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ON THE CAUSES, CONSEQUENCES, AND TREATMENT OF INFLAMMATION OF THE VEINS:

WITH EXPERIMENTS ILLUSTRATING THE EFFECTS OF THE MIXTURE
OF FOREIGN MATTER WITH THE BLOOD.

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PART I.

I. JOHN HUNTER expressed his belief that the blood has "the power of action within itself",¹ and that when it coagulates, it does so in consequence of an "impression" which it receives. Such an impression may be communicated by separation from the living vessels, or from "cessation of natural action"² in them. In certain circumstances also the living vessels themselves may be the means of exciting coagulation.³ In others, the admixture of extraneous substances may either retard or hasten this operation.⁴ The experiments made to determine the last point, Mr. Hunter informs us, "were rather imagined than fully carried out; and the subject rather broached and touched upon, than prosecuted".⁵ In these experiments, different articles used in medicine were mixed with portions of blood taken from the body; and it was found that, in some cases, they altered both "the time," and "the firmness of the coagulation".⁶ The circumstance of medicines being used in such experiments, conveys the idea, that, in instituting these researches, Hunter conceived that substances which would tend to produce such actions out of the body, might likewise produce some effect upon the blood in living animals. In endeavouring to prosecute the idea thus thrown out, I have been led to try the effect of different substances upon the blood, and to consider the changes which may be produced in that fluid, by the admixture of animal secretions. The experiments which will be hereafter detailed, not only confirm Mr. Hunter's notion, that foreign substances may induce actions in the blood

¹ HUNTER on the Blood. Ed. 1794, p. 21.

² P. 25.

³ P. 24.

⁴ P. 97.

⁵ P. 94.

⁶ P. 98.

when withdrawn from the body, but also show that some of these effects may be produced still more rapidly in the living vessels.

In these experiments, pus was used in preference to any other fluid; first, because the power of coagulating the blood which it was found to possess, enables its influence to be traced within the body; and secondly, because, being an animal secretion, the results obtained are likely to be analogous to those produced by the admixture of other secretions with the blood.

When pus is mixed with blood, fresh-drawn from a healthy animal, it is found in a marked manner to favour coagulation. This effect does not take place immediately, as in the case of the mixture of an acid with the blood; and I have reason to believe, that where the blood has lost its natural power of coagulation, no visible change is produced in it by the addition of pus. It appears, therefore, that this effect depends rather upon a vital than a chemical influence. In some cases, the coagulation takes place in less than two minutes; in others, after a longer period; but in all the experiments made, the influence of pus, when added to blood, in promoting its coagulation, was sufficiently evident. Putrid pus was found to act more rapidly than healthy pus (Exp. 1, *b*), but the admixture of water was found to retard the operation; the result, in this respect, differing in some degree from the conclusion drawn from a similar experiment performed by Hunter.¹ The causes which usually favour coagulation out of the body, are rest, and separation of the blood into small quantities. These conditions are, in some degree, brought into play during the circulation of the blood through the capillaries; and when the influence of the admixture of pus with the blood is not sufficient to produce coagulation at once, we should naturally expect the effect to be more readily induced, where these two additional causes concur in favouring such an action. When the pus introduced is in any quantity, the coagulation of the blood is at once determined, and the entrance of pus into the circulation thereby prevented. The experiments VI, VII, and VIII, appear to furnish evidence of the correctness of this opinion, and to show that the result may be produced more quickly in the vessels than elsewhere. In these cases, so sudden was the effect, that the mixture of blood and pus coagulated before it could traverse the jugular vein, as indicated by the induration and cord-like feeling of the vessel.

In Experiment VIII, the obstruction formed was sufficient to resist even firm pressure, and in a great measure, if not altogether, to prevent the pus injected from finding its way along the vein. The coagulum was felt in the vessel during the operation, and was there found after death. One effect of the coagulation of the blood thus immediately produced, is necessarily to retain the vitiated blood in the part, and to prevent its being carried in the course of the circulation. This intention may be interfered with, either by accident or design. The coagulum, as in Experiment VI, may be broken up during the process of its formation, or after it has formed, and the parts of which it was composed carried forward with the circulating blood. In such a case, the vein in which the coagulum first formed, is found in its natural condition (except at the part where it may have been mechanically injured),

¹ Op. cit. p. 98.

and dark patches of congestion may be found in distant systems of capillaries. If the coagulum be allowed to remain, the vein in which it is formed soon becomes thickened; but, as the experiments cited prove, *this thickening is the effect and not the cause of the coagulum of blood lodged in the vessel.*

II. When blood coagulates in a serous cavity, a thin pellicle forms upon its surface, and, becoming thickened by deposition from the fibrin of the blood, forms a cyst, which completely circumscribes the effusion. This point has not probably received the attention which it deserves; and as it is believed to be of primary importance in the investigation of the present subject, a short space will be devoted to the purpose of fully establishing it, and tracing its connexion with other and subsequent changes. Every layer of lymph observed upon dissection, has perhaps too generally been considered as the result of inflammation; and hence there has arisen a confusion in the terms employed. That lymph may be derived from the blood directly, and deposited in the form of a membrane, without being secreted by any vessel, has been fully shown by a paper in the *Medico-Chirurgical Transactions*.¹ Such layers of lymph assume so much the appearance of others, derived by secretion from inflamed capillaries, that they have been described as identical. But the mode of their formation in the two instances is altogether different. In the one case, the process is a local one, confined to the blood itself, and subsequently to the membrane with which it happens to be in contact. In the other case, it is an effort of the constitution, accompanied by constitutional symptoms. The former of these processes was clearly described by Hunter. In describing the process of union by the first intention, "Coagulation", he says, "I imagine to proceed upon exactly the same principle as the union by the first intention. It is particle uniting with particle by the attraction of cohesion, which, in the blood, forms a solid; and it is this coagulum uniting to the surrounding parts which forms the union by the first intention: for union by the first intention is no more than the living parts when separated, whether naturally, or by art, forming a reciprocal attraction of cohesion with the intermediate coagulum, which immediately admits of mutual intercourse, and, as it were, one interest."² "When the blood has coagulated, so as to adhere to both surfaces and to keep them together, it may be said that union has begun."³ "The uniting medium becomes immediately a part of ourselves, and the parts not being offended at it, no irritation is produced." "If the quantity of blood extravasated be large, the whole will not become vascular, but the surface only, which is in contact with the surrounding parts."⁴ The process thus described in general terms may take place in serous cavities. In the third plate at the end of Mr. Hunter's work, is represented a coagulum of blood adhering to the *tunica vaginalis*. "The adhesion was firm, though it admitted of a separation at one end; when separated, fibres were seen running between it and the testis."

It might seem unnecessary to dwell upon this process further, had not some of the highest authorities in surgery, both here and on the continent, described it as identical with adhesive inflammation. Thus

¹ Vol. x, p. 45-82.

² Op. cit. p. 26.

³ P. 200.

⁴ P. 205.

Bichat¹ says, "The cicatrization of wounds in veins after bleeding is a result of inflammation." Now, it is submitted, that when the blood coagulates, either in serous cavities or in veins, the process of union is not usually one of inflammation, or one in which the powers of the constitution are called into increased activity. It is true, that in both cases, inflammation may take place, and lymph, as the result of such inflammation, may be secreted; but this is only when, to use Mr. Hunter's language, the "primary intention" has not been fulfilled.²

When a membranous layer of lymph is deposited from effused blood, it adheres with some firmness to the surface with which it is in contact; but, as there is at first no vascular connexion established between them, it may be separated, leaving the part to which it adhered in its natural condition. Lymph derived from adhesive inflammation, on the other hand, when separated, leaves the surface upon which it was formed rough and uneven. Coagulated fibrin, when recently deposited, may thus be distinguished from effused lymph. The changes which blood undergoes when effused in serous cavities, may likewise take place when it is detained in injured or exposed veins. The coagulation of the blood in such cases (Experiments VII and VIII) serves as a bond of union between the sides of the veins (which may be either temporary or permanent), so as to prevent the entrance of any foreign matter into the circulation. When the blood thus coagulates in veins, changes may be produced analogous to those mentioned as occurring in serous cavities. If the quantity of blood be large, a thin pellicle is at first formed upon its surface (see Preparations 1523-25 and 1525-64, in the Museum of Guy's Hospital). This membrane becomes thickened and adheres to the internal surface of the vein (see plate No. 13, Cooper and Travers' *Surgical Essays*, Part I, and Prep. No. 1736, in the Pathological Museum of the College of Surgeons). It then becomes vascular, and finally so firmly united to a part of the circumference of the vessel as to be inseparable from it, without lacerating its lining membrane.

If the wounded vessel be small, or if the animal be strong and robust, the whole of the blood in the vein may at once coagulate and become united to its sides. The usual economy of nature, however, is here exercised, with a precision proportionate to the strength of the patient. A simple wound in a vein, in healing by the first intention, will not obstruct the circulation through the vessel under ordinary circumstances. A coagulum will form, sufficient to unite together the divided edges, and the circulation of blood through the vessel will be uninterrupted; but if the wound does not readily heal, coagula may form, which encroach more or less upon the cavity of the vein. There are then three ways in which a coagulum may obstruct the circulation through a vein. 1. By the outer layer of the coagulum forming a membrane, which contains the more fluid parts of the blood. 2. By the whole of the blood contained in the vessel forming a solid coagulum. 3. By a coagulum adhering to the injured side only of the vessel.

In whichever of these ways the process of repair is commenced, it

¹ Anatomie Générale, vol. ii, p. 423.

² In speaking of the two principles, I shall use the term by "first intention", to designate that the fibrin is derived from coagulated blood; and restrict the term "adhesive inflammation" to indicate the effusion of lymph from inflamed vessels.

may be interfered with, and the union dissolved. This is practically known to farriers; who, when they want to bleed a second time from the same orifice, break down the "union by the first intention" by a blow upon the vein. During the time that the parts are united only by the fibrin from the blood, any violence must tend to produce the same effect. If the constitution is good, and the coagulating power of the blood unimpaired, the union may be frequently interrupted, and yet be as frequently re-established in the same way. When from any local cause, or from any constitutional peculiarity, the union by the first intention fails at the seat of the injury, it may yet be attempted at some distance up the vein; and then we have coagula formed at different distances along the vessel. If these coagula fill the vein, are firm, and remain undisturbed by violence, the union may be complete, and the vessel sealed at those parts, even although the original wound should suppurate. But it sometimes happens, that the same peculiarity of constitution, or the same local cause, which prevented the union at the original wound, may prevent complete union by the first intention at any other point of the vein; and then its canal is open to any secretion that may be introduced into it. Foreign matter may thus find its way along a vein; but still there is a provision against its being carried the round of the circulation. It has been already shown that the blood, when in a natural condition, has a tendency to coagulate around pus, and, probably, many other fluids, even out of the body (Experiments I, V), and that this property is exercised in a still more remarkable manner in the living vessels (see Experiments VII, VIII). Foreign matter, even after it has got into the veins, may then, by the same means, be prevented from proceeding farther towards the centre of circulation. The process that takes place under such circumstances, is strictly analogous to union by the first intention. The blood may coagulate and adhere to the sides of any part of the vascular system. The union thus formed may be permanent, or the coagulum may be again broken up and carried with the blood in the course of the circulation, as shown in Experiment VI. When this occurs, as is shown in the same experiment, other changes supervene in remote parts of the body. This tendency to coagulate around the foreign matter once impressed upon the blood, cannot be destroyed by the coagulum being mechanically broken up, as indeed is proved by the fact already mentioned, that after one attempt at union in a vein (in consequence of the introduction of foreign matter) has failed, another attempt is made immediately farther up the vessel. Under these last circumstances, we may find a vein partially obliterated at different points, leaving intervals where lymph or pus are secreted. If the purulent matter introduced is allowed to remain a short time only in the vein, no inflammation is produced (Experiment VI). But when any irritating fluid is detained there in consequence of the blood coagulating around it, adhesive ulcerative, or suppurative inflammation, will be excited (Experiments VII and VIII).

The slowness with which veins inflame when cut, tied, or bruised, has been made a subject of comment by different authors; and Mr. Travers, in particular, has endeavoured to reconcile "the infrequency of its occurrence" with the rapid and violent character of the inflammation in certain cases. Although, under ordinary circumstances, a wounded vein

does not inflame, yet the annexed experiments show, that pus introduced into its cavity will produce inflammation, in which the system will sympathize. Other fluids besides pus will no doubt produce similar effects; but those of pus are here particularly noticed, as affording a good illustration of the series of changes produced by the introduction of foreign matter into the blood.

What the symptoms are which characterize the presence of pus, as distinguished from other secretions in the blood, it would probably be difficult to determine in cases as they occur in practice. The examination of the blood in these instances affords no very satisfactory information; for the characters of pus, when the blood has once coagulated round it, are so altered, that I know of no means by which a small quantity can be recognized, when it has once entered the circulation. The conclusions drawn from the different facts now stated are,—first, that inflammation of a vein, or phlebitis, is no essential part of the primary affection which precedes constitutional symptoms, even when morbid matter has found its way into the circulation through a vein. Secondly, that when inflammation of a vein does occur, in some instances at least, it is not the cause, but the consequence of the introduction of diseased or foreign matter into the blood. Thirdly, that although veins are with difficulty inflamed by any mechanical injury, they are susceptible of rapid inflammation, accompanied with constitutional disorder, whenever any irritating fluids are introduced into their cavities.

III. When the principal veins in a part become obstructed, it is natural to suppose that changes should be produced in the smaller veins which supply them. These changes may be expected in a more marked degree, when the obstruction depends upon coagulation of the blood, than when it arises from other causes, inasmuch as the coagulum usually extends to several veins at the same time.

In the experiments that have been made upon animals, it has been a matter of surprise that, while extreme pain was evinced upon the injection of irritating fluids into the veins, comparatively little or no suffering was produced, when similar experiments were performed upon the arteries. The foreign matter introduced in these cases would probably have the effect of coagulating the blood, as in the instances already mentioned. If this occurred in an artery, the supply of blood below the obstruction would be diminished; but if in a vein, the return of blood would be prevented: in the latter case, the continued influx of blood to the part would necessarily distend the capillaries.

In M. Cruveilhier's¹ experiment, of injecting ink into the veins of dogs, he found, that in thirty-six hours the legs swelled, and a number of bloody patches (*foyers apoplectiques*) were found in the substance of the muscles and the cellular tissues of the limb. The large veins were distended with adherent coagula of blood, and the smaller veins around the livid patches were also filled with coagulated blood. If the animal were allowed to live, the congested spots suppurated. The appearances thus produced in the muscles and cellular tissue of the limb were evidently not those of inflammatory action propagated along the coats of the veins, for the affection in the capillaries was circumscribed, and ter-

¹ CRUVEILHIER'S Path. Liv. xi.

minated in many places abruptly, leaving the veins in the immediate neighbourhood perfectly healthy; still less could the appearance produced depend upon the injected fluid finding its way through the veins (contrary to the course of the circulation) to the capillary system; nor, lastly, could it depend upon the ink finding its way into the general circulation, and producing its effects in its course a second time through the limb; for, not to mention that the capillaries of the lungs and other parts would be equally liable to be affected, one essential condition of the success of the experiment is mentioned to have been, that the fluid injected should *not* find its way along the vein in the usual course of the blood. We therefore conclude, that it was the coagulation of the blood in the large veins which caused the congestion of the capillaries, those veins remaining unaffected which could discharge their contents by some collateral channel. In cases of phlegmasia dolens after child-birth, the same principle can in some instances be clearly traced; thus, in a dissection performed by Mr. Lawrence¹ it is mentioned, that the external and common iliac veins were filled with a substance like the laminated coagulum of an aneurism. "The tube was completely obstructed by this matter, adhering as firmly as the coagulum does in any part of an old aneurismal sac. In its centre was a cavity containing about a teaspoonful of thick fluid of the consistence of pus, of a light brownish red tint, and pultaceous appearance." The femoral vein was in this case also filled with a coagulum; but, as is observed in the account of the dissection, the red colour of that vein might have been caused by the clot everywhere in contact with it, and therefore cannot be deemed a proof of inflammation.

Mr. Guthrie² has published a case of inflammation of the veins after amputation, resembling phlegmasia dolens, in which the veins of the opposite limb, even down to the foot, had become affected. In this case, on the fourteenth and fifteenth days after amputation of the right thigh, the left leg began to swell, and became intolerably painful. "The swelling was elastic, yielding to the pressure of the finger, but not in any manner like an œdematous limb. *Upon a careful examination, no pain was felt in the course of the iliac vessels upon that side*; the stump looked well, save at one small point, corresponding to the termination of the femoral vein." On examination after death, the termination of the vein on the surface of the stump *was open*, and in a sloughy condition. At the left groin, the iliac vein was greatly distended with pus. Sir Henry Hallford³ has also mentioned three cases of what he has termed phlegmasia dolens, occurring in the male, in one of which the iliac vein was found obliterated after death. In this case, the patient had suffered, for several years before his death, from swelling of the left leg and thigh. In the interior of the obliterated vessel there is a coagulum, which has lost its colour, and become firm and completely adherent to the inner surface of the vein. (See Prep. No. 1732, Path. Mus. Coll. of Surgeons.) The rapid swelling and general pain of the limb in such cases, indicate a sudden obstruction to the circulation, while the absence of tenderness in the course of the vessels during the first stages

¹ Medico-Chirurgical Transactions, vol. xii.

² Medical and Physical Journal, vol. lvi.

³ London Medical Gazette.

of the disease, tends to show that the contents of the vessels, and not the vessels themselves, are primarily interested in its production.

The foregoing remarks have appeared necessary, in order to explain a circumstance mentioned by Hunter, upon which considerable stress has been laid by subsequent writers. Mr. Hunter observed that the whole side of the head in horses that had been bled would frequently become swollen and inflamed. The explanation of this fact appears very simple, when viewed in relation to the general principle illustrated by the above cases. The horse has only one jugular vein upon each side; and, although in the usual operation of bleeding, its channel is not obstructed, yet if the wound do not readily heal, its contents will coagulate. The circulation will then be obstructed in all the distant branches, and the blood, if long retained, will coagulate in them also. It will then part with its serum, and give rise to all the symptoms of inflammation in the distant vessels; a pulpy elastic swelling, accompanied with great pain, will then be the principal symptom, while the turgescence on the surface will be less than where the superficial veins have been mechanically compressed. It will, however, very frequently happen, that a vein in a part may be felt distended without any symptom of inflammation being present; and, in other cases, the pain and swelling will appear and disappear too rapidly to allow the idea that they depend upon inflammation of the coats of the vein. It has occurred to the author, to feel a vein in the arm and hand distended during life, and after death, to find it empty, and its coats of their natural colour and thickness; in such a case, the coagulum gives way, becomes broken up, and mixed with the circulating blood.

IV. When pus, or other diseased fluid, is confined to the cavity of a vein, the constitutional symptoms produced are comparatively mild, as long as it remains limited and circumscribed by adherent coagula; that is to say, so as to be excluded from the rest of the circulating system. (Compare the frequency of the respiration in Experiments VI and VII.) But the tendency of a clot of blood is to contract; and a time comes when the coagulum is either broken up, or shrinks, so that if no further changes are produced, the current of blood through the vein is re-established.¹ Meanwhile, however, the coats of the veins have undergone changes corresponding to the degree of irritation produced by the contained fluids, and the intention or result to which the inflammation tends. If the coagula have long remained, the coats of the veins are always found thickened, sometimes to three or four times their natural thickness, and sometimes so as to completely obliterate the vessels. The contents of the veins are occasionally found to consist, as far as can be seen, simply of coagulated blood; at other times, they are found filled with soft yellowish coagula, deprived, more or less perfectly, of their colouring matter; more rarely, the cavity of a vein will be found filled with dark-coloured membranous layers, leaving still a channel through the vessel; and occasionally it will be found completely obstructed by "dense, dark-coloured, bluish membranes."

¹ This remark I have had opportunities of verifying in cases, where needles have been introduced under varicose veins in the lower extremities, and allowed to remain, with a ligature around them, for ten days or a fortnight. The circulation through the vein will in such cases be obstructed; but, in a year or two, will be found to have become completely re-established.

As the coagulum contracts in a vein, if the intention is to obliterate the vessel, its sides are gradually approximated. In the smaller veins, and in the divided extremities of large veins, the sides are soon completely drawn together. But the latter, if not wounded, may for a long time (see Prep. 1732, Path. Mus., Coll. of Surg.) retain coagulated blood in their contracted, but not completely closed, cavities. In both cases, the coagula which close the veins are liable to be displaced by accident, or to have their adhesions loosened by the changes which they undergo. The position of a vein, and the structure of the organ through which it passes, may be unfavourable to its healthy reparation. The process of repair goes on frequently during a continued flow of blood over the part, and sometimes during the constant action of the muscles in the neighbourhood: at other times, an injured vein will be situated immediately in the bend of a joint, and will be subject to be continually bent and extended with the motions of the limb. In the structure of the bones, the veins lie in unyielding channels, and are consequently deprived of the assistance derived from the approximation of their sides, as in soft parts, during the process of reparation. As the coagula contract in such a case, there is danger lest the union by the first intention should be disturbed, and that the cavities of the injured veins should be left exposed. Again, in the uncontracted uterus after child-birth, the veins which open upon the placental surface, pass through the firm texture of the organ, and are incapable of contraction independently of the muscular structure which surrounds them. The coagula which close their extremities secure them against the entrance of any foreign matter; but should these coagula be removed before the vessels are otherwise protected, their open mouths are exposed to any secretions that the uterus may happen to contain. In these cases, if a coagulum is not firmly formed, or if it is displaced by violence, it may be broken up, and portions of it mixed with the fluid blood. Subsequent coagula may form in the veins and offer fresh obstructions to the admission of any foreign matter, but these may, as in the first instance, be disturbed, and carried, together with any admixture of the secretions of the part, in the course of the circulation. The period at which the union of a coagulum in a vein is dissolved, is sometimes marked with great precision. In a case recorded by Dr. Davis,¹ a patient was convalescent from an attack of phlegmasia dolens, when death took place instantaneously, while the patient was in the act of changing the sitting for the recumbent posture; the left external iliac vein was thickened, and its internal tunic was studded in several places with deposits of adherent lymph. The portion most remarkable for this incrustation, as well as for other disease, was immediately beneath Poupart's ligament; the vein, although contracted, was *manifestly pervious*.

V. It has been shown in the previous sections, that secretions mixed with the blood will alter its properties, and influence the period of its coagulation: that when the blood is thus altered, it may pass through a vessel without leaving any trace of its passage; but that if it coagulates and remains in a vein, the coats of the vessel will then take on increased action. The exciting cause of the inflammation in such cases appears to be conveyed by means of the contents of the vessels to the

¹ Medico-Chirurgical Transactions, vol. xii.

vessels themselves. But, as in post-mortem examinations, the changes produced in the vessels are much more easily recognized than the alterations in their contents, the former have of late years almost exclusively occupied the attention of pathologists. The cases in which constitutional symptoms follow inflammation of the veins, will be found to divide themselves principally into three large classes. 1. Those in which one of the larger veins has been opened. 2. Those in which some portion of bone has been involved in the original lesion. 3. Those that occur after child-birth.

In each of these three classes of cases, a free communication will be found to exist between the injured part and the general circulation. The natural mode of sealing this communication, when it is no longer proper, is the coagulation of the blood in the veins of the injured part. When, from some constitutional affection, or from some local peculiarity of structure, this intention is not fulfilled, a ready passage remains open, through which the blood may become infected. In injecting fluids into the veins, it has frequently happened, that no great constitutional disturbance, and no signs of secondary inflammation, have been produced; but this is believed to have depended upon the coagula in the veins having prevented (as probably occurred in Experiments VII and VIII) the foreign matter from finding its way along the vessels. But if this obstruction be not offered, or be overcome, then the appearance of secondary inflammation, accompanied by corresponding constitutional symptoms, will be produced. If water be injected into the cancellous structure of bone, it will find its way out in drops through the apertures of the nutritious vessels. The ready communication which is thus shown to exist between the interior of bones and the veins, has been but too often exemplified by M. Cruveilhier's experiments of introducing mercury into their cancellous structure, and finding it subsequently in the vascular system. This fact assumes peculiar significance, when taken in conjunction with the very large proportion of cases, in which some portions of bone will be found to have been involved in the primary lesion, in those who have died of secondary inflammations. Of fifty-two consecutive cases, occurring in surgical hospital practice, of which I have preserved notes, in no less than forty-one was some portion of the osseous system implicated. Again, in the third class of cases, if the vena cava be injected after parturition, the injection will very speedily find its way into the uterus.¹ The ready communication which is thus shown to exist between the vascular system and the local affection, in each of the three large classes of cases which usually give rise to subsequent disease, would of itself afford at least a very remarkable coincidence. But more direct evidence presents itself of the way in which the system becomes contaminated in these affections: thus, after an operation for hæmorrhoidal tumours, an effusion of lymph and pus has been found in the hæmorrhoidal veins,² from thence the same appear-

¹ DANCE. *Archives Générales de Méd.* vol. xviii, p. 480, Dec. 1828.

² In cases where pus has been found in veins surrounded by coagula, its presence and detention there have been differently accounted for. M. Cruveilhier appears to have imagined that the loose coagula act as filters, through which the blood passes, while the pus is retained. (*Dict. de Méd. et de Chir.* t. xii, p. 641.) The true explanation of the way in which coagula form round pus in the veins has already been given.

ances have been traced to the inferior mesenteric vein, and the severity of the secondary affection, indicated both by the symptoms and the post-mortem appearances, has fallen upon the liver. These circumstances all tend to point to the venous system as the means by which morbid matter in such instances is introduced: and the still more conclusive facts afforded in the production of secondary disease, by injecting fluids into the veins,¹ allow scarcely a doubt to remain upon the mind, that the unprotected veins are the channels, in a very large proportion of cases, through which the blood becomes infected.

VI. The cancellous structure of bone may be compared to the cellular tissue in soft parts. When inflamed, its intervals become filled up by effusion from the vessels, and an abscess may be as accurately circumscribed in the hard as in the soft structures of the body. In a healthy constitution, the adhesive inflammation will always precede the suppurative; but where the inflammation is not circumscribed by adhesion, the secretions may permeate from cell to cell in unadhering parts. In soft structures, a remedy is at hand for allowing the escape of the secreted fluid, by a free division of the parts; but in bone, where the same thing takes place, the hard unyielding sides offer an effectual obstruction to the escape of any effused fluid. The cells of the bone then become infiltrated, and the same want of power which is manifested in the deficient adhesion in the bone, will probably be indicated by want of union in the veins. There is nothing, then, to prevent any secretion permeating the cancellous structure from finding its way into the circulation.

M. Cruveilhier assures us, that a single drop of mercury introduced into the cancellous structure of living bone, may subsequently be detected in the capillaries of the lung, where it becomes the centre of one or more patches of livid congestion. This experiment appears to afford a perfect illustration of the way in which diseased secretion may be conveyed into the circulation, when the natural processes of repair in bone are abortive. These processes, as we have seen, are,—first, union by the first intention; secondly, adhesive inflammation. In soft parts, as the fibrin, which forms the bond of union in the first of these, is absorbed, the divided veins collapse, and thus continue closed; but in bony structures, where the injured vessels are held open, as the fibrin which at first closed their extremities becomes removed, their channels may be left as much open to the diseased secretions of the part, as to the globule of mercury in M. Cruveilhier's experiment.

The low degree of organization in bone, and the comparative slowness with which actions are there carried on, render it, in a peculiar degree, liable to interruptions in the process of repair; especially when, as not unfrequently happens, there is reason to believe that the vitality of some portion of the bone has been threatened. The offensive smell of the bone, as well as the appearance of its cancellous structure infiltrated with puriform matter, will frequently show in such cases, that the processes above-named have not followed their natural course.

VII. As a necessary deduction from the accompanying experiments, and those of M. Cruveilhier, alluded to in the previous section, we

¹ See M. Gaspard's experiments.

arrive at the conclusion, that a vitiated condition of the blood may give rise to inflammation of the veins in different parts of the body. The circumstances which occasionally attend reparation of the uterine veins after child-birth, will be found to lead to the same inference; and the same general proposition will derive fresh support from the consideration of this class of cases.

The veins which terminate upon the placental surface of the uterus are necessarily open when this organ is distended, and become more or less perfectly closed when it contracts. In cases when the contraction is incomplete, innumerable open-mouthed orifices are left bathed in secretions, which are often offensive and undergoing decomposition; the natural protection to the vessels then, is the coagulation of the blood in them. If examined, the uterine veins will be found filled with coagula for some distance. But in cases where this power is impaired, all the uterine veins and arteries recently separated from the placenta may be found bathed in the secretions of the part, under circumstances most favourable for their absorption. The passage of diseased secretions through the vessels cannot always be traced in this, any more than in the other forms of the disease. Many of the substances introduced artificially into the circulation by M. Gaspard, produced no action upon the coats of the veins through which they passed, and yet the general symptoms were precisely similar to those originating from genuine phlebitis. In accordance with this, it may be observed that the uterine veins are often found perfectly healthy when the spermatic, or renal, or still more distant veins are thoroughly disorganized. In either case, the healthy condition of the veins near the original lesion forbids the idea of inflammation having been propagated along the coats of the vessels, while all analogy appears in favour of the disease being transmitted through their contents.

In a certain number of cases no lesion will be found in any of the veins of the body, but the uterine veins will be found to contain some unnatural fluid; at other times coagula of blood, which have lost their elasticity, gritty to the feel, and greyish or light brown in appearance, will be found filling the veins or leaving intervals in them, where lymph or pus may be recognized. It matters little whether the unnatural fluids, thus found in the uterine vessels, have been absorbed from the cavity of the uterus, or are the product of venous inflammation. The effect upon the blood in either case would be the same.

When obstructions form in the spermatic veins, they are not indicated by any external symptoms; but when the veins opening into the internal iliac are similarly affected, the coagula are liable to extend into its cavity, and even beyond it to the external and common iliac vessels. The free return of the blood from the inferior extremity, will then be prevented. The effects of this have already been described (sec. III.)

The connection of this form of disease with affections in distant parts of the body, has been noticed by several eminent writers. Legallois has expressed his conviction, that phlegmasia dolens, puerperal fever, and many other puerperal ailments, are solely dependent upon the absorption of pus from the uterine surface. This opinion appears to have been formed upon too hasty a generalization, inasmuch as other fluids besides pus, as evinced by some of the annexed experiments, may pro-

duce similar effects upon the blood. But that pus, when absorbed, will determine the coagulation of the blood in the iliac as well as in other veins, must be allowed; and that the symptoms of obstructed venous circulation arising from this cause, will exactly resemble those of phlegmasia dolens, will scarcely be denied.

"Besides depositions of pus in certain portions of the frame," observes Dr. Ferguson, "I have seen two other states of the limb, which are connected with and traceable to the cause originating puerperal fever. In one of these the malady looks like erysipelas . . . ; in the other, the leg is attacked with a disease so exactly resembling phlegmasia dolens, as to leave no doubt in my mind that they are one and the same malady. In this, as in other forms of the disease, there may be a tendency to gangrene of the skin."

The period of the occurrence of what has been described under the name of uterine phlebitis is marked with much precision, and the affection of the system is often general and sudden. It may be stated as the result of all the observations hitherto made, that it occurs most frequently from the 10th to the 20th day after parturition.¹ If the inflammation in such cases were propagated along the vessel only, it would be difficult to account for such an apparently capricious selection of time for its development. This difficulty, however, disappears when the period is observed to be so strictly in accordance with the time at which the same symptoms occur after other local complaints, and to be, moreover, the time at which the coagula formed in the veins, may naturally be expected to shrink.

It has been observed, that inflammation after child-birth usually attacks the spermatic veins alone, and for the most part the one only on that side of the uterus to which the placenta has been attached. The hypogastric veins are comparatively rarely affected. The appearances observed upon dissection in the spermatic vein, usually terminate abruptly at its opening into the vena cava on the right side, or into the renal on the left. This fact is in perfect accordance with that observed by Mr. Arnott, that the coagulum in veins extends usually only to the nearest collateral branch; the explanation appears to be the same in both cases, as illustrated by Experiment vi. If the coagulating blood be left undisturbed, it will form adhesions to the sides of the vessel and produce increased action in its coats; but if mechanically disturbed, it will be carried forward before the process of coagulation is completed, and leave the vein in its natural condition. When any portion of a vein is obstructed, the blood is kept at rest between the obstruction and the next collateral branch; and, if disposed to coagulate, there is nothing to interfere with such an action. But the case is different, as soon as one vein opens into another. A fresh current of blood is then continually sweeping the orifice of the obstructed vessel; and, even although the blood at this point should have a tendency to coagulate, it is carried on in the course of the circulation, before it can adhere to the sides of the unobstructed vein. The sudden termination of the diseased appearances in these cases, affords an additional proof that the blood is the medium by means of which this affection is transmitted. It is true, in

¹ DR. LEE. *Medico-Chirurgical Transactions.*

such instances the diseased fluid cannot be always, or even generally, traced in the veins, and very many cases occur where a retained and putrid placenta, or decomposing coagula, remain in contact with the mouths of the uterine veins, without any of the symptoms of local phlebitis being produced; but this is only in accordance with what is observed in cases where purulent or other fluids have been directly injected into the blood. The examination of the blood, or of the vessels, in such cases, will by no means invariably indicate the presence of foreign matter after it has once become thoroughly mixed with the blood, nor will inflammation of the vein through which the fluid passes, be by any means invariably produced.

When a foreign substance is introduced into an artery, any immediate effects upon the blood may naturally be looked for in the system of capillaries which it supplies. If the blood then coagulates, local symptoms alone, will, in the first instance, be produced, and the constitution will remain unaffected. M. Magendie,¹ indeed, asserts that fluids injected into the arteries of animals, return quickly through the corresponding veins, and that this takes place even more rapidly in the living than in the dead body. If this were universally true, it would matter little whether foreign matter were introduced into the arterial or venous system. The effect upon the constitution would be the same in either case. But if, as is now maintained, extraneous matter introduced into the blood may, under certain circumstances, produce its coagulation, then the effects will be confined, more or less completely, to the first system of capillaries which the blood meets with in the natural course of its circulation, and the constitution will be affected only in consequence of the changes which then take place. M. Gaspard has shown that greasy fluids, and such as contain sediments, do not find their way readily from the small arteries into the veins. They become entangled in the intermediate capillaries, and there produce, first patches of local congestion, and subsequently serous effusion and abscesses. Some clear fluids, on the other hand, such as solutions of tartar emetic, of opium, and of nux vomica, when introduced into an artery, pass readily in the course of the circulation, and produce their full effect upon the constitution; and in such cases no irritation is manifested in the capillaries through which they pass. The first of these poisons produces vomiting and purging, the second stupor, and the third tetanic rigidity, exactly in the same manner as if they had been introduced into the stomach, or injected into a vein.

There are yet another class of substances differing in their effects from both of the former; and under this head are classed infusion of tobacco, solution of acetate of lead, putrid fluids, etc. These are distinguished from the first class above mentioned, as not offering in themselves any mechanical impediment to the circulation of the blood, and from the second, as not producing the same constitutional symptoms when injected into an artery as when thrown into a vein. M. Gaspard found that, when introduced into an artery, the infusion of tobacco neither produced vomiting nor stupor, the solution of acetate of lead did not act upon the intestines, and the putrid fluids did not produce the evacua-

¹ Précis Élémentaire de Physiologie, t. ii, p. 389.

tions usually observed after their introduction into the system by other means. All these substances, however, were found to produce violent local irritation in the parts to which the branches of the injected artery were distributed, and the constitutional symptoms were those produced in consequence of the local irritation, and not those which would arise directly from the action of those poisons upon the system.

In Experiment xx, seven or eight cubic inches of common air were gradually injected into the carotid artery of a dog, and half an hour afterwards an ounce of water, to which seventy drops of medicinal prussic acid had been added, was thrown into the same vessel ; none of the peculiar effects of the poison followed this operation. At the expiration of another quarter of an hour, an ounce of a saturated solution of nux vomica was likewise injected, still without producing any constitutional symptoms. It is very remarkable in this experiment, that M. Gaspard¹ should have considered that the elasticity of the air contained in the vessels was sufficient to counteract the impetus of the blood, and thus to prevent the progress of the poison along the vessels, especially when we find him stating that, on a post-mortem examination, the smaller vessels appeared to have been *obstructed by very hard clots of blood*.

EXPERIMENTS.

I (a). On the 25th of September, 1848, having procured four small vessels of equal sizes, I placed in the first some dilute sulphuric acid, in the second some offensive pus, and in the third some water. The fourth vessel was left empty. They were then all equally warmed, and some blood from the jugular vein of a healthy horse was received into each of them so as to fill them to the same level. They were now stirred with separate pieces of wood. At the expiration of two minutes (noted by a watch), the contents of the second vessel had become coagulated into one uniform mass. The contents of the first vessel (containing the acid) were thickened and of a dark brown colour ; in the third and fourth cups the blood was of its natural fluidity, but darker coloured in the cup containing water than in the other. At the expiration of ten minutes, the blood contained in the fourth cup had begun to coagulate ; the blood and water still remained fluid. At the expiration of a quarter of an hour, the blood had completely coagulated in the fourth cup, containing blood alone ; and had very partially coagulated in the third cup containing the blood and water.

(b). Four vessels were taken, each capable of holding three fluid ounces. In the first was placed half an ounce of cold water, in the second half an ounce of dilute sulphuric acid, and in the third half a drachm of pus, which was quite fresh and sweet. All the vessels were then quickly filled with blood, from the jugular vein of a horse. The contents of each vessel were stirred. The blood and dilute sulphuric acid became thick, and changed in colour almost immediately, as in the first experiment, but did not coagulate. The pus and blood coagulated in six minutes, and the mass was firm in seven. The pure blood coagulated in twelve minutes and was firm in sixteen. The blood and water

¹ Journal de Physiologie, t. v, p. 328 and 336.

coagulated in about the same time, but took nineteen minutes to become firm.

The above and the following experiments were made at the suggestion of the author, in conjunction with Mr. T. W. Mayer,¹ veterinary surgeon.

II. An abscess was opened in the groin and a quantity of pus received into a gallipot; some blood from the divided vessels was also received into the same vessel; they were then stirred together, and in two minutes the mass coagulated. Some blood taken from the same patient in the same manner, but not mixed with pus, coagulated in eleven and a half minutes.

III. On the 20th of January, 1849, an inflamed and suppurating abscess was opened, and the blood and pus which flowed from it were mixed together. They coagulated in two minutes and twenty seconds. This experiment was repeated several times, with nearly similar results.

IV. In June 1849, a tense inflamed swelling was opened in the perinæum of a patient, who had for years laboured under a very obstinate stricture. A quantity of matter first escaped, and subsequently serum, mixed with shreds of lymph and small quantities of pus and blood, continued to flow for some time. Portions of this mixed fluid were received into separate vessels; they coagulated on an average in about two minutes.

V. Two ounces and six drachms of blood were taken from a healthy horse, and two drachms of pus were mixed with it. The mass coagulated in three minutes and three-quarters.

VI. A healthy male ass, three years old, was procured, and, with the assistance of Mr. Mayer, was made the subject of the following experiment, on the 23rd of September, 1848. Three drachms of pus were collected from an issue in the chest of a horse, which laboured under inflammation of the lungs. The pus thus obtained was quite pure and sweet, and having been warmed, was injected, by means of a syringe, into the left brachial vein of the ass. The animal lay quiet, till nearly the whole of the pus was injected; it then struggled, and a small quantity of the pus may have been lost. When the operation was completed, the sides of the vein were brought together with a pin, and the animal was allowed to get up. The vein above the opening could now be felt as a hard, unyielding cord, as high as it could be traced with the hand; but upon gentle pressure being made, so as to propel the blood in the course of the circulation, the hardness completely disappeared. The vein which, immediately after the operation, was hard and prominent, no longer presented anything remarkable to the touch. The animal now moved from side to side, as if inclined to lie down.

Two hours and a half after the operation, the pulse, which naturally was 36, had risen to 60; and the respiration from 12 per minute had increased to 26.

September 24th. Pulse 52; respiration 20; mouth hot; ears cold. In the evening the pulse became 48 and the respiration 16; he coughed occasionally.

25th. Pulse 48; respiration 12; some dulness of countenance, but

¹ The present mayor of Newcastle-under-Lyme.

he is lively and occasionally playful. The left fore-leg is swollen; the ears are very cold. In the afternoon he was killed, and the blood was allowed to flow from the body.

Post-mortem appearances. The wound in the left leg opened directly into the brachial vein, which was filled with lymph and a thin pus for a very short distance, both above and below the external opening; immediately above this, the vein was healthy, nor was there any appearance of disease in any of the other veins of the limb, nor in the veins leading to the heart. The glands in the axilla were swollen. The lungs were found studded irregularly in different parts, with circumscribed spots of livid congestion: these existed both upon the surface and in the substance of the lungs; they were generally about the size of a filbert; but in some places they occupied a single lobule, and were accurately circumscribed by its outline.

VII. On the 23rd of November, 1848, about an ounce of perfectly pure pus (previously warmed) was injected into the right jugular vein of an aged ass; the vein immediately became "corded", and the blood appeared to have coagulated in the vessel. The operation did not much excite the breathing; but the pulse, which naturally was 35 in the minute, rose to 60, and subsequently fell to 55.

24th. The animal dejected; appetite indifferent. The vein can be traced as a thickened cord as far as the sternum. Respiration 12 (the natural standard); pulse 50.

25th. The parts around the vein much infiltrated with serum: pulse 55; respiration 12.

26th. The wound in the neck began to suppurate, and an abscess subsequently formed in the course of the vein, about midway between the opening and the sternum. The general symptoms continued, with very slight variation, until the 4th of December, when the animal was destroyed.

Post-mortem appearances. The jugular vein was found to have become inflamed only in the course of the circulation, and to be obliterated a short distance below the external opening. The surrounding parts were greatly infiltrated with serum and lymph, and several abscesses had formed in the immediate neighbourhood. The lungs did not present any well-defined patches of congestion, as in the last mentioned experiment.

VIII. A healthy ass, six years old, was operated on upon the 16th of November, 1848. The respiration was naturally 14 in the minute, and the pulse 38. About two ounces of highly offensive pus, obtained from the frontal sinus of a horse, were injected into the left jugular vein; the pus had unintentionally been mixed with water previous to its being injected. The vein became full during the operation, as though the blood in it were in a semi-coagulated state. The pulse now became 60, and the respiration 20 in a minute; slight rigors occurred in two hours.

November 17th. The animal is tranquil; appetite good; pulse 48, small and wiry; respiration 16. In the evening he was rather more excited; the vein was becoming inflamed downwards towards the heart; pulse 60; respiration 20.

November 18th. The vein was more inflamed, and slight suppuration was visible at the orifice of the wound. Respiration 16; pulse 55. From

this period to the 23rd, the pulse continued from 55 to 60, and the respiration varied from 12 to 18.

November 26th. The swelling in the situation of the vein is rapidly subsiding; pulse 55; respiration 12.

The animal gradually recovered, and on the 26th of February, 1849, was made the subject of another experiment. The right jugular vein having been opened, two fluid ounces of pure healthy pus were injected, and propelled in the course of the circulation, by pressure upon the vein externally. The vein became tense during the operation, and sensibly resisted the attempts that were made to propel its contents towards the heart. *Even forcible pressure was not sufficient to overcome the resistance offered to the return of blood.* Soon after the operation, the animal had a rigor; the breathing became laborious, but not accelerated; pulse 57.

After the lapse of seven hours, the animal appeared dejected; he refused to eat or drink; the extremities were cold; breathing 16 in the minute; pulse 60, small and irregular.

February 27th. The vein can be felt thickened as far as the sternum. The general symptoms are the same as on the previous evening.

28th. There appears less constitutional irritation; pulse 60; respiration 14.

March 2nd. Appetite still indifferent; pulse 60; respiration 16.

From this date to the 7th, when the animal was destroyed, the general symptoms continued much the same, but the induration and swelling around the jugular vein, from the opening to the sternum, became greater.

Post-mortem appearances. The left jugular vein was found completely obliterated. The remains of a firm coagulum obstructed its canal for some distance below the opening which had been made into it, and terminated, below, in an elongated conical portion, which adhered to one side only of the vessel. On the right side, an abscess had formed in the course of the vein; and for two inches, the whole of the parts were imbedded in a confused mass of pus and lymph, in which it was impossible to distinguish the structure of the vein. Both above and below this, for several inches, the vein was filled with coagula, which effectually obliterated it. These coagula extended for several inches in the course of the circulation; but beyond them, in both directions, the vessel was pervious. The lungs presented some slight spots of congestion, but not of the same characteristic kind observed in Experiment vi. The other organs were healthy.

IX.¹ Two drachms of pus, somewhat fetid, derived from a large common ulcer, and diluted with a little water, were injected into the jugular vein of a middling-sized dog. The animal immediately made several convulsive efforts to swallow, and soon became faint. It showed indications of pain, and vomited more than six times in the course of the day. At the expiration of an hour, it appeared slightly relieved by an evacuation, and by passing turbid urine. In the evening, it was very ill; it lay upon its side with its legs extended; had a very feeble pulse and scarcely perceptible respiration. Ten hours after the experiment, it

¹ This, and the following experiments, are among those recorded by M. Gaspard, referred to in the foregoing dissertation.

passed black, liquid, and extremely offensive motions; these were accompanied by immediate relief. The animal regained its appetite, eat and drank freely, and went to sleep. The day following, it appeared nearly well. On the third day, three drachms of the same pus were injected into the opposite vein; after the lapse of a certain time, there occurred, as in the first instance, faintness, vomiting, and frequent desire to pass urine; twelve hours after the injection, frequent liquid, white, and very fetid motions were passed, and it died at the expiration of twenty-four hours. On opening the body, no alteration was found either in the intestines or other organs.

X. The last experiment was repeated on a greyhound with the same results: faintness, fever, vomiting, and repeated evacuations succeeded each other, with recovery after the first experiment, but not after the second. On opening the body, no lesion was observed, except that the inferior lobes of the lungs were gorged and almost hepatized.

XI. Three drachms of recent pus, derived from the same patient as in the last experiments, were injected into the jugular vein of a small emaciated unhealthy dog. After the expiration of three minutes, there was an abundant evacuation of urine, followed by repeated vomiting, and repeated ineffectual efforts to pass fæces. For nearly a quarter of an hour, there was a kind of emprosthotonos, rigidity of the limbs, and a death-like condition. Subsequently, fresh vomiting ensued, with very fetid liquid evacuations, which were followed by apparent relief; soon after, however, long continued tenesmus made its appearance, and terminated in death, five hours after the injection of the pus. On opening the body, the mucous membrane of the intestines was found red, swollen, and inflamed, especially in the colon and rectum.

XII. Half an ounce of pus, similar to that used in the preceding instances, but more putrid, in consequence of having been longer kept, was introduced into the veins of a middling sized dog. The animal, as in the other cases, was seized with vomiting, accompanied by violent straining. Subsequently, strongly marked nervous symptoms made their appearance. The eyes wandered; there was extreme sensibility, and involuntary convulsive twitching over the whole body, accompanied by faintness, hiccough, and short piteous cries. The walk was unsteady, staggering, and without apparent object. There was furious delirium, ardent thirst, dyspnoea, palpitation of the heart, etc. This state lasted for nearly two hours, and the animal died in frightful convulsions, without having experienced any critical evacuations, as in the former cases.

Post-mortem appearances. On opening the body, while still warm, the venous blood was found very firmly coagulated, not parting with any of its serum when left at rest; the left ventricle of the heart showed, on its external surface, some stains of the colour of lees of wine, formed by a kind of concrete pellicle, which disappeared only after long rubbing and maceration. The other organs appeared healthy.

XIII. Some beef was allowed to decompose in some dog's blood; half an ounce of the fluid resulting from the decomposition, was injected into the jugular vein of a little bitch. Immediately, the animal made several convulsive efforts to swallow, and soon became oppressed, uneasy, and faint. At the expiration of an hour, there was great prostration, accompanied by repeated gelatinous and bloody evacuations, and vomiting of

bilious matter. The strength became gradually less, and the animal died three hours after the injection.

Post-mortem appearances. The lungs were found inflamed in a very peculiar manner. They were gorged with blood, of a violet or black colour, and presented many petechial spots, like small ecchymoses. These spots existed also on the left ventricle of the heart, in the spleen, in the mesenteric glands, in the gall-bladder, and even in the subcutaneous cellular tissue. The peritoneum contained some spoonful of a reddish serum; but the mucous membrane of the digestive organs was found to have been principally affected. In the stomach it was slightly inflamed; in the intestines, but especially in the duodenum and rectum, it was of a livid colour, presenting many black spots, and covered by a gelatinous and bloody secretion, resembling lees of wine. The tissues in these parts were slightly thickened.

XIV. The preceding experiment was repeated, by injecting into the jugular vein of a moderately large dog, an ounce of fluid, derived from the maceration of putrid beef in water. The animal very soon passed extremely offensive, liquid evacuations, with much urine. The breathing became quick and deep, the pulse small and quick. Repeated efforts were made to empty the bowels. There was great depression and want of strength. At the expiration of an hour, a kind of diarrhoea or dysentery made its appearance. Liquid, bloody, and fetid evacuations, continued for an hour and a half, when the animal died.

Post-mortem appearances. Livid, brown, and black patches were found scattered over the lungs. The intestinal canal was filled with a bloody mucous secretion, resembling the matter that had been voided; its mucous membrane was of a livid colour, as in the preceding case.

XV. Two ounces and a half of thick fetid fluid, derived from the maceration of cabbage leaves in an equal quantity of water, for two days, at a temperature of 77 Fah., were injected into the right jugular vein of a moderate sized dog. During the operation, the animal made several efforts to swallow, and soon became faint, and vomited several times. Some hours afterwards, there was great uneasiness and oppression, with recurrence of the vomiting, and continued faintness during the day. After nine hours, a most copious and very fetid evacuation took place. The discharge was as black as soot, and composed of mucus, with a little faecal matter, and a large quantity of what appeared to be corrupted blood. Some time afterwards, there was a second evacuation of bloody mucus, exactly resembling the first. On the following day, there was much loss of strength: the animal lay upon its side, or staggered as it walked. There was great and insatiable thirst, with a small feverish pulse. But the most remarkable symptom was the occurrence, at intervals, of palpitation of the heart, accompanied by extraordinary force and sound, resembling that produced by long continued hypertrophy of that organ, in consequence of aneurism¹ of one of the large arteries. On the third and

¹ I once observed a similar condition in a young woman in St. George's Hospital. Each pulsation of the heart could be heard with great distinctness at a distance of two or three yards from the patient; during the paroxysms, there was the greatest difficulty of breathing; the countenance became anxious and livid, and a distinct thrill was communicated to all the arteries. After death, the countenance and upper part of the body were found livid from venous congestion. The lungs did not

fourth days, the animal was better, but there were still great thirst, fever, and occasional rejection of fluids from the stomach. On the fifth day, the symptoms became aggravated; there was extreme weakness, a tottering gait, excessive thirst, the eyes red and filled with gum; the nostrils were stuffed, swollen, and obstructed with mucus; and the lining membrane of the mouth was tumid, and of a violet red colour. In the middle of the day, there was a liquid greyish white evacuation, resembling pus in its odour, consistence, and appearance, mixed with some clots of putrified blood. Death occurred during the following night.

Post-mortem appearances. The mucous membrane of the eyes, nose, and mouth, was red or violet, and covered by a very abundant thick mucus. The lungs were of a dark colour, with some black patches, but still crepitant. The left ventricle of the heart presented several brown stains, resembling ecchymoses, which penetrated into its tissue. Its internal surface was of the colour of lees of wine, offering a singular contrast to that of the right side, which, however, contained a hard fibrinous concretion, two drachms and a half in weight, of a light yellow colour, resembling grease. This was of the same consistence throughout, everywhere free, with the exception of a portion of the size of a finger nail, which adhered to an irregular and apparently inflamed spot on the inner surface of the ventricle; no appearance of the injected fluid could be recognized in this clot, which was continued of the same colour and consistence into the pulmonary artery, and into the vena cava, the azygos, the axillary, and even the right jugular vein.

The intestinal mucous membrane, especially in the rectum, the duodenum, and a small portion of the small intestines, was of a violet red colour, inflamed principally in longitudinal stripes and in patches, which gave a mottled appearance, even to the outer surface of the intestines, before they were opened. This discolouration was not accompanied by any thickening of the tissues, nor by ulceration, and appeared rather the result of ecchymosis or hæmorrhage. The lining membrane of the rectum was principally affected, and its mucous glands were swollen and very prominent. This intestine contained puriform fluid, resembling the matter evacuated before death. The other intestines contained a very thick greyish white mucus. The mesenteric glands were inflamed, and appeared as if infiltrated with blood. The gall bladder was mottled on its surface by brown and violet patches, and contained black, thick, ropy bile, resembling melted tar.

XVI. Effects of the introduction of Mercury into an artery. An ounce and a half of mercury, mixed with water, was injected into the left carotid artery of a sheep. The animal immediately evinced pain, and stood immovable upon its feet. The head was held down, there was stupor and heaviness, and the eyes were protruded and widely open. The fore legs subsequently became bent, and the head inclined over the right shoulder with a kind of convulsive rigidity, which continued

readily collapse when the chest was opened. The auricles of the heart were greatly distended with black blood; the inner surface of the left ventricle presented a white patch, of about two square inches in extent; the lining membrane of the aorta, for several inches, was of a bright red colour; this extended round one-third only of the circumference of the vessel. No other structural change could be found in the heart or vessels, which would account for the symptoms observed during life.

till death. Two hours afterwards, the animal became comatose, with some convulsive motions of the limbs, and the left eye became red and inflamed. Death took place fifty hours after the operation.

Post-mortem appearances. The left eye was found in a state of suppuration, and contained mercury. Many of the branches of the left carotid also contained some mercury, which had not penetrated to the capillary system. All the organs supplied with these vessels were red, swollen, and inflamed, in consequence of the presence of the foreign matter. The thyroid gland, the tongue, the cheeks, and the lips, were, however, only affected as far as the median line, leaving the opposite halves pale and in their natural condition.

XVII. A drachm and a half of mercury, mixed with some warm water, was injected into the crural artery of a large dog. The animal evinced no pain, and walked resting slightly on the affected limb, which became sensibly colder. After the expiration of an hour, the animal refused its food, became restless, and indicated severe pain in the limb, which was now very hot. On the following day, the leg was swollen and œdematous. On the third day, there was extreme thirst, increased œdema, and great suffering. The animal was killed sixty hours after the operation.

Post-mortem appearances. No disease was found in any organ, excepting the affected limb. This was swollen and œdematous in every part; abscesses of different sizes had formed, which contained sanious fluid, mercury, and pus; some parts were in an incipient state of mortification, and gave out a considerable quantity of air. Globules of mercury were found in different parts, occupying usually the centre of the abscesses, and ran out upon the scalpel when incisions were made into the limb.

XVIII. *Effect of the injection of Oil into an artery.* Three drachms of olive oil were thrown into the crural artery of a large dog. Slight pain was experienced, and the limb became evidently cold, and the pulse under the tendo-Achillis could no longer be felt. Two hours afterwards, a like quantity of oil was again injected. The leg now began to inflame, and became tender. The following day, the whole limb was œdematous, much swollen, and very painful. Twenty-nine hours after the first experiment, the muscles of the thigh and leg, as well as the cellular tissue, were found in some places gorged with blood, and inflamed in lived patches; in others, infiltrated with yellow serum and gelatinous exudations. No oil could be detected in the affected parts.

XIX. An ounce of putrid water, in which some beef had been macerated, was injected into the crural artery of a middling-sized dog. The artery having been tied, the pulse ceased below the tendo-Achillis; the limb, however, preserved its usual degree of heat, offering a contrast in this respect to the last experiment. A considerable degree of fever and restlessness followed the operation; this continued the whole day and the following night, without any vomiting or evacuations, which so constantly followed similar operations upon the veins. The next day the limb was very painful, but not swollen; there was thirst, with the ordinary secretion of fæces and urine. On the third day, the animal was evidently better; the appetite had become almost natural, and he could walk more easily, although the limb was still very painful. In the night, there were some soft, almost liquid, evacuations. The fourth day, the

animal was evidently recovering, when an ounce and a half of very fetid and very concentrated fluid (derived from the maceration of beef), was injected into the crural artery of the opposite limb. The animal immediately evinced pain, accompanied by very violent and remarkable palpitation of the heart. It walked lame, keeping the leg raised, and soon became feverish and uneasy. The symptoms were exactly the same as after the first experiment. The leg became gradually more and more painful, extremely sensitive, but not infiltrated with serum. During the night, there was much expression of pain; the animal was in continual motion. Death occurred nineteen hours after the second injection. The limb had become swollen only within five or six hours previous to death.

Post-mortem appearances. The limb presented a very large quantity of bloody fluid infiltrated in all the tissues. The superficial muscles were black, and presented more or less the appearances of gangrene. The deep muscles existed as such no longer, but were entirely disorganized, and converted into a putrid pulp, resembling masses of the red lees of wine, extremely fetid, and disengaging a quantity of gas. The limb first injected was still swollen, and presented, in the interior of the adductor muscles, two or three cavities filled with a putrid bloody serum. In the chest, the lungs were healthy, as were also the right cavities of the heart; but the left cavities presented several reddish-black spots, scattered over the external surface. In the left auricle was a firm yellowish-white coagulum, adhering to an inflamed spot on its inner surface. The intestinal canal was filled with a brownish red fluid, resembling altered blood, which, in the stomach and duodenum, was of the colour of soot. The mucous membrane of these organs, as well as of the jejunum and rectum, were gorged with blood, of the colour of the lees of red wine, but without any inflammatory thickening of their coats.

XX. *Effect of the introduction of Air into an artery.* Seven or eight cubic inches of common air were injected gradually into the crural artery of a large dog. A peculiar rustling noise, depending upon the admixture of the air with the blood, accompanied the operation. No particular symptoms followed; but after some minutes the corresponding vein became distended with frothy blood, which moved with difficulty, and became stagnant in the vessel. The whole limb crepitated upon pressure, but no untoward symptom presented itself for more than half an hour. An ounce of water, to which seventy drops of medicinal prussic acid had been added, was now injected into the same artery. This produced no apparent effect upon the constitution.

A quarter of an hour after, an ounce of saturated solution of nuxvomica was injected into the same vessel. This also was followed by no particular symptoms. An hour after the first injection, half an ounce of a weak infusion of tobacco was introduced into the same artery. Excessive pain immediately followed, accompanied by great rapidity of breathing. The animal now appeared as if he were going to die; however, he slowly recovered, appeared giddy and inclined to vomit, and kept himself in a continual state of restlessness. This condition was succeeded by fever, accompanied by extreme sensibility of the limb, and irregularity of the pulse. At the expiration of some hours, he appeared better; the pulse became more regular and less feverish, but the leg continued swollen, and extremely painful upon

pressure. During the night, the pain returned, indicated by howling and restlessness. There were several evacuations of feces and urine. The following morning, there was great prostration with much fever, and continued howling. The limb was slightly emphysematous, greatly swollen, inflamed, and infiltrated with serum.

On the following day, two ounces and a half of water, in which some nux vomica had been boiled, were injected into the crural artery of the opposite limb. The dog expressed no pain; but, at the expiration of ten or twelve minutes, slight convulsive motions became evident, which were gradually converted into violent tetanic spasms. The animal threw himself backwards with his limbs extended, and died, after repeated convulsive attacks, an hour and a half after the last injection.

Post-mortem appearances. On opening the body, *no unusual appearances were observed in the limb* upon which the last experiment had been tried, but the opposite one was tumid and emphysematous, infiltrated with a greyish red frothy serum of a fetid odour. *The small vessels were obstructed by firm clots of blood.* The gall-bladder was greatly distended; and the intestinal canal contained a quantity of yellowish mucus.

(To be continued.)

ON PROCREATIVE POWER.

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THE physiological and mathematical determination of the Procreative Power of Man is a portion of vital statistics, which, I believe, has not hitherto been properly investigated. When we contemplate the very interesting nature of the inquiry, and its importance as applied to individuals and national exigencies, and to emigration societies in particular, the cause of this omission is not very clear. Probably this neglect has, in a great measure, arisen from a natural disinclination in most persons to contend with controverted facts and dismembered statistics, and to perform the heavy arithmetical calculations required. There is, it is true, always more or less difficulty in investigating any new subject; and more especially in applying statistical data, originally drawn out for a totally different object. Moreover, many of the investigations are often, after all, founded on insufficient data; and what is still more embarrassing, frequently this disadvantage is not discovered till a series of heavy calculations, founded upon them, has been made, and a palpably absurd result has been brought out. Herein, therefore, is a source of great delay and annoyance. Further, when a question like the present involves a point in the physiology of man, he who would investigate its real nature, must consult statistical data, not only founded upon the experience of one, but of several nations. In making, however, this comparison, he is met at once by a most embarrassing difficulty. The statistics of no two nations involving questions of population are founded upon the same general plan; and it thus often happens, that a point elicited by the examinations of the vital statistics