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WATSON (B.A.)

PYÆMIA
AND
SEPTICÆMIA.

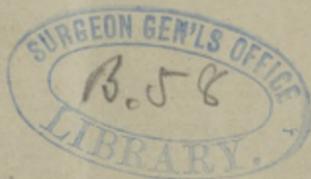
Presented
by the Author

BY

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ERRATA.

Page 7, twenty-seventh line from top, should read "substances which excite."

Page 15, twentieth line from top, should read "would still leave."

Page 23, thirty-fifth line from top, should read "the theories."

Page 33, eleventh line from top, should read "The term miasmatic."

Page 44, ninth line from top, should read "the acute sepsis mentioned."

Page 45, twenty-ninth line from top, should read "*sine quibus non.*"

Page 51, sixth line from top, should read "The first effort."

PYÆMIA AND SEPTICÆMIA.¹

I. HISTORY.—The morbid conditions now designated pyæmia and septicæmia were recognized by the “Father of Medicine,” who reports² a well-defined case of puerperal fever terminating fatally on the twentieth day of the disease; and also the following fatal case of erysipelas: “Criton, in Thasus, while still on foot, and going about, was seized with a violent pain in the great-toe; he took to bed the same day, had rigors and nausea, recovered his heat slightly, at night was delirious. On the second, swelling of the whole foot, and about the ankle erythema, with distention, and small bullæ (phlyctænæ); acute fever; he became furiously deranged; alvine discharges bilious, unmixed, and rather frequent. He died on the second day from the commencement.”³

Further confirmation of the fact that Hippocrates was familiar with the phenomena of these diseases may be found in his dissertation on “Empyæma and Fevers.”

Prof. C. Hueter, under the head of “Septic Fever,” says: “Hippocrates and Celsus observed the fever in cases of injuries which proved so dangerous, and that this danger must have originated neither from the inflammation nor from the wound alone, but from some unknown cause.

¹ President's Address before the New Jersey Academy of Medicine at its Annual Meeting, June 20, 1877.

² Works of Hippocrates, translated by Adams, vol. i., p. 373.

³ *Ibid.*, p. 377.

“Jacotius, a commentator of Hippocrates, has even mentioned putrid fevers, the same as Adrianus Spigelius, who spoke of fevers which arise from putrefaction; but both authors, as well as their followers, did not discriminate between septicæmia arising from the putrescence of wounds, and pyæmia. In the mean time, both varieties were regarded as intermittent fever.¹

“Aretæus lived during the middle of the second century of the Christian era. In his remarks on pneumonia, Aretæus observes that the subjects of this disease die mostly on the seventh day. ‘In certain cases,’ he says, ‘much pus is formed in the lungs, or there is a metastasis from the side if a greater symptom of convalescence be at hand. But if, indeed, the matter be translated from the side to the intestine or bladder, the patients immediately recover from the peripneumony.’ He speaks of metastasis to the kidneys and bladder being peculiarly favorable in empyema. He ascribes suppuration of the liver to intemperance and protracted disease, especially from dysentery and colliquative wasting. The symptoms described by him resemble those of chronic pyæmia.”²

A new era in the literature of this subject dawned during the sixteenth century.

Ambroise Paré and Bartholomew Maggi each published a work in which they pointed out the old errors and announced new truths. Carl Thiersch, in his lecture on “*Klinische Ergebnisse der Lister’schen Wundbehandlung und über den Ersatz der Carbolsäure durch Salicylsäure*,” says: “When, in the year 1536, a strong army of the ‘famous King Francis’ marched over Mt. Cenis into Piedmont, it was accompanied by an inexperienced surgeon only nineteen years of age—the subsequently so highly honored Ambroise Paré. The storming of the mountain citadel of Vallane, near Susa, gave him indeed, for the first time, plenty to do, and he put in practice everything in accordance with the example of his older colleagues. Like them, if also with fear, he poured the boiling oil of elder into the gun-shot wounds, in order to destroy the poison; but as

¹ Pitha u. Billroth, “Handbuch der Chirurgie,” 1. Band, 2. Abth., 1. Heft, 1. Liefg., 6, S.

² Braidwood on “Pyæmia,” p. 2.

there was not sufficient oil, he was compelled to dress the remainder of the wounded with a salve prepared from oil of rose and turpentine. Pained by the fear that the latter, in a short time, would become a sacrifice to the poison, he passed a sleepless night, arose early from his bed in order to examine the unfortunates, but was greatly surprised to find the half-given-up almost free from pain, without inflammation or swelling. 'Then I determined,' said he, 'never again to burn the poor wounded soldiers so cruelly.'"

Paré's "Treatise on Gun-shot Wounds" first appeared in Paris in 1551, fifteen years after the occurrence of the previously-narrated event, in which he declared in favor of the non-poisonous character of these wounds. He had spent a part of the intervening time in Italy, and it is supposed that he there became acquainted with the investigations of the learned Bologna physician, Bartholomew Maggi, and had appropriated to himself the demonstrations on the non-poisonous nature of gun-shot wounds. Maggi's treatise appeared a year later (1552), at Bologna. In whatever manner Paré may have obtained the priority, certain it is that it required all the influence which he in more mature years enjoyed, especially in things pertaining to military surgery, in order to provide a gradual introduction for the new theory. Still one meets with the old error among the more modern physicians. How this error could have attained such a widespread influence is, indeed, scarcely susceptible of demonstration. It is certain that, originally, gun-shot wounds passed for contused wounds, and were usually treated with warm, moist poultices. But as gun-shot wounds are naturally inclined to a bad course, especially if complicated with a fracture, and as this bad termination has become more frequent since the introduction of firearms, depending on an increase in the number of that kind of injuries, while the care of the wounded at that time was always insufficient: in this way was encouraged the formation of a false opinion, based on the experience at the bedside, of the special danger of gun-shot wounds.

Cases of acute sepsis which developed after the infliction of gun-shot wounds, and which agreed in essential points with the results of the bite of poisonous snakes, had given a turn

to events. There were such cases during the late Franco-Prussian war, which here and there among the laymen even excited suspicion that the enemy used poisoned missiles.

Thus it was only necessary for Johannes de Vigo, in the commencement of the sixteenth century, to express in dogmatic form the already firmly-held views of physicians. "The gun-shot wound," said he, "is a contused wound, for the ball is round; it is a burned wound, for the ball is heated; it is a poisoned wound, for the powder is poisonous. The poison is the chief characteristic; therefore the treatment should be directed against that, before anything else." And it was on this theory that J. de Vigo stood to decide the fate of gun-shot wounds for many years. Among the different forms of treatment, that most frequently used against the poison was the repeated application of escharotics—e. g., pouring boiling oil into the fresh wounds. Should the topic of discussion at the present time be the treatment of wounds, then it might be said that this historical information was rather far-fetched; nevertheless, the lapse of three and a half centuries is only apparently a long time. The theoretical error is merely removed, but there remains the undetermined question which Paré sought to explain. We no longer seek the poison in the powder and lead; but, as at that time, we speak of a poisonous effect of the wound on the body; now, as then, this poisonous condition forms the central point of our therapeutical efforts. Indeed, J. Lister's first method of cauterizing fresh wounds with concentrated carbolic acid has certainly much to remind one of the burning-out of gun-shot wounds in the citadel of Vallane. That a poisonous substance develops in wounds, or may insinuate itself into them, more especially in gun-shot wounds—a substance which has nothing to do with powder and lead—was the next step advanced. Paré himself came to this conclusion.

When he was present with the besieging army before Rouen, many of the wounds became putrid, and the stench arising from them highly offensive. In the bodies of the dead on whom autopsies were made, there were found numerous pus infarctions in various organs. The pus was greenish and the odor very disgusting. Besieger and be-

sieged believed themselves wounded with poisoned missiles. Paré sought the cause in the contamination of the atmosphere through the accumulation of decaying material, and advised for such cases the scabbing treatment: cauterization with Egyptian ointment, prepared from equal parts of alum, verdigris, and sulphate of copper. Thus he seems to have accepted the doctrine, as it is received to-day, that there is an immediate effect produced on the wound by the vitiated air. The contaminating influence of the air, combined with the products of putrefaction, not merely on the wound but on the organism generally, has never disappeared from the intellectual horizon of physicians. That the mouldering couch of straw, the putrefying bodies of men and animals, the floor and earth saturated with excrement, the overcrowding of badly-ventilated hospitals, give rise to infectious fevers and a bad course to wounds, is not the result of recent observation; also, that it depends on a kind of fermentation, which, by means of the germs contained in the air, is transferred to the body, has become a familiar notion; citing one only of the many authors on this subject, viz., John Pringle, in his "Observations on the Diseases of the Army," published in 1775, in which he devotes a special chapter to the diseases in consequence of the more putrid air, and his forty-eight experiments on septic and antiseptic substances. This chapter contains experiments similar to those made at the present day, in order to prove the anti-putrefactive power of this or that material. Still there remains a vague idea of the nature of the substance which excites putrefaction, and they are mostly sought among the gaseous, bad-smelling products of decomposition.¹ "Ambroise Paré (1582) first taught that secondary abscesses in surgical cases," which he had observed in the spleen, lungs, liver, and other viscera, "were due to a changed condition of the fluids, produced by some unknown alteration in the atmosphere, and determining a purulent diathesis."²

"He also recognized the fever which is dependent on the production of pus, and classified here especially that fever which arises between the tenth and fourteenth days after the

¹ Volkmann's "Sammlung klinischer Vorträge," No. 84 u. 85, S. 639.

² Braidwood on "Pyæmia," p. 2.

receipt of an injury, and is ushered in by a chill." ¹ The following quotations force the conclusion that in the early history of medicine there was supposed to be some important relation between wounds of the head and multiple abscesses:

"Nicolaus Massa (1553) mentions a case of abscess of the left lung, following an injury of the head."²

"Valsalva (1707) was induced by his own observations to say that the viscera of the thorax were sometimes affected in wounds of the head."³

"Desault (1794) considered abscess of the liver to be a very frequent sequence of head-injuries."⁴ The fact that wounds of the head were frequently followed by abscesses of the lungs, liver, and other organs, probably led to the opinion expressed by Desault, Barthez, Brodie, W. Phillips, Copland, and others, that the disease had its origin from a nervous agency.

"Bertrandi and Audouillé (1819) sought for a mechanical explanation of the occurrence of hepatic abscesses after head-injuries, and in cases of apoplexy."⁵

"Morgagni (1740) somewhat obscurely hinted at the doctrine of the reabsorption of pus—a doctrine which was afterward elaborated by Quesnay in 1819. Morgagni, after quoting a great number of instances of wounds of the head followed by visceral abscesses, opposes the idea of a mechanical transport of pus thither—states that such abscesses are not confined to the liver—and that they may follow wounds and ulcers of other parts besides the head. He ascribes their formation to particles of pus ('not always deposited in the form of pus'), resulting from the softening and suppuration of small tubercles, which, having been mixed with the blood and disseminated, are arrested in some of the narrow passages, perhaps of the lymphatic glands, and by obstructing and irritating these, as happens in the production of venereal buboes, and by retaining the humors therein, distend them, and give origin to the generation of a much more copious pus than what is carried thither.

¹ Pitha u. Billroth, "Handbuch der Chirurgie," 1. B., 2. A., 1. H., 1. L., 57. S.

² Braidwood on "Pyæmia," p. 2.

³ *Ibid.*, p. 3.

⁴ *Ibid.*, p. 5.

⁵ *Ibid.*, p. 10.

‘And by this means,’ he says, ‘we may also conceive how it is that much more pus is frequently found in the viscera and cavities of the bodies than a small wound could have generated.’”¹

“Cheston (1766) remarks that ‘translations of matter from one part to another are by no means uncommon, but are frequently to be met with after amputations of the larger limbs, when the *vis vitæ* is impaired, and cannot support that discharge of matter, so necessary to complete the design of Nature in healing a large wound; but, under such circumstances, there is very little, if any, appearance of an inflammation, and the matter is rather disseminated through the viscus on which it falls, than is collected in one or more large vomicæ.’”²

“John Hunter (1793), in this country, and after him Velpeau, in France, demonstrated the existence of pus in blood. Hunter further pointed out the influence and mode of action of phlebitis. He described three forms of inflammation of the veins—viz., adhesive, suppurative, and ulcerative. Pyæmia he considered to be an aggravated form of phlebitis. He remarks that in all cases where inflammation of the veins runs high, or extends itself considerably, it is to be expected that the whole system will be affected.”³ Hodgson (1815) believes in the doctrine of phlebitis, “and affirms that the inflammation extends in some instances even to the membrane which lines the cavity of the heart.”⁴

“Arnott (1829) concluded from his observations—1. That death does not result from the extension of the inflammation of the veins to the heart; 2. That the dangerous consequences of phlebitis have no direct relation to the extent of the vein which is inflamed; and, 3. That the presence of pus in the veins, though the principal, is not the sole cause of the secondary affection. He, accordingly, opposes the idea of Abernethy, Carmichael, etc., that the constitutional affection is owing to the extension of the inflammation to the heart. The publication of Arnott’s and Dance’s treatises led to the general opinion being held in England and France that phlebitis and puru-

¹ Braidwood on Pyæmia, p. 3.

² *Ibid.*, p. 4.

³ *Ibid.*, p. 4.

⁴ *Ibid.*, p. 7.

lent infection were identical affections; or, at least, that the latter was invariably caused by the former.”¹

“Cruveilhier (1829), admitting the doctrine of the formation of secondary abscesses being due to capillary phlebitis, further laid down an axiom, since proved untenable, ‘that any foreign body introduced into the veins, whose elimination by the emunctories is impossible, will produce visceral abscesses similar to those which occur after wounds and operations, and that these abscesses are the result of capillary phlebitis of those viscera.’”² Liston (1837) and Bérard (1842) held the phlebotic doctrine. The following authors believed pyæmia to be produced by the admission of pus into the blood, viz.: Boerhaave and Van Swieten (1737), Morgagni (1740), Cheston (1766), Berthelot (1780), John Hunter (1793), Larrey (1812), Montezzia (1813), R. Carmichael (1818), Quesnay (1819), Velpeau (1823 and 1826), Sir Astley Cooper (1827), Maréchal (1828), Dance (1828), Arnott (1829), Piorry (1831), Liston (1837), Dupuytren (1839), Castelnau and Duerest (1848), Sédillot (1849), Solly (1851), Wilks (1861), and Baker (1866). “Haller made the first experiments as to the action of putrefying substances on animals, and said, ‘Nothing destroys our fluids more powerfully than putrefaction.’ B. Gaspard, Doctor of Medicine in St.-Étienne, published the first complete work, founded on abundant experimental material, on the action of putrefying substances on the organism; and since that time (1822) one may look upon the doctrine of septicæmia as established. Leuret and Dupuy followed him; so that in France the doctrine of septic blood-poisoning soon won the ground. Soon, however, the investigators who followed them rejected both the septicæmic and pyæmic conditions, and the effect of the former investigators could have been only unimportant. Ernst R. Virchow, who repeated the experiments of Gaspard, discriminated with *greater precision* between the surgical diseases—septicæmia as a *sharply-defined* group, the opposite of pyæmia. From this date (1848) the difference between septicæmia and pyæmia has been fully established in the literature. . . . The most important series of experiments

¹ Braidwood on “Pyæmia,” p. 14.

² *Ibid.*, p. 14.

conducted according to Gaspard belong to Stich (1853) and Panum (1856); the latter endeavoring to separate the putrefying poison. In this, however, neither he nor his followers have succeeded very satisfactorily. These experimenters were followed by Urfrey, Saltzmann, and others. . . . In 1865-'66 the Faculty of Medicine in Munich offered a prize-question on the action of putrefying substances on the animal organism, and awarded the prize to Hemmer for his work, which was distinguished for its accurate delineation of the pertaining literature and the number of prepared experiments. In the mean time Pasteur was making a noise in France by his researches. . . . Billroth, Roser, and O. Weber published new and valuable works, which considered the observations at the bedside, as well as the experiments."¹

"Lister, fully appreciating the necessity of protecting wounded surfaces, as far as possible, from the contaminating influences arising from contact with the vitiated air of hospitals, has, by the antiseptic treatment, already accomplished much good. He still adheres to the use of carbolic acid. Binz has proved that a solution of one part of quinine to four hundred parts of water still sufficed with certainty to destroy the life of bacteria. R. Geissler, a few years previously, had mentioned the anti-putrefying property of the salts of quinine, and has used the same as a surgical dressing in carbuncle, cancer, bed-sores, etc."²

Bergmann, and others, have sought to determine the poisonous element contained in decomposing animal substances, and for this purpose have chemically treated putrid fluids, hoping to find the agent that would excite all the symptoms of septic poisoning. Bergmann obtained a body of this nature from decomposing yeast, which he calls *sepsin*, although we have no proof that either he or any one else has ever found the same in pus or any decomposing animal substance; and even if it had been found in these substances, it would then become necessary to demonstrate the fact that no other substance contained in putrefying fluids could produce septic

¹ Pitha u. Billroth, "Handbuch der Chirurgie," 1. B., 2. A., 1. H., 1. L., 6. u. 7. S.

² Langenbeck, "Archiv f. klin. Chirurgie," Band 4, S. 550, 564.

poisoning. It has, however, been satisfactorily shown that several elements found in decomposing animal bodies, when injected into the blood, excite septic action.

II. NOMENCLATURE.—The want of an established nomenclature of pyæmia, and the loose manner in which the terms pyæmia and septicæmia are used by the profession, have doubtless led to much embarrassment.

It will be observed that the early writers on medicine were ignorant of the causes of these diseases, as well as of their pathology. Prior to the publications of Ambroise Paré and Bartholomew Maggi, we find that the diseased conditions now described as pyæmia and septicæmia were supposed to be due to a direct poisonous influence of the powder in cases of gun-shot wounds. It appears that the first pathological condition that attracted the attention of the early observers was the formation of metastatic abscesses in the lungs, liver, and kidneys. At that time the deposits were usually supposed to arise from the mechanical transport of pus from wounds on the surface to the visceral organs. At a later period, John Hunter, and others, supposed pyæmia and phlebitis to be identical diseases; but the more modern writers have used the term "suppurative fever." "*Virchow* has proposed the name *ichorrhæmia*. *O. Weber* uses the name *embolhæmia* for the condition in which emboli are found in the blood. The classification given by *Hueter*, in his excellent work on this subject, appears to me very practical. In pure cases of purulent infection without metastasis he calls the disease 'pyohæmia simplex;' in cases with metastasis, 'pyohæmia multiplex.'"¹ The term hospitalism is used by John Eric Erichsen and Sir James Y. Simpson. The former says: "The overcrowding of wounded people—whether the wound be accidental or surgical matters not—will develop septic disease in one of four forms, viz., hospital gangrene, septicæmia, pyæmia, or erysipelas."² And the latter: "The general and acknowledged cause of death after operations in

¹ Billroth, "Surgical Pathology," p. 345.

² "On Hospitalism" (1874), p. 59.

hospitals is some of the forms of surgical fever—as pyæmia, erysipelas, phagedæna, etc.”¹

Erichsen further says, “The term pyæmia is used in a very wide and elastic manner, and by many is made to include various forms of blood-poisoning.”² This remark is especially true of the English writers. Thus G. W. Callender, under the head of “Pyæmia,” says: “It signifies little whence these matters are derived—whether from decomposing pus, unhealthy secretions, decomposing hides, dead bodies, vegetable putrefactions, or from animals suffering from acrid discharges, as in glanders; since the influence of all such, regulated by the intensity of the poison, for they vary in this respect, and by predisposing causes presently to be mentioned, may be conveniently described under two modifications.”³ The modifications here referred to are designated as *acute* and *chronic*.

American authors, much more than the English, are inclined to use the term pyæmia in the restricted sense. In fact, the German nomenclature has already been adopted in a great measure; and the present indications are, that at no distant day this perplexing question will be finally settled. A correct idea of the sense in which the Germans use this word may be derived from the following extract from Prof. C. Hueter, who says, “If we give to pyæmia, at the start, a definite scope, then we must regard suppuration as the *first* and *most necessary condition* for its existence.”⁴ The above remark is the foundation, and at the same time supplies the boundary, for the use of the term pyæmia by a large majority of German practitioners, although Prof. Roser divides the cases of septic blood-poisoning into four classes: “(1.) Traumatic sepsis (pure traumatic, primary traumatic sepsis). (2.) The poisoning with ichorous pus (secondary infection, self-infection). (3.) Infection from dissecting wounds and similar material (infected wounds). (4.) The specific zymotic septic process (hospital gangrene, carbuncle, cancer, etc.).”

¹ “Anæsthesia, Hospitalism,” etc., p. 350.

² *Loc. cit.*, p. 73.

³ Holmes’s “System of Surgery,” vol. i., p. 253.

⁴ Pitha u. Billroth, “Handbuch der Chirurgie,” 1. B., 2. A., 1. H., 1. L., 89. S.

“Stromeyer furnishes the following classification, viz.: (1.) A very rapid decomposition of the blood prior to the commencement of suppuration. (2.) Acute pyæmia with the commencement of suppuration. (3.) Subacute pyæmia. (4.) Chronic pyæmia.”¹

It will be observed that Stromeyer's classification does not differ materially from the one ordinarily used. The first order refers to septicæmia, while the second, third, and fourth indicate the varieties of pyæmia.

Roser's classification is intended to cover all cases of septic blood-poisoning, which may truly be viewed as a single chain composed of many links. Take, for example, a case of amputation of the thigh, followed within a few hours by traumatic fever, later by septicæmia; afterward there may develop secondary fever, formation of ichorous pus with absorption, and its concomitants, pyæmia, accompanied by embolism, thrombosis, abscesses in the lungs, liver, etc. To these may also occasionally be added phlebitis, inflammation of the joints, terminating speedily in suppuration. The chain may in this case be further lengthened or varied with traumatic erysipelas, hospital gangrene, etc. In fact, the variations in these cases are very numerous, and all these conditions, together with many others, are due to septic blood-poisoning. The nomenclature of septicæmia requires little attention here, although now and then we find the terms “septic fever” or “putrid fever” used in its place.

III. PATHOLOGY.—The study of the pathology of pyæmia may be advanced by adopting Hueter's classification, which is based on recognized post-mortem lesions, and designated pyæmia simplex and pyæmia multiplex. The pathological appearances in these forms of the disease differ widely, although the clinical symptoms are often similar. In pyæmia simplex the pathological conditions are essentially more negative. This variety of the disease can only destroy life by the height and duration of the fever, which is maintained by the absorption of the fluid or molecular elements of pus. There

¹ Pitha u. Billroth, “Handbuch der Chirurgie,” 1. B., 2. A., 1. H., 1. L., 40. S.

is found, as an essential basis of this form of the disease, extensive suppuration in the subcutaneous or subfascial tissues. We are not able to demonstrate the pyrogenous substance in the blood, since its chemical composition is unknown. It is supposed that possibly the pyrogenous material finds its admission into the blood with the pus-corpuseles, but still it remains to be proved that pus-corpuseles are thus admitted. The arguments in favor of the admission of the pus-corpuseles into the blood are as follows: 1. The blood in pyæmia is known to contain more white granular spherical bodies than are normal. The question has been raised, Are they pus-cells, or white-blood-corpuseles? The answer is difficult, and has not yet been attained. Virchow, in the mean time, has proved that we cannot differentiate, morphologically, between blood and pus corpuseles. 2. Cohnheim has demonstrated the existence of the wandering corpuseles in cases of inflammation. Therefore it appears probable that in cases of pyæmia the blood may contain the pus-corpuseles, but further investigation is needed to establish the fact. However, the establishment of this point would still have the more important one undetermined. Billroth supposes the pyrogenous substance exists in connection with the pus-corpuseles; but this may be justly questioned after the experiments of O. Weber and Frese. These experiments consisted in carefully filtering pus and then injecting the filtrate into healthy animals. It was found that these injections were uniformly followed by a marked increase in the temperature. Therefore, these investigators supposed that the pyrogenous elements of the pus are contained, at least in part, in its serum. There are other important changes observed in the blood of patients dead of pyæmia, to which I desire now to direct attention. The red corpuseles of the blood, even in the early stages of the disease, in many cases show signs of disintegrating into molecules, and are observed to be accumulated in masses without showing the slightest tendency to form roulettes. There is a steady increase in the number of pus or white-blood corpuseles in the blood of pyæmic patients, during the whole course of the disease, in fatal cases. The condition of the red corpuseles, already mentioned, becomes more and more marked toward

the fatal termination. In all cases of pyæmia multiplex the increased coagulability of the blood may be observed in the early stages of the disease, which steadily increases as the disease progresses. In pyæmia simplex this condition is less marked, although generally present; "while, e. g., we know septic poison diminishes or destroys the coagulability of the blood. Hereby the possibility is given, at least on the cadaver, to differentiate between pyæmia simplex and septicæmia; if, in the mean time, the study of the pathology of septicæmia was prosecuted even by comparison, since cases occur of the more fatal septic infection, in which the post-mortem condition is a complete, or almost complete, negative. Therefore the differential diagnosis on the cadaver must be limited to this, that we are able to demonstrate the existence of a purulent or ichorous deposit."¹ It will be readily observed that the differential diagnosis mentioned above relates to pyæmia and septicæmia, and not to the different varieties of the former disease. The following facts should be kept constantly in mind by the surgeon, to enable him to differentiate between the two forms of pyæmia. In pure cases of purulent infection without metastasis, the disease is called pyæmia simplex; and in cases with metastasis, pyæmia multiplex. The various conditions on which the metastasis may depend are shown by Hueter, who says: "The metastatic abscesses of pyæmia multiplex met with in the lungs, liver, spleen, and other internal organs, are regarded, with the greatest possibility, as a result of the embolic process. The metastatic inflammation of the serous membranes, of the cellular tissue, and of the parotid glands, and probably also a few metastatic inflammations of the internal organs, are at present supposed to arise from a general inflammatory diathesis."² It has already been shown, by numerous experiments on animals, that metastatic abscesses in the lungs, liver, and other visceral organs only arise after the introduction of ichorous pus, while healthy pus has uniformly failed to produce this result. I shall take occasion to refer to this subject more fully under the "Etiology of Pyæmia." It

¹ Pitha u. Billroth, "Handbuch der Chirurgie," 1. B., 2. A., 1. H., 1. L., 70. S.

² Ibid., 88. S.

now remains to be shown how the introduction of ichorous pus acts in the production of pyæmia multiplex. The ichorous pus, having found its way into the venous circulation, gives rise to the formation of thrombi in the veins; these clots become more or less broken up, and are carried forward by the blood to the right auricle; from this auricle to the right ventricle; from this ventricle to the pulmonary artery, and through its ramifications to every part of the lungs. In the minute ramifications of this vessel are found wedge-shaped clots of various sizes, in different conditions, some softened and others still firm. The possibility of these clots ever passing through the lungs, and afterward being arrested in other visceral organs, has been demonstrated on animals. It has been shown that fine particles of foreign matter, injected into the veins, have passed through the lungs, and subsequently lodged in the liver. This theory enables us to account for the existence of metastatic abscesses in the liver, which have apparently originated as the result of primary infection, but thus far only on a mechanical basis. In other cases these abscesses are supposed to arise from secondary infection. Thus ichorous pus, having found its way into the venous circulation, produces primarily venous thrombi, which, as in the other instances, break up, the clots being carried in the same manner into the terminal branches of the pulmonary artery, where they are designated as emboli. The first action of the emboli is the mechanical closure of these vessels, thus depriving the surrounding parts of nutrition, to a greater or less extent. It will be proper now to recall the fact that the composition of these emboli is such as to favor rapid suppuration; this commonly commences in the clot and surrounding tissues, having been preceded by a brief stage of congestion and inflammation. There is also occasionally found around these points more or less extravasation. The metastatic abscess thus found in the lungs is favorably situated for the production of secondary infection. From this abscess thrombi arise in the pulmonary veins, which become disintegrated, and are carried to the auricle, thence to the left ventricle, and finally through the aorta, and find lodgment in the terminal branches of the arteries of the various organs, where they produce the characteristic

trouble. The organs that most frequently become the seat of this secondary infection are the liver, spleen, kidneys, brain, and eyes. Let us now briefly examine this mechanical theory. Do metastatic abscesses arise from a single cause, or from a combination of causes? I am inclined to the opinion that the proximal cause of metastatic abscesses in the visceral organs is the existence of emboli in the terminal branches of arteries. The vitiated atmosphere surrounding the patient, the existence of a wound, and the formation of ichorous pus, are conditions which should not be lost sight of. These are the elements acting on the blood, producing in it morbid changes, and may therefore be regarded as the predisposing causes. The morbid condition of the blood, the increased number of white-blood-corpuscles (possibly pus), the disintegration and other changes in the red corpuscles, may be regarded as the exciting causes of metastatic abscesses. It is thus readily observed that emboli may form in the lungs and liver at the same time, or the origin of those in the lungs may precede the formation in other organs. Again, the formations may be limited to a single or exist in several organs at the same time. Is the formation of emboli in the terminal branches of arteries always dependent on the disintegration of thrombi? The answer to this question must, I think, be a negative, although in surgical practice it rarely happens that an embolus takes its origin from any other cause. In the large majority of cases, unquestionably, the thrombi primarily exist in the vicinity of the wound in which the ichorous pus is generated; but it not unfrequently happens, during the process of disintegration, that broken-up clots are carried forward by the current of blood, receiving accretions on the way, until finally they fill a large venous trunk. In confirmation of these facts relating to the primary origin of thrombi, it is said to have been observed, in epidemics of "puerperal fever" which were complicated with metastatic abscesses of the visceral organs, that the thrombi occurred in the pelvic veins. In case of wounds of the lower extremity the clot is frequently found in the common iliac vein, although probably it should always be regarded as a secondary formation. In rare cases the only thrombi discovered at the autopsy are found situated

far away from the injury. Billroth records the case of a young woman who died of phlegmonous erysipelas of the lower extremities, where thrombi were only found in the brain. Observation fully establishes the fact that pathological changes are much more frequently met with in the lungs than in any of the other organs of patients dead of pyæmia. This certainly strengthens the embolic theory. Billroth mentions eighty-three cases of true pyæmia multiplex in which the metastatic abscesses occurred as follows: seventy-five times in the lungs, seventeen times in the spleen, eight times in the liver, and four times in the kidneys.

“Prof. Sédillot, of Strasburg, who has studied this disease with great care, and who has combined the results of his observation in a highly instructive and interesting monograph, published in 1849, remarks that, in one hundred cases of pyæmia, we should find the lungs affected in ninety-nine; the liver and spleen in one of twelve, the muscles in one of fifteen, and the heart and peripheric cellular tissue in one of twenty; the brain and kidneys are comparatively seldom involved.”¹ The theory previously mentioned as the embolic relates to the aggregation of the fibrine into clots; but another theory has been recently advanced by E. Wagner, who “found in many cases the capillaries in the lungs filled with fat, and was inclined, from the direction it extended in these vessels, to explain a certain number of the pyæmic cases by the fat-emboli. Here arose the necessity for the experimental examinations of this question, which were soon undertaken by different parties. As still further pathological observations followed these experiments, so arose over the question of fat-emboli an extensive literature, to the analysis of which I cannot now give my attention. This condition is not very rare, especially after severe injuries of bones; and the medullary substance appears to be the most frequent source of the fat-emboli, although the fatty connective tissue, the collection of fat-drops in venous thrombi, etc., are also to be taken into consideration. The easiest method to produce the fat-emboli experimentally is by crushing a medullary cavity in animals,

¹ Gross, “System of Surgery,” vol. i., p. 150.

or otherwise by the direct introduction of fluid fat into the veins. We have satisfied ourselves, by such experiments, that fat-emboli destroy life only when the occlusions of the capillaries of the lungs are very numerous, and when the act of respiration is thereby greatly disturbed. Insignificant fat-emboli are easily borne. The existence of fat-emboli in pyæmia is therefore purely accidental, and has no characteristic significance. Multiple pyæmia very frequently occurs without fat-emboli, and *vice versa*; either process may complicate the other, and so the fat-emboli may acquire special importance by obstructing the respiration, and probably also in this way the embolic fat may serve as a carrier of a putrid and phlogogenous material."¹ Having already examined the theories pertaining to the various forms of pyæmia, and the general characteristics of this disease, as well as of septicæmia, we are now prepared to begin with the *post-mortem appearances of pyæmia multiplex*.

General Appearance of the Body.—Rigor mortis, commonly well marked a few hours after death; great emaciation, and other important changes, rendering the appearance of the body repulsive, and sometimes hideous.

Skin and Cellular Tissue.—The integument is flabby, pale, or occasionally of a deep icteric hue; sometimes sudamina, circumscribed ecchymoses, pustular eruption, irregular spots of a dusky color, gangrenous patches, etc. The cellular tissue in some cases is the seat of diffuse suppuration. The pus formed is generally thin, fetid, and unhealthy. This suppuration may be limited to certain parts of the body, as an injured extremity, or, as frequently happens, it may be found on the trunk and limbs at the same time. The pus in this form of suppuration is exceedingly apt to burrow, on account of the peculiarities of the tissues in which it occurs, and also the condition of the surrounding structures, especially the relaxed and flabby condition of the skin. These abscesses in some instances are superficial, in others deep-seated. The edges of the wound, after death, are of a blackish-green color, frequently showing evidences of the separation of a recent

¹ Pitha u. Billroth, "Handbuch der Chirurgie," 1. B., 2. A., 1. H., 1. L., 88. u. 89. S.

slough. The surface is usually dry, but may be covered with foul pus.

Muscles.—There are few changes which occur in the muscles, and none are uniform or constant. They are occasionally the seat of abscesses, and these have been observed in the heart, tongue, and other organs. They may be of a light-brown or greenish color, when they have been covered for a considerable time with pus, and are sometimes softened and pultaceous. Suppuration does occasionally take place beneath the fascia of the tendons.

Brain and its Membranes.—Neither the brain nor its membranes are constantly the seat of pathological changes, although congestion of one or more of its membranes is by no means rare, “particularly where death has been preceded by great dyspnœa.”¹ Occasionally there have been observed suppurative meningitis, engorgement of the venous sinuses, blood-extravasations on the surface of the brain, lymph-deposits on the membranes, softening of the cerebral tissues, circumscribed abscesses in the substance of the brain, which in some cases have been traceable to embolism of its vessels. The fluids in the ventricles may be either diminished or increased, and very rarely are found mixed with pus. The changes in the spinal cord and its membranes probably are similar to those found in the brain, but appear to have been rarely examined.

Eyes.—“H. Meckel first called attention to the fact that examinations of the eye in persons who died of pyæmia, which is certainly rarely enough performed, might lead to the discovery of pyæmic ophthalmia. Virchow found, in a few such cases, emboli of the retinal and choroidal vessels. Probably this would be proved correct by more industrious examinations of the eye, that these conditions are somewhat less seldom than, until now, had been supposed.”² “Arnott thus describes this affection of the eye: ‘There is redness of the conjunctiva, intolerance of light, and contracted pupil; rapidly followed by opacity of the cornea, and excessive chemosis. The eye ultimately sloughs, and its contents escape.’”³

¹ Pitha u. Billroth, “Handbuch der Chirurgie,” 70. S.

² Ibid., 71. S.

³ Braidwood on “Pyæmia,” p. 168.

Ears.—"The late Mr. Toynbee, in his admirable treatise on 'Diseases of the Ear,' relates several cases of 'purulent infection' following suppuration in the ear. 'Cases of disease in the mastoid cells terminate fatally,' he says, 'from two different causes: first, from purulent infection, arising from the introduction of pus into the circulation through the lateral sinus; second, from disease of the cerebellum or its membranes. Cases of purulent infection,' he further remarks, 'have not been met with when the disease occurs in the tympanic cavity.'"¹

Bones.—There are numerous changes, in pyæmic cases, occurring in the bones—probably from the fact that pyæmia results very frequently in cases of bone lesions; but these changes have very little diagnostic importance. The following have been observed: thickening, absence, or infiltration of the periosteum, which may be found to separate readily from the bone after the death of the patient; or there may be pus found between the periosteum and bone. In the bone-structure there are found caries and necrosis, "while in other cases the whole thickness of the 'compact' tissue is perforated in a honeycomb-like manner by minute cavities, filled with thickish pus, or caseous matter of a pinkish-white color."² "To sum up—the chief morbid alterations met with in the bones are, congestion, dilatation of the Haversian canals, and cancellated tissue, leading to abscess formation, and the excavation of cavities by the unhealthy pus."³

Joints.—The pathological lesions of the joints commence with marked congestion of the synovial membranes, increase of the synovial fluid, and afterward the fluid is mixed with pus; these conditions are followed by erosion of the cartilage and ligaments, the former thus becoming separated from the bone. Both the large and small joints are occasionally the seat of morbid changes.

The Glandular System.—Lymphatic glands are only secondarily affected in pyæmia, and even this takes place very rarely. The changes, when observed, are similar to those

¹ Braidwood on "Pyæmia," pp. 168, 169.

² *Ibid.*, p. 192.

³ *Ibid.*, p. 194.

which happen in the other tissues of the body, viz., congestion, inflammation, and suppuration.

Blood.—The changes in the blood have been so fully detailed in other portions of this article, that it is now thought unnecessary to enter again on the subject. The arteries are usually found empty after death from this disease, and the coats are sometimes apparently thickened. The veins are commonly found, on the contrary, filled, or even distended, with firm fibrinous clots. They are also sometimes found inflamed or altered, although commonly healthy. The distended condition of the veins gives rise to the cord-like feeling often mentioned by different observers. In some cases of phlebitis there may be pus deposited between the coats of these veins. The thrombi are occasionally observed as firm fibrinous clots, but they are frequently found, in the rapidly-fatal cases, to have undergone suppurative changes. These changes begin in the centre of the clots, which often contains true pus, or a greenish puriform fluid.

Pericardium and Pleuræ.—The pericardium occasionally contains a small amount of serum tinged with blood, but is rarely covered with recent lymph. “The pleuræ are generally inflamed in this disease, along with the pulmonary tissue proper. The costal and visceral layers are sometimes found firmly, even inseparably, agglutinated together by old adhesions. They are, however, more commonly united by recently-formed lymph, which covers more or less of their extent, and is easily broken down. Occasionally both sides of the chest, but generally one only, is the seat of this inflammatory process. The pleural cavities commonly contain some opaque, muddy, sero-purulent fluid mixed with blood and having masses of lymph floating in it.”¹

Lungs.—It has already been shown that the lungs, much more frequently than the other organs, are the seat of metastatic abscesses and other morbid changes in pyæmia multiplex. The theory of their formation and frequency are in complete accord. The following is a summary of the morbid changes in these organs :

¹ Braidwood on “Pyæmia,” p. 172.

Emboli in the branches of the pulmonary veins, metastatic abscesses surrounded with capillary congestion, and other evidences of inflammation. "The smaller vessels, trying to overcome this afflux of blood, may produce ecchymoses or extravasations beneath the lining membrane of the air-vesicles; but these minute capillary congestions are generally observed as red points studded over the pulmonary surface, which by-and-by exhibit yellowish-white or bluish-white centres. While one part, generally the lower half of the lung, is thus hepatized, solid, and of a dark-greenish color, the remainder of the lung is emphysematous, and more or less œdematous. A section of the former presents the same appearance as is observed in the lungs of pneumonic patients. Whether these incipient abscesses are developed from the minute points of congestion aforementioned by the breaking down of some thrombic clot in their centres, or whether the pus is developed out of the serum exuded by the walls of the engorged capillaries, cannot be easily determined, and has as yet not been decided. These secondary abscesses vary in size from that of a hemp-seed to that of a hen's-egg."¹ These are generally situated on the periphery of the lungs and in the lower lobe, although in some cases they are found imbedded deeply in the pulmonary tissue. The contents of these abscesses are similar to those found in other parts of the body in this disease. The bronchial mucous membrane is commonly of a bright pink color, while its secretion is increased in quantity, and may be clear and frothy. These conditions in this membrane are the result of acute bronchial catarrh. The peritoneal cavity may contain an increased quantity of clear or cloudy fluid.

Spleen, Liver, and Kidneys.—Billroth and Sédillot observed pathological lesions involving a solution of continuity in these organs, in the order in which they are mentioned above; other authors, however, assert that the liver, next to the lungs, is the most frequent seat of purulent deposits. Enlargement of the spleen is frequently met with in cases of pyæmia multiplex. The metastatic abscesses found in the

¹ Braidwood on "Pyæmia, p. 173.

spleen and kidneys are much smaller than those found in the lungs and liver, but in other respects are of a similar character. The capillary congestion and the accompanying infarctions require no special attention here. The liver, like the spleen, is sometimes enlarged, and at other times is found to have undergone fatty degeneration to a greater or less degree—in which condition its tissues are generally soft and friable. Abscesses in the liver are so much like those in the lungs as to need no separate description. The same may be said of the other pathological changes found in this organ in pyæmia multiplex. The abscesses found in the kidneys vary from the size of a hemp-seed to that of a bean, and are surrounded by the usual zone, marking, more or less definitely, the extent of the inflammation. The capsule is generally healthy. There are, also, in very rare cases of this disease, abscesses found in the stomach and intestines, involving the thickness of the mucous membrane; and it is further supposed that these abscesses may be found, occasionally, on any portion of the mucous membrane lining the alimentary canal. Post-mortem examinations in pyæmia multiplex have established the fact that there is no organ in the body but what may become the seat of the pathological lesions in this disease; but there is unquestionably a vast difference in the relative frequency of these changes in the various organs. It is now readily observed that the pathological lesions in pyæmia multiplex are so positive as to render further discussion of the subject unnecessary.

Pyæmia simplex may be readily mistaken for septicæmia, and *vice versa*. In both conditions the pathological appearances are, occasionally, nearly or completely negative. "The materies morbi occasionally induces death ere the local lesions have had time to manifest themselves."¹ I shall now attempt to point out the pathological peculiarities pertaining to each of these diseases, and also mention the important difference in origin, for the purpose of aiding in the determination of the differential diagnosis on the cadaver. I must therefore call attention to the fact that *pure septicæmia* is a disease which

¹ Braidwood on "Pyæmia," p. 164.

owes its origin to the absorption of *septic, not purulent, matter*. In all cases where there is absorption of both septic and purulent matter, the disease is properly called septopyæmia; and should the autopsy reveal the presence of metastatic abscesses, then we would immediately recognize the fact that there had been an absorption of ichorous pus and septic matter; while the non-existence of metastatic abscesses, under somewhat similar circumstances, would certainly imply the absorption of non-ichorous pus and septic matter. Pus is often rendered ichorous by the action of the atmosphere; therefore the pus exposed to this action may be regarded as possessing the power of producing metastatic abscesses. In other cases there may be extensive suppuration while the pus does not, at any point, come in contact with the air; and here the purulent absorption would fail to produce these peculiar lesions—metastatic abscesses—but might produce pyæmia simplex. This subject is further explained under the “Etiology of Pyæmia.” The question now arises, How soon after the receipt of an injury, or the performance of an operation, may pus form? Hueter, who has given much time and attention to the study of pyæmia and septicæmia, and who certainly has written the best monograph on this subject ever published in any language, thinks the formation of pus must require four or five days. It therefore becomes probable that, in all cases of blood-poisoning before the lapse of that time, the case is one of pure, unmixed septicæmia; after the lapse of this period there is always a possibility that the case is one of septopyæmia. We have previously mentioned the fact that septic poison diminishes or destroys the coagulability of the blood. Here is the important point in our differential diagnosis on the cadaver. In septicæmia there is at least *diminished* coagulability of the blood. In pyæmia simplex, generally, there is increased coagulability, with the other changes already noted.

Pyæmia simplex must take its origin from the development of pus in the patient's body, or the pus must certainly be brought in contact with a wounded surface. The existence of suppuration in any portion of the patient's body would certainly render doubtful the diagnosis of pure septicæmia. In

pure septicæmia there are no purulent deposits to be found on the cadaver. In pyæmia simplex there is a purulent deposit, or deposits, but these are generally excluded from the atmosphere. In both forms of septopyæmia there are purulent deposits, or at least there must be evidence of suppuration having taken place.

IV. ETIOLOGY. 1. *Pyæmia*.—It is said by Billroth that “the term septicæmia essentially depends on the etiology,”¹ and the same remark would apply with equal force to the term pyæmia. The latter term was first used by Piorry, and the disease is supposed to be due to the absorption of pus, or its constituents, into the blood. In fact, if we use the term pyæmia in the restricted sense in which it is now commonly employed by German and American authors, then it may be safely asserted that the origin of the disease has been *fully demonstrated* by an almost unlimited number of experiments. That pus, or some of its elements, produces this condition, is not denied by any observer; but there are many disputed points bearing on this question, and I regret that, for the present, I shall be obliged to limit myself by merely mentioning the same without giving either the experiments or arguments relating to them.

The injection of pus into living animals produces local, remote, and constitutional symptoms. The character of these symptoms depends largely on the kind of pus, laudable or ichorous, the quantity injected, and the site of injection. It will be readily perceived that, in cases where the pus is directly thrown into a vein, the local symptoms would be unimportant, while the danger of remote trouble—metastatic abscesses in the lungs, liver, etc.—would be very great; but, should the injection be made into the connective tissue, then the relations would be reversed. Constitutional symptoms may exist in both cases, but will differ in character and degree. In regard to the character of the pus, and its agency in the production of this disease, Billroth says: “The old view, that pyæmia is only induced when decomposed pus (ichor) is reabsorbed, is entirely erroneous. There are cases where decom-

¹ “Surgical Pathology,” p. 336.

posed, putrid pus enters the blood, and which present a combination of the symptoms of septicæmia and pyæmia (septo-pyæmia of Heuter)."¹

Dupuytren failed to produce metastasis by injections of pus into the veins of dogs; these results were confirmed by Boyer, who only obtained metastasis when he used ichorous pus in his experiments. The same results are recorded in the works of Günther and Sédillot, based on numerous experiments. Beck made fourteen experiments, very carefully, but did not succeed in producing metastasis in a single case. The same results are recorded by a commission of the Physiological Society of Edinburgh. O. Weber has recently shown, by extended experiments, that carefully-filtered pus will not produce metastatic abscesses in the lungs. Therefore it may be considered as proved that *fluid pus injected into the veins of an animal produces no metastatic points of inflammation*. It should not be supposed, however, that because injections of fresh (non-ichorous) pus failed to produce metastatic abscesses, it was therefore without results, as the earlier experimenters thought. Billroth and O. Weber have shown, by their recent experiments, that these injections are uniformly followed by fever, and if subcutaneous, by abscess; and further, that injections of fresh pus produce even a higher temperature than the ichorous; but the pus taken from cold abscesses has apparently very slight effects. The fresh, non-ichorous, dried pus was found to possess in a similar degree the power to excite inflammation and suppuration; even the removal of the albumen did not change its character or power. It will be observed that these injections caused not only local inflammation, but severe constitutional symptoms, as high temperature, etc. Unfortunately, thus far all the experiments made have completely failed to show the agent that excites the inflammation, although it is generally admitted that it exists, at least, in the molecular bodies. Virchow and Panum have shown conclusively, by their experiments on living animals, that the introduction of foreign bodies into veins—as powdered coal, wax-balls, and quicksilver—fail in all cases to produce metastatic abscesses in the visceral organs,

¹ "Surgical Pathology," p. 344.

or other symptoms of pyæmia. These foreign bodies were frequently found blocking up the terminal branches of the pulmonary artery, in some cases encapsuled; frequently resembling miliary tubercles, and occasionally surrounded by evidences of slight local inflammation, but in every instance without suppuration. The same experimenters, however, observed that the introduction of ichorous pus and decomposing animal tissue into the veins was attended with the formation of metastatic abscesses and other symptoms of pyæmia. They therefore conclude that the introduction of putrid animal substances into the veins and the further transport of the same to the branches of the pulmonary artery, produce metastatic abscesses, and that the origin of these deposits is independent of the mere stopping up of the branches of this artery. The occlusion of the blood-vessels in this diseased condition is a subject which has given rise to much discussion. Some of the earlier writers supposed this phenomenon constituted the disease pyæmia, while others believed it to be the essential cause. Prof. Roser says, "But the thrombus is, as can be easily proved, not the cause but only a symptom of pyæmia. If a surgical patient, e. g., one suffering with an injury of the head, is attacked by inflammation and occlusion of a large vein, perhaps the common iliac, then there are three different theories for the inflammation of the occluded vein, viz., Hunter's, Rokitansky's, and Virchow's. According to the old Hunterian phlebitic theory, the coagulation of the blood should be a result of the inflammation of the vein. On account of the circumstances under which the coagulation in the vein should have occurred, one represents that the cause must be an oozing of coagulable exudation from the inflamed walls of the vein. But pathological dissections, especially Rokitansky's, would not accord with it. Large veins were found plugged up without the existence of corresponding indications of inflammation, and frequently perfectly clear indications that occlusion preceded the inflammation. Consequently the occlusion of the vein was the primary condition, and this must be explained in some other way than by its inflammation. Rokitansky, in his theory, recognized an independent disease of the blood.

Certainly, had these diseased conditions of the blood been examined into, it would have supplied no theory for the explanation of the preceding facts. If it is recognized as correct that a primary disease of the blood is to be admitted, yet the coagulation of the blood in a large vein has not been traced back to it. It remained wholly unexplained why a single vein, especially one so large and strong as the common iliac, should become the seat of the local coagulation. The necessity of finding a local basis for the local coagulation could not be denied. For that reason it was greeted as a highly-desirable advance when Virchow pointed out that the occlusion of such large veins could be dependent on the coagulation of the blood in the concave spaces behind the valves of the veins, or through the coagulation in the small branches, e. g., the hypogastric vein, which is gradually carried forward until it reaches the common iliac, and by the continual increase this vein also may be filled up. At the same time it was demonstrated that not unfrequently, much oftener than was formerly supposed, the coagulated masses of blood are broken up and carried further on in the circulation, in this manner producing occlusion of the pulmonary artery or its branches.”¹ The examination of this subject finally brings Prof. Roser to this conclusion: “Contamination of the blood is essentially the primary cause of pyæmia; thrombosis is only a result of this morbid contamination, and cannot therefore be regarded as the cause of pyæmia—but only as an apparent part, as one of the symptoms of the same.”² The opinion here expressed by Prof. Roser I believe to be the one generally entertained by the profession at this time. This fact being admitted, the most important question presenting itself for our examination is, “How is this contamination of the blood produced?” A complete investigation of this subject would require the presentation of the entire subject of “Disease Germs; their Nature and Origin.” I shall not venture to enter on this disputed field, but shall confine myself strictly to that form of the disease arising from, or associated with, traumatic injuries. In

¹ “Archiv der Heilkunde,” erst. Jahrg., erst. Heft, S. 4.

² Ibid., S. 43.

these cases surgeons recognize two principal sources of contamination of the blood, viz., the wound itself and the vitiated condition of the atmosphere surrounding the patient: contamination in the first place directly from the wound through the blood-vessels; and in the second, by the passage of disease-germs, or the poisonous elements, into the blood along the respiratory tract. These germs may be generated in the wound, or be received into it from the surrounding atmosphere. The character of the wound and the conditions surrounding the patient thus become important subjects for the consideration of the surgeon. It has been observed, and is now generally admitted, that those wounds complicated with a fracture of the long bones of the extremities, opening large medullary cavities and extensive lacerations of the soft parts, always increase the danger of blood-poisoning. This fact may be more thoroughly understood by a brief consideration of the condition of the parts.

Frequently, in open fractures, large quantities of pus constantly remain in contact with the surface of the wound, detached fragments of bone, which become speedily necrosed, moving about with every motion of the injured limb, lacerating more or less the surrounding tissues, and thus exciting inflammation and suppuration. The periosteum becomes inflamed, a wide-spread *suppurative periostitis* is the result; necrosis of the bone, from insufficient nutrition, follows, while mechanical pressure on the pus aids in its absorption. The medulla frequently takes on this suppurative inflammation, and here the surgeon fails to receive a prompt warning of danger; slowly the suppuration progresses, without pain or other symptoms, unless the disease has extended to the other tissues; the medullary cavity, at the fractured end of the bone, may be completely or partially occluded by a new osseous formation; in such cases the absorption of pus by the comparatively large venous vessels of this cavity is greatly facilitated. The soft parts also may be the seat of dangerous trouble. The same force that produced the wound and fracture may have also contused the soft parts, destroying in a greater or less degree their nutrition, thus giving rise to gangrenous sloughs, or in other cases to the formation of

abscesses, etc. I will also call attention to the fact that the laudable pus in these cases is most favorably situated for a rapid change into that commonly called ichorous. The heat of the parts and the contact of the pus with the atmosphere will not fail to effect its rapid decomposition. The question may be with propriety asked here, "Is fatal pyæmia, independent of a wound, produced by breathing vitiated air?" The answer to this question must generally be a negative, although it is certainly true that poisoning of the blood does take place to a certain degree, as is abundantly shown by the different symptoms arising in patients thus exposed who are not suffering with wounds. It is said that dogs exposed in this way are found to rapidly emaciate, and suffer from severe and constant diarrhœa. The various symptoms arising in patients confined in the overcrowded and pus-infected wards, among which might be mentioned loss of appetite, with diarrhœa and emaciation, are too well known to require an enumeration here. Therefore it appears highly probable that living in and breathing a vitiated atmosphere may act as a strongly *predisposing cause*, only requiring a slight scratch or abrasion of the skin, in which the infection may be said to act as an exciting cause, to produce pyæmia. In reference to such complications the following questions are asked by Prof. Roser: "Is it a specific deleterious material, a miasmatic or contagious disease-poison, or, as it is generally expressed, a zymotic agent? Must we regard each particular typhus-like fever, with its remarkable changes of the blood, with its various localizations in all the organs and membranes, with its chill, furred tongue, petechiæ, delirium, etc., as we regard typhus, scarlatina, variola, etc.? or, as Virchow teaches us, is this pyæmia, so greatly feared by all surgeons, only an ontological idea? Is the word pyæmia only a general name for three different conditions, viz., leucocythæmia, thrombosis and embolism, or ichorrhæmia and septicæmia? or are there, as many have supposed, two ways in which pyæmia may originate? Is there one primary miasmatic pyæmia analogous to the other epidemic, so-called zymotic diseases? and again, a secondary pyæmia arising from suppurative inflammation wherein the poison is formed in the patient's own body which

is infected by a single organ?"¹ That this disease is caused by a *specific deleterious material*, in the large majority of cases, is no longer a question for discussion. The only question to consider is, whether it always arises from this cause. We must necessarily admit that spontaneous cases do occur, especially if we include in our classification of pyæmia puerperal fever and erysipelas. Are there really any cases of sporadic origin, or are they always due to endemic or contagious influences? No definite answer can be given to these questions, although undeniably the weight of argument is opposed to a sporadic origin. The true miasmatic, as used by Prof. Roser, probably refers to the vitiated condition of the atmosphere, as seen in the overcrowded surgical and obstetrical wards of hospitals. In no other sense can the word be appropriately used in connection with the subject of pyæmia. It is true that pyæmic diseases are found to prevail at certain seasons and in certain localities much more extensively than under other circumstances. The same, however, is true of cholera, typhus fever, scarlatina, variola, and other contagious diseases. That pyæmia is contagious has been frequently demonstrated. I therefore conclude that the prevalence and spread of this disease must be explained by the same rules as are applied to the existence and propagation of these allied affections.

2. *Septicæmia*.—The etiology of septicæmia primarily involves two essential facts, viz.: (a) the development of putrid poison, and (b) its reception into the blood. That the origin of this disease may be more easily understood, it may be advantageous to examine the circumstances under which it too frequently occurs. Take, for example, a patient who has received a compound comminuted fracture of the leg, necessitating amputation of the thigh. The amputation is performed a few hours after the injury; the flaps are closed, after which some oozing takes place which is mechanically retained within the flap, where the warmth of the parts and the presence of the atmosphere are favorable conditions for a rapid decomposition of this effused blood. Here we have a very rapid

¹ "Archiv der Heilkunde," erst. Jahrg., erst. Heft, S. 39.

formation of the putrid poison, and further examination shows a condition highly favorable to its speedy absorption. It is a fact recognized by all surgeons that opening the medullary cavities of long bones is an invitation to putrid poison to enter the circulation; but here we find not only an invitation, but compulsion, in the form of pressure. The flaps are nicely approximated, this approximation aided by sutures and straps of adhesive plaster—conditions facilitating the agglutination of the lips of the wound which speedily follows. Other conditions which undoubtedly act as predisposing causes are, a fresh wound and the lowered vitality of the patients due to loss of blood, shock, etc. In reference to the former condition, C. Busch has shown by experiments on animals that a rapid absorption of colored oil, which as a test he injected into the medullary cavities, took place in the lymph and blood-vessels.¹ Cases answering the above description are still occasionally seen, and, should septicæmia fail to develop within forty-eight hours, it certainly could not be attributed to good surgery. Probably it is very rarely the case that all, or even a majority of the conditions detailed above, are present, but they exist in a modified form; for instance, they frequently occur in cases of compound fracture of the long bones, with or without contusion of the soft parts, with or without extravasation into the cellular tissue, during an effort to save the limb. This putrid poison, the existence of which in the blood is a *conditio sine quâ non* for the production of septicæmia, is supposed to act as a ferment in the blood, so deteriorating it that it cannot perform its physiological functions. The disease may be induced in animals at any time by the injection of putrid animal or vegetable substances, and Hemmer declares in regard to the intensity of its action that it can only be compared with woorara and the poisonous bites of snakes. Further, other experimenters have shown that the intensity of action principally depends on the quantity of poison introduced into the circulation; hence injections made into the connective tissue are less fatal than those directly into the veins. Granulating

¹ Pitha und Billroth, "Handbuch der Chirurgie," 1. B., 2. A., 1. H., 1. L., 28 S.

wounds may be with impunity covered with putrid substances so long as the granulations are not destroyed.

Healthy integument and mucous membranes resist the absorption of putrid materials, while, on the contrary, fresh wounds permit absorption to take place readily, and it may be greatly facilitated by pressure. The question has been frequently discussed, in relation to pyæmia and septicæmia, whether molecular bodies ever sufficiently enter the circulation through healthy tissues to act as ferments in the blood. Billroth says: "That deleterious, infectious matters may also enter the body otherwise than through wounds, especially through the lungs, cannot be doubted; we explain to ourselves thereby, in fact, the origin of all infectious diseases, that substances find their way into the organism which act as organic poisons upon the blood and upon the whole organism; but whether these disease-elements which cause the infectious diseases occurring chiefly in the wounded enter the organism otherwise than through the wound is a question the answer to which must depend very much upon the particular interpretation of the cases observed."¹ That septicæmia may arise from an ulcer, covered by necrotic tissue, in the alimentary canal, or from a similar condition in the respiratory tract, is undoubted. The fact that many questions pertaining equally to the etiology of septicæmia have already been discussed under the etiology of pyæmia, has caused their omission here.

V. SYMPTOMS. 1. *Pyæmia*.—The symptoms which pyæmia in its various forms give rise to are numerous and not easily described. Therefore it is necessary that the surgeon keep the fact constantly in mind, that this disease depends on *suppuration, cannot exist without it*, although it does not follow that in every case of suppuration there will be pyæmia; but it does follow that in every case of pyæmia there must be a vitiated condition of the blood, due to pus or its elements. Taking the natural order in which the symptoms occur, I shall begin with the chill which commonly announces the commencement of a new era in surgical cases—one of extreme

¹ Billroth's "Surgery," vol. i., p. 218. "New Sydenham Society Translations," vol. lxxiii.

danger to the patient, and the occasion of great anxiety on the part of the surgeon. The importance that will naturally be attached to this phenomenon must, to a certain degree, depend on the circumstances attending its occurrence, and therefore the following question will present itself: "Is the chill associated with suppuration?" A negative answer to this question, based on the fact that insufficient time has elapsed since the occurrence of the injury to render suppuration possible, can never fail to be a source of satisfaction to the surgeon whose experience has taught him to dread pyæmia.

Prof. Billroth has observed, in 83 cases of true multiple pyæmia, that 62 commenced with a chill, and 21 without; in 81 cases of septicæmia and simple pyæmia, 24 commenced with a chill and 57 without. The number of chills in each individual patient occurred according to the following table:

Number of patients,	19	21	14	15	9	5	2	3	4	1	1	1
Number of chills,	1	2	3	4	5	6	7	8	9	10	13	14

In one patient, during three weeks sixteen chills were observed, and sex appeared to have no influence on the number; but probably the longer the duration of the disease the greater is the number of chills. Still there are chronic cases with a single chill, and acute cases with many. It rarely occurs that a patient has more than one chill in twenty-four hours. Billroth noticed among his patients only 16 who each had two chills, and only six who each had three chills, in one day. The experience that fewer chills occur during the evening and night than in the morning and afternoon has been confirmed by statistics. Among 287 chills, 220 occurred from 8 A. M. to 8 P. M., while during the night, from 8 P. M. to 8 A. M., only 67 were observed. By this striking division of the twenty-four hours, Billroth desired to take into consideration the daily exacerbation, the usual daily irritation of the wound, the bandaging, and other manipulations. He saw, for example, a chill occur three times from the introduction of a sound, and twenty times after opening an abscess. The time which elapsed from first injury to first chill is seen by the following table:

First chill began, times,	14	19	15	9	4	3	2	4
In the week,	1	2	3	4	5	6	7	8

Patients who had fever before the operation were more inclined to early chills than freshly-injured healthy individuals. Billroth's experience was to have only the first chill before the end of the first week.¹ It may be further stated that nervous, irritable patients suffer much more frequently from chills than those of a phlegmatic temperament. This fact has given rise to the opinion that the absorption of pus acts especially on the central nervous system. The chills in pyæmia are supposed by Billroth to be associated with inflammation, and he says: "It must be mentioned, as a matter of observation, that chills occur almost exclusively in the commencement of acute inflammations, and are intermittent only in intermittent fever and reabsorption of pus, while they do not occur in acute septicæmia."² But the fever in pyæmia rarely entirely intermits; it is generally lower, however, in the morning than in the afternoon. This symptom is even more important than the rigors in enabling the surgeon to make a correct diagnosis. The use of the thermometer enables us to determine, at will, the presence or absence of fever, and there is no disease in which it should be more frequently used than in the one now under consideration. Let it, however, be remembered that the temperature frequently becomes very high within a few hours after the receipt of an injury, or the performance of a surgical operation; that this high temperature is due to septic absorption and the diseased condition we designate septicæmia. Another condition, less marked, with an elevated but somewhat lower temperature, is usually spoken of as traumatic fever. In both the conditions already mentioned the fever may gradually increase for a few days, or possibly only hours, and then slowly disappear. The patient, on or before the tenth day, in favorable cases, will be found to be free from fever. It will now be observed that sufficient time has elapsed for the formation of pus, and the patient may, with or without a chill, be again attacked with fever. This fever, if moderate, may be designated as secondary fever, and, if more marked in

¹ Pitha und Billroth, "Handbuch der Chirurgie," 1. B., 2. A., 1. H., 1 L., 97 und 98 S.

² "Surgical Pathology," p. 344.

its character, as pyæmia. Again, in cases of severe, acute septicæmia, the patient may die before the lapse of sufficient time for the formation of pus, or, as occasionally happens, before the disappearance of fever. Associated with the septicæmia, the system becomes contaminated still further by the absorption of pus, thus producing a condition appropriately called septo-pyæmia. One important peculiarity of the temperature in pyæmia is the sudden and great changes; thus, at one hour the temperature may be but slightly raised above the normal, and at the next the thermometer may mark 105° Fahr. These sudden changes of temperature, in this disease, are of frequent occurrence, are not observed in other diseases, and therefore supply a very important diagnostic indication. It is impossible to know, or even to anticipate with any degree of certainty, when the highest temperature will exist; consequently, Prof. Billroth and other writers have suggested the desirability of having a thermometer constantly kept in a position to indicate every change in the heat of the body, and a careful attendant to note the same; but, thus far, I am not aware that it has been attempted, probably on account of the inconvenience it would entail on the patient, and the additional labor in nursing. It has been further observed that, during the existence of a chill, the temperature continues to steadily increase, and the highest seen during the whole course of the disease is attained during the hot stage which immediately follows the rigors. "This condition is followed by profuse, cold perspirations. The perspirations which accompany this disease are most profuse, like those of advanced phthisis. They never precede the rigors, but may occur independently of them. They either are continuous in their duration, or exhibit more or less distinct exacerbations. They are occasionally accompanied by sudamina and they do not abate with the use of any known remedy. . . . Occasionally perspiration is scanty; but, before death, a cold, clammy sweat and a 'tawny' discoloration of the skin occur."¹

Besides the sudamina, there are frequently observed on the skin vesicles, pustules, and boils, purpuric patches, and

¹ Braidwood on "Pyæmia," p. 112.

various discolorations. There is frequently observed to arise in the neighborhood of the wounds a reddish, erythematous blush, which soon extends to the whole limb, and commonly begins to disappear in the early part of the second week. This recently occurred in a patient under my care, and was speedily followed by an abscess of the knee-joint. The wound was situated at the hip-joint: at this point—on the lips of the wound—the first change in the color of the integument took place. It extended rapidly downward until it covered the foot, and even the toes; but the extension upward was slight, not much above the nates, on which there was situated at the time a bed-sore. It observed the same order in passing off as in coming on, viz., where it first made its appearance it first disappeared. The superficial veins leading from the wound were inflamed and cord-like. This condition of the integument and the abscess of the knee-joint were followed by diarrhœa, on which medicines had no beneficial effect. Diarrhœa continued, with occasional vomiting, until the death of the patient. The pulse in pyæmia is variable—often nearly normal as regards frequency, and at other times very frequent. It has been remarked, in some cases, that the pulse seldom rose above 90 per minute, until near the fatal end. The pulse, although only moderately accelerated at the commencement of the disease, always becomes more rapid, frequent, feeble and irregular, toward the termination of the unfavorable cases; while in cases of recovery it returns gradually to the normal standard. In all cases in which the blood has been examined during the progress of pyæmia, the examiners have agreed in regard to the extreme coagulability, diminution of the number of red corpuscles, and the increase of granular spherical bodies. The red corpuscles, even in the earlier stages of the disease, show evident indication of disintegrating; but, as the disease progresses, the microscopical examination steadily confirms, with increasing proofs from day to day, that the first idea was correct. There is a steady diminution in the number of red corpuscles, a steady increase in the number of pus- or possibly white blood-corpuscles. Epistaxis occasionally occurs, and also venous oozing from the wound. The condition of the tongue in pyæmia may be

regarded as an important symptom, indicating the state of the alimentary canal; not, however, during the prodromal stage, but after the disease has progressed a few days. It is then observed that the tongue has become peculiarly smooth, dry, and frequently excessively red. This smoothness is caused by the collapse of the papillæ, and the dryness by a diminished secretion.

The organ now frequently appears as though covered with a thin layer of collodion, which had been caused to dry on the surface, presenting something of a glazed look. Again, the tongue may be covered with brown crusts, and the teeth with sordes. These brown crusts and sordes are usually seen in advanced cases, following the first condition described. Much importance is attached to these brown crusts by many experienced surgeons, and although there may be very marked improvement in all other symptoms, still they insist on a very guarded prognosis until the tongue has assumed a healthy appearance. Aphthæ on various parts of the mouth and pharynx are frequently present in chronic cases and absent in acute cases. Herpes of the lips sometimes occurs in the commencement of the disease; vomiting is comparatively rare; but there is, even in the early stages, a complete failure of the appetite, with great thirst. Singultus is rarely present, possibly never in genuine pyæmia, but frequently in septicæmia, and occasionally in septo-pyæmia. Diarrhœa is not so frequent, or the stools so copious, in pyæmia as in septicæmia. Billroth observed, in one hundred and eighty cases of pyæmia, thirty-two cases of diarrhœa. It is impossible to determine whether these cases in which the diarrhœa occurred were pure or mixed pyæmia. The stools are generally of a pappy consistence, and often passed involuntarily in bed. There are, however, severe cases of pyæmia with a high fever, accompanied by obstinate constipation, which requires the administration of cathartics. Examination of the heart may, in rare, exceptional cases, show the existence of pericarditis, although usually the only indications of disease are the too feeble sounds. Auscultation and percussion over the lungs, even in cases of diffuse metastatic abscesses, are frequently unsatisfactory, for the same reasons as in miliary tuberculosis. The large depos-

its in the lungs are by these means readily determined. There may be a sensation of suffocation, the pneumonic sputa, the friction-sounds of pleurisy or pleuritic effusion; and the existence of these symptoms would materially aid in the diagnosis of metastatic abscesses. Enlargement of liver and spleen may be determined before death, and in connection with other symptoms would aid in diagnosing deposits in these organs. The urine in the first stage of the disease is scanty, high-colored, contains a large amount of salts, and is of a high specific gravity. Epithelial, fibrinous, and blood casts, and albumen, are also occasionally found in it during the course of the disease. Billroth mentions a case in which there was complete suppression, with uræmia. In many cases of pyæmia, suppuration of the joints, one after another, takes place with great rapidity and with comparatively little pain; but occasionally some swelling, redness, etc., are present. In most cases these suppurations are easily diagnosed. Instead of the suppuration taking place in the joints, there are cases in which it occurs in the cellular tissue; and I have recently seen a case where abscess after abscess formed with such rapidity that within a single week the patient was literally covered with abscesses, from the crown of his head to the soles of his feet. Delirium generally exists during some stage of the disease, more frequently the last; is then mild in its character, although active delirium has been observed in the first stage. Patients are low-spirited, and very apprehensive of death. The face at the beginning of the attack may be flushed or pallid, and toward the end becomes careworn. The breath sometimes has a "sweetish" or "purulent" odor. The patient rapidly emaciates. The changes in the wound are in some cases very marked, even in the first stage of the disease. The suppuration, which has been previously free and healthy, may suddenly be checked, the wound becoming dry. The discharge, if it continues, becomes scanty, thin, ichorous, or greenish. The granulations, if previously healthy, soon slough. These changes may not always appear in the first stage, but, should they not then take place, they may be expected later in the disease.

Summary of the Symptoms.—Suppose that a patient, suf-

fering with a compound fracture of the leg, has been admitted to a ward in a hospital in which this disease is prevailing. The surgeon is determined to save the limb, if possible. The dressings are carefully applied, the wound frequently cleansed, and the patient appears to be doing well, until the twelfth day, when he is suddenly seized with a chill, which is followed by a high fever and profuse sweating. The countenance shows anxiety; the patient is evidently depressed; the face flushed; the conjunctivæ congested; the pulse frequent; he complains of great thirst; and his breath has a sweetish odor. Several days have elapsed—the temperature of the body has been taken very frequently, and always found above the normal. There is now observed a dusky and icteric discoloration of the skin; tongue peculiarly smooth, red, and glossy; disinclination to take food; frequently bronchial, pleuritic, or pneumonic symptoms now make their appearance, or the patient may complain of pain in some joint, which an examination will show to be slightly tender to the touch, œdematous, and the integument over it slightly reddened; abscesses quickly form. The wound assumes an unhealthy appearance. The discharge from it either ceases, or is changed in character. Granulations, slough, and abscesses, now form in the cellular tissue with great rapidity. Diarrhœa may make its appearance; if so, the stools are passed involuntarily. The patient loses strength, and rapidly emaciates. At this stage of the disease he remains in an unconscious condition, and death soon closes the scene.

2. *Septicæmia*.—The symptoms of septicæmia may be sketched as follows: A patient is admitted to the hospital with a severe injury of the leg, requiring an amputation of the thigh. The amputation is performed, and the flaps are closed. The surgeon visits the patient twenty-four hours after the operation, and finds the pulse frequent; tongue, lips, and throat dry; skin hot, and the temperature of the body high. The patient replies accurately to questions, but with some hesitation. He is much inclined to sleep; has entirely failed to take nourishment; drinks frequently when aroused from his lethargic condition; and has vomited everything taken into his stomach since the operation. The dressings are now removed from the stump, when the foul odor of putrefac-

tion greets the attendants. It is observed that there is considerable discoloration of the flaps, the edges of which are blackened. Above these blackened edges the integument is reddened, and slightly œdematous. The sutures are cut, and there escapes a few drachms—possibly ounces—of highly-offensive, odorous fluid, the decomposed remains of blood, etc. Further examination of the flaps on their inner surface shows that their capillary circulation has ceased. The tissues, instead of presenting a life-like appearance, are now of a very dark brown color and occasionally mottled with dull grayish spots, although the movements of the ligature at the point where it embraces the femoral artery show that the blood still rushes against the artificial boundary. Let us now leave our patient, without further comment, for the next forty-eight hours, when we will resume the examination. We now find the same dryness of the mouth that was previously noticed; the pulse is more frequent, and has become very feeble; he complains of much thirst; has vomited frequently; taken but very little nourishment, and that only at the urgent solicitation of the attendants. The temperature of the body is higher than at the former examination; has been steadily increasing; in the morning it is lower, however, than in the evening of the same day. The patient is lethargic; is suffering with a profuse diarrhœa. The odor of the stools is highly offensive: they are properly described as rice-water evacuations. Abdomen tympanitic, body bathed in perspiration; respiration rapid; slight bronchial symptoms; urine scanty, high-colored, and contains albumen. The examination of the stump shows that gangrene has extended rapidly, involving not only the flaps but a portion of the adjacent tissues. The stench arising from the wound is almost stifling. The decomposing fluids are continuously dropping. That portion of the thigh not already gangrenous is now very œdematous; the integument over it is much discolored, being of a dark, icteric, or reddened hue. We now allow twenty-four hours to elapse, and then make our final examination. The patient's tongue more moist, body still bathed in perspiration; eyes dull; conjunctivæ icteric, and the same hue extends to the body, though in a less marked degree; pulse very frequent, feeble, and not easily counted;

temperature below normal. Singultus is now present, and has been, during the last twenty-four hours, very troublesome. Bronchial symptoms, combined with marked symptoms of œdema of the right lung; diarrhœa the same; gangrene still extending.

It must be admitted that the report here offered shows only the symptoms that are found in a single class of cases. These symptoms vary much in different cases, and the variations are especially marked in the acute sepsis maintained by Maisonneuve, under the head of "Gangrene Foudroyante." In these cases there appears, immediately after the receipt of an injury, enormous œdema about the wound, which extends rapidly in every possible direction, followed by the death of the patient within a few hours, unless prompt measures are adopted. The puncture of the cellular tissue, or of the blood-vessels involved in the œdema prior to the death of the patient, gives rise to the escape of a highly-offensive gas. Roser mentions a case of this disease in which he promptly amputated the limb of the patient through the healthy parts without even waiting for the administration of an anæsthetic, and the patient recovered. The symptoms of septicæmia must, necessarily, greatly depend on the condition of the patient and the amount of septic material introduced. But it is not deemed necessary to dwell longer on this subject. The intelligent surgeon has little difficulty in making the differential diagnosis in pyæmia, septicæmia, and septo-pyæmia. The chill at the commencement of pyæmia may possibly be mistaken for the chill of intermittent fever; but the proper use of the thermometer cannot fail to correct this error. It will be remembered that in cases of intermittent fever there is, usually, a distinct intermission; but in pyæmia the fever is constant, with a tendency to exacerbations. Again, the chills of intermittent fever occur usually at regular intervals, while in pyæmia they are irregular.

VI. TREATMENT. 1. *Pyæmia*.—The treatment of pyæmia and septicæmia necessarily opens the whole question of surgery as it pertains to the management of wounds. The prevention of these diseases is of primary importance, and he who desires to save the greatest number of lives possible is,

therefore, compelled to use all available means for the accomplishment of this object. The knowledge that the profession now possesses in regard to variola and its management teaches us an important lesson. The prevention of both pyæmia and septicæmia is probably within the scope of possibility in the large majority of cases; but the cure of the affection when fully developed is always doubtful and frequently impossible. Every surgeon will readily admit that, were it possible to secure union by first intention in all cases of wounds, then it would be impossible for either septicæmia or pyæmia to occur in surgical practice. Therefore it follows that the character of the wound, the method of operation, the surroundings of the patient, and the character of the treatment, thus become proper points to consider in this division of the subject. The character of the wound and its relations to pyæmia and septicæmia have already been briefly referred to under the etiology of these diseases. The various methods of operating, their respective advantages and disadvantages, require more consideration than space will admit of here. The surroundings of the patient is a subject of vast importance in a prophylactic view, and should never be lost sight of in the construction of hospitals. I desire here to express my firm conviction that surgical pyæmia is *essentially* and almost *wholly* a hospital-disease. It is true there are some eminent surgical authorities who deny its contagiousness, but this denial seems to me a mere quibble—opposed to the etiology and history of the disease. The question of surroundings for the patient presents to my mind the following demands as *sine quæ non* for obtaining the best possible results in surgery:

- (1.) Absolute cleanliness. This demand should be strictly enforced in regard to the wound, the patient's body, the bedding, and everything else, including nurses and instruments.
- (2.) Absolute purity of the atmosphere.
- (3.) Moderate and equable temperature, containing a proper amount of moisture.
- (4.) Proper quantity of nutritious and easily-digestible food, with suitable drinks, etc.
- (5.) Cheerful and pleasant surroundings, especially in companions, nurses, and other attendants. It may be objected to these conditions that they can never be obtained. I must confess that perfection in every

detail cannot always be attained, but I am thoroughly convinced that he who makes a determined effort in this direction will succeed far better than that person who is constantly looking about for some excuse for his negligence. The overcrowding of surgical wards with severe surgical cases, especially where the ventilation is defective, is only one step removed from homicide. I remember a small ward, crowded with the worst surgical cases which could be conveniently collected, in which there was less than six hundred cubic feet of air to each patient, and this in mid-winter, with no other means of ventilation than that furnished by lowering or raising the windows; the odor of pus constantly pervaded this ward in spite of fruitless attempts made every day to purify it; the windows were frequently lowered by the attendants, but very quickly closed by some of the patients. The result was here, as had been anticipated, an outbreak of pyæmia, which carried off three of the nine patients. There should be allowed to each surgical patient, while there is considerable suppuration still going on, two thousand cubic feet of air, and more if possible. The ventilation should be so arranged that neither the patient nor the nurse can change it. The ventilation ought to be wholly under the control of the attending surgeon. There are very few surgeons who give to these important matters the time and consideration that they should receive, and few who accomplish here as much as they might. The question of treatment brings up the entire subject of antiseptics. The favorite remedies of this class are carbolic and salicylic acids, permanganate of potash, chloride of zinc, and liquor sodæ chlorinatæ. There is no doubt that good results may be obtained with any of these remedies. Much more will depend on the manner in which they are used than on the remedy itself. The surgeon should never forget that he uses medicines merely as agents to enable him to accomplish certain objects, and, keeping these in mind, he need very seldom fail with his antiseptic when the object is to prevent putrefaction in an open wound. He should at all times, by the proper use of the senses of sight and smell, be able to decide promptly whether or not the antiseptic is accomplishing the work. In certain cases, while

using certain antiseptics, it will be found advantageous to keep up constant irrigation; and in other cases, by certain methods of treatment, the antiseptic is stored up for gradual use, as may be required.

Therefore, it appears certain that each method of treatment may possess special advantages in particular cases, and probably the same may be said of the antiseptic itself. The importance of this subject may be more fully appreciated when it is remembered that it is generally admitted by the best surgical authorities that more lives are lost from septic infection than from all other causes combined during a war. The further consideration of this subject may be arranged for convenience under the heads of local and general treatment. The local treatment of the wound should, if possible, be of such a character as to prevent the absorption of either putrid substances or pus. It, therefore, becomes highly important, in cases of amputations and other operations, that all tissues injured to such a degree as to be likely to excite either putrefaction, irritation, or inflammation, should be removed. The same care is necessary in removing all foreign bodies from the wounds in cases where no operation is performed. The amputation of the injured limb may be necessary to prevent the development of these diseases, or may be resorted to in certain rare cases after the origin of pyæmic symptoms; however, in the latter instance great care should be taken to remove all the tissues already infiltrated with serum, otherwise nothing will be gained. The use of the surgeon's knife at the proper time may be the best prophylactic measure against both pyæmia and septicæmia, but this measure should be directed by an intelligent mind, and the instrument guided by a practised hand. Again, it is found that opening a large medullary cavity is attended with danger to the patient. This fact teaches an obvious lesson. The wound existing, or the operation having been performed, the surgeon now turns his attention to the prevention of putrefaction and inflammation. The first source of danger requiring attention from the surgeon is the fluid escaping from the wounded surface. Do not allow it to undergo putrefaction in contact with the wound. Whether or not there is danger to be apprehended from in-

flammation, depends largely on the character of the wound: contuso-lacerated wounds are especially liable to become inflamed, and many other varieties, only in a less degree. The use of sutures is a question to be decided in each particular case. The same may be said of the use of antiphlogistic remedies. The question having been decided in favor of their use, then comes the selection of the special remedy. Prof. Billroth has recently given this subject much thought, and thus records his opinion: he inclines to the belief that the bath may be properly used in the treatment of contuso-lacerated wounds confined strictly to the hands and feet. Here the patient finds comfort when the temperature of the bath is properly regulated and the limb allowed to float in the water. In the majority of cases he prefers the use of ice either with or without the ice-bags. He found that the application of ice to a limb lowered the general temperature of the body, diminished the size of the capillaries in the diseased parts, and retarded putrefaction, also lessening the absorption of putrid substances and limiting the extension of inflammation. He also claims that wounds heal kindly even during the continuation of the treatment. There are cases in which the use of leeches may be advantageously resorted to for the purpose of relieving inflammation. Warm poultices may be used for the purpose of effecting a more speedy removal of the necrotic tissues covering the surface of the wound than would otherwise take place, but it should never be forgotten that the "poultice is a means of applying continuous heat with moisture, and of softening the tissues. An afflux of blood takes place to the parts, the vessels dilate, the tissues, softened by the combined influence of heat and moisture, permit the easy diffusion of fluids. . . . Foul-smelling wounds requiring the use of poultices are best treated with the yeast or charcoal poultice. . . . The application of poultices sometimes degenerates into abuse. If too long continued the skin becomes white, wrinkled, and sodden, small abscesses or boils form, and the vessels of the parts very slowly regain their tone. If kept too long in contact with wounds or ulcerated surfaces, the granulations become pale and flabby, and the healing process is retarded. Applied indiscreetly to inflamed joints, they may

promote suppuration, and thus permanently injure these structures. If kept long in contact with a large extent of surface, they will lower the general tone and vigor of the system, depress the systemic circulation, exhaust the irritability of the vaso-motor nerves, and thus seriously embarrass the reparative process, if not wholly prevent repair."¹

It appears probable that more injury than good results from the use of poultices in cases where there is reason to fear pyæmia. I think, in all such cases, the use of the poultice should be limited to the cleansing of the wound by hastening the removal of necrotic tissues, and am satisfied that the practice of wrapping the whole arm or leg in hot poultices, in cases of cellulitis arising in connection with septic absorption, is highly *injurious, especially when continued for a long time*. Free scarification of the integument where there is great tension of the parts may possibly become necessary for the purpose of relieving pain and aiding the circulation; but the surgeon should not forget here that he is opening new avenues for the admission of the poison. Abscesses should be opened as soon as discovered, in the majority of cases, because of the pain and fever caused by them. Tincture of iodine is serviceable, in certain stages of inflammation, as a local application. Caustics may be used to aid Nature in throwing off a slough, and occasionally as a stimulant to an indolent wound which fails to granulate properly. Healthy granulations should never be destroyed lest their destruction should open other channels for the admission of the septic poison in the system. Drain-tubes may be required to prevent any accumulation of pus within the wound. It has been suggested as a prophylactic measure against pyæmia that a ligature of the veins between the thrombus and the heart would be a rational measure. It seems to present an almost insurmountable obstacle in the determination of the venous branch which should be ligated, and the impracticability of ligating the principal venous trunk of the limb. However, it is said that Lee has successfully ligated the cephalic vein at the elbow, in two cases of injury of the hand, after the appearance of the

¹ Bartholow, "Materia Medica and Therapeutics," pp. 515, 516.

pyæmic chill. It has also been suggested that transfusion of healthy blood ought to be tried in suitable cases of this affection. In the general treatment of pyæmia there has been recommended at various times a great variety of drugs; but the general want of success attending their use leaves comparatively few to be mentioned here. The mineral acids are still employed, and are found, at least, agreeable drinks, and as such can still be recommended. The sulphites of magnesia, soda, potassa, and lime, are recommended by Giovanni Polli for the treatment of typhus fever, scarlet fever, small-pox, septicæmia, and pyæmia. He further suggests that the medicine should be given until the whole quantity taken bears to the weight of the patient's body the proportion of one to a thousand. The experiments made on animals with these salts seem to confirm their value in the treatment of septic disease. It is certainly true that animals treated with these salts are not so easily affected by septic poison as those which have not received the treatment. Further, it has been shown that putrid substances when mixed with either the permanganate of potassa or the carbolate of soda, and then injected, are harmless, although the same quantity of putrid matter without the salts destroys life. Quinine certainly, in most cases of pyæmia, is a valuable agent. In large doses it enables the surgeon to reduce the temperature of the patient, and in smaller doses it frequently serves a valuable purpose as a tonic. It has also undoubtedly considerable value as an antiseptic. Labbin has recommended the use of large doses of ergotine in infectious fevers, which should begin on the day the injury is received. The use of drastic cathartics should be avoided, and also sudorifics, on account of their prostrating effects. In some cases hypnotics may be required to secure sleep. Tonics are always more or less useful. The free use of stimulants is also indicated. Brandy, wine, and whiskey, may be used by the patient in accordance with his own taste. Musk, ammonia, and camphor, are occasionally required. However, it should not be forgotten that, in cases where the disease has become fully developed, the usual termination is death, few recoveries being recorded. In the early stages of this affection, by the removal of the patient from an overcrowded hospital-ward to

some place where pure air, proper hygeinic arrangements, and a judicious use of medicines, can be obtained, recovery may take place; but under other circumstances the prognosis is exceedingly grave.

2. *Septicæmia*.—The treatment of septicæmia in most particulars is the same as that of pyæmia. The first effect should be to prevent the development of the disease, and the second to cure the patient in cases where the affection has already developed. It is not in our power to limit or in any way regulate the primary injury, but we are obliged to take the patient as he is. The amount of destruction to living tissues may be great or small. The question of an operation, the character of the same, and the subsequent management, must be determined in accordance with the circumstances of each particular case. The primary death of the parts is generally due chiefly to the injury itself; the secondary, frequently to bad surgical management. Let us take a case in which the primary injury has been severe, greatly diminishing but not destroying the circulation in the injured parts: here the immediate application of ice would be locally injurious, but an evaporating lotion or warm applications might assist Nature. We have already seen, while speaking of the treatment of pyæmia, that the continuance, for a long time, of hot applications, is frequently injurious, or *even pernicious*. Let us now call to mind a case of contusion situated in the neighborhood of a large joint, where the injury to the soft parts will probably be followed by much sloughing if ice is used; but the great danger is inflammation of the synovial membrane, and, to avoid this danger, the surgeon requires perfect rest of the parts, the application of leeches, and finally cold, or even ice. It is humiliating to the profession that we are obliged, even at this date, to admit that the treatment of septicæmia is largely symptomatic. The profuse choleraic diarrhœa which generally accompanies this disease may be regarded as an effort of Nature to eliminate the septic poison; but, nevertheless, it is so prostrating in its effects on the patient, that it requires to be controlled with properly-selected astringents, and these remedies may be still further aided by the use of tonics and stimulants. The treatment of septicæmia may be

summarized as follows : (1.) A strict adherence to the five rules given under the head of prophylactic treatment. (2.) The avoidance of all putrefaction in contact with the wound, especially prior to the development of sufficient granulations to completely cover its surface. This object is to be accomplished by the removal of all necrotic tissues, the avoidance of putrescent fluids by cleanliness, and the proper use of antiseptic agents. (3.) Free use of the alkaline sulphites and hyposulphites. These drugs should be used, in all cases where there is reason to anticipate the development of septic disease, as soon after the receipt of the injury as practicable, but should not be neglected even after the development has occurred. (4.) Sulphate of quinine should be used in all cases where the temperature is above 100° Fahr., and its persistent use in large doses may be necessary to prevent its rising still higher. It will be remembered in this connection that experience has taught that "a temperature of $108\frac{1}{2}^{\circ}$ Fahr. is the limit beyond which life can no longer exist,"¹ and a much lower temperature is not without danger. "The essential danger of fever in acute diseases consists, then, in *the deleterious influence of a high temperature on the tissues.*"²

¹ Liebermeister, "New Sydenham Society Translations," vol. lxvi., p. 278.

² Ibid., p. 280.

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