Researches on suppuration. Sect. 1. On the frequent presence and on the effects of pus in the blood, in diseases attended by inflammation and suppuration / by George Gulliver.

XXV. *Researches on Suppuration.* *By* GEORGE GULLIVER, *Esq., Assistant Surgeon to the Royal Regiment of Horse Guards.*

SECT. I.—*On the frequent presence and on the effects of Pus in the Blood, in diseases attended by Inflammation and Suppuration.**

IN the prosecution of an inquiry in which I have been long engaged concerning Inflammation and Suppuration, I soon perceived the necessity of instituting a careful examination of the blood in these affections, and particularly in the different forms of inflammatory fever and hectic.

The result has been the detection of pus in the blood in almost every instance in which there was either extensive suppuration, or great inflammatory swelling without a visible deposition of pus in any of the textures of the body: and the contamination of the blood by pus appears to me to be the proximate cause of the sympathetic inflammatory, sympathetic typhoid, and hectic fevers. Since the writings of Dr. Lee, Mr. Lawrence, Mr. Arnott, of MM. Velpeau, Dance, and others, the profession has become familiar with cases in which pus has been found in the veins, particularly after surgical operations and in uterine phlebitis; but although the humoral pathology has of late years begun to assume some of its ancient importance, I am not aware that any writer has attempted to demonstrate the dependence of the fevers under consideration on the presence of pus in the blood.

Previous to a brief notice of some of the experiments and observations from which the results have been drawn, it may be proper to mention the means by which I have detected pus in the blood. The examination was very simple,—partly chemical, and partly by the aid of the microscope. Those who are acquainted with the minute constitution of the animal fluids are aware of the rapid and energetic action of water on the blood-corpuscles: now the globules of pus undergo no change after having been long kept in water; accordingly, if the suspected blood be mixed with this fluid, the blood corpuscles will soon become invisible, and any globules of pus that may be present will subside to the bottom of the vessel, and may be easily seen, and their characters determined, with a good microscope. Ammonia instantly renders the blood-corpuscle invisible, while that of pus is acted on but slowly by the alkali; and the different action of acetic acid on pus

* Read before the Royal Society, June 14, 1838; and now communicated by the Author.

and blood is equally remarkable. Hence I have employed these agents advantageously in conjunction with the other means; and I have also seen pus-globules in the blood, though rarely, without any preparation. With water, however, the examination is most easy, simple, and satisfactory, if the observer be thoroughly familiar with the microscopic characters of the fluids under examination. A good instrument, nevertheless, is necessary; and the admirable deep object glass of Mr. Ross is the one I have principally employed. It is hardly necessary to add, that chyle-globules are not likely to be mistaken for those of pus, since, independently of other distinctions, the medium diameter of the latter is at least $\frac{1}{2000}$ths of an inch, which is above twice that of the former.

Exp. 1. A weak solution of corrosive sublimate was injected into the subcutaneous cellular tissue of a dog's thigh; great swelling of the limb took place, and he died forty-five hours after the injury. A good deal of serum mixed with fibrine was found in the cellular tissue of the thigh, but there was no purulent deposit.

Several pus-globules were detected in some blood obtained from the right ventricle of this dog's heart.

Exp. 2. A large dog had both his tibiæ injured by some operations connected with necrosis; great swelling of the limbs, with violent fever, succeeded, and he died forty-three hours subsequently.

A large quantity of fibrine was found effused into the cellular tissue of the extremities, mixed, in one of them, with a very scanty proportion of purulent matter.

In some blood, obtained from the vena cava, numerous globules of pus were observed.

Exp. 3. An irritating fluid was injected into the peritoneum of a dog; he had great thirst, refused food, and died the third day after the operation.

A large quantity of coagulated lymph and sanguinolent serum with some pus was found in the belly.

In some blood obtained from the inferior cava vein many globules of pus were seen.

Exp. 4. Two ounces of pus were injected into the left pleura of a dog, and very carefully confined there; he was thirsty and feverish for fifty-five hours after the operation, when he was killed.

An ounce of fluid, almost entirely serum, was found in the pleura, and some fibrinous exudation on the membrane.

Blood from the heart, as well as from the vena cava was examined, and found to contain several pus globules.

Exp. 5. Four ounces and five drams of pus were injected into the peritoneum of a dog, and the wound carefully closed; he died thirty-seven hours after the injury.

There were only nine drams of a sero-sanguinolent fluid found in the peritoneum, and a considerable quantity of coagulated lymph on the membrane.

Pus was detected in the blood.

Exp. 6. Half a dram of pus, mixed with half an ounce of water, was gradually injected into the crural vein of a dog.

Some fever followed, and he refused solid food for two days, but recovered at the end of a week.

The same quantity of pus was soon afterwards injected into the other crural vein, when similar symptoms were produced, and he perfectly recovered in a few days.

Exp. 7. Six drams of pus having been injected into the crural vein of another dog, he was not much affected at first, but in a few hours became very weak, was stupid, thirsty, and refused his food. After thirty hours he took but little notice of surrounding objects, his respiration was hurried, and he died thirty-six hours after the operation. In the blood of the inferior cava some pus globules were readily detected.

Case 1. A girl died of confluent small pox on the ninth day of the disease. There was great swelling of the integuments.

In the blood of the right ventricle numerous pus-globules were found.

Case 2. A woman had confluent small pox, uncomplicated with erysipelas or inflammation of the viscera.

On the eighth day of the disease some blood was drawn from a vein in the arm: several pus-globules were found in this blood.

Case 3. A male child, æt. 15 months, died on the ninth day of small-pox. Only a few pustules appeared, and these were imperfectly developed: there was considerable swelling in the face, slighter in other parts.

At the post-mortem examination, it was observed that a small quantity of a white opake fluid might be squeezed from the cut surfaces of the lymphatic glands of the neck and groin: this fluid had the microscopic and chemical characters of pus.

In some blood obtained from the right ventricle and from the inferior cava vein, pus was detected.

Case 4. In a woman who died of puerperal peritonitis, the peritoneum contained a large quantity of coagulated lymph, serum, and purulent matter.

Pus was detected in the blood obtained from the right ventricle of the heart.

Case 5. James Green, æt. 27. was admitted into hospital with an ulcer of the leg. Seven days afterwards, the limb began to swell, and there was hardness in the femoral vein, with some redness in the course of the absorbents on the inner side of the thigh. The swelling of the limb increased gradually; he had first pain in the head, thirst, and quick pulse; then purging, pain in one wrist, with restlessness, incoherency of speech, and offensive breath; finally, low muttering delirium, accelerated respiration, and coma preceded his death, which took place on the twelfth day after his admission into hospital.

At the post-mortem examination, the large veins of the limb were found to be occluded throughout by firm clots of blood, mixed with pus and coagulated lymph, and the lining membrane of the femoral vein was in many places of a red colour, and coated with fibrine. In the iliac vein no such signs of inflammation appeared, although there was a large coagulum of blood, which had lost its red colour, containing in its centre a small quantity of matter resembling pus. Several purulent deposits presented in the sheath of the femoral vessels, and in the intermuscular cellular substance.

The matter resembling pus in the clot of the iliac vein had neither the chemical nor microscopical characters of that fluid.

In some blood obtained for examination from the right ventricle and from the vena cava, numerous globules of pus were found.

Case 6. James Hawke, æt. 22, had a superficial wound of the tibia, followed quickly by considerable pain and swelling. There was a very scanty deposit of pus in the subcutaneous cellular tissue. The swelling of the limb increased and extended rapidly, the integuments becoming discoloured, and the slight suppuration ceasing. His dissolution was preceded by subsultus, collapsed face, accelerated breathing, hiccough, and coma.

The swelling of the limb was found to be produced by effusion of fibrine and sanguinolent serum. A few pus-globules were found in the blood obtained from the vena cava.

Case 7. M. Jackson, æt. 42, had erysipelas of the face, which decreased, and was succeeded by jaundice and effusion

into the pleura. He became listless and low, with accelerated respiration, and died six days after the appearance of the erysipelas.

An ounce of turbid serum, with a little purulent matter, was found in the right pleura, and eight ounces of sanguinolent serum in the left.

Some blood was obtained for examination from the larger veins, and found to be greatly contaminated with pus.

Case 8. Sergeant Dunn, æt. 29, had profuse suppuration between the muscles and beneath the integuments of the thigh; he died, after some weeks' suffering, exhausted by hectic.

The purulent matter was extremely offensive, putrefying with great rapidity, and sometimes coagulating spontaneously, when set aside for a short time. It was poor in true pus-globules, but contained a large quantity of flaky fibrinous matter, to which its opacity was chiefly owing. Many pus-globules were found in the blood obtained from the right ventricle.

Case 9. Wm. MacLean, æt. 19, died of pulmonary consumption. In his lungs were several vomicæ, containing pus and softened tubercular matter.

In the blood obtained from the vena cava and right ventricle, many pus-globules were found.

Case 10. A man had irritative fever, in the Marylebone Infirmary, consequent on a large abscess behind the trochanter femoris.

An ounce of blood was drawn by cupping from the neighbouring sound parts, and some pus was detected in this blood.

Case 11. An officer's charger died with vomicæ and tubercles in the lungs, and sero-purulent fluid in one pleura. Some time before his death his respiration and circulation were much accelerated.

The vomicæ contained pus mixed with gangrenous sanies.

In the blood obtained from the vena cava inferior pus was detected.

The preceding instances by no means comprehend the whole number in which I have found pus in the blood. In the detail I have rather been anxious to give examples of interesting varieties, than to increase the number by needless repetitions.

It is satisfactory to add, that the observations of Dr. Davy tend to confirm the accuracy of those which I have just related. He detected pus in the blood of consumptive patients, after my general results had been submitted to him, but be-

fore I had turned my attention to the state of the blood in phthisis. He has lately informed me that he has found pus in the blood in seventeen instances after death, in sixteen of which there was declared suppuration, and in one none could be detected: in the latter, the patient died of acute inflammatory disease.

Before considering the conclusions to be deduced from the preceding observations, it may be proper to advert briefly to the nature and use of suppuration, although I shall have occasion to bring forward the evidence on matters of opinion in a more systematic form in a future part of these researches.

Since the microscopic observations of Mr. Hunter, Sir Everard Home, and Mr. Bauer, the opinion has often been expressed in this country, that the globules of pus are nothing but those of blood, modified by the inflammatory process. I believe Sir Astley Cooper and the late Dr. Young came long ago to this conclusion. Finally, on the continent, M. Gendrin, without much regard to the observations of English pathologists, adopts precisely the same theory, supported indeed by a series of very ingenious experiments, which have been generally considered conclusive on this subject.

I have repeated the experiments of M. Gendrin with great care, and although I see no reason to dissent from that part of his conclusion already stated as having been long since advanced in this country, I have not been able to observe the phænomena related in his work. It seems not improbable that M. Gendrin was influenced by the erroneous views of M. Milne Edwards as to the globular structure of fibrine; for M. Gendrin states in one place that pus is but a modification of fibrine, although in others he informs us that it is a transformation of the blood-corpuscles that constitutes suppuration. By cauterizing the web of a frog's foot under the microscope, or by elevating on the polished blade of a lancet a film of the edge of a wound previously made in the part, he assures us how easy it is to see the blood-particles gradually transformed into those of pus. I regret to say that I have not been able to succeed in this observation, because I found, after repeated trials, that I could not by any means induce suppuration in batrachian reptiles.

With regard to the conversion of clots of fibrine into pus, some experiments to be adduced in another section of this inquiry, render it extremely probable that the matter often found in the centre of such clots in the heart and great vessels, is nothing more than softened fibrine; and which, although it resembles pus in some particulars, presents neither the chemical nor the microscopical character of that fluid. I have

seen nothing like pus-globules in the softened fibrinous clots of the heart; and the rounded particles which sometimes occur in softened coagula of veins are probably the remains of blood-corpuscles. The conversion of the latter into those of pus is extremely probable, and it is equally probable that this change may take place either in the capillaries or out of them. In the former case, after the stagnation of the blood in these vessels which preceded the suppurative process, as the clot softened and the pus became mature, it would be carried into the circulation, and hence its presence in the blood independently of wounds or abscesses.

In instances of idiopathic or traumatic phlebitis, the manner in which the pus may become mixed with the blood is obvious enough. There is a class of cases to which the latter appellation is commonly applied, which are probably not examples of inflamed veins. They seem rather to be of an opposite nature; for I have seen large veins, which had been divided many days before death, containing purulent fluid, although their inner surfaces presented no marks of inflammation; and the total failure of this process in them would seem to have left open their wounds, so as to favour the entrance of pus into them from the neighbouring parts: and this consideration would involve an important point of practice.

It might be asked if, on a suppurating surface, the pus-globules, considerably larger than those of blood, escape from the capillaries, how comes it that the latter particles do not escape as well? To which it may be answered, that the discharge of the pus-globules is preceded by the coagulation of the blood in these vessels; and that their closure, where there is a breach of continuity, is provided for by the formation of the clot keeping pace with its decomposition during the suppurative process; and the blood corpuscle, reduced in size by being broken down, or by losing its external part, may escape, and still become enlarged out of the vessels from the addition of new matter, till it assumes the character of a true pus-globule: hence its larger and more unequal size and irregular surface than the blood corpuscle.

I think my experiments will render it probable that suppuration is a sort of proximate analysis of the blood. As the effused fibrine produces swelling, or is attracted to the contiguous tissue for the reparation of injury, the blood corpuscles, altered by stagnation, become useless, and are discharged in the shape of pus, as waste from the system. Suppuration, therefore, would appear to be a physiological rather than a pathological phænomenon—pus being an excrementitious discharge—a part of the blood which has become effete and

noxious during the reparative process, whether this process may have been employed in limiting the extent of an abscess or in healing breaches of continuity. If, however, there should be a formation of pus in the capillaries, in consequence of the stagnation and coagulation of their contents, this pus might be mixed in large quantities with the blood in cases where there was no declared suppuration, as in some of the examples brought forward in this paper.

With regard to the correct observation of Müller, that the smaller capillaries have only the diameter of a blood corpuscle, I shall on a future occasion show, from the result of experiments, that these vessels become sufficiently enlarged during inflammation to contain a row of pus-globules.

If it should be remarked that pus is often formed without any obvious addition of fibrine to the neighbouring parts, it should be recollected that this is not a healthy, but a diseased form of suppuration; and the distinction and explanation are not difficult. In the formation of the unhealthy pus in question, the fibrine is broken down, mixed, and excreted with the pus; and hence the flaky, curdy appearance of such matter, its proneness to putrefaction, and the cases cited by some authors as instances of suppuration without inflammation, and the old term, "badly matured matter." Independently of the paucity of true pus-globules in this kind of discharge, with the abundance of flaky particles, its tendency to putrefaction would afford strong proof of its containing fibrine but little changed in its composition; for of all the animal fluids, pus is probably that which resists putrefaction with the greatest pertinacity. The eighth case, that of Dunn, is but one among many that I could cite in illustration of these observations.

It remains to deduce the conclusions from the experiments and observations related in this paper.

The term suppurative fever is not new, and its signification is probably now extended; for it seems to be an appropriate one for the different forms of constitutional disturbance under consideration. If the presence of pus in the blood and the fever in these cases be not related as cause and effect, the coincidence would appear to be no less interesting than remarkable.

What a field of inquiry this view opens to us! Henceforth, whenever a patient is affected with inflammatory fever, or that low typhoid state which is so generally a forerunner of death, as a consequence of traumatic or idiopathic inflammation, the state of the blood will present an interesting subject of investigation. And this is not merely a matter of curiosity; for the question will arise, whether, in the treatment

of such cases, it would not be advantageous to produce suppuration as soon as possible on the surface of the body, so as to establish a drain by which the blood might be deprived of the offending matter. It may be asked also, whether the benefit so often effected by blisters, setons, and issues, in certain internal inflammations,—or by incisions, which cause suppuration, in inflammatory affections of the integuments, be not explicable by this theory? It is well known that in cases of traumatic or idiopathic inflammation, attended with great swelling and febrile excitement, the establishment of suppuration in the part is generally a favourable symptom, the separation of the pus from the blood being a sort of crisis to the symptomatic fever. In small-pox, it is a popular belief that "the striking in," as it is termed, or suppression of the pustules, is a bad symptom; and this is so far true, that the worst cases of this disease are those in which there is great swelling of the integuments without the due formation of pus in the usual situation. In every instance in which I have examined it, I found pus in the blood of patients affected with small-pox.

In the fourth and fifth experiments the pus which was injected into the serous sacs would appear to have been absorbed. A more careful inquiry, however, would be requisite to warrant this conclusion; for in some experiments made by Dr. Davy, the quantity of matter injected seemed to be increased; and I have since made an experiment with the same result.

The absorption of pus being the cause of hectic fever is an old hypothesis, which the detection of pus in the blood in cases of chronic abscess and in pulmonary consumption might be supposed to confirm. It does not seem necessary, however, to assign two causes for one effect. When pus in large quantities is incessantly forming in the capillaries, it is easy to imagine how it may become mixed with the blood.

I have related instances of pus in the blood, independently of suppuration out of the vessels: this fact appears to be of some importance, for it must be inferred that the pus was not absorbed, but formed in the blood.

If it be objected to some of the foregoing views, that pus and extravasated blood are often absorbed without any ill effects, and that no constitutional disturbance may ensue after inflammation and the consequent effusion of fibrine—it may be remarked, first, that pus and blood are probably absorbed in a modified state; and secondly, that a small quantity of pus, like other poisons, gradually added to the circulation may not be productive of bad symptoms. The sixth and seventh experiments may be cited in illustration. It is pro-

bable that the degree and type of the fever induced by the presence of pus in the blood may be found to depend on the extent to which it may be contaminated.

Of the inflammatory, hectic, and low typhoid fever, it seems hardly necessary to observe, that they appear to be all comprehended under the common designation of constitutional irritation in the interesting work of Mr. Travers, which I had not read till my attention was directed to it by Mr. Liston after this paper was written. Under the term typhoid, I have included that grave form of fever in which the vital powers sink rapidly, as I believe, from somewhat sudden and extensive mixture of pus with the blood, as sometimes occurs after operations on veins, or amputations, or even independently of wounds. The patient seldom complains of much pain; he has, among other symptoms, dilated nostril, flushed face, encrusted tongue and teeth, restlessness, small quick pulse, cold clammy sweats, offensive breath, hiccough, subsultus, stupor.

I cannot conclude this paper without expressing a hope that it will lead to a still more careful and extensive examination of the blood in various diseases than has hitherto been attempted. The microscope may become as important an instrument to the pathologist, and even to the medical practitioner, as the stethoscope. If my results should be confirmed, it is hardly too much to expect that some important discovery, particularly in diagnosis, may be made by a patient investigation of the blood in many malignant diseases, such as cancer: it is not long since the urinous fever, as it is called, was found to depend on the accumulation of urea in the blood.

[From the London and Edinburgh Philosophical Magazine and Journal of Science for Sept. 1838.]