Roberts (J. B.)

THE

RELATION OF BACTERIA

TO

PRACTICAL SURGERY.

THE ADDRESS IN SURGERY

DELIVERED BEFORE

THE MEDICAL SOCIETY OF THE STATE OF PENNSYLVANIA,

JUNE 4, 1890.

BY

JOHN B. ROBERTS, A.M., M.D.,

PROFESSOR OF SURGERY IN THE WOMAN'S MEDICAL COLLEGE, AND IN THE PHILADELPHIA POLYCLINIC.

THE RELATION OF BACTERIA TO PRACTICAL SURGERY.

THE ADDRESS IN SURGERY

DELIVERED BEFORE

THE MEDICAL SOCIETY OF THE STATE OF PENNSYLVANIA,

JUNE 4, 1890.

BY

JOHN B. ROBERTS, A.M., M.D.,

PROFESSOR OF SURGERY IN THE WOMAN'S MEDICAL COLLEGE, AND IN THE PHILADELPHIA POLYCLINIC.

PHILADELPHIA:

WM. J. DORNAN, PRINTER.

1890.

ADDRESS IN SURGERY.

By JOHN B. ROBERTS, M.D.,

OF PHILADELPHIA.

THE revolution which has occurred in practical surgery since the discovery of the relation of microörganisms to the complications occurring in wounds has caused me to select this subject for discussion. Although many of my hearers are familiar with the germ theory of disease, it is possible that it may interest some of them to have put before them in a short address a few points in bacteriology which are of value to the practical surgeon.

It must be remembered that the groups of symptoms which were formerly classed under the heads "inflammatory fever," "symptomatic fever," "traumatic fever," "hectic fever," and similar terms, varying in name with the surgeon speaking of them, or with the location of the disease, are now known to be due to the invasion of the wound by microscopic plants. These bacteria, after entering the blood-current at the wound, multiply with such prodigious rapidity that the whole system gives evidence of their existence. Suppuration of wounds is undoubtedly due to these organisms, as is tubercular disease, whether of surgical or medical character. Tetanus, erysipelas, and many other surgical conditions have been almost proved to be the result of infection by similar microscopic plants; which, though acting in the same way, have various forms and life-histories.

A distinction must be made between the "yeast-plants," one of which produces thrush, and the "mould-plants," the existence of which, as parasites in the skin, gives rise to certain cutaneous diseases. These two classes of germs are foreign to the present topic, which is Surgery; and I shall, therefore, confine my remarks to that group of vegetable parasites to which the term bacteria has been given. These are the microörganisms whose actions and methods of growth particularly concern the surgeon. The individual plants are so minute that it takes in the neighborhood of ten or fifteen hundred of them grouped together to cover a spot as large as a full-stop or period used in punctuating an ordinary newspaper This rough estimate applies to the globular and the egg-shaped bacteria, to which is given the name "coccus" (plural, cocci). The cane- or rod-shaped bacteria are rather larger plants. Fifteen hundred of these placed end to end would reach across the head of a pin. Because of the resemblance of these latter to a walking-stick they have been termed bacillus (plural, bacilli).

The bacteria most interesting to the surgeon belong to the cocci and the bacilli. There are other forms which bacteriologists have dubbed with similar descriptive names, but they are more interesting to the physician than to the surgeon. Many microörganisms, whether cocci, bacilli, or of other shapes, are harmless; hence they are called non-pathogenic, to distinguish them from the disease-producing or pathogenic germs.

As many trees have the same shape and a similar method of growing, but bear different fruits—in the one case edible, and in the other poisonous—so, too, bacteria may look alike to the microscopist's eye, and grow much in the same way, but one will cause no disease, while the other will produce perhaps tuberculosis of the lungs or brain.

Many scores of bacteria have been, by patient study, differentiated from their fellows and given distinctive names. Their nomenclature corresponds in classification and arrangement with the nomenclature adopted in different departments of botany. Thus, we have the pus-causing chain-coccus (streptococcus pyogenes), so-called because it is globular in shape; because it grows with the individual plants attached to each other, or arranged in a row like a chain of beads on a string; and because it produces pus. In a similar way we have the pus-causing grape-coccus of a golden color (staphylococcus pyogenes aureus). It grows with the individual plants arranged somewhat after the manner of a bunch of grapes, and when millions of them are collected together the mass has a golden-yellow hue. Again, we have the bacillus tuberculosis; the rod-shaped plant which is known to cause tuberculosis of the lungs, joints, brain, etc.

It is hardly astonishing that these fruitful sources of disease have so long remained undetected, when their microscopic size is borne in mind. That some of them do cause disease is indisputable, since bacteriologists have, by their watchful and careful methods, separated almost a single plant from its surroundings and congeners, planted it free from all contamination, and observed it produce an infinitesimal brood of its own kind. Animals and patients inoculated with the plants thus cultivated have rapidly become subjects of the special disease which the particular plant was supposed to produce.

The difficulty of such investigation becomes apparent when it is remembered that under the microscope many of these forms of vegetable life are identical in appearance, and it is only by observing their growth when in a proper soil that they can be distinguished from each other. In certain cases it is quite difficult to distinguish them by the physical appearances produced during their growth. Then it is only after an animal has been inoculated with them that the individual parasite can be accurately recognized and called by name. It is known then by the results which it is capable of producing.

The various forms of bacteria are recognized, as I have said, by their method of growth and by their shape Another means of recognition is their individual peculiarity of taking certain dyes, so that special plants can be recognized, under the microscope, by the color which a dye gives to them ; and which they refuse to give up when treated with chemical substances which remove the stain from, or bleach, all the other tissues which at first have been similarly stained.

The similarity between bacteria and the ordinary plants with which florists are familar is, indeed, remarkable. Bacteria grow in animal and other albuminous fluids; but it is just as essential for them to have a suitable soil as it is for the corn or wheat that the farmer plants in his field. By altering the character of the albuminous fluid in which the microorganism finds its subsistence, these small plants can be given a vigorous growth, or may be actually starved to death. The farmer knows that it is impossible for him to grow the same crop year after year in the same field, and he is, therefore, compelled to rotate his crops. So it is with the microscopic plants which we are considering. After a time the culture-fluid or soil becomes so exhausted of its needed constituents, by the immense number of plants living in it, that it is unfit for their life and development. Then this particular form will no longer thrive; but some other form of bacterium may find in it the properties required for functional activity, and may grow vigorously. It is probable that exhaustion or absence of proper soil is an important agent in protecting man from sickness due to infection from bacteria. The ever-present bacteria often gain access to man's blood through external wounds, or through the lungs and digestive tracts; but unless a soil suited for their development is found in its fluids, the plants will not grow. If they do not grow and increase in numbers, they can do little harm.

Again, there are certain bacteria which are so antagonistic to each other that it is impossible to make them grow in company, or to coëxist in the blood of the same individual. For example, an animal inoculated with erysipelas germs cannot be successfully inoculated immediately afterward with the germs of malignant pustule. This antagonism is illustrated by the impossibility of having a good crop of grain in a field overrun with daisies. On the other hand, however, there are some microörganisms which flourish luxuriantly when planted together in the same fluid; somewhat after the manner of pumpkins and Indian corn growing between the same fence rails. Others seem unwilling to grow alone, and only flourish when planted along with other germs. It is very evident, therefore, that bacteriology is a branch of botany, and that Nature shows the same tendencies in these minute plants as it does in the larger vegetable world visible to our unaided eyes.

As the horticulturist is able to alter the character of his plants by changing the circumstances under which they live, so can the bacteriologist change the vital properties and activities of bacteria by chemical and other manipulations of the culture substances in which these organisms grow. The power of bacteria to cause pathological changes may thus be weakened and attenuated; in other words, their functional power for evil is taken from them by alterations in the soil. The pathogenic, or disease-producing, power may be increased by similar, though not identical, alterations. The rapidity of their multiplication may be accelerated, or they may be compelled to lie dormant and inactive for a time; and, on the other hand, by exhausting the constituents of the soil upon which they depend for life, they may be killed.

It is a most curious fact, also, that it is possible by selecting and cultivating only the lighter colored specimens of a certain purple bacterium for the bacteriologist to obtain finally a plant which is nearly white, but which has the essential characteristics of the original purple fungus. In this we see the same power which the florist has to alter the color of the petals of his flowers by various methods of selective breeding.

The destruction of bacteria by means of heat and antiseptics is the essence of modern surgery. It is, then, by preventing access of these parasitic plants to the human organism (aseptic surgery), or the destruction of them by chemical agents and heat (antiseptic surgery) that we are enabled to invade by operative attack regions of the body which a few years ago were sacred.

When the disease-producing bacteria gain access to the tissues and blood of human and other animals by means of wounds, or through an inflamed pulmonary or alimentary mucous membrane, they produce pathological effects, provided there is not sufficient resistance and health-power in the animal's tissues to antagonize successfully the deleterious influence of the invading parasitic fungus. It is the rapid multiplication of the germs which furnishes a *continuous* irritation that enables them to have such a disastrous effect upon the tissues of the animal. If the tissues had only the original dose of microbes to deal with, the warfare between health and disease would be less uncertain in outcome. Victory would usually be on the side of the tissues and health. The immediate cause of the pathogenic influence is probably the chemical excretions which are given out by these microscopic organisms. All plants and animals require a certain number of substances to be taken into their organisms for preservation of their vital activities. After these substances have been utilized there occurs a sort of excretion of other chemical products. It is probably the excretions of many millions of microörganisms, circulating in the blood, which give rise to the disease characteristic of the fungus with which the animal has been infected. The condition called sapræmia, or septic intoxication, for example, is undoubtedly due to the entrance of the excretory products of putrefaction bacteria into the circulation. This can be proved by injecting into an animal a small portion of these products obtained from cultures of germs of putrefaction. Characteristic symptoms will at once be exhibited.

Septicæmia is a similar conditon due to the presence of the putrefactive organisms themselves, and hence of their products, or ptomaines, also in the blood. The rapidity of their multiplication in this albuminous soil and the great amount of excretion from these numerous fungi make the condition more serious than sapræmia. Clinically, the two conditions occur together.

The rapidity with which symptoms may arise after inoculation of small wounds with a very few germs will be apparent, when it is stated that one parasitic plant of this kind may, by its rapidity of multiplication, give rise to fifteen or sixteen million individuals within twenty-four hours. The enormous increase which takes place within three or four days is almost incalculable. It has been estimated that a certain bacillus, only about one-thousandth of an inch in length, could, under favorable conditions, develop a brood of progeny in less than four days which would make a mass of fungi sufficient to fill all the oceans of the world, if they each had a depth of one mile.

Bacteria are present everywhere. They exist in the water, earth, air, and within our respiratory and digestive tracts. Our skin is covered with millions of them, as is every article about us. They can circulate in the lymph and blood and reach every tissue and part of our organisms by passing through the walls of the capillaries. Fortunately, they require certain conditions of temperature, moisture, air, and organic food for existence and for the preservation of their vital activities.

If the surroundings are too hot, too cold, or too dry, or if they are not supplied with a proper quantity and quality of food, the bacterium becomes inactive until the surrounding circumstances change; or it may die absolutely. The spores, which finally become full-fledged bacteria, are able to stand a more unfavorable environment than the adult bacteria. Many spores and adults, however, perish. Each kind of bacterium requires its own special environment to permit it to grow and flourish. The frequency with which an unfavorable combination of circumstances occurs limits greatly the disease-producing power of the pathogenic bacteria.

Many bacteria, moreover, are harmless and do not produce disease, even when present in the blood and tissues. Beside this, the white blood-cells are perpetually waging war against the bacteria in our bodies. They take the bacteria into their interiors and render them harmless by eating them up, so to speak. They crowd together and form a wall of white blood-cells around the place where the bacteria enter the tissue, thus forming a barrier to cut off the blood-supply to the germs and, perhaps, to prevent them from entering the general blood-current.

The war between the white blood-cells and the bacteria is a bitter one. Many bacteria are killed; but, on the other hand, the life of many blood-cells is sacrificed by the bacteria poisoning them with ptomaines. The tissue cells, if healthy, offer great resistance to the attacks of the army of bacteria. Hence, if the white cells are vigorous and abundant at the site of the battle, defeat may come to the bacteria; and the patient suffer nothing from the attempt of these vegetable parasites to harm him. If, on the other hand, the tissues have a low resistive power, because of general debility of the patient, or of a local debility of the tissues themselves, and the white cells be weak and not abundant, the bacteria will gain the victory, get access to the general blood-current, and invade every portion of the organism. Thus, a general or a local disease will be caused; varying with the species of bacteria with which the patient has been affected, and the degree of resistance on the part of the tissues.

From what has been stated it must be evident that the bacterial origin of disease depends upon the presence of a disease-producing fungus and a diminution of the normal healthy tissue-resistance to bacterial invasion. If there is no fungus present, the disease caused by such fungus cannot develop. If the fungus be present and the normal or healthy tissue-resistance be undiminished, it is probable that disease will not occur. As soon, however, as overwork, injury of a mechanical kind, or any other cause diminishes the local or general resistance of the tissues and individual, the bacteria get the upper hand, and are liable to produce their malign effect.

Many conditions favor the bacterial attack. The patient's tissues may have an inherited peculiarity, which renders it easy for the bacteria to find a good soil for development; an old injury or inflammation may render the tissues less resistant than usual; the point at which inoculation has occurred may have certain anatomical peculiarities which make it a good place in which bacteria may multiply; the blood may have undergone certain chemical changes which render it better soil than usual for the rapid growth of these parasitic plants.

The number of bacteria originally present makes a difference also. It is readily understood that the tissues and white blood-cells would find it more difficult to repel the invasion of an army of a million microbes than the attack of a squad of ten similar fungi. I have said that the experimenter can weaken and augment the virulence of bacteria by manipulating their surroundings in the laboratory. It is probable that such a change occurs in nature. If so, some bacteria are more virulent than others of the same species; some less virulent. A few of the less virulent disposition would be more readily killed by the white cells and tissues than would a larger number of the more virulent ones. At other times the danger from microbic infection is greater because there are two species introduced at the same time; and these two multiply more vigorously when together than when separated. They are, in fact, two allied hosts trying to destroy the blood-cells and tissues. This occurs when the bacteria of putrefaction and the bacteria of suppuration are introduced into the tissues at the same time. The former cause sapræmia and septicæmia, the latter cause suppuration. The bacteria of tuberculosis are said to act more viciously if accompanied by the bacteria of putrefaction. Osteomyelitis is of greater severity, it is believed, if due to a mixed infection with both the white and golden grape-coccus of suppuration.

I have previously mentioned that the bacteria of malignant pustule are powerless to do harm when the germs of erysipelas are present in the tissues and blood. This is an example of the way in which one species of bacteria may actually aid the white cells, or leucocytes, and the tissues in repelling an invasion of disease-producing microbes.

Having occupied a portion of the time allotted to me in giving a crude and hurried account of the characteristics of bacteria, let me conclude my address by discussing the relation of bacteria to the diseases most frequently met with by the surgeon.

Mechanical irritations produce a very temporary and slight inflammation, which rapidly subsides because of the tendency of Nature to restore the parts to health. Severe injuries, therefore, will soon become healed and cured if no germs enter the wound.

Suppuration of operative and accidental wounds was, until recently, supposed to be essential. We now know, however, that wounds will not suppurate if kept perfectly free from one of the dozen forms of bacteria that are known to give rise to the formation of pus.

The doctrine of present surgical pathology is that suppuration will not take place if pus-forming bacteria are kept out of the wound, which will heal by first intention without inflammation and without inflammatory fever.

In making this statement I am not unaware that there is a certain amount of fever following various severe wounds within twenty-four hours, even when no suppuration occurs. This wound-fever, however, is transitory; not high; and entirely different from the prolonged condition of high temperature formerly observed nearly always after operations and injuries. The occurrence of this "inflammatory," "traumatic," "surgical," or "symptomatic" fever, as it was formerly called, means that the patient has been subjected to the poisonous influence of putrefactive germs, the germs of suppuration, or both.

We now know why it is that certain cases of suppuration are not circumscribed but diffuse, so that the pus dissects up the fascias and muscles and destroys with great rapidity the cellular tissue. This form of suppuration is due to a particular form of bacterium called the pus-causing "chain-coccus."

Circumscribed abscesses, however, are due to one or more of the other pus-causing microörganisms.

How much more intelligent is this explanation than the old one that diffuse abscesses depended upon some curious characteristic of the patient. It is a satisfaction to know that the two forms of abscess differ because they are the result of inoculation with different germs. It is practically a fact that wherever there is found a diffuse abscess there will be discovered the streptococcus pyogenes, which is the name of the chain-coccus above mentioned.

So, also, is it easy now to understand the formation of what the old surgeons called "cold" abscesses, and to account for the difference in appearance of its puriform secretion from the pus of acute abscesses. Careful search in the fluid coming from such "cold" abscesses reveals the presence of the bacillus of tuberculosis, and proves that a "cold" abscess is not a true abscess, but a lesion of local tuberculosis.

Easy is it now to understand the similarity between the "cold abscess" of the cervical region and the "cold abscess" of the lung in a phthisical patient. Both of them are, in fact, simply the result of invasion of the tissues with the ubiquitous tubercle bacillus; and are not due to pus-forming bacteria.

Formerly it was common to speak of the scrofulous diathesis, and attempts were made to describe the characteristic appearance of the skin and hair pertaining to persons supposed to be of scrofulous tendencies. The attempt was unsuccessful and unsatisfactory. The reason is now clear because it is known that the brunette or the blonde, the old or the young, may become infected with the tubercle bacillus. Since the condition depends upon whether one or the other become infected with the generally present bacillus of tubercle, it is evident that there can be no distinctive diathesis. It is more than probable, moreover, that the cutaneous disease, so long described as lupus vulgaris, is simply a tubercular ulcer of the skin, and not a special disease of unknown causation.

The metastatic abscesses of pyæmia are clearly explained when the surgeon remembers that they are simply due to a softened blood-clot containing pus-causing germs being carried through the circulation and lodged in some of the small capillaries.

A patient suffering with numerous boils upon his skin has often been a puzzle to his physician, who has in vain attempted to find some cause for the trouble in the general health alone. Had he known that every boil owed its origin to pus-bacteria, which had infected a sweat-gland or hair-follicle, the treatment would probably have been more efficacious. The suppuration is due to pus germs either lodged upon the surface of the skin from the exterior, or deposited from the current of blood in which they have been carried to the spot.

I have not taken time to go into a discussion of the methods by which the relationship of microörganisms to surgical affections has been established; but the absolute necessity for every surgeon to be fully alive to the inestimable value of aseptic and antiseptic surgery has led me to make the foregoing statements as a sort of *résumé* of the relation of the germ theory of disease to surgical practice. It is clearly the duty of every man who attempts to practise surgery to prevent, by every means in his power, the access of germs, whether of suppuration, putrefaction, erysipelas, tubercle, tetanus, or any other disease to the wounds of a patient. This, as we all know, can be done by absolute bacteriological cleanliness. It is best, however, not to rely solely upon absolute cleanliness, which is almost unattainable, but to secure further protection by the use of heat and antiseptic solutions. I am fully of the opinion that chemical antiseptics would be needless if absolute freedom from germs was easily obtained. When I know that even such an enthusiast as I myself is continually liable to forget or neglect some step in this direction, I feel that the additional security of chemical antisepsis is of great value. It is difficult to convince the majority of physicians, and even ourselves, that to touch a finger to a door knob, to an assistant's clothing, or to one's own body may vitiate the entire operation by introducing one or two microbic germs into the wound.

An illustration of how carefully the various steps of an operation should be guarded is afforded by the appended rules, which I have adopted at the Woman's Hospital of Philadelphia for the guidance of the assistants and nurses. If such rules were taught every medical student and every physician entering practice as earnestly as the paragraphs of the catechism are taught the Sunday-school pupil (and they certainly ought to be so taught) the occurrence of suppuration, hectic fever, septicæmia, pyæmia, and surgical erysipelas would be practically unknown. Death, then, would seldom occur after surgical operations, except from hemorrhage, shock, or exhaustion.

I have taken the liberty of bringing here a number of culture tubes containing beautiful specimens of some of the more common and interesting bacteria. The slimy masses seen on the surfaces of jelly contained in the tubes are many millions of individual plants, which have aggregated themselves in various forms as they have been developed as the progeny of the few parent cells planted in the jelly as a nutrient medium or soil.

With this feeble plea, Mr. President and Members of the Society, I hope to create a realization of the necessity for knowledge and interest in the direction of bacteriology; for this is the foundation of modern surgery. There is, unfortunately, a good deal of abominable work done under the names of antiseptic and aseptic surgery, because the simplest facts of bacteriology are not known to the operator.

Rules to be observed in Operations at Dr. Roberts's Clinic at the Woman's Hospital of Philadelphia.—After wounds or operations high temperature usually, and suppuration always, is due to blood poisoning, which is caused by infection with vegetable parasites called bacteria.

These parasites ordinarily gain access to the wound from the skin of the patient, the finger-nails or hands of the operator or his assistants, the ligatures, sutures, or dressings.

Suppuration and high temperature should not occur after operation wounds if no suppuration has existed previously.

Bacteria exist almost everywhere as invisible particles in the dust; hence, everything that touches or comes into even momentary contact with the wound must be germ-free—technically called "sterile."

A sterilized condition of the operator, the assistant, the wound, instruments, etc., is obtained by removing all bacteria by means of absolute surgical cleanliness (asepsis), and by the use of those chemical agents which destroy the bacteria not removed by cleanliness itself (antisepsis).

Surgical cleanliness differs from the housewife's idea of cleanliness in that its details seem frivolous, because it aims at the removal of microscopic particles. Stains, such as housewives abhor, if germ-free, are not objected to in surgery.

The hands and arms, and especially the finger-nails of the surgeon, assistants, and nurses should be well scrubbed with hot water and soap, by means of a nail-brush, immediately before the operation. The patient's body about the site of the proposed operation should be similarly scrubbed with a brush and cleanly shaved. Subsequently the hands of the operator, assistants and nurses, and the field of operation should be immersed in, or thoroughly washed with, corrosive sublimate solution (1:1000 or 1:2000). Finger-rings, bracelets, bangles, and cuffs worn by the surgeon, assistants, or nurses must be removed before the cleansing is begun; and the clothing covered by a clean white apron, large enough to extend from neck to ankles and provided with sleeves.

The instruments should be similarly scrubbed with hot water and soap, and all particles of blood and pus from any previous operation removed from the joints. After this they should be immersed for at least fifteen minutes in a solution of beta-naphthol (1:2500), which must be sufficiently deep to cover every portion of the instruments. After cleansing the instruments with soap and water, baking in a temperature a little above the boiling-point of water is the best sterilizer. During the operation the sterilized instruments should be kept in a beta-naphthol solution and returned to it when the operator is not using them.

[The antiseptic solutions mentioned here are too irritating for use in operations within the abdomen and pelvis. Water made sterile by boiling is usually the best agent for irrigating these cavities, and for use on instruments and sponges. The instruments and sponges must be previously well sterilized.]

Sponges should be kept in a beta-naphthol or a corrosive sublimate solution during the operation. After the blood from the wound has been sponged away, they should be put in another basin containing the antiseptic solution, and cleansed anew before being used again. The antiseptic sutures and ligatures should be similarly soaked in beta-naphthol solution during the progress of the operation.

No one should touch the would but the operator and his first assistant. No one should touch the sponges but the operator, his first assistant, and the nurse having charge of them. No one should touch the already-prepared ligatures or instruments except the surgeon and his first or second assistants.

None but those assigned to the work are expected to handle instruments, sponges, dressings, etc., during the operation.

When anyone taking part in the operation touches an object not sterilized, such as a table, a tray, or the ether towel he should not be allowed to touch the instruments, the dressings, or the ligatures until his hands have been again sterilized. It is important that the hands of the surgeon, his assistants and nurses should not touch any part of his own body, nor of the patient's body, except at the sterilized seat of operation, because infection may be carried to the wound. Rubbing the head or beard, or wiping the nose requires immediate disinfection of the hands to be practised.

The trailing ends of ligatures and sutures should never be allowed to touch the surgeon's clothing or to drag upon the operating-table, because such contact may occasionally, though not always, pick up bacteria which may cause suppuration in the wound.

Instruments which fall upon the floor should not be again used until thoroughly disinfected.

The clothing of the patient, in the vicinity of the part to be operated upon, and the blanket and sheets used there to keep him warm, should be covered with dry sublimate towels. All dressings should be kept safe from infection by being stored in glass jars, or wrapped in dry sublimate towels.