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TREATMENT OF ACUTE INFECTIONS OF THE JOINT BY LAVAGE AND DIRECT MEDICATION

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Since the publication of a paper¹ in 1915 in which a new method for the treatment of acute infections of joints, particularly of the knee joint, was described, I have been interested in the further development of the apparatus devised for this purpose and in the collection of further clinical data as to the efficiency of the method. The rather crude machine described in my first article answered the purpose well, but there were a number of mechanical defects in it, and these made it somewhat awkward. These defects have been entirely overcome, and an apparatus that is simple and efficient has now been devised, so that the problem of thorough irrigation and cleansing of a joint cavity is solved.

As I stated in my former article, any attempt to apply an antiseptic to the lining membrane of a joint, with the hope that this substance would reach and penetrate cells of that lining, is sure to be unsuccessful unless a preliminary cleansing has been effectively carried out. My attention was called to this fact by my complete failure to stain the mucosa of the pharynx by painting it with gentian violet, because the secretions of the mucous glands of the pharynx covered the surface with a thin slimy layer, which was renewed

by fresh secretions as rapidly as it was removed, and which prevented intimate contact between dye and mucous membrane as effectually as a layer of grease would have done. It seemed to me likely that the pus, fibrin and mucus accumulating on the surface of a synovial membrane must certainly interfere in a similar, and equally decisive, fashion with any attempts to apply to its surface a diffusible antiseptic.

The apparatus described herein is the result of attempts to devise some method by which an infected joint can be first mechanically cleansed with complete thoroughness, so that diffusible antiseptics applied to the joint may then come actually into contact with the

cells of the synovial membrane. Repeated trials of the apparatus to be described have proved that a mechanical cleansing of this sort may be done with great readiness under local anesthesia. I wish to consider also the attempts to make clinical use in infected joints of the observations as to the bactericidal value of gentian violet, to which attention was first called² in 1912, and to the study of which several other papers during that and subsequent years were devoted. It is hardly necessary to repeat in detail what those findings were, for in the first paper¹ I summarized them. Suffice it here to say that a selective bactericidal property was

found to be possessed by gentian violet; that this selective property ran roughly parallel with the gram reaction; that the property was exhibited by the dye either when the dye was applied directly to the bodies of the organisms or when it was applied to the medium in which they were grown (Figs. 1, 2 and 3); that it was manifested in extremely weak solutions, and that

Fig. 1.—Effect of staining organisms with gentian violet: Gram-negative organisms are unaffected, gram-positive organisms are killed. A, tube on left inoculated with *Bacillus prodigiosus* (gram-negative) for control; tube on right with *B. prodigiosus* that had been stained one hour with gentian violet. The growth of the stained organisms has been unaffected by the dye. B, same experiment with *B. subtilis* (gram-positive). Tube on left inoculated with *B. subtilis* for control; tube on right with *B. subtilis* that had been stained for one hour with gentian violet. The growth of *B. subtilis* has been completely inhibited by the dye.

1. Churchman, J. W.: The Treatment of Joint Infections by Lavage and Direct Medication, *Ann. Surg.*, 1915, **62**, 409.

2. Churchman, J. W.: The Selective Bactericidal Action of Gentian Violet, *Jour. Exper. Med.*, 1912, **16**, 221.

it was shown to be a vital phenomenon, since living cells stained with the dye continued to grow.

In addition to these studies on gentian violet itself, subsequent studies also were reported on a similar action possessed by stains closely allied to gentian violet, and it was shown in these that the selective property was common to a number of stains closely related in chemical structure. Experiments were reported as having proved that the dye possessed a relatively low degree of toxicity, and it was also shown that the dye possessed the power of staining living cells. This was proved, first, by cultural experiments, in which a small amount of gentian violet was added to the medium in which epithelial tissue was growing; it was shown that the cells picked up the dye (both their bodies and nuclei being stained with it) and that, in spite of this fact, cell division continued. That the dye possessed the power of staining living cells was also shown by a number of experiments on animals in which the bladder of the living animal was filled with the dye; on removal of the organ, the mucosa was shown to be stained throughout its depth.

I wish to report the application of the apparatus thus devised, and the knowledge as to the bactericidal

leading from a to-and-fro pump. By means of properly arranged valves and stopcocks it is possible to blow or suck fluid into or out of the joint and also from or into any one of the connecting chambers of the apparatus. The system is an entirely closed one, and there is therefore no danger of contamination of the joint from without; the air from the pump passes through a sterilized cotton filter. The essential parts of the apparatus may be readily seen in the illustrations.

The whole apparatus will fit into an ordinary autoclave, and may be sterilized with the chambers containing the fluids to be used; Chamber *I* contains gentian violet; Chamber *E*, salt solution; and Chamber *D*, 2 per cent. procain (novocain). These fluids are introduced by the removal of Cap *K* and the turning of Stopcock *L* into the proper position. The irrigation and treatment of the knee are done under local anesthesia; it is a simple procedure and practically painless. The skin is anesthetized, either at the inner or outer surface of the joint, and the trocar inserted into the joint. It is quite essential that a trocar as large as the one illustrated be used (Fig. 7), for large quantities of fluid must have thorough access to the joint,

Fig. 2.—Effect of gentian violet in the mediums on which organisms are grown: Gram-positive organisms will not grow in the presence of the dye; gram-negative organisms grow as well in gentian violet as in plain agar. The lower half of the Petri dish in these two illustrations contains plain agar; the upper half, agar to which gentian violet (1:100,000) has been added. *A*, an emulsion of *Sarcina rosea* (gram-positive) has been streaked across the plate. The organism grows well in the plain agar, but does not grow at all in the gentian violet agar, growth ceasing some distance before the dividing line is reached. *B*, an emulsion of *B. prodigiosus* (gram-negative) has been streaked across the plate. Growth of the organism occurs in the plain agar and on the gentian violet agar with equal profusion.

property of a dye capable of staining living cells without doing them any apparent damage, to the treatment of suppurative infections of the joint; for it seemed to me that joint infections of this kind presented the best point of attack in making practical application of the bactericidal observations which I have published. The studies have thus far been confined to the knee joint, first because this is the joint most easily aspirated and irrigated, and second, because, though a sharp lookout has been kept for suitable cases, the fairly active service of the New Haven Hospital has provided me no suitable infections in other joints. I have, indeed, been surprised to find that suppurative infections of the knee are much less common than I had supposed.

APPARATUS AND METHOD

The apparatus (Figs. 4, 5 and 6) consists essentially of a series of interconnecting chambers leading ultimately to a single tube, *F*, which is attached to an aspirating needle for insertion into the joint. The apparatus is connected also with another single tube, *G*,

and one must also be able to suck out of the joint bits of mucus and fibrin that may be there.

In my first cases I was rather fearful that the use of such a large trocar might lead to the formation of a permanent sinus; but there seems to be no danger whatever of this, as the puncture hole closes almost immediately.

After the needle is inserted, Stopcock *A* is turned into proper position, suction applied, and the contents of the knee joint run into Chamber *B*. By the turning of Stopcock *A* and application of pressure through the pump, this fluid is then forced through Tube *C* into a flask, to be preserved for study. Stopcock *A* is then put in the proper position, pressure applied by the pump, and the procain is driven from Chamber *D* through Tube *F*, into the knee, in sufficient quantity to distend it. This is left in the knee for a few moments and again withdrawn (by the turning of

Fig. 3.—Selective action of gentian violet on a mixture of gram-positive and gram-negative organisms: *A* divided plate, the upper half containing gentian violet agar and the lower half plain agar. The left half of the plate has been streaked with a mixture of *Bacillus subtilis* and *Micrococcus aureus*, both gram-positive; the luxuriant growth in the plain agar ceases some distance from the dividing line, and there is no growth whatever in the gentian violet agar. The right half of the plate has been streaked with the same mixture plus *B. typhosus* (gram-negative). At the point where the growth of *B. subtilis* and *M. aureus* ceases, a pure culture of *B. typhosus* is seen crossing the line and growing well in the gentian violet agar.

Stopcock *A*) into Chamber *B*. Salt solution is now allowed to run from the containing Chamber *E* into Chamber *D* by turning Stopcock *J*; and then, by turning Stopcock *A* into the proper position and applying pressure on the pump, the salt solution is forced into the joint to complete distention. It is then sucked out into Chamber *B*. This is repeated until the salt solution returns clear. Chamber *D* is then filled with hydrogen peroxid by turning Stopcock *A* and applying suction, which draws the fluid from a stock bottle through Tube *H* into Chamber *D*. This peroxid is then forced into the joint just as the salt had been, and is again withdrawn. The joint is then washed out again with salt solution. After this process has been repeated, the fluid will return perfectly clear, and one may feel sure that the knee joint is now clean of pus, mucus and fibrin. Gentian violet, 1:1,000, is now allowed to pass into Chamber *D* from retaining Chamber *I* by turning Stopcock *J*; and is then forced into the joint, as the saline and hydrogen peroxid have been, to the point of distention. This dye is left in the joint for five minutes, at the end of which time one can feel reasonably certain that the synovial membrane has been thoroughly stained. It may then be withdrawn and a small amount of weaker dye, 1:10,000, introduced.

If the results within the knee are at all parallel to the results obtained in the bacteriologic laboratory, one is justified in assuming that after the mucus, fibrin and pus have been got rid of by mechanical cleansing, the stronger solution of gentian violet kills organisms lying loose within the joint, on the surface of the synovia, or in its depths; and that if certain organisms do escape this dye, their development must be retarded by the presence of a weaker solution of the dye in the medium in which they are growing. This is the reason why strong dye is first used to stain the synovia, and a smaller amount of weaker dye left in the joint. After the dye has been introduced in this manner, the needle is withdrawn, a small piece of dry gauze placed over the puncture hole, and a pressure bandage of flannel applied. If there are indications that another irrigation and staining are necessary, the process can be repeated very readily at the end of a few days.

RESULTS OF TREATMENT

By the method just described, a series of infections of the joints, all of them infections of the knee, have been treated in the New Haven Hospital. The number of cases in this series is not large, but certain of them offered such excellent opportunity for the study of the effect of the method of lavage and staining that they may be regarded as crucial experiments. The first point that struck me in these cases was the ease with which a joint could be not only washed out but also distended with no pain, or at most, a very slight amount. This

was contrary to my expectations, as the pain of joint effusions is usually thought of as associated with distention and based on it; but there is no question at all that a joint can be distended to its utmost capacity with very slight pain, and if a simple local anesthetic is used there is no pain. The studies have also proved, what my experimental work had led me to expect, that gentian violet can be used in strong solutions applied to the surface of synovial membranes without the slightest damage. I had not been prepared to find that there would be no symptoms of irritation whatever, but this is in fact the case.

The series of cases treated contains eight infections of the knee, two of them pyogenic, five gonorrheal, and one of unknown character, probably tuberculous. It is Cases 7 and 8 to which I wish to call special attention, for the first six were done during the time when the apparatus for irrigation was being developed, and the cases themselves were not as carefully studied as later cases. In spite of this fact there were complete

Fig. 4.—Front and side views of apparatus for irrigation and lavage.

cures in Case 1, in which there was a purulent effusion of the knee which was entirely cured by one or two irrigations. The same is also true of Cases 2, 3 and 4. Particularly instructive was Case 2. This patient suffered from a double gonorrheal arthritis of the knee, with the usual golden effusion, and he was completely relieved of all signs and symptoms. In Cases 7 and 8, however, the effect of the treatment was controlled not only by clinical observations but also by roentgen-ray and bacteriologic studies.

CASE 7.—A boy entered the hospital with an acute pyogenic infection of the left knee, following a slight wound of the lower leg. It was impossible to do the operation under local anesthesia, as the boy was difficult to control and became unmanageable on entering the operating room. Primary ether anesthesia was therefore given. The fluid withdrawn from the joint was thickly purulent. It contained staphylococci on smears, and a pure culture of *Staphylococcus aureus* was grown from it. The joint was irrigated with salt solution and then stained with 1:1,000 gentian violet in the manner described. A small amount of 1:10,000 gentian violet was left in the joint. Five or six days later the opera-

tion was repeated. At this time the fluid withdrawn from the knee was normally limpid synovial fluid, very slightly stained with gentian violet, and the cultures made from this fluid were negative. The washings and stainings were repeated. The clinical symptoms promptly disappeared, and the boy had a normal knee when he was discharged, except that the tissues about the knee were still slightly swollen. The motions were normal; both flexion and extension could be actively carried on to completion.

negative diplococcus was found in the smear. These organisms could not be grown in culture. The knee was washed out with salt solution, after which it was stained with 1:1,000 gentian violet. The clinical symptoms promptly subsided, and the boy regained complete use of his knee in a short time.

In both of these cases the roentgen-ray studies showed no definite bone changes, though there was possibly some periosteal thickening in Case 7.

COMMENT

One is justified, I think, then, in concluding that apyogenic or gonorrheal infection of the synovial membrane of the knee may be cured simply and promptly by lavage of the joint and staining with gentian violet. It is probable, of course, that the success of this treatment would be less likely the longer the process had continued, and it should hardly be necessary to say that no hope should be entertained that, if bone lesions are present, these can be influenced by the treatment. The question, of course, at once arises whether the gentian violet used played any part in the results obtained, or whether the cure of the condition was simply due to thorough cleansing of the joint. I do not think any data exist at the present time to make a positive answer to this question possible. It seems to me rather likely, however, that the gentian violet does play a part, for I have shown experimentally that gentian violet kills with great ease gram-positive organisms, and that it prevents the growth of gram-positive organisms when present in weak dilutions. It also prevents the growth of gram-negative organisms when used in strong dilutions. I have also shown experimentally that this stain, if applied to the surface of a mucous membrane, reaches its depths. It seems to me reasonable to suppose that in these cases of purulent synovitis the organisms lying on the surface or in the depths of the synovial membrane are killed by the stain used, pro-

Fig. 5.—Outline of views illustrated in Figure 4.

CASE 8.—The condition was one of gonorrheal arthritis of the left knee. The clinical picture was quite typical, but the symptoms were less acute, as regards extreme tenderness,

APPLICATION OF THE TREATMENT IN EIGHT CASES									
Case and Joint	Diagnosis	Roentgen Ray Findings	Character of Effusion	Smear		Culture		Function	
				Before	After	Before	After	Before	After
1. Knee	.....	.....	Purulent	.....	.....	.....	..	Re- stricted	Good
2. Knee	.....	.....	Gonorrheal	.....	.....	.....	..	Re- stricted	Good
3. Knee (double)	.....	.....	Gonorrheal	.....	.....	.....	..	Re- stricted	Good
4. Knee	.....	.....	Gonorrheal	.....	.....	.....	..	Re- stricted	Good
5. Knee	.....	.....	Gonorrheal Gonorrheal (old)	.....	.....	.....	..	Re- stricted	No im- prove- ment
6. Knee	.....	.....	Tuber- culous (?)	.....	.....	.....	..	Re- stricted	Slight im- prove- ment
7. Left knee	Septic	Nega- tive (slight irregu- larity joint sur- face)	Puru- lent	Staph- ylo- cocci	Limpid syno- vial	Pure staph- ylo- coccus au- reus	Neg.	Marked limita- tion	Normal
8. Left knee	Gonorrheal	Nega- tive	Golden yellow serum with fibrin clots	Gram- Neg. diplo- cocci	Only 1 treat- ment	Sterile	..	Marked limita- tion	Normal

than is usually the case. The operation was done under local anesthesia. At aspiration the usual golden yellow fluid, containing fibrin clots, was withdrawn. A gram-

Fig. 6.—Detail of valve leading to tubes H, F and C, and controlled by Stopcock A.

vided the surface of the membrane has first been subjected to a thorough mechanical cleansing.

It is evident that these findings open up possibilities for the treatment of other confined infections. For example, I am now working on the treatment of abscesses near the surface, which I hope to aspirate, irrigate, and stain in the same way, and it is my intention also to see if this sort of treatment cannot be applied to other cavities, particularly to the pleural cavity, and to the pelvis of the kidney.

The apparent success of the use of gentian violet in this manner has also led me to attempt to use it in a somewhat different fashion, namely, by actual injection into the tissues themselves. Here, of course, I have had to proceed with the greatest possible care, first testing out on animals and on certain individuals who offered themselves for this purpose the irritating effect of the dye when thus injected. There is no doubt that it is slightly irritating when injected directly into the tissues. The pain of this irritation can be completely overcome by dissolving the dye in

2 per cent. procain solution instead of in salt solution; but even when this is done, if the dye is used in solutions as strong as 1:1,000, there is some danger that it will lead to necrosis.

I am not sure whether this necrosis is entirely due to the dye itself or to the distention, for I do not think sufficient

care was used in these experiments to rule out the possibility of necrosis due to distention.

The experiments went far enough, however, for us to begin the study of treatment of infections by direct injection of the dye into the tissues, and I selected for this purpose the treatment of pyorrhea alveolaris. A few severe cases of this disease have been under treatment by Dr. Gompertz of New Haven, who, under my direction,

has been injecting weak solutions of gentian violet in procain directly

into the gum about the pus pockets at the roots of the teeth. These studies have gone far enough to allow us to say that injections of this sort may be made without pain and with impunity. The results in these cases I have not been able to control as well as I wished, and it is too early to draw any positive conclusions. They have at least been encouraging, and in one of the cases were quite striking; for this patient, who had been suffering for a long time with pyorrhea alveolaris and had been advised by a very good dentist that the only hope for her was to have all her teeth removed, has been relieved of practically all her symptoms and still has her teeth. I think, however, that we are not justified in saying more than that this method of treating infections is promising.

I am also studying the effect of staining, with gentian violet, skin infected with parasitic diseases, with the hope that the application of this stain to the surface and its injection under the surface may render the tissue so hostile to parasitic growth as to conquer the infection.

Slackers.—The milkman who takes the temperature of milk with his finger; the grocer who moistens his fingers to lift the tissue paper he puts over butter.—*Pub. Health*, Mich.

THE TREATMENT OF CANCER OF THE LIP BY RADIUM

A REPORT OF TWENTY-FOUR CASES

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Epithelioma of the lip offers favorable conditions for successful treatment, whether by operation or by radium, more frequently than the majority of other forms of epidermoid carcinoma. This circumstance depends, not on less malignant tendencies, but rather on the exposed position of cancer of the lip. A malignant new growth of the lip excites the concern of a patient in a far earlier stage than the same kind of growth inside the mouth. For this reason, patients having cancer of the lip with great regularity seek assistance when their growth is still small and superficial. In these stages cancer of the lip offers particularly favorable conditions for successful treatment by radium. The growth is most accessible and can be completely covered by radium. If it is justifiable to treat any form of early cancer by radium instead of by operation, it is cancer of the lip.

In the report¹ on radium therapy in cancer at the Memorial Hospital for 1915-1916, the results in the treatment of six patients with early cancer of the lip were published. In four of these patients the disease was superficial, but two had considerable submucous infiltration of the substance of the lip. One of these patients (one of the four with the more superficial cancer) has not been traced to date. When last seen his lesion had entirely disappeared, and the lip appeared normal.

The remaining five have been traced to Jan. 1, 1918. In one of them a recurrence has developed. This patient (N. N., Hospital No. 22251) was one of the two with considerable submucous infiltration of the lip. He received his single radium treatment, July 7, 1915. The recurrence developed two years later in the cervical lymphatics, and only his infirmity (he is now 77 years old), rendering him unable for the past few months to leave his home, has been responsible for the failure to remove these glands. He still has no local recurrence, and had it been possible to dissect out the glands in the neck at an early period, it is possible that he would still be free from disease.

The remaining four patients are still free from disease. These patients were first treated as follows:

1. Janeway, H. H.: Radium Therapy in Cancer at the Memorial Hospital, New York (First Report: 1915-1916), New York, Paul B. Hoeber, 1917; The Action of Radium on Cancer, Surg., Gynec. and Obst., 1918, 26, 233.

Fig. 7.—Needle used in lavage of the joint, illustrated to emphasize the need for using a needle of large caliber.

Fig. 1 (Case 2).—Before treatment, Feb. 21, 1917.

Fig. 2 (Case 2).—After treatment, Feb. 18, 1918.