THE PATHOGENESIS OF LOCAL TETANUS

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MEDICAL literature is rich in historic records of many of our most commonplace diseases which have held the interest of all branches of medicine for centuries. In many instances some of these diseases have defied human intelligence and medical research, and forced the profession to realize that the day is far distant when medical science will have conquered all diseases.

Today I wish to invite your attention to the discussion of a certain phase of one of the oldest diseases known to man—tetanus—for which much has been done in a preventive way but for which the present day method of treatment is practically the same as it was many centuries past.

As a preamble to this discussion, an article from the works of Aretaeus the Cappadocian, written in the third century A.D., will serve to give you an idea of what was known of tetanus at that time and how bewildered those medical men were when called upon to treat a case of tetanus. In discussing this disease, Aretaeus (Group I[15]) wrote as follows:

"Tetanus, in all its varieties, is a spasm of an exceedingly painful nature, very swift to prove fatal, but neither easy to be removed. They are affections of the muscles and tendons about the jaws; but the illness is communicated to the whole frame, for all parts are affected sympathetically with the primary organs. There are three forms of the convulsions, namely in a straight line, backwards and forwards. Tetanus is in a direct line, when the person labouring under the distension is stretched out straight and inflexible. The contractions forwards and backwards have their appellation from the tension and the place; for that backwards we call opisthotonos; and that variety we call emprosthotonos in which the patient is bent forwards by the anterior nerves. For the Greek word *tonos* is applied both to a nerve and to signify tension.

"The causes of these complaints are many; for some are apt to supervene on the wound of a membrane, or of muscles, or of punctured nerves, when, for the most part, the patients die; for, 'spasm from a wound is fatal.' And women also suffer from this spasm after abortion; and, in this case, they seldom recover. Others are attacked with the spasm owing to a severe blow in the neck. Severe cold also sometimes proves a cause; for this reason, winter of all the seasons most especially engenders these affections; next to it, spring and autumn, but least of all summer, unless when preceded by a wound, or when any strange diseases prevail epidemically. Women are more disposed to tetanus than men, because they are of a cold temperament; but they more readily recover, because they are of a humid. With respect to the different ages, children are frequently affected, but do not often die, because the affection is familiar and akin in them; striplings are less liable to suffer, but more readily die; adults least of all, whereas old men are most subject to the disease and most apt to die; the cause of this is the frigidity and dryness of old age, and the nature of the death. But if the cold be

along with humidity, these spasmodic diseases are more innocent and attended with less danger.

"In all these varieties, then, to speak generally, there is a pain and tension of the tendons and spine, and of the muscles connected with the jaws and cheek; for they fasten the lower jaw to the upper, so that it could not easily be separated even with levers or a wedge. But if one, by forcibly separating the teeth, pour in some liquid the patients do not drink it but squirt it out, or retain it in the mouth, or it regurgitates by the nostrils; for the isthmus faucium is strongly compressed, and the tonsils being hard and tense, do not coalesce so as to propel that which is swallowed. The face is ruddy and of mixed colours, the eyes almost immovable, or are rolled about with difficulty; strong feeling of suffocation; respiration bad, distension of the arms and legs; subsultus of the muscles; the countenance variously distorted; the cheeks and lips tremulous; the jaw quivering, and the teeth rattling, and in certain rare cases even the ears are thus affected. I myself have beheld this and wondered! The urine is retained, so as to induce strong dysuria, or passes spontaneously from contraction of the bladder. These symptoms occur in each variety of the spasms.

"But there are peculiarities in each; in Tetanus there is tension in a straight line of the whole body, which is unbent and inflexible; the legs and arms are straight.

"Opisthotonos bends the patient backward, like a bow, so that the reflected head is lodged between the shoulder blades; the throat protrudes; the jaw sometimes gapes, but in some rare cases it is fixed in the upper one; respiration stertorous; the belly and chest prominent, and in these there is usually incontinence of urine; the abdomen stretched, and resonant if tapped; the arms strongly bent back in a state of extension; the legs and thighs are bent together, for the legs are bent in the opposite direction to the hams.

"But if they are bent forwards, they are protuberant at the back, the loins being extruded in a line with the back, the whole of the spine being straight; the vertex prone, the head inclining towards the chest; the lower jaw fixed upon the breast bone; the hands clapsed together, the lower extremities extended; pains intense; the voice altogether dolorous; they groan, making deep moaning. Should the mischief then seize the chest and the respiratory organs, it readily frees the patient from life; a blessing this, to himself, as being a deliverance from pains, distortion, and deformity; and a contingency less than usual to be lamented by the spectators, were he a son or a father. But should the powers of life still stand out, the respiration, although bad, being still prolonged, the patient is not only bent up into an arch, but rolled together like a ball, so that the head rests upon the knees, while the legs and back are bent forwards, so as to convey the impression of the articulation of the knee being dislocated backwards.

"An inhuman calamity! an unseemly sight! a spectacle painful even to the beholder! an incurable malady! owing to the distortion, not to be recognized by the dearest friends; and hence the prayer of the spectators, which formerly would have been reckoned not pious, now becomes good, that the patient may depart from life, as being a deliverance from the pains and unseemly evils attendant on it. But neither can the physician, though present and looking on, furnish any assistance, as regards life, relief from pain or from deformity. For if he should wish to straighten the limbs, he can only do so by cutting and breaking those of a living man. With them, then, who are overpowered by this disease, he can merely sympathise. This is the great misfortune of the physician."

A careful analysis of this article warrants the conclusion that many conditions were confused with the disease known to us as tetanus. It is evident that Aretaeus confused cases of brain injury having convulsions, as well as cases of infectious meningitis with tetanus. No mention of treatment is contained in this article, but as time goes on we find records of how cases were treated.

As late as 1828, Doctor Marsh, at the Dublin Hospital, reports several cases of tetanus, together with his treatment. It was fallacious, as is all treatment of disease where the proper knowledge of pathology is lacking. His cases were kept in vapor baths at 90° F. for five and six hours at a time, and because the moisture dissolved the crust which had formed over the original wound and made it appear cleaner, he concluded that his method was good, despite the fact that his patients all died. This is demonstrated by quotations from his article, when he says, "Notwithstanding the want of success, should we be called upon to treat other cases, we should be disposed to pursue a similar plan."

Later, in 1847, we read where cases of tetanus were purged with croton oil to eliminate toxins, and various preparations of opium used in an attempt to control convulsions. In 1848, two years after the discovery of ether as an anesthetic, an article was published by Dr. E. W. Theobald of Boston reporting the successful treatment of a case of tetanus by vapor of sulphuric ether. Following this report, ether was used rather generally, and in many instances when the initial infection was on one of the extremities, amputations were performed to rid the patient of the focus of infection. While this may seem radical, it is in line with the accepted treatment of today, when we advocate débridement in conjunction with sedatives and even anesthetics such as avertin.

Our knowledge of tetanus continued to be meager, and treatment chaotic, until a little over 30 years ago, in 1903, when Meyer and Ransom propounded their theory as to how the symptoms were produced. They believed that in cases where only a small amount of toxin is absorbed slowly, it passes up the axis-cylinder of the nearest motor nerve and affects the anterior horn cell or its connections, and local symptoms appear in the muscles supplied by those cells. When a large amount is absorbed, the toxin passes via the perineural lymphatics into the cerebrospinal fluid, and then to the central cell, as stated above, finally affecting the entire central nervous system. They explained that the jaws were first affected because the fifth nerve was short and the toxin had less distance to travel before it reached the motor cells.

Meyer and Ransom's theory of the spread of the toxin from the clostridium tetani has persisted and has continued to be the accepted theory until John J. Abel (Group I[9]) and his coworkers published the results of their experiment, in 1935, which appear far more plausible. They reported that by injecting dyes into the axis-cylinder under great pressure they were unable to force it into the central cell. They also report that by injecting

the tetanus toxin into the axis-cylinder, and not allowing any to escape into the surrounding tissues, large doses failed to produce any symptoms whatever. Nor were any symptoms produced by injecting the toxin into the perineural sheath. But when they injected small amounts of this toxin into the muscle itself, after having severed all nerve supply, they produced *local* tetanus in the muscles affected by the toxin. Larger doses involved other groups of muscles, and if sufficient amounts were injected intravenously, they produced *generalized* tetanus. Therefore, they concluded that the theory of Meyer and Ransom was incorrect. They held that symptoms are produced by the direct action of the toxin on the muscle and that the spread of the toxin was through the blood stream and lymphatics. The latter collect the toxin from the tissues, empty it into the circulation, which in turn disseminates it through the entire body and produces general tetanus. This theory is based on sound anatomic and physiologic facts and is the only plausible explanation of local tetanus.

Appended is the report of a case of local tetanus which developed as local tetanus and ran its entire course to recovery as local tetanus.

Case Report.—J. W. Mc., white, male, age 37, was first seen December 2, 1935, suffering from a laceration of the right forearm. Thirty minutes before, he had been "sideswiped" by an automobile, the door handle striking his right forearm on the lateral aspect, just below the elbow, and tearing the muscles. On examination there was a deep, ragged, transverse laceration of the lateral antibrachial muscles on the right, about one and one-half inches distal to the lateral epicondyle of the humerus. The radial nerve was exposed but uninjured.

Under 1 per cent novocain infiltration anesthesia the wound and surrounding skin were cleansed with iodine and alcohol; the muscle bellies were sutured with interrupted chromic catgut and the skin with interrupted silkworm gut. A dry sterile dressing was applied, the arm placed in a sling, and 1,500 units of tetanus antitoxin given intramuscularly into the right thigh.

The postoperative course was uneventful, the wound healing by primary union; the skin sutures were removed on the seventh day.

On the eleventh day, because of fluid underneath the skin, the skin edges were spread and a few cubic centimeters of clear straw colored fluid removed.

On December 14—12 days after the injury—the patient complained of pain in the right shoulder associated with tonic contraction of the deltoid muscle. This continued for two days, the contraction and pain becoming more marked, and on December 16—two weeks after the injury—he was admitted to the hospital.

On admission the wound was healed; the right arm was held vertical. The contraction of the deltoid could be overcome, but this caused agonizing pain. There was no trismus, opisthotonos or rigidity of any of the other muscles. The reflexes were normal and the sensorium clear.

Temperature 99° F., pulse 100, respiration 25. Blood pressure 110/70, R. B. C. 5,200,000, Hb. 90 per cent, W. B. C. 13,000 with 85 per cent polymorphonuclears, Uranalysis negative.

Two days after admission to the hospital, the contractions spread to involve the biceps, coracobrachialis and brachialis muscles, and, in addition to the vertical position of the arm, the forearm was held in extreme flexion.

Three days after admission, the wound was explored under ether anesthesia to determine the presence of any injury or pressure which might cause irritation to the motor nerves. No such conditions were found.

Four days after admission to the hospital, and 18 days after the injury, the contractions had spread to involve all the flexors of the wrist and fingers. The accompanying pain was intense and continuous.

The course of treatment can be divided into three stages:

(1) During the first four days of hospitalization the patient was given large and frequent doses of the barbiturates and salicylates with an occasional hypodermic of pantopon.

(2) During the next six days narcotics were given.

(3) Beginning on the tenth day avertin was given daily in doses of 100 mg. per kilo of body weight for a period of four days, supplemented by occasional injections of morphia or pantopon. Thereafter the patient was kept fairly comfortable with phenobarbital.

In addition to the sedatives, narcotics and avertin, a total of 69,000 units of tetanus antitoxin were given intramuscularly, none intravenously and none intrathecally.

The patient was discharged home from the hospital January 10, 1936—25 days after admission—at which time the contractions of the deltoid and upper arm had subsided. There was still moderate contraction with some pain in the flexor muscles of the forearm, the wrist and fingers being held in extreme flexion. All muscles returned to normal one month later.

Résumé.—(1) On admission pain in shoulder with continuous, *tonic* contraction of the deltoid.

(2) Contraction of the biceps ensued two days after admission.

(3) Two days later the flexors of wrist and fingers were involved.

(4) The treatment consisted of the administration of barbiturates, narcotics and avertin.

In the literature we found 17 cases reported in private practice since the World War, but every one of them finally developed in general tetanus. The case herein cited never involved any groups of muscles except those of the shoulder, arm, forearm, and hand (abduction of shoulder and flexion of arm, forearm and hand); and the only basis upon which this can be explained is the theory reported by Abel and his coworkers, which appears to have entirely disproved that of Meyer and Ransom.

REFERENCES

Group I comprises references relative particularly to the etiology, paths of ascent of the toxin, and types of tetanus; also the pathologic findings; Group II contains references to case reports since the War.

EARLY REFERENCES TO THE ETIOLOGY OF TETANUS

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REFERENCE TO THE DISCOVERY OF ANTITOXIN

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DISCUSSION OF THE PAPERS OF DOCTORS HART, REID AND GREEN

DR. HUBERT A. ROYSTER (Raleigh, N. C.)—Doctor Reid has brought out beautifully and simply the basic principles of wound treatment. The first of these is that if antiseptics are used in wounds for killing organisms, they also kill the tissue cells. For many years we have not in our service used any so called germicides in the treatment of wounds. For the past seven years we have used a 50 per cent soap solution in sterile water, really a reliable antiseptic, not only to wash the outside but also for irrigating the inside of the wound. We do this carefully with this solution and then use a soap poultice of the same type. With this bland method, wounds have healed kindly and quickly. The colored solutions of so-called antiseptics are for the purpose of dolling up and they do no good, but possibly harm. If you have a choice between a perfectly aseptic wound with dead spaces and a wound with loose sutures and proper pressure, you will invariably choose the latter. On that account we have been using in all of our clean operative wounds what we call a pressure dressing, which exerts pressure not only from above downward but from the sides. It consists of narrow pieces of

gauze in layers which are put over the incision, with short adhesive straps crossing it. Outside this we place a large dressing, in the shape of a melon slice, which is also held in position by adhesive straps; so that we not only obtain pressure from the bottom but from both sides and above. In such cases we invariably see a considerable amount of serum collect on the outside, in the gauze, instead of in the wound. This obliterates the dead spaces with proper pressure in three directions.

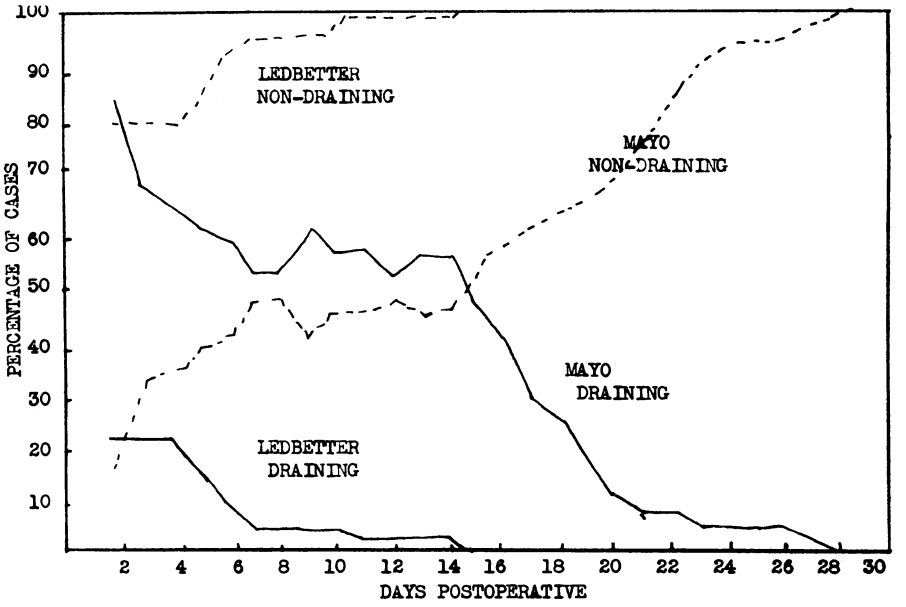
DR. GEORGE A. HENDON (Louisville, Ky.).—Anyone who has a correct conception of antiseptics will realize at once their inefficiency. The mere matter of putting an antiseptic in a wound with the object of having it come in contact with the germs is not always tenable. You cannot kill a germ unless you catch him. To think of sterilizing a wound by antiseptics is just like painting a barn to get rid of rats. Remember, the germs are buried down in the depths of the tissue. They are hidden in the recesses and remote places, and they have the mechanism of self-defense as highly developed as you or I. Keeping that phase in view, we have devised a plan for treating septic wounds and abscess cavities, which consists of a positive pressure apparatus that operates by the electric current and which forces a stream of air through a unit that is heated by electricity. The air thus heated is forced into the wound under pressure. If one so desires, a chamber containing iodine or other antiseptic can be interposed between the heat unit and the patient. The heated air volatilizes the iodine and carries it into the depths of the wound.

DR. SAMUEL L. LEDBETTER, JR. (Birmingham, Ala.).—I would like to briefly discuss Doctor Reid's paper. Of course, surgery would be impossible without proper wound healing and I think that we as surgeons can still go a little further in obtaining better results, and getting better healing of our wounds, by paying more attention to the little details and following the suggestions as outlined by him. My only wish is that all the interns and young doctors in the country could have been present and heard him. For some time I have been comparing the difference in the healing of wounds in which silk was used with wounds in which catgut was used. Also, I have been comparing the wound healing in thyroidectomies which have been drained and those that were not drained, and have come to the very definite conclusion that when silk is used and the wound not drained, wound healing is very definitely better than when we use catgut and employ drainage.

In the December 4, 1935, issue of the Proceedings of the Staff Meetings of The Mayo Clinic, Dr. H. W. K. Zellhoefer reported some very interesting observations on the wound healing of the last 50 thyroidectomies, of their 1935 series, in comparison with the last 50 cases, of their 1934 series. In this report he stated that all cases were operated upon with local anesthesia, and all, or practically all, were drained. I was interested in comparing the wound healing in his cases in which catgut was used and in which drainage was employed with our cases in which silk was used and no drainage employed. Of course, no really fair comparison could be made, due to the fact that my 50 cases represented six months' work, or a fair average of what I was doing, and the cases he analyzed were undoubtedly operated upon in a very short period of time and possibly did not represent a fair average of their wound healing, as a large percentage of these may have been very large vascular glands, substernal adenomata, *etc.*, necessitating more prolonged drainage. Chart I is an exact duplicate of his diagram upon which mine has been superimposed, and which shows very clearly the differences in the wound healing of the two technics. It will be noted that, in

Doctor Zellhoefer's series, approximately 58 per cent of his cases were still draining at the end of ten days, the average time for complete healing was 14 days, and one case drained as long as 28 days. In my last 50 cases of the 1935 series, 40, or 80 per cent, of these were closed and only ten, or 20 per cent, were drained. Of the closed cases, none drained postoperatively, the wounds were healed within 48 hours, and all dressings removed on the fifth day. Of the wounds that were drained at the time of operation, only one drained as long as 14 days (Chart I).

CHART I.



PERCENTAGE OF DRAINING AND NON-DRAINING THYROIDECTOMY WOUNDS DURING THE POSTOPERATIVE PERIOD IN THE 1935 SERIES OF 50 CASES

I think that the reason Doctor Zellhoefer's cases drained longer than those cases which I drained was due to the fact that we removed the drain after 24 hours, whereas he stated that they left them in from two to four days. Local anesthesia was also employed in my series. Chart I demonstrates very clearly the superiority of silk and nondrainage over the use of catgut and drainage.

DR. WARFIELD M. FIROR (Baltimore, Md.).—I wish to congratulate Doctor Green on bringing to the attention of this group the work of Doctor Abel on tetanus. It has been my good fortune to assist Doctor Abel in some of this work. Some four years ago Doctor Abel, in his presidential address before the American Association for the Advancement of Science, reviewed the subject of bacterial toxins. In gathering the material for this paper he was impressed with the fact that Meyer and Ransom's theory concerning tetanus toxin was out of harmony with the known facts relative to all other bacterial toxins. Doctor Abel's curiosity was aroused, and he began a series of investigations to test the validity of the theory of nerve transportation of tetanus toxin. It might be interesting to tell you of just two of our recent experiments. In order to demonstrate the existence of local tetanus, Doctor

Abel devised a method of making multiple minute injections of diluted toxin into muscles. As little as 1/200 of a lethal dose is sufficient to cause the entire hind limb of a dog to become rigid if intramuscular injections are made in 30 or 40 different places. Such a dog remains in good health and runs around with the limb fixed in extension. The rigidity is so great that one cannot alter it even under anesthesia. After three months the muscles relax and the limb returns to normal. Recently we have tried the effect of sectioning the spinal cord on the development of this type of rigidity. Regardless of whether the cord is transected before or shortly after the intramuscular injections, the limb becomes stiff and remains so. If, however, all the nerves to the limb are divided, thus interfering with the reflex arc and destroying the tone of the muscles, no stiffness results following the injection of toxin.

The second experiment that we have performed recently consisted in injecting 1/1,000 cc. of tetanus toxin into the anterior horn cells of the lumbar cord. Such an injection produces a hyperexcitable condition of the limb; the slightest sensory stimulation will precipitate a succession of forceful jerks that will last for a minute or so, until the muscles become fatigued, and then gradually subside. This type of injection does not result in a stiff leg. It reproduces, we think, the central form of the disease.

DR. ALBERT O. SINGLETON (Galveston, Tex.).—Doctor Hart's paper deserves some discussion, I am sure. At his request we ran a series of cultures in our operating room. Before doing so we felt that we were taking the usual precautions against infection, as is commonly done in most places, and we were rather surprised to find the large number of colonies following the exposure of the media for one hour on a number of days. We found that the larger the personnel in the operating room the greater the number of colonies, and seeing that certainly impresses upon one the fact that bacteria are in the air, and in prolonged operations, particularly, many of them contaminate open wounds.

I am not sure whether his method of sterilizing the air is practicable, but I am looking forward to some method which will be practicable, for I am convinced that air infection is a menace. Of course, this is not a new subject, but we had come to the conclusion that there was little danger from this source.

I visited an operating room in Copenhagen several years ago in which the floor of the amphitheater was about one inch deep in water. Everyone one the floor wore rubber boots and they were convinced that keeping down dust was very essential in lessening the bacterial content in the air.

DR. CURTIS F. BURNAM (Baltimore, Md.).—Doctor Reid has presented, in a most instructive and convincing way, the importance of increasing resistance in surgical wounds by greater care in handling and taking care of the tissues; that this will always be a fundamental principle in surgical technic is beyond doubt.

Doctor Hart has brought us something new from the other side of the picture. I think that his charts demonstrate that the so-called aseptic fever after operations is in all likelihood a septic fever. Every surgeon is familiar with the unexplained breakdown of some incisions. In addition to the wound infections, there are, now and then, some special and unusual deep seated infections which cause death. Any work directed toward removing this source of danger, provided it does not entail impossible expense, should be given the greatest consideration. Frankly, I am surprised that, using ultraviolet light, Doctor Hart is able to kill the bacteria so quickly and that the

use of radiation of this kind over an incision does not injure the tissues themselves. However, as I have had no experience personally with this matter, I think we must remember that experience is the best teacher and that preconceived ideas must be given up in the light of actual experimentation. It would seem to me that it might be possible to sterilize the air in the operating room, and to use some form of mask for the operator and his team, which would prevent any infection from their respirations.

I feel that Doctor Reid and Doctor Hart should be congratulated on the splendid work they have done and their excellent presentation of it.

DR. FRANK H. LAHEY (Boston, Mass.).—Doctor Overholt has been particularly interested in Doctor Hart's work and we are installing a similar apparatus. He has interested Doctor Wells in the department of physics at Harvard, where they are also installing an apparatus which I think may be useful. I have objected to having to operate with goggles and with my head encased. They have suggested that they put in the lights so that they throw the rays upward and this will irradiate the upper air. They think it may be possible to sterilize all the air in the operating room by exposing the upper layer of air to these rays, the motion of air eventually resulting in its all being irradiated. I do not know whether it will accomplish the same results that Doctor Hart has. We have exposed plates for various periods, and it is true that the air in all operating rooms is contaminated.

DR. J. M. T. FINNEY (Baltimore, Md.).—I, too, want to pay tribute, as did Doctor Reid, to that great surgeon-teacher, Doctor Halsted. Doctor Reid has epitomized in an admirable way the principles, not all original, to be sure, with Doctor Halsted, but the fundamental principles of good surgery for which he stood and contended throughout his entire surgical life. This was one of Doctor Halsted's outstanding contributions; namely, the scrupulous observation and practice of the fundamental principles of surgery in the gentle handling of tissues, the avoidance of trauma, the stoppage of hemorrhage, the avoidance of foreign bodies in the wound, such as tissue masses that had been strangulated by ligatures, the accurate coaptation of wound edges, and the avoidance of tight sutures. It is curious how often one sees these cardinal principles being violated by surgeons all over the country, unconsciously to be sure, in the undue hurry to get through with the operation. One will at times unconsciously violate these fundamental principles if one is not constantly on one's guard. In doing so, drainage of the wound is rendered necessary when the proper observance of these rules would make it unnecessary.

I think Doctor Hart's work is deserving of great credit. I am thoroughly in favor of any advance, but I think we should stop and think as we go along, and be sure that we ourselves are not guilty in our work, of violating those principles which have been so splendidly brought to our attention by Doctor Reid. Every surgeon knows from experience that the peritoneum will take care of infection better than any of the other tissues composing the abdominal wall; that next perhaps is the muscular tissue, and that most liable to infection is the skin and subcutaneous fatty tissue. In closing infected wounds I have for some time been using instead of skin sutures, long narrow strips, one-sixteenth or one-eighth inch wide, of flamed adhesive plaster and applying these instead of sutures to hold the skin in apposition. They should be long in order to splint, as it were, the adjoining skin. By this means we can bring and hold the tissues in as exact approximation as with sutures. We have yet to see infection in a wound where these

narrow strips of flamed adhesive have been used instead of sutures. It is a small thing, of course, but it has proved most useful.

DR. DERYL HART (closing).—I wish to express my indebtedness to my associates and staff for their assistance in this work, and also to those who made cultural observations for me in different parts of the country. Since there were few reports in the literature, I requested these cultures in order to confirm my impression that contamination of the air in operating rooms is quite universal, and to refute the statement that had been made that it was a local condition with us.

Referring to Doctor Burnam's discussion, it has been quite surprising to find that with such a small amount of current we could kill bacteria within a distance of eight to ten feet, and particularly that this could be done within such a short period of time. We believe that this high bactericidal effect and relatively low irritative action is due to the fact that this radiation is of a wavelength predominantly below 2,600.

As to the radiation extending upward over the operating region, as mentioned by Doctor Lahey, I hope that will work successfully, as it will simplify the matter of protection for the staff. In my opinion, the major part of the contamination of the air of the operating room comes from the personnel. The organisms given off by them will therefore be beneath the tent of rays and therefore they may get into the wound without being exposed to the radiation. This distribution of radiation may cut down the air contamination by sterilizing the air that passes within its effective range. It will not interpose an effective barrier between the wound and the source of the contamination.

I thoroughly believe in all the principles Doctor Reid brought out in his excellent paper. I do not feel, however, that we should rely upon them entirely to prevent bacterial growth in a wound if we have a method that will prevent, or greatly reduce, the inoculation of this wound. Aseptic surgery should be our ideal. Relatively atraumatic surgery should be practiced at all times, and antiseptic surgery used if the necessity arises.

DR. CHARLES C. GREEN (closing).—I wish to bring out one interesting fact in connection with the work of Doctor Abell and his coworkers; namely, that he has proved the statement made, in 1861, by the Norwegian, Doctor Heiberg, to be correct. At that time Doctor Heiberg stated: "Tetanus is not a disease of the nervous system, but a blood disease, or blood poisoning, which has its direct effect upon the muscle tissue."

Despite this statement, however, the medical profession accepted the theory of Meyer and Ransom in 1903; but now some of the statements of Meyer and Ransom appear almost as ridiculous as the article quoted from Aretaeus the Cappadocian, as, for example: Meyer and Ransom explained the stiffness of the jaws by saying that the fifth nerve was so short that the toxins traveled through its axis-cylinder so quickly that the rigidity appeared in the muscles of the jaws first. At this time that statement appears ridiculous, but how do we know that in 25 years more the things we are saying today will not appear even more ridiculous?