories, prominent among which is that of the totally lost or greatly deficient coagulability of the blood in yellow fever, still remain with us, not because they are believed, but because the finishing touches have not as yet been put to the facts that are to cause their final relegation to the domain of the historian.

The majority of the early writers believed that in yellow fever, and especially in the latter stage, the histological elements of the blood were completely destroyed, that, in the greater number of cases, the blood was always carbonized, and that its fluidity was greatly increased. From these conjectures they concluded that the power of coagulation was either completely lost or most tardily established. The following extracts have been selected from the vast amount of literature on this subject, spread out over a period extending from 1793 almost to the present day.

Dr. Rush, a Philadelphia physician, reports eleven different appearances presented by the blood of yellow fever patients in that city during the epidemics of 1793 to 1794. Three of these appearances, being pertinent to this paper, are given herewith: (1) "In the greater number of cases it (the blood) was without any separation into crassamentum (clot) and serum. (2) In some cases there was separation into crassamentum and yellow serum. (3) There was in every case in which the blood was not dissolved, or in which the second appearance, that has been mentioned, did not take place, a beautiful scarlet colored sediment in the bottom of the bowl, forming lines or a large circle. It seemed to be a tendency of the blood to dissolution."

Nassy speaks of "the fluidity of the blood."

Dr. Cathrall, in his treatise on the above epidemic (1794), remarks that "the blood, drawn in the early stage, very seldom separates into serum and crassamentum; when it does, the former is nearly of a natural color, though small in quantity in proportion to the latter."

Dr. Caldwell found in the epidemic in Philadelphia in 1805 that "the blood which flowed in hemorrhage was never capable of firm coagulation, thereby evidencing that its vitality was nearly extinguished."

La Roche¹ accounts for the hemorrhagic tendency in yellow fever thus: "The frequency of hemorrhage in yellow fever, the tendency to effusion, especially during the later stage of the disease, from the several outlets of the body, and through textures, and into parts which, in the natural state and in diseases generally, do not afford passage to blood, must depend upon a general cause, and that cause no one acquainted with yellow fever will fail to detect in the particular alteration of the blood."

Joseph Jones,² in his work on yellow fever, published in 1894, makes this statement: "In the marked diminution of fibrin we have an important explanation of the cause of the hemorrhagic tendency in yellow fever."

La Roche, in summarizing, adds: "Similar observations, as the above (those of Drs. Rush, Cathrall, Caldwell, and others), as to the fluidity and defective coagulation and dark color of the blood were made during the fever of 1820 in Philadelphia. But, on this occasion, it was discovered that, although the blood presented these appearances, and, when examined after death, was found in a fluid state, its power of coagulation was often rather tardily established than lost."

Pariset remarks on an epidemic at Barcelona in 1821: "The blood found in the cavities of the heart is black and fluid. If clots exist they are small and diffuent. The blood is apparently deprived of fibrin and no longer red. No longer separating itself into a solid part and yellowish serum. And always remaining black, carbonized, and fluid. The blood is certainly more fluid and black."

Desportes, in commenting upon the yellow fever in San Domingo, states: "The blood obtained by venesection is always very red, florid, and frothy, containing but little serum. If we bleed after the cessation of the fever the blood remains a long time in a liquid state, sometimes three or four hours after the operation, and there is no serum."

Hillary states that "in the last stages the blood is so attenuated and dissolved as to flow from different parts."

Dr. Stevens, a West Indian observer, adds to the above: "The blood found after death has the character of a dissolved fluid, nearly as thin as water, almost as black as ink, and evidently so diseased as to be totally incapable of either stimulating the heart or supporting life."

¹ Yellow Fever considered in its Historical, Pathological, Etiological, and Therapeutical Relations, vol. i. Philadelphia, 1855.

² Original Investigations on the Natural History (Symptoms and Pathology) of Yellow Fever, 1854-1894. Chicago, 1894.

Bienparthy, in 1844, gave new life to the dissolution theory by stating that under the microscope "the corpuscles disintegrated, broke down, and dissolved in the fluid plasma."

In order successfully and conclusively to refute the above statements, as to the fluidity, destruction, carbonization, and total loss of the power of coagulation of the blood, it will only be necessary to give place hereunder to the findings of contemporaneous and of later writers.

Dr. Kelly, another West Indian observer, tells us: "I have seen the blood coagulate as perfectly in yellow fever as in ordinary intermittent fever."

Henson made the following experiments in 1820: "I collected portions of blood in cups, in the course of ten to fifteen minutes it was firmly coagulated, and this was found in subsequent observations invariably to occur."

Lawson, in Jamaica, as early as 1802, examined the blood of yellow fever patients, and concluded: "This theory of disorganization has no foundation. The blood is not dissolved; on the contrary, the corpuscles appear entire and well-shaped."

Prof. Joseph Leidy, one of the most eminent scientists of the nineteenth century, stated in 1854: "I have not been able to discover the slightest evidence of the destructive process suffered by the morphological elements of the blood in this disease, as described by Bienparthy."

Sternberg¹ observed in 1879, in Cuba, that "both the red and white corpuscles retained their normal appearance, and I have frequently seen the leukocytes undergoing their characteristic movements, even after twenty-four hours, in blood which had been preserved in culture cells."

Dr. J. Crevaux, a French naval surgeon, studied the blood microscopically in French Guiana in 1877. He states clearly and definitely that he could find "no unusual alteration in the blood corpuscles."

Dr. Carlos Finlay, of Havana, in writing on this subject, in 1882, stated that "not only is the integrity of the blood corpuscles maintained in yellow fever, but their number is apparently increased during the course of the malady." Dr. Finlay believed at this early date that the hemorrhagic tendency was due to a lesion of the vascular endothelium, which he considered the characteristic lesion of yellow fever.

Dr. H. D. Schmidt,² pathologist of the Charity Hospital, New Orleans, and one of the authorities of his day on the pathology of yellow fever, concludes from his extensive experience that "it must be admitted that the condition in which its (the blood's)

¹ Yellow Fever, in Reference Handbook of the Medical Sciences, 1894, vol. viii.

² The Pathology and Treatment of Yellow Fever, Chicago, 1881.

morphological elements were found actually offers nothing remarkable or otherwise which in any way could be interpreted as peculiar or characteristic of yellow fever."

To confirm the findings of Lawson, Sternberg, Crevaux, Leidy, Finlay, and Schmidt, I might record here that in over twenty thousand examinations of fresh and stain preparations of blood of yellow fever patients made by the various workers at the Emergency Hospital in New Orleans during the epidemic of 1905 not one specimen showed the slightest evidence whatsoever of corpuscular degeneration.

The view of Finlay on the causation of the hemorrhagic tendency in yellow fever is almost proved, while the views of La Roche and Jones on this same subject are completely overthrown by Sternberg's most sensible remark, that "the hemorrhages are due to the disorganized and diffuent condition of the blood a moment's reflection should show, that this explanation is insufficient, and that the blood, however diffuent, cannot escape so long as the vessels are intact." The above statement of Sternberg is itself transformed into a fact by the knowledge which we possess to-day of the fearful damage inflicted by this disease, especially upon the smaller bloodvessels and capillaries of the various organs throughout the body.

I shall now proceed to the remaining question, of "the tardy coagulability of the blood."

La Roche after perusal of all the available literature concluded: "The inability or reluctance to coagulation, though generally exhibited, is not universal, and cases occur in which the blood coagulates with as much readiness and firmness as in other diseases."

From the works of Dr. Jones, we gather: "The following are the chief characteristics of the blood in the stage of depression in yellow fever: Specific gravity of blood and serum not specially altered. Blood coagulates slowly and imperfectly. Clot voluminous and soft. Fibrin quantity deficient and not more than one-tenth the normal amount. Reaction of blood alkaline," etc.

In order to refute the above, I shall first state briefly our macroscopic findings, and then record the results attained by actual experiments with an accurate instrument.

1. I have repeatedly seen blood drawn from the median vein of a yellow fever patient coagulate before it could be forced out of the aspirator into a receptacle held ready to receive it—the blood not remaining in the aspirator more than from three to five minutes.

2. Blood drawn from the median vein of a yellow fever patient and placed in a large test-tube alongside of another similar tube containing normal blood, drawn in the same manner, did not differ in the slightest degree from the latter, and one not knowing which was which could not so state.

3. In performing certain filtration experiments, it was found impossible to filter unaltered blood, and to overcome this readiness

to coagulate, it was necessary to add a solution of potassium oxalate to prevent rapid coagulation.

In making the actual experiments, Wright's coagulometer was used. Space will not be consumed here in describing the technique employed, as this can be found in almost any standard text-book on clinical diagnosis. However, a record must be made herewith that the heating chamber of this instrument was discarded, since the temperature prevailing in the city at the season of the year during which these tests were made was fairly constant and not sufficiently below the standard as to affect materially the results. Eight of the most typical cases of yellow fever were selected for these tests, with the following results:

In speaking of symptoms existing prior to tests, I shall only record those which are considered characteristic of the disease, and make no mention of pain, temperature, etc.

CASE I.—M. P., white, male, aged thirty-five years; nativity, France; occupation, barkeeper. One year in New Orleans. Symptoms prior to test: Injected sclera, general jaundice, spongy and bleeding gums, profuse epistaxis. Vomited at intervals large quantities of unaltered blood. Maximum amount of albumin, 13 per cent. (Purdy's method.) Bile-stained casts.

Test No. 1 on twelfth day of illness: Coagulation was negative in three minutes and thirty seconds; positive in four minutes.

Test No. 2 on fourteenth day of illness: Coagulation was negative in three minutes and thirty seconds; positive in four minutes.

CASE II.—F. W., white, male, aged forty-three years; nativity, Texas; occupation, blacksmith. Symptoms prior to test: Jaundiced sclera, gums spongy, afterward bleeding; maximum amount of albumin, 6.5 per cent.; bile-stained casts later in disease.

Test No. 1 on second day of illness: Coagulation was negative in two minutes and forty-five seconds; positive in three minutes (four tubes).

Test No. 2 on sixth day of illness: Coagulation was negative in three minutes and thirty seconds; positive in four minutes (six tubes).

CASE III.—J. S., white, male, aged twenty-three years; native of New Orleans. Symptoms prior to test: General jaundice, spongy and bleeding gums. Maximum amount of albumin—trace.

Test No. 1 on fifth day of illness: Coagulation was negative in three minutes and ten seconds; positive in four minutes (six tubes).

CASE IV.—E. J. M., white, male, aged twenty years; native of New Orleans. Occupation, boilermaker. Symptoms prior to test: Injected sclera, general jaundice, profuse epistaxis, bleeding gums, black vomit. Maximum amount of albumin, 14 per cent.; bile-stained casts.

Test No. 1 on seventh day of illness, one-half hour after black

vomit. Coagulation was negative in three minutes and ten seconds; positive in four minutes and ten seconds.

Test No. 2 on ninth day of illness: Coagulation was negative in three minutes and eleven seconds; positive in four minutes.

CASE V.—J. B., white, male, aged twenty-six years; native of New Orleans. Symptoms prior to test: General jaundice, bleeding gums, black vomit (once), slight renal suppression. Maximum amount of albumin, 5 per cent.; large number of casts, *not* bile-stained.

Test No. 1 on sixth day of illness: Coagulation was negative in three minutes and thirty seconds; positive in four minutes and twenty seconds.

CASE VI.—A. L. B., white, male, aged twenty-eight years; native of Louisiana; occupation, clerk. Symptoms prior to test: Bleeding gums, slight jaundice, injected sclera. Maximum amount of albumin, 7 per cent.; bile-stained casts.

Test No. 1 on third day of illness: Coagulation was negative in three minutes; positive in three minutes and forty-five seconds.

CASE VII.—F. A., white, male, aged twenty-one years; nativity, France; occupation, tramp. Walked into New Orleans twelve days before beginning of attack. Symptoms prior to test: Spongy gums, eyes injected. Maximum amount of albumin, 2.5 per cent. Vomited several times; unaltered blood. Large number of bile-stained casts.

Test No. 1 on eleventh day of illness: Coagulation was negative in three minutes and ten seconds; positive in four minutes.

Test No. 2 on twelfth day of illness: Coagulation was negative in three minutes and ten seconds; positive in three minutes and forty seconds.

CASE VIII.—C. L., white, male, aged thirty years; nativity, Germany. Symptoms prior to test: Marked jaundice, gums spongy and bleeding, vomited once on eighth day small amount of black vomit. Maximum amount of albumin, 4.5 per cent.; bile-stained casts.

Test No. 1 on eleventh day of illness: Coagulation was negative in three minutes; positive in three minutes and thirty seconds (five tubes).

A brief summary of the foregoing shows: Minimum time of positive coagulation, two minutes and forty-five seconds; maximum, four minutes and twenty seconds; average, three minutes and fifty-two seconds.

From these findings I can state almost without hesitancy that the coagulability of the blood in yellow fever is normal.

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