A Clinical Lecture

ON THE

TREATMENT OF SEPTIC PERITONITIS.*

BY

F. J. STEWARD, M.S., F.R.C.S.,
SURGEON, GUY'S HOSPITAL.

In recent years there has been a very marked diminution in the death rate from septic peritonitis, and this is no doubt in the main due to better knowledge of the causes of the condition and of the importance of early diagnosis and treatment. There are, nevertheless, still many deaths from septic peritonitis, some of which might, I believe, be prevented by more adequate treatment, and I have for this reason chosen this subject for the present lecture.

I shall first touch upon certain points regarding causation and pathology, and then deal with treatment, and shall describe to you a method of treatment which I have used for the past two years with marked improvement in results obtained.

Septic peritonitis may be produced by a great variety of causes, which may be summarized as follows:

1. *Infection from without* by any form of wound which perforates the abdominal wall.
2. *Infection from within* by traumatic rupture of any hollow viscus, the perforation of ulcers, or by spread of infection from septic processes within the abdomen, such as appendicitis, salpingitis, cholecystitis, and abscesses of various kinds.
3. *Infection through the blood stream*, such as pneumococcal infection.

With such a diversity of causes it is obvious that the type and degree of peritonitis must vary greatly. Consequently it is necessary to make some classification of cases for practical purposes.

It is quite usual to describe cases of septic peritonitis as being either local or general, but the term general is not at all a good one, for it implies something which really very seldom occurs, and it is more in accordance with the facts to use the terms localized and spreading.

Where resistance is high and the infection not very virulent, the area of peritoneum involved quickly becomes limited by a barrier of lymph which produces adhesions between the surrounding structures, the result being a *localized peritonitis*, which may go on to the formation of a localized abscess.

Where, however, resistance is low and the infection a very virulent or massive one there will be little or no attempt at localization and a *spreading peritonitis* will rapidly develop. The area of the peritoneum involved in any given case will depend principally upon the time that has elapsed before the case is operated upon, so that in any early case the peritonitis, although not localized, may yet be local, but in a late case so much spread will have taken place that the condition may approach more nearly to a general peritonitis. There is, however, no hard and fast line between these two types, for the one form may merge into the other; thus a localized peritonitis may, under certain circumstances, become a spreading peritonitis, or peritonitis at first quickly spreading may later become localized by the formation of adhesions. Moreover, the adhesions in such a case may form in different localities, separate localized foci resulting, perhaps, in a number of abscesses being the final stage in a case of acute spreading peritonitis. Some time ago I operated upon a little girl of 5, who was in a desperate condition from a gangrenous appendix. The appendix was removed and much stinking sero-pus let out. There were no signs of adhesions. She did well for a time but relapsed on several occasions and in the end abscesses were opened in the right lumbar region, the left iliac region, and above and to the left of the umbilicus.

Now, what are the pathological results of septic infection of the peritoneum?

They are, in the first place, precisely those associated with inflammation in any other part, but, in addition, there are also special changes which have an important bearing upon treatment. In the first place, a large amount of fluid is poured out, partly as free fluid in the peritoneal cavity,

and partly into the tissues of the various organs. This fluid is highly toxic; consequently the patient suffers from an acute toxæmia. Partly owing to this toxæmia, and partly the direct result of irritation of the peritoneum, there is vomiting, which is often very severe and frequent. In the later stages the intestine becomes paralysed and obstruction results, the bowel becoming more and more distended with highly toxic fluid and gas. This in the final stages leads to permeation of the intestinal wall by the organisms in the septic bowel contents, so that a fresh cause of septic peritonitis is added to the original one.

Taken together, these various changes produce in the patient three definite conditions, which must be reckoned with when treatment is instituted:

1. *Loss of fluid* from vomiting, and from the pouring out of fluid into the tissues of the viscera and into the peritoneal cavity.
2. *Toxæmia* due to absorption from the septic peritoneal fluid, and from the septic contents of the bowel.
3. *Intestinal paralysis*, which may pass on to the production of complete obstruction.

TREATMENT.

Bearing the foregoing points in mind, it will be seen that in treating a case of septic peritonitis certain very definite indications can be recognized.

These must be considered separately, and are as follows:

1. To remove the cause.
2. To provide drainage.
3. To make good the loss of fluid.
4. To prevent or treat intestinal paralysis.

Although there can be no doubt as to the advantage of removing the cause of the infection, this should not be a fixed rule never to be departed from, or the patient's life may be sacrificed in carrying it out. For it must be remembered that these patients are many of them very ill indeed, and, above all things, they cannot stand a prolonged operation. In fact, the general condition of the patient must decide. If this is good—in other words, if the case is early—the appendix or tube may be removed or the perforation of an ulcer closed. On the other hand, if the peritonitis is of several days' standing and the patient's condition desperate it may be far wiser to make no attempt to find and remove the cause, except perhaps in the case of a gangrenous appendix which is not tied down or difficult to reach.

The second indication is to provide drainage. Now successful drainage is, I venture to say, the crux of the whole question, for the peritoneum is so tolerant and its reparative power so great that if drainage is efficient improvement as a rule commences at once.

Numerous devices are employed, and their very number is an index of the uncertainty of their efficacy. The following may be considered:

Tubes.

It is obvious that if an abscess has to be drained the simplest and most efficient plan is to make an opening in such a position that the cavity is kept empty by the action of gravity. It is equally obvious that a collection of pus in the abdomen, and especially in the pelvis, cannot be efficiently drained by a tube passed into the cavity through an opening in the anterior abdominal wall. No actual drainage will be accomplished in that way, although a small amount of advantage no doubt does result in two ways—for the tube, in the first place, acts as an overflow pipe, so that tension is relieved and the size of the cavity is no longer an increasing one; and, in the second place, the respiratory movements help by pushing the fluid up the tube.

Nevertheless, this quite inefficient plan is by no means infrequently adopted, and I have seen not a few patients dying from septic peritonitis with one or more drainage tubes full to the brim of foul fluid sticking out through openings in the anterior abdominal wall.

A short time ago I was reading an article written by a well-known surgeon. He describes a case of pelvic appendicitis in which at the operation "offensive purulent fluid welled up from the pelvis," and goes on to say, "a large drainage tube was left in the pelvic cavity." Five days later a second operation was performed for paralytic obstruction, and "the lower three feet of the ileum were

* Delivered at Guy's Hospital, December 17th, 1919.

found to be acutely inflamed and in a state of paralytic collapse."

This account clearly proves that the pelvis was not efficiently drained by the tube, or there would have been no peritonitis five days later, and therefore no paralytic obstruction. A tube may, however, at times be used to advantage if it can be placed in such a position that it will drain a given site with the help of gravity—for instance, through a stab wound in the right loin to drain the kidney pouch. Used in this manner there is nothing more efficient, but, as a general rule, a tube passed from the anterior abdominal wall into the pelvis or elsewhere is, by itself, entirely unsatisfactory.

In order to help matters where tubes are used in this way the plan of sucking them out from time to time by means of a syringe is sometimes adopted, but I cannot say that this has given much satisfaction.

Gauze Drains.

Gauze drains, either in the form of large tampons or as cigarette drains formed of gauze within a rubber tube, are very commonly used. Here the suction action of capillarity is made use of to counteract the effects of gravity, and often with considerable success, but if the amount of fluid is large the gauze soon tends to become blocked and sodden and no longer acts efficiently, so that it must be frequently changed, and herein lies the chief objection to its use.

Continuous Irrigation.

Since, owing to the physical conditions present, drainage in the ordinary sense is so difficult, it is reasonable to attempt to bring about the same effect by other means, such as continuous irrigation. This acts in at least two ways, for it not only washes the pus away but it dilutes it and so diminishes its toxicity. Two years ago I first began to employ the following method of irrigation, and I may say at once that I am more than satisfied with it, for although I have used it in a number of extremely bad cases, some of which I shall describe, the result has in every case been successful.

The method adopted is as follows: After the bulk of the pus has been gently mopped up with gauze sponges, several Carrel tubes are passed into the abdomen in different directions, one or more being carried down to the bottom of the pelvis. A large-bore rubber drainage tube is also carried down to the bottom of the pelvis and fixed to the lower part of the abdominal incision by a fishing-gut suture.

The upper part of the incision is partially closed with sutures; then lightly packed with gauze, which surrounds the tubes, and a large dressing applied. The patient is propped up in bed in the Fowler position with a bedpan beneath him, large wool pads intervening. The Carrel tubes are connected up with a saline bag with a drop regulator in the circuit, and warm normal saline solution is allowed to drip continuously at about the rate of a drop a second. At this rate the amount run in in twenty-four hours is nine pints, which, as far as one can judge, appears to be a sufficient quantity. The irrigation is continued usually from three to six days, according to the condition of the patient. The large tube and all the Carrel tubes excepting one are then removed, the one Carrel tube remaining in the pelvis a few days longer.

The striking rapidity with which the patients thus treated have shown signs of improvement is clear proof of the efficacy of the treatment, for in all of them vomiting has quickly ceased, in a few hours the general condition has improved, and up to the present no case has had any marked degree of intestinal paralysis.

The loss of fluid in these cases of septic peritonitis is very great, and it is of first-rate importance to lose no time in taking measures to replace it. This may be done by saline infusion either into a vein or into the subcutaneous tissue of the axillae, or per rectum.

Axillary infusion should be commenced as soon as the patient is partly under the anaesthetic and continued during and for some time after the operation. In very bad cases the intravenous method is better because more rapid, for the fluid very quickly leaves the circulation and thus replenishes the loss of fluid from the tissues. After the patient is back in bed rectal infusion should be started and continued until vomiting has ceased, when fluid can be given by the mouth.

Paralysis of the intestine is always present in great or less degree in bad cases. If it has not become a serious feature, as judged by the character of the vomit, and the appearance of the intestine at the time of operation, it will usually pass off if drainage is efficient, but in order to assist the process pituitrin in doses of $\frac{1}{4}$ or 1 c.cm. should be given every six hours according to the age of the patient, and, after four doses, this should be followed up with a turpentine enema. In severe cases, however, the most distended coils should be incised and emptied of their contents at the time of operation. Several lengths of small intestine can be quickly emptied in this way and the incisions closed by one or two fine sutures.

Such are, in general, the main indications and the means of meeting them. I shall now describe certain points regarding the practical application of these principles to actual cases.

Many patients suffering from severe septic peritonitis are in a state of collapse when first seen, often owing to being moved some distance to the hospital. No harm will be done in such a case by a short delay before the operation is performed in order that methods of resuscitation may be applied. These consist in the application of warmth, a hypodermic injection of morphine and atropine, and the administration of fluid in the form of rectal or subcutaneous saline.

At the end of an hour the general condition of the patient will usually be so much improved that the operation may be safely proceeded with. In these critical cases details count for much and an apparently small point may make all the difference. Care must be taken, therefore, in the first place, to avoid chilling, the patient's limbs must be warmly clad, the theatre warm, and, if possible, the table specially heated. The patient, already in a toxic condition, must not be unnecessarily poisoned by the anaesthetic, chloroform must therefore be avoided and either gas and oxygen or warm ether vapour given. I do not advise spinal analgesia in these cases, as this involves turning the patient on to the side and back again, a course that must be liable to do harm. Moreover, the fall of blood pressure so often seen during spinal analgesia would be at any rate very serious and might be fatal.

As regards the operation itself, this will vary according to the condition present, and the following types of case may be considered.

A. Cases Not Requiring Drainage.

Bearing in mind the fact that the peritoneum is capable of dealing with a considerable degree of infection without harm resulting, one can, in certain cases of early septic peritonitis, be satisfied with removing the cause of infection without drainage, the abdominal wound being completely closed.

For instance, cases of perforation of gastric and duodenal ulcers, if operated upon within eight hours of the catastrophe, may usually be safely treated in this manner, provided that the perforation can be securely closed and the peritoneal cavity efficiently cleansed of escaped gastric or duodenal contents by irrigation with a large quantity of warm saline.

Again, during operation upon certain cases of acute appendicitis the question of drainage or closure of the wound without drainage arises.

Consideration of the following points will help in arriving at a correct decision.

1. *The Character of the Fluid Present.*—If this is only slightly turbid and does not smell much, it may be gently mopped out and the wound safely closed; but if the fluid is thick and more approaching to pus and is foul-smelling, the safer plan will be to drain.

2. *The Condition of the Patient.*—A healthy young adult, whose general condition shows that he is putting up a good resistance to his infection, as indicated by good colour and pulse and a temperature raised a few degrees, may usually be safely treated by complete closure of the wound; but in the case of children whose resistance to peritoneal sepsis is notoriously so poor, in old people, and when the general condition is not good, it is far better to play for safety and provide some adequate form of drainage for a few days.

The following case is a good example. The patient was a healthy boy of 16, in good condition, who was admitted to hospital on November 11th, 1919, for acute abdominal pain of three days' duration. He was tender

and rigid in the right iliac region, his pulse was 104, and temperature 100.2°. At the operation the appendix was found swollen and congested, and there was some fluid in the pelvis, slightly brown but clear. This was mopped out and the wound closed without drainage, except for a gauze wick in the subcutaneous tissue. The patient made an uninterrupted recovery.

B. Cases Suitable for Gauze Drainage.

In the next group of cases the area of involvement of peritoneum is small in extent, but there is usually considerable lymph deposit and the fluid is purulent. The causal factor in these cases is usually an inflamed and possibly gangrenous appendix or an inflamed Fallopian tube. In such cases, after removing the appendix or tube, I pack the infected area with sterile gauze tampons, bringing the ends out at one end of the wound, closing the rest of the wound with a few temporary sutures.

After three days, if the patient is doing well, an anaesthetic is given, the tampons removed, and the wound closed completely. The great advantage of this plan is that the wound heals per primam, so that the risk of ventral hernia is disposed of, and, moreover, much time is saved. It may be objected that the second anaesthetic and second operation here advised would be avoided by simply draining the cavity, but to my mind the advantages already mentioned clearly outweigh this objection, and, further, the anaesthetic affords an opportunity of thoroughly inspecting the parts, and thus of detecting early and dealing with any separate collection which may be forming.

C. Late Cases.

We now come to those late cases in which a large area of peritoneum is involved in a spreading peritonitis, the cases so often wrongly labelled general peritonitis. If the cause is a perforated gangrenous appendix, as frequently happens, it can be removed, but in other cases the cause may not be discovered at the operation, often because the patient's condition is so desperate that any extended search is out of the question. These are the cases in which the method of continuous irrigation I have already described to you is so valuable. Here are some cases which illustrate the practical application of the method.

CASE I.

Rose W., aged 29, was admitted into Guy's Hospital on April 4th, 1918. She had not felt well for some months, and ten days before admission became very ill with pain in the abdomen and legs and constant vomiting. She became steadily worse, and on admission was in a condition of collapse, with a rapid running pulse and subnormal temperature. The abdomen was somewhat distended, did not move on inspiration, and was rigid and tender all over.

Operation was performed immediately, a median incision evacuating a large quantity of foul pus which filled the pelvis and the lower part of the abdomen but appeared to be partially shut off by omental adhesions above. As the patient was too ill to permit of any search being made for the source of infection, the pus was as far as possible rapidly mopped up and the wound partially closed. Several Carrel tubes were introduced in different directions, one going to the bottom of the pelvis, and with it a large-bore drainage tube for return flow as already described.

The patient remained in a critical condition for several days and then slowly improved. The continuous irrigation was kept up for eight days, and as there was then very little discharge the tubes were removed. A small collection subsequently formed, and was evacuated spontaneously through the wound on the nineteenth day after operation. Apart from this, progress was uninterrupted, and the patient was discharged well on May 23rd.

CASE II.

Annie S., aged 7, was admitted on October 1st, 1918, after four days' illness, with symptoms of appendicitis. The child was obviously very ill and presented a typical picture of spreading peritonitis in an advanced stage.

At the operation the appendix was found to be gangrenous and perforated, the lower part of the abdomen, so far as seen, and the pelvis were full of foul pus, and there was practically no sign of lymph or limiting adhesions. The irrigation treatment already described was adopted and the child soon began to show signs of improvement, but the pulse remained rapid and the temperature continued to swing for several weeks. Four weeks after admission a subphrenic collection on the right side was evacuated, and a few days later signs developed at the right base and proved to be due to a localized empyema, which was drained. Moreover, a faecal fistula formed at the site of the original incision and did not finally close for over two months. However, the child eventually recovered completely and left the hospital in good health on January 16th, 1919.

CASE III.

A man, aged 37, was admitted on January 6th, 1919, having been ill for six days with pain in the lower part of the abdomen and continuous vomiting. The abdomen was distended, rigid, and tender all over, these signs being of maximum intensity in the right lower quadrant. At the operation the appendix was found to be gangrenous and perforated, and free pus was present in the abdomen and pelvis with absolutely no evidence of adhesions.

The general condition of this patient was not so serious as that of the other two, and he improved more rapidly. The irrigation was continued for five days, and after this there was very little discharge, healing being complete at the end of four weeks.

The next case was operated upon by my surgical assistant, Mr. Slesinger, who has kindly supplied me with the following notes.

CASE IV.

J. C., a woman aged 16. No previous attacks. On December 3rd began with abdominal pains and diarrhoea. On December 6th vomiting began accompanied by constipation. Pain became worse, and tended to settle in the right iliac fossa. Vomiting and constipation continued until admission on December 10th.

On admission, pulse 130, temperature 102.4°, respirations 30. Abdomen rigid, distended, and immobile. Tender all over, particularly in right iliac fossa. Tongue dry and furred; well-marked abdominal facies.

Operation December 10th: appendix incision. Appendix gangrenous at base, with perforation of caecum where it was attached discharging faeces. Generalized peritonitis with no signs of adhesions, and quantities of pus everywhere. Appendix removed, and four Carrel tubes—two into pelvis, one across abdomen towards the left, and one towards the liver—inserted, tied to large drainage tube, running down to pelvis. Axillary saline during operation, and rectal saline sodium bicarbonate given later. Continuous saline drip into peritoneum for four days. Attempt to keep pelvis dry by capillary vacuum suction apparatus.

Bowels open with enema on second day and daily after with liquid paraffin. Tongue moist on third day, no vomiting, pulse and temperature settling, abdomen much more supple; general condition very good by fourth day.*

The above cases sufficiently illustrate the method, which I may say has been applied in a large number of other cases with similar results.

Treatment after the operation consists in keeping the patient propped up in the Fowler position, as this helps to prevent spread of infection upwards towards the diaphragm and chest, the administration of saline per rectum or subcutaneously, and injections of pituitrin to overcome the paralysis of the bowel. Sleep very often does not come easily to these patients, owing partly to the position and partly to general discomfort, for there is not usually much actual pain subsequent to the operation. I am sure it is unwise to give morphine if it can be avoided, and as a matter of fact sleep can usually be obtained by other means. I find that medinal gr. 10 or dial gr. 1½ are most useful, and if there is vomiting either can be given with 15 or 20 grains of aspirin in a small rectal saline, and this combination usually acts well. Failing these, heroin gr. ½ or omnopon gr. ⅓ should be tried before morphine is given, and one or other will usually succeed.

Under this treatment the patient usually does well, and this will be evidenced by dropping of the pulse rate, cessation of vomiting, and cleaning of the tongue.

Complications.

From this time on a sharp look-out must be kept for the onset of complications. The most likely complications are the following:

1. *Cardiac Failure.*—In elderly patients and in the subjects of organic disease an operation for septic peritonitis, although apparently successful for twelve or even twenty-four hours, is liable to be followed by heart failure which almost always is fatal. The patient, who may be otherwise doing well, becomes restless and perhaps a little delirious, and with this the pulse is noticed to be less strong and more rapid, and soon the extremities show signs of becoming cold. In such a case you will, of course, apply the usual remedies—warmth, pituitrin, camphor, and so forth—but they are not likely to be successful.

2. *Paralytic Ileus.*—I have already mentioned that there is always some paralysis of the intestine involved in peritonitis. With appropriate treatment this will usually pass

* This patient died two weeks after this lecture was delivered. She did well for a time, but subsequently developed an empyema and a number of intraperitoneal collections.

off, but sometimes, and especially in cases operated upon late and where the drainage is not really satisfactory, the paralysis after a time gives place to definite obstruction which is accompanied by all the results met with in cases of mechanical obstruction of the intestine. The bowel above the paralysed part becomes distended more and more, and finally the wall becomes sodden and no longer prevents the passage of organisms from the inside, so that a fresh cause of peritonitis may in this way be added to the original one. All this is accompanied by persistent vomiting, first of duodenal and later of intestinal contents, increasing abdominal distension, and a rising pulse rate.

The management of these cases is no easy matter, for it is difficult to say at any given moment whether or no the condition present is due to a degree of paralysis that will pass off or whether the condition has already passed this stage. Moreover, much depends upon the determination of this point, for on the one hand needless secondary operations must be avoided, and on the other hand it is important not to waste valuable time.

Unfortunately, I can give no very definite rules for your guidance, but the progress of the case and the results of treatment are the data upon which opinion must be based.

If several doses of pituitrin followed by enemata result in the passage of flatus, all will probably be well, but if vomiting continues, and no flatus is passed, in spite of these measures, and if, further, the enemata are retained entirely, the outlook is usually bad, and in this case the abdomen should be reopened under gas and oxygen, and several of the most distended coils of intestine opened, and thoroughly emptied of their contents and closed again. Except in the most advanced and hopeless cases this treatment will relieve the condition.

3. *Local collections* frequently form after a spreading peritonitis has been successfully relieved by suitable treatment, and must be carefully watched for.

The danger signal is usually a rise of temperature, and in the presence of this indication careful and repeated examination must be made for local areas of resistance and tenderness, not forgetting rectal and vaginal examination for collections in the pelvis.

If evidence of a collection is found there need not be too much haste to attempt to evacuate it, provided the general condition of the patient is good, for it is not always easy to find a small subphrenic abscess or a collection amongst coils of intestine, and, moreover, the attempt to do so may result in the formation of a faecal fistula from tearing a coil of softened intestine while separating adhesions. Again, there is no doubt that small collections may be absorbed, for a tender lump associated with a rise of temperature may persist for some days and then gradually disappear, especially in the later stages of convalescence. It must be remembered also that empyema is not an uncommon complication of septic peritonitis, so that the chest must be carefully examined from time to time, especially if the temperature continues to swing. This is illustrated in the second case I described to you, in which there was first a subphrenic collection and later an empyema.

4. *Faecal fistula* also complicates a certain proportion of these cases, and is due sometimes to the separation of a gangrenous appendix, at others to pressure from a hard drainage tube too long retained, and occasionally from the giving way of the wall of the caecum when greatly distended and exposed in the wound. In the majority of cases the fistula will close in course of time, but in a few the mucous membrane becomes continuous with the skin and a secondary operation is needed later.

Finally, *ventral hernia* must inevitably occur as a late complication in many cases, and may require an operation for its cure.

A COURSE in dermatology and venereal diseases, open to foreign as well as French graduates, is about to begin in the Faculty of Medicine, Strasbourg. It will consist of forty clinical and ten laboratory demonstrations. It will begin on May 1st and terminate on July 14th. Full particulars can be obtained on application to Professor Pautrier at the Faculty of Medicine, Strasbourg. The fee for the course is Fr. 300. Should a sufficient number of applications be received a further practical course on the Bordet-Wassermann reaction will be arranged.

A Lecture

ON

THE SOLDIER'S HEART AND WAR NEUROSIS:

A STUDY IN SYMPTOMATOLOGY.

DELIVERED AT THE CLINICAL INSTITUTE, ST. ANDREWS.

BY

SIR JAMES MACKENZIE, M.D., F.R.S., F.R.C.P.

(Concluded from page 494.)

IX. THE MECHANISM OF VISCERAL PAIN (THE VISCERO-SENSORY REFLEX).

THE remarkable difference between the sensitiveness of the external body wall and the viscera in response to mechanical stimulation brings out clearly the difference in function of the two divisions of the nervous system—a difference which it is necessary clearly to understand if the symptoms of disease are to be fully comprehended. It shows that when pain is evoked from the organs or tissues which are not supplied by the sensory nerves of the cerebro-spinal system some other mechanism must take part in its production.

The nature of this mechanism is revealed by the study of the symptoms produced in certain forms of visceral disease. If we take the symptoms that are present in certain simple diseases—for example, a gastric ulcer, appendicitis, or renal colic—the mechanism by which a number of symptoms are produced will become clear. In many cases of gastric ulcer there is pain, limited to a small area, in the epigastric region. This pain has a different location from the ulcer. Thus the pain may be situated in the middle line, as in Fig. 6, where the shaded area, A, indicates the site of pain, while the ulcer, revealed at the *post-mortem* examination, is situated at the pylorus, which was found at x in Fig. 6. Moreover, if a patient with this pain breathes deeply, the stomach, with the ulcer, shifts its position, but the site of pain remains fixed. With these facts before us, the mechanism of pain in visceral disease becomes clear. When the disordered sensations of toothache were considered it was seen that the only reasonable explanation was that from the offending tooth a stimulus had been sent into the central nervous system. The effects of this stimulus were not limited to the cells of the nerve supplying the tooth, but spread to the cells of sensory nerves in the immediate neighbourhood, with the result that there was pain and hyperalgesia in neighbouring teeth and in the skin of the cheek.

FIG. 6.—The shaded area in the centre shows the position of pain and hyperalgesia in a case of ulcer of the pylorus situated at x.

From the stomach a stimulus is conveyed by the sympathetic nerves into the central nervous system. But as these nerves are not "sensory" nerves in the sense that they are directly connected with any perceptor in the brain, no sensation is felt (Fig. 7). In like manner, so long as the impulses conveyed from the ulcer do not spread no pain is felt. When, however, the stimulus is of such a nature that it spreads to other cells, then we get a reaction peculiar to the cells stimulated. In this case the stimulus reaching the nearest sensory cells of the cerebro-spinal system irritates them, and the pain which results is referred to the peripheral distribution of the nerve stimulated—that is, the nerves supplying the area of skin as already described in paragraph V on referred pain. Fig. 8 illustrates the mechanism by which pain is produced in visceral disease, showing how an organ itself insensitive and supplied only by sympathetic nerves can produce pain by reacting upon the cells of the cerebro-spinal sensory system. The stimulus arising in the organ x passes to the central nervous system, where its cell, x', has no direct connexion with the sensorium, s, but when an adequate