

fever. I see, as a plausible explanation of this effect, putrid substances and their absorption. But I can go no further, and that is why I told you at the beginning that, whatever we might do, we always brought up in this research against something that was inexplicable and hypothetical.

I presume that the poison of purulent infection has a complex origin, and that the molecules furnished by the putrescent marrow of the bones play a large part in it. I presume that the poison formed during the first few days, that which occasions traumatic fever, is different from that which is developed later and which gives rise to purulent infection. I recognize that according as the symptoms of the presence of the former have been more marked, so is the latter more likely to be produced. I understand how distinguished surgeons, M. Billroth, in Germany, M. Verneuil, in France, seeing so often grave traumatic fever precede and in some sort prepare the way for purulent infection, have been led to think that these two affections are but one and the same, and that pyæmia is the second degree of a septicæmia of which traumatic fever is the first. But upon this point we are all unable to prove anything. We are obliged to confine ourselves to suppositions, to ask indulgence for our theory in consideration of the excellent points it furnishes for prophylaxis as I shall try to show you in another lecture.

2d. Let us now see how the multiple suppurations, often internal, sometimes external, the so-called metastatic abscesses, can be explained by the theory of septicæmia.

Here again I shall be compelled to admit that a rigorous explanation is nearly impossible.

I have already spoken of the original theory, the deposit in all parts of the body of pus taken up or absorbed from the surface of the wound, and you know the reasons why we could not adopt it.

The first was that it is difficult to believe in an absorption sufficiently abundant to supply the numerous and sometimes large collections which we find, especially those which form within the synovial and serous cavities.

Next, the theory being true, the microscope ought to show large quantities of leucocytes in the blood of pyæmic patients; but, as I told you, the blood contains only the usual number. And finally, since the facts have led us to the opinion that it is not pus but invisible and intangible poisons which cause the infection, we cannot admit that the pus is all formed in the blood and has only to be deposited in the organs.

I spoke also of the suppurative capillary phlebitis admitted by Dance and Cruveilhier as a means in the formation of metastatic abscesses. These authors thought that the blood, by admixture with pus, became irritant, phlogogenic, as it is termed to-day, and that, passing into the venous capillaries of certain viscera, especially those of the liver and lung, it produced in them a suppurative inflammation similar to that caused by mercury and other foreign bodies when injected into the veins, as in Cruveilhier's and Darcet's experiments.

I should be willing to accept this interpretation if the metastatic abscess developed everywhere in the same manner, that is, if it passed everywhere through a first stage characterized by the black spot resembling an ecchymosis, and which might possibly be attributed to the stoppage of clots in the inflamed veins. But this first stage is seen only in the lungs, sometimes in the spleen. We do not find it in the liver, where the abscess seems to begin by a yellow spot which is not blood, and which is not pus either. Still less do we find it in the serous and synovial membranes and the muscular interstices, where the pus forms very rapidly without being preceded by any appreciable lesion.

The same objections can be made to Darcet's fibrinous and Virchow's sanguineous embolus. You may possibly accept it for the lung, but you need another explanation for the liver, the serous and synovial membranes, and the muscular interstices.

In presence of these varieties in formation, as shown by anatomical investigation, there is only one thing to be said, and that is that as soon as the blood has become altered by its infection, and the fever has declared itself, the whole economy becomes apt for suppuration. So long as there is no poisoning, the suppuration remains local, and all the efforts of the organism are turned to the process of repair, of which the regular secretion of pus is an essential condition. As soon as poisoning has occurred, the pyogenic aptitude is disarranged; it becomes generalized, and the organism makes pus, at the expense of the altered blood, everywhere except at the point where it first prepared to make it.

## LECTURE XXXI.

### ETIOLOGY OF SURGICAL SEPTICÆMIA.

General etiology of traumatic fever and purulent infection. 1st. Local or anatomical causes. 2d. Individual general causes—Influence of age, sex, temperament, alcoholic habits, moral emotions, physical suffering. 3d. Atmospheric general causes, vitiation of the air by crowding—Possible absorption of miasms by the wound and by the respiratory organs.

GENTLEMEN: I gave you in a former lecture my opinion upon the mode of development of purulent infection. But that lesson would remain sterile if I did not try to show you how, on the one side, the tangible causes of the disease accord with this pathogeny; and how, on the other, the knowledge which we have of the relations between the etiology and the pathogeny leads to therapeutical and prophylactic notions. But, as a close connection exists between traumatic fever and purulent infection, and since the prophylactic measures

employed against the one are equally suited for the other, I prefer now to unite them under the name of *septicæmia*, or, as M. Jules Guérin has styled it, of *purulent intoxication*, and to apply to both the considerations which I have to present you.

I warn you, moreover, that these considerations apply not only to gunshot fractures but to all wounds and operations which expose to surgical septicæmia.

*Etiology.*—Purulent poisoning (and by this term it is understood that we mean that which starts from a wound in which suppuration is impending, as well as from one which has begun to suppurate) recognizes three kinds of causes: local or anatomical causes, individual general causes, and atmospherical general causes. Let us see how these causes accord with the pathogeny I laid before you.

1st. *Local or Anatomical Causes.*—We know them; they may be summed up as follows: formation upon the wound of putrid substances or septic poisons, and possible absorption either before or after the establishment of the suppuration. We know that deep wounds, especially those in which the bones inflame and take on putrid osteo-myelitis, are more likely than any others to cause it.

Do not lose sight of the fact, that, if decomposition of the pus is one of the sources of the formation of the poisons, it is not the only one,—it is not even the most important. In fact, if putrefaction does not occur upon the surface and in the deep parts of the wound during the first few days, and if the pus alone appears there, poisoning is rare. Next, when the wound has passed this period of twenty or twenty-five days, during which putrid substances are formed upon and remain in it, and when there is no longer anything but pus, poisoning again becomes more difficult and rarer. If then I have retained the name of purulent infection, it is in order to conform to general usage, and also because the formation of the poisons coincides with the beginning of the formation of the pus. Do not forget, on the other hand, that this formation of putrid substances upon wounds is the consequence of a process of destruction which follows the traumatism and precedes the definitive establishment of the process of repair. Certainly it would be much better if things took place differently; but the fact is none the less true, that a large wound, before it becomes lined with a red and freely suppurating membrane which is the indication of properly advancing repair, covers itself with sloughs more or less deep, useless exudations, and blood clots, and that all these products exposed to the air may there undergo putrid changes.

This preliminary destruction is more or less marked. It is accompanied by a more or less considerable putrefaction. There lies the explanation of the differences which we see in practice, certain subjects being much more exposed to putrefaction and its consequences than others. The study of the general causes will also show us the same thing.

2d. *Individual General Causes.*—It has been correctly said that persons of every age, of both sexes, of every temperament may be attacked by septicæmia. But with respect to frequency there are individual variations which we must recognize in practice.

Let us first consider age.

Beyond all question, children may have both kinds of poisoning. But traumatic fever, violent enough to be fatal, is quite exceptional among them, and it is undeniable that of one hundred children who have suffered amputation or have received gunshot fractures, the number attacked by purulent infection is much less than is the case with adults. I wish I could indicate this proportion by figures, but I cannot, since it has been my lot to treat only a few children. I make this statement in accordance with the general impression left by my personal experience, limited though it may be, and with the results furnished me by surgeons of hospitals for children. This diminished frequency can be easily understood. The constitution of a child has not been exhausted by the general causes just mentioned: bodily fatigue, moral impressions, alcoholisms, syphilis; furthermore the marrow of their bones is less abundant, less fatty, more vascular, less liable to putrefy; lastly the vitality of all their tissues is greater. There is then less tendency to destruction, and consequently fewer obstacles to the process of repair than in the adult; it is more difficult for the phlebitis and osteo-myelitis to take on a putrid character.

Let us now consider sex.

It seems to me that women are rather less exposed than men to purulent infection. This is both the result of a general impression and of my own statistics. In the paper which I read before the Medical Congress of 1867,<sup>1</sup> I reported eight cases of amputation of the thigh or leg, in women, with three deaths, two of which were by purulent infection and one by hectic fever. I had had these two cases of purulent infection out of eight operations, a proportion of twenty-five per cent. The same operations performed upon men have given me, on the contrary, the proportion of about forty per cent. of the same affection. Again, I recall the cases of women treated by me after the civil war in 1871, for gunshot wounds involving important parts of the skeleton. They are not numerous: a fracture of the shoulder, a fracture of the humerus, two fractures of the leg, a fracture of the superior and inferior maxilla. None of them had purulent infection, none died, and yet all had at first acute and then chronic suppurative osteo-myelitis. But the osteo-myelitis was not putrid, or was so to so slight a degree that poisoning did not follow. Three of them had traumatic fever, but it was moderate and, as happens in such cases, did not lead to the fever of pyæmia. In this respect there is a distinction to be made between traumatic erysipelas and purulent infection in women. They suffer more frequently from the first and less frequently from the second than men do. The explanation is to be found in causes analogous to those favouring childhood. Although a woman is more impressionable, her constitution is ordinarily less broken down by bodily toil, irregular hours, and alcoholism, than a man's is, and this is especially true of the men of the working classes in large cities, those who supply most of our hospital cases.

As for temperament, I know nothing in particular, and I am forced

<sup>1</sup> Actes du Congrès Médical International de 1867, p. 269.

to recognize that the most robust, as well as the most delicate, may be affected in the same proportion as soon as the other causes begin to act.

The facts which came to our notice after our late battles convinced me that fatigue resulting from long marches and loss of sleep, alcoholic habits, exposure to cold prolonged over several hours, especially at night, after receipt of the injury predispose, as essentially debilitating causes, to the spread of the preliminary destructions which are the main source of the poisoning.

Moral emotions—those resulting from the discouragement produced by defeat, those caused by the prospect of a long illness, of a permanent infirmity, by the fear of death, a fear necessarily increased in a hospital ward by the sight of the death of neighbours or comrades wounded on the same day—these emotions are incidental, though not predisposing causes of poisoning. In order that repair shall go on regularly, and that the putrefaction of the preliminary work of destruction shall remain limited, it is necessary for the patient to eat, sleep, and digest. This he does not do, or he does badly, if his mind is preoccupied and saddened, as it often is after severe injuries.

I have spoken elsewhere<sup>1</sup> of the influence of physical sufferings, the long duration, or too frequent repetition of which, produces similar results.

3d. *Atmospheric General Causes.*—These are certainly the ones which exert most influence.

Tessier, when opposing Dance's doctrine of the consequences of suppurative phlebitis, was the first to show clearly that purulent infection was due mainly to the crowding of the wards of a hospital with sick and wounded, and that this crowding did not explain the development of venous suppuration and the consequent passage of pus into the blood, and that it certainly acted in another way.

Since then hospital surgeons in large cities have learned from those of their confrères who practise in the country and small towns, and who treat their wounded at home or in hospitals containing few patients, that purulent infection and grave traumatic fever are very rare among them. When Messrs. Topinard<sup>2</sup> and Léon Lefort,<sup>3</sup> after their visits to England, taught us that surgical poisonings were less frequent in the London than in the Paris hospitals, they indicated as principal causes of this difference: 1st, the fact that the English wards were less crowded than the French; 2d, the more complete renewal of the air in the wards by the frequent opening of the windows as well as by an efficient system of ventilation.

Still later American surgeons confirmed these views by the statistics of the wounds and operations which the war of the rebellion gave them the opportunity of observing upon a large scale.

While in France, at the time when Malgaigne published his first and important work upon the results of capital operations in the

<sup>1</sup> Actes du Congrès Médical International de 1867, Paris, 1868.

<sup>2</sup> Topinard, Thèses de Paris, 1860, No. 28.

<sup>3</sup> L. Lefort, De la Résection de la Hanche dans les Cas de Coxalgie et de Plaies par armes à feu (Mém. de l'Acad. de Médecine), 1861, tome xxv. p. 445.

Paris hospitals, the proportion of deaths, almost all of them due to purulent infection, was from 70 to 75 per cent., in these American statistics the proportion was only 30 to 35 per cent. for the same operations. The difference was explained by the two circumstances that in America the patients' beds were widely separated from one another, and, above all, were placed in tents far from other habitations and almost constantly open.

The general impression which resulted from these works,—and which, for my part, I aided to create in France by giving the greatest publicity to M. Lefort's comparative studies upon the English and French hospitals in my report to the Académie,<sup>1</sup> and in the long discussion upon nosocomial hygiene which followed,—the general impression, I repeat, was that vitiation of the air by crowding is the principal cause of surgical poisonings.

In what does this vitiation consist? Is it due simply to the various emanations arising from the presence of too many people in a limited space where the air is not sufficiently renewed? Is it due to special miasms arising in wards occupied by wounded persons from suppurating wounds, or to specific miasms coming from those already affected by surgical poisons? Does it occur in all these ways at once? Thus far our experience has not enabled us to pronounce upon this subject. Everybody admits and ought to admit, for clinical experience proves it most positively, that the crowding of patients vitiates the air, and that this vitiation engenders septicæmia in patients who have deep suppurating wounds. But no one can say positively in what this vitiation consists.

And here another question naturally arises. The air being vitiated by these miasmatic emanations, by what way do they penetrate into the organism of the wounded patients, and how do they act in producing surgical poisoning?

As for the penetration, we have to choose between two routes; that of the wound, and that of the respiratory organs, unless we admit that the poison enters by both.

Our learned colleague, M. Alphonse Guérin, did not hesitate to choose the first. He distinctly maintains the opinion that wounds, being able to absorb, introduce into the general circulation the miasms which the vitiated atmosphere deposits upon them; the first conclusion that he drew was one confirming Tessier's views, that we should prevent, above all, the vitiation of the air by crowding. Afterwards, in 1871, he adopted a second one, the necessity of the occlusive apparatuses of which I shall soon speak.

This theory, which has had the merit of giving a great impulse to the search for and application of prophylactic measures, is certainly very attractive. But I have made and still make this objection to it: all wounds are capable of absorption, the superficial as well as the deep ones, the ossifluent as well as those which do not communicate with the bones, and yet they do not all absorb those atmospheric miasms which are supposed to be able to develop the infection. You

<sup>1</sup> Bulletin de l'Académie de Médecine, 1861-62, tome xxxvii. p. 53.

know that patients with superficial wounds are less exposed to it than those with deep wounds, and those with deep wounds, and without osteo-myelitis, much less than those with deep wounds and osteo-myelitis. It is in vain that M. Alphonse Guérin replies that deep and ossifluent wounds have much larger surfaces of absorption. The answer to that is in these enormous solutions of continuity seen in burns and in certain accidental wounds which pass through all their phases without becoming the occasion of purulent infection. Moreover, if the infection were caused by the absorption of atmospherical miasms by the wound, why should this absorption take place during the first twenty-five days and not afterwards? The wounds of which we are speaking last for forty, sixty, ninety days. During all this time they are able to absorb, during all this time they are in contact with vitiated air, yet the further we get from their beginning the less is infection to be feared.

I do not deny, if you will, the absorption by the wound of miasms contained in the air. But it is impossible for me, for the reasons I have already given, to believe that this absorption is sufficient by itself to give rise to grave traumatic fever and purulent infection. We can, moreover, explain the local action of the vitiated air otherwise than by the direct penetration of the miasms into the circulation. I have told you that the mortifications and putrid changes in wounds were due to two main causes: a certain quality of the inflammation which depends upon the idiosyncrasy of the patient, and the contact of the air. Now it is possible that air vitiated by these invisible miasms in hospital wards exerts its decomposing influence more easily than perfectly pure air does. Still, I do not hide from you that this is only a presumption, and that I can in no way prove the proposition.

Let us now examine the other route, that of the respiration. If the vitiated air enters the lungs at each inspiration, it is allowable to believe that the deleterious miasms contained in it penetrate into the blood, and that this penetration affects the health in a way that is injurious to the progress of a wound. Two serious objections present themselves here: First, this same vitiated air is breathed by other patients who have no wounds. They are not attacked by any fever, and their health does not seem to be affected in any way by this hygienic condition which is so unfavourable to those with serious wounds. Then all those who have wounds do not become poisoned, notwithstanding that they all breathe the same air. How is it then that this vitiated air, if it acts through the respiratory organs, produces upon some what it does not produce upon others?

There is, it is true, a new difficulty in the explanation. But it seems to me capable of removal by the ideas which I propounded upon the conditions of local putridity necessary to the development of surgical poisonings. In order that these putrid substances should not form it is necessary, as I have already told you, that the patient's health should be good, and that all his functions should be regularly performed. It is especially needful that the blood should be properly transformed and purified, and that no foreign element should change it. This condition is necessarily affected by respiration in an atmos-

phere charged with miasms. If the passage of these latter into the blood does not sensibly affect the health of those who have no open wounds, or have only superficial ones, yet I can understand that it might so affect those who have to undergo deep suppuration, and especially that of osteo-myelitis. In fact it is at the expense of the blood that the exudations necessary for the formation of a good pyogenic membrane are made. If this blood is not sufficiently pure it produces unhealthy membranes, which mortify; it excites this excessive inflammatory process, which leads to the partial death, and ultimately to the putrid decomposition of the tissues covering the solution of continuity. In a word, vitiation of the blood by imperfect hæmatisation acts upon the wound which is about to suppurate in the same way as vitiation caused by fatigue, loss of sleep, moral emotions, alcoholism, and prolonged exposure to cold; and you understand that when all or many of these causes of vitiation act at the same time, the patient has but a slight chance of escaping a grievous poisoning. Happily there are organisms which resist everything, and we see from time to time in our wards patients who, notwithstanding the existence of unfavourable conditions, escape suppuration, or, in whom, if it occurs, it does not assume the putrid character.

I sum up my views upon the influence of unfavourable atmospherical conditions in saying that if this influence is local in a certain measure, which I cannot prove, it is also general, in the sense that it gives the blood, through the respiratory organs, certain qualities which predispose it to furnish upon the wound and in the medullary canal products which putrefy easily.

And I express my views upon the general etiology of traumatic poisonings in saying that they depend upon a series of individual and atmospherical causes, each of which acting alone may produce them, but which in all probability unite and act simultaneously; and it is not unlikely that poisons varying in nature and amount may result from the complex intervention, and in different proportions, of all these causes. Thus may, perhaps, be explained both the differences which we see in the more or less rapid course of regular traumatic fever and purulent infection, and those unusual forms of fever which do not appear early enough to belong to primitive septicæmia, and which, on the other hand, not presenting the ordinary symptoms of purulent infection, ought to be considered as intermediary or incomplete septicæmias, to which the clinic has as yet given no special name.