a positive reaction obtained. The method used was that recently published by McKee (in the JOURNAL, October 23rd, 1915).

P.S.—On February 28th Mrs. K. presented herself again at the hospital for examination. She seemed quite well, and said she felt well. She had done all her housework almost from the date of leaving the hospital. Her tongue, pulse, temperature were all normal; appetite good, bowels regular. Complexion now well coloured, and all the tallowy tint had disappeared. She was strongly urged now to have her mouth attended to and all bad teeth removed from unhealthy gums. Dr. Hare made a fresh blood examination, which is here appended.—C. A.

Blood Examination, February 28th, 1916.

Haemoglobin	...	...	48 per cent.
Red blood cells	...	...	3,950,000 per c.mm.
White blood cells	...	...	41,000 per c.mm.
Differential leucocyte count:			
Polymorphonuclears	...	...	48 per cent.
Lymphocytes small and medium...	...	...	44 per cent.
Large mononuclears	...	...	5 per cent.
Hyalines...	...	...	1 per cent.
Basophiles	...	...	2 per cent.
Nucleated red cells,	1 per cent.	of leucocytes counted.	

REFERENCES (collected by Dr. Ede).

- ¹ Hutchinson, *Proc. Roy. Soc. Med.*, 1913, vi, Surg. Sec., 241. ² Faltin, *Deutsch. Zeit. Chir.*, cx, 160. ³ Noguchi, *Berl. klin. Woch.*, 1912, li, 1839. ⁴ Thursfield and Gow, *St. Bartholomew's Hosp. Reports*, Vol. I, Part 1. ⁵ Fuhs, *Amer. Journ. Med. Sci.*, 1911 cxlii, 713. ⁶ Rolleston, *Clin. Journ.*, xix, 403. ⁷ Johnston, *Ann. Surg.*, 1908, xlviii, 50. ⁸ Rodmand and Willard, *Ann. Surg.*, 1913, lvi, 601. ⁹ Boyd, *Clin. Journ.*, April, 1915. ¹⁰ Banti, *Fol. Haemat.*, 1910, x, 33. ¹¹ Otto, *Wien. klin. Woch.*, 1910, 54. ¹² Brill and Mandelbaum, *Amer. Journ. Med. Sci.*, 1913, cxlvi, 863. ¹³ Roth and Bernstein, *Arch. of Ped.*, 1914, xxxi, 340. ¹⁴ Chaurfard, *Presse med.*, 1907, xv, 345. ¹⁵ Thursfield, *Proc. Roy. Soc. Med.*, 1914, vii, Clin. Sec., 84. ¹⁶ Muhsam, *Deutsch. med. Woch.*, 1914, 377. ¹⁷ Ziegler, *Deutsch. med. Woch.*, 1910, li, 2410. ¹⁸ Seefisch, *Sem. med.*, 1914, 35. ¹⁹ Weber, *Quart. Journ. Med. Sci.*, 1908, iii, 85. ²⁰ Kidd, *Proc. Roy. Soc. Med.*, 1913, vi, Surg. Sec., 231.

THE PRINCIPLES OF TREATMENT AND THEIR APPLICATION TO WOUNDS.

BY

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A WOUND is the local effect produced by an irritant on the tissues, and the consideration of irritation should include (1) its cause, (2) its effects, (3) the reaction to it, and (4) its complications.

1. *The cause of irritation* is described as an irritant. Irritants may be classified as (a) non-infective, and (b) infective; in the former class are included mechanical, chemical, electrical, and thermal agents, x rays, etc.; the infective are micro-organisms.

2. *The effects of irritation* are essentially destructive in nature, and they are general (shock) and local (tissue destruction). Whereas one has been accustomed to regard a wound as entailing a breach of surface, ordinarily produced by a mechanical agent, it is more in accordance with reality to include under the term all destruction of tissue, of whatever degree, in whatever situation, and by whatever variety of irritant brought about—for example, contusions, ruptures of viscera, fractures, burns, and injuries of all kinds.

3. *The reaction of the tissues to irritation* consists of vascular changes and cell proliferation (Rutherford Morison), vascular changes predominating in the acute and cell proliferation in the chronic form.

4. *The complications of irritation* result from (a) extension of the process of irritation; (b) superadded irritation; or (c) healing.

PRINCIPLES OF TREATMENT.

The principles of treatment are: (1) Remove the cause; (2) combat the effects; (3) assist the reaction; (4) prevent complications, or deal with them if they have arisen.

1. Removal of the Cause.

A sterile metallic body gives rise to a minimum of irritation sufficient for the production of a fibrous capsule, whereby the body is completely isolated. In a large proportion of cases missiles have come to be regarded as

sterile, particularly rifle bullets presenting a small wound of entry. Under special circumstances, even where the bullet is apparently sterile, it may require removal—for example, when from its position it gives rise to irritation of nerves, interferes with the movements of a joint, etc. Operative measures for the removal of metallic bodies ought to be restricted where x rays are not available. It is unjustifiable, then, to do any extensive dissection, and difficult operations should be postponed till the base is reached. The commonest and most important indication for the removal of bullets, etc., is sepsis in the track. Should operative measures be determined upon, it is essential to bear in mind that too small an incision increases shock from the excessive retraction demanded, and the longer time necessary for the operation.

2. Combating the Effects.

There is general agreement that in the present campaign the degree of shock is greater than might have been anticipated from the nature of the injury, and there seems to be little doubt that it is due especially to excessive mental and nervous strain; in prolonged engagements, also, insufficient food, arising from the difficulty of its transfer, contributes in no small measure. Rough transport following the receipt of the wound, especially in motor ambulances over paved roads, is responsible for a considerable increase in the degree of its severity.

The requirements of the milder cases are met by a good meal, with some tea or cocoa, immediately followed by quiet and sleep. In the more severe cases, rest, with the foot of the stretcher elevated, is essential. Should pain or restlessness be present, morphine must be administered hypodermically. It is remarkable what tolerance to the drug these patients exhibit, half a grain being a regular and not infrequently inadequate dose; it is of advantage as a prophylactic before transporting the patient from one place to another. Stimulants, whether by the mouth or hypodermically, must be given with caution, the rule being "repeated small doses." For example, one tenth of a grain of strychnine will increase the shock (Crile), while one-fifth of that amount given perhaps each hour will benefit the condition. Should the temperature, as is usual, be subnormal, no time must be lost in raising it by the careful application of heat, internally and externally. Lastly, in the worst cases, the chief stand-by is transfusion in one or other of its various forms. The use of saline is the commonest method, and it may be given per rectum, subcutaneously, or intravenously. Of these, the first two are preferable for ordinary use, since absorption takes place according to demand, while the rectal method has this commendation—that sepsis is almost impossible. With most people the intermittent administration of saline per rectum is more successful than the continuous, and it should be given, according to the tolerance of the individual, six to ten ounces every three or four hours. Half an ounce of brandy may be added to the injections, making an average of three ounces for an adult male in twenty-four hours. Auto-transfusion, though useful, is much less in vogue; rectal injection of one pint of hot coffee and half an ounce of sugar is an excellent substitute.

In the treatment of the local condition wounded blood vessels must be dealt with first, as haemorrhage predisposes to both shock and sepsis. Temporarily any of the first aid means may be utilized, while for permanent arrest the method must be chosen according to the case—for example, pad and pressure, forcipressure, ligature, suture or vessel suture, the last being reserved for vessels of some size. The effects of haemorrhage are counteracted ideally by blood transfusion, but, more commonly, saline transfusion, in one or other way already mentioned, is the means resorted to.

The importance of ascertaining that no tourniquet is left on a limb too long (anything above two hours is dangerous) cannot be too strongly emphasized.

3. Assisting the Reaction.

The reaction of the tissues, consisting of vascular changes and cell proliferation, is usually directed against both cause and effects. When dealing with the cause it is called "inflammation," and when dealing with the effects, "repair," but it is essentially similar.

Where open wounds are aseptic the first essential is to close them, but in war wounds do not often fulfil the

necessary conditions, and such treatment is frequently contraindicated by the presence of sepsis.

4. Complications.

Irritation may extend by continuity, contiguity, lymphatics, or blood stream. The mechanical irritants under consideration only produce further mischief by continuity or contiguity, and by the time the patient comes for treatment all the damage likely to occur has been done. Treatment, then, resolves itself into dealing with those complications which have arisen—for example, injuries to vessels, nerves, bones, joints, or viscera, such as brain, lung, liver, gut, etc.

Superadded irritation must be either non-infective or infective, though in warfare they are usually found together. This is especially so in shell wounds, into which portions of clothing, soil, etc., are commonly driven, and these are necessarily infected, calling for early antiseptic dressing of the wounds; as a prophylactic antitetanic serum, 1,500 units administered as soon as possible, has established a well-merited reputation. Antisepsis vaccine, given much less frequently, is likely also to be of value, when the problems of vaccine administration are more completely worked out.

All war wounds must be regarded as septic in greater or lesser degree, and a large number of them contain additional non-infective material as well which must be removed.

Removal of the Irritants.—Keeping in mind the limitations imposed by an absence of *x* rays, three types of mechanical removal are at the surgeon's disposal, the wound being well laid open (1) by forceps or some such other instrument, (2) by irrigation, and (3) by the introduction of hydrogen peroxide, the mechanical agent being the oxygen liberated. No extensive search, especially in the dark, should be made. An extension of this method is advocated by many surgeons—namely, excision of the whole wound, whereby it is hoped to remove all irritants in the tissues forming the walls of the wound. The telephone probe and *x* rays, as accessory to one or other of these methods in the case of metallic irritants, require no comment. Should a mechanical irritant not be removed by one of these methods, it is usually necessary to leave it *in situ* and allow the tissues to deal with it themselves, in which case it is either encapsulated or attempts are made to extrude it, usually through an abscess. The other type of irritant present is infective, the commonest being the ordinary pyogenic cocci, though others are often present, including the *B. coli* and several varieties of anaerobes. These may be removed by the means above described, but, short of excision of the wound surfaces, it is not likely that they will. After the lapse of a few hours excision of the wound is no guarantee that they have been entirely removed, and if all are not removed the opening up of large new surfaces to infection may lead to serious complications. Seeing that these methods are not likely to meet with success in the removal of micro-organisms from wounds, strong antiseptics should be employed as the lesser of two evils. These, in varying degree, act on the organisms present in the tissues of the wound-wall, and hence the method is used as an alternative to that of excision. Pure carbolic acid, from its penetrating antiseptic power, is still the best of these chemical agents, though numerous others are in common use. Hypochlorous acid is at present on trial, and so far results are exceedingly good. The actual cautery is an efficient though destructive germicide, and is no longer in vogue.

Assisting the Reaction.—Acute active inflammation is always the reaction to infection with micro-organisms, and its chief function is to deal with the irritant itself. The redness and heat, and in part the swelling and the pain, are due to the increased vascularity present, the chief part of the swelling and pain being due to fluid exudation with increased tension in the part, while the impaired or arrested function is controlled by the pain. The increased metabolism in inflammatory fever is associated with the production of bodies antagonistic to the organisms and their products, while the general impairment of body function, by enforcing rest, provides for a minimal expenditure of energy. Locally the increased vascularity and fluid exudation combat the organisms and their products both chemically and physically, while the impaired function, governed by the pain, produces the rest necessary for a maximal beneficial effect.

Thus we assist the increased metabolism and avoid the evil effects of impaired body function, by keeping the patient in the recumbent posture, keeping up the body strength by easily assimilable liquid nourishment (the thirst indicates the need for fluids), and regulating the excretory action of the lungs by fresh air, the skin by hot bathing, bowels with saline, and kidneys with abundant fluids. Locally, rest and elevation of the part, the application of moist heat, and Bier's bandage or suction glasses, all favour increased blood flow, while hypertonic saline dressings, if they can be borne, assist in marked degree the increased flow of lymph. On the other hand, the avoidance of ill effects of the local reaction is mainly confined to the relief of tension in the tissues by timely incision, and also the provision of efficient drainage, whereby infective material is removed. This includes the evacuation of abscesses, and the careful emptying of all pockets where discharges may be retained.

Incomplete healing may be due to imperfect reaction either to the cause or to its effects, but the commonest cause is superadded infection inadequately combated. Where healing is complete complications are due to the formation of fibrous tissue in the soft parts, with its subsequent contraction, or callus where bony tissues are involved. Treatment is chiefly preventive either by accelerating healing and so diminishing the formation of fibrous tissue, or controlling deformity by careful attention to position, splinting, skin grafting, etc. Should the complications have arisen they must be dealt with according to their nature—for example, adhesions separated, contractures divided, callus removed, etc. The preventive treatment alone is of immediate importance.

TREATMENT OF HEAD INJURIES.

In a clearing hospital it is not possible to watch results unless exceptionally, as the cases are sent out as soon as they can be safely removed. Though I have treated all wounds that have come under my care by the same method, I have only been able to watch throughout their course some of the skull injuries, which have been detained on account of their serious nature. They were treated as follows:

1. The wound was dressed, the lotion used for the removal of the old dressing being 1 in 20 carbolic. Mercury perchloride was contraindicated because iodine had invariably been used lavishly, often producing blistering. If further investigation proved to be necessary, the wound was packed with spirit gauze wrung out of 1 in 3,000 mercury biniodide.

2. An anaesthetic was administered.

3. The head was washed with 1 in 20 carbolic lotion, and the hair shaved off whilst the carbolic was dripped on, following the razor.

4. The bruised edges of the wound were trimmed with mouse-toothed forceps, knife, and scissors, and the wound dried and swabbed throughout (including exposed brain) with pure carbolic acid. In more extensive wounds the excess of carbolic was neutralized by methylated spirit, otherwise it was mopped away.

5. A large flap was reflected, usually with the wound in its centre.

6. The skull was trephined, all loose depressed bone removed, and projecting edges nibbled away. No extensive search was made for distant pieces of bone or foreign body. Bleeding was arrested by fine suture, muscle tissue, or packing.

7. Exposed brain and dura mater were covered with spirit gauze wrung out of 1 in 3,000 mercury biniodide, the free end being pulled through the original wound. A tube was or was not introduced.

8. The operation wound was sutured with silkworm gut.

9. Three days later the gauze was removed; the tube might or might not be removed; if left it was removed at next dressing.

10. Where the original wound resembled an incised wound secondary sutures were inserted on the fifth or sixth day. In punctures this was not necessary, and in extensive laceration and destruction it was not possible.

The number of skull wounds operated upon was 14. Flaps were always sutured up at the time of the operation, and in three cases secondary suture of the original wound

was possible, each time with success. In no case was the wound dressed in less than forty-eight hours. In only one case did sterilization of the track of the projectile as far as the dura mater fail; in this case the sepsis was mild, and was limited to the track, the flap uniting by first intention. There was one death, from meningitis and cerebral abscess, one week after operation; outside the cranial cavity there was no sepsis in this case. In only one patient was there any suggestion of a hernia cerebri. This was in a case with most extensive injury, a large lacerated scalp wound, with marked comminution and depression of skull and extensive laceration and discharge of brain substance. There was also considerable intracranial haemorrhage with pressure symptoms and paralysis of the left arm and face. A large clot was removed at the time of the operation, and subsequently a small protrusion of brain occurred. The protrusion gradually diminished and the face and arm steadily improved. No untoward symptom developed.

NOTES ON WAR SURGERY.

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ALTHOUGH I cannot speak with any great authority on the subject of the treatment of wounds seen in this war, because the contingent of which I am a member remained on Salisbury Plain until early in 1915, and their medical units were the last to be established in France, yet five months of active surgical service in that country has enabled me to make certain observations which will, I trust, be at least suggestive to some who, like the writer, are placed on "the lines of communication," where atypical rather than typical methods of treatment are necessitated.

In dealing with wounds in hospitals on the lines of communication, the first aim of the surgeon is to save the soldier's life, and the second aim is to save the part affected, the two greatest dangers to both being infection and secondary haemorrhage.

In considering the first it must be realized that the great majority of wounds seen in the hospitals of the lines of communication are infected. Of these infections one sees principally three varieties, which should be considered in order of their ordinary seriousness.

I. Infection by Tetanus.

This fortunately is rare because of the faithful use of antitetanic serum at the front, yet because prophylactic treatment is efficacious, whilst treatment of the incident infection is more rarely so, it is wiser to assume that all our wounded have been infected by tetanus, and that all have not been treated with a prophylactic dose of serum at the front. It may be argued that those who have received antitetanic serum are usually tagged, with an inscription giving the dose administered, when they are received at the hospitals of the lines of communication, but the importance of the wounded being protected against tetanus and the fact that the immunity conferred is probably only temporary makes it wise to consider the administration of a second dose in these hospitals. There is but one danger in this practice, namely, that of anaphylaxis, but this danger may be disregarded, and a dose of 1,500 units of antitetanic serum administered subcutaneously on admission, provided always that the patient has not been so treated at a date earlier than one week previously. In this latter case the antitetanic serum must be administered in a different manner; thus, the dose of this serum must be divided into two parts. The first part, containing 1 c.cm., should be given intravenously. The remaining part should be administered subcutaneously half an hour to an hour later.

Two weeks after this administration of antitetanic serum in the hospitals of the lines of communication the administration of another dose should be considered, and if found necessary it should be given in a divided dose, both intravenously and subcutaneously, as already directed.

II. Infection by Gas-producing Organisms.

These are of the anaërobic variety. Of these, the bacillus of malignant oedema is the most common. More rarely found is the *Bacillus aerogenes capsulatus* (Welch). Infections by these are characterized by their virulency. It is necessary, therefore, to recognize them early, because at first the infection is local, although usually of a deep wound, and practically always of the lower extremity.

A wound so infected is dirty in appearance. It contains pus, or pseudo-pus, with a faecal-like odour, which is similar to liquid faeces in colour and consistency. The parts about it are swollen and congested, but at this stage no characteristic crackling may be elicited by palpating the surrounding tissues; thus it may be difficult to differentiate it from an infection by the colon bacillus. Later there may be localized gangrene around the wound about which crackling can be elicited on careful palpation. In some cases this latter may be noticed without a suggestion of gangrene. The condition at first is really one of cellulitis. The patient's general condition, which is due to toxæmia, is often far worse than is suggested by the local lesion. In those cases where crackling is found on palpation there can be no doubt as to either diagnosis or treatment. In the earliest stages, where there is doubt as to the diagnosis, open freely and drain. Where crackling is found, treat at once as one would a fulminating cellulitis, when the freest incisions and drainage are indicated. At the same time hydrogen dioxide may be injected into the surrounding subcutaneous tissues in an attempt to limit the infection. The infected area must be kept under constant surveillance, always remembering that to save life amputation, in the case of a limb, may be necessitated at any time. When gangrene has appeared, amputation is necessary. This may be done through the emphysematous tissues if the open methods to be described later are employed.

In dealing with infections by gas-forming organisms it is necessary to keep in mind that the patient's life is endangered from the very beginning, and, although very free incisions may relieve the patient even at this date, in cases where we are dealing with a cellulitis alone, in a great number amputation with free drainage will have to be resorted to in the end, in order to save the patient's life.

III. Infections by *Staphylococcus*, *Streptococcus*, and Mixed Infections.

These are the more ordinary conditions met with—indeed, are seen in the majority of wounds. They are combated by drainage; often drainage of the most thorough character is necessary, consequently this subject will deserve special study.

It is generally known that, of all wounds, shell wounds require the greatest care. Where there is any possibility of portions of clothing being retained in the wound, cleansing and free drainage must be instituted. If these wounds are superficial, they may often be laid open with advantage. If the wound, on the other hand, is deep and filled with blood clot, this must be cleaned out and care must be taken to tie any bleeding point, but, if none is discovered, such wound will demand special care, as in such not only is secondary haemorrhage to be feared, but concealed haemorrhage may be followed by clot formation and infection. In dealing with all these wounds, primary suture must never be considered, but rather suture to maintain the patency of the wound is often of great advantage. The excision of superficial wounds is advised with the closing of new surfaces, but no wound in which suppuration can be expected is ever closed.

The method of laying open infected wounds by means of sutures, already suggested, is worthy of consideration. Suppose, for instance, a piece of shell is projected under the skin and, more or less, superficial tissues for a distance of some inches. Its track is probably infected, and its surfaces necrosed. It is often found to be wisest to lay such track open, thus converting a tunnel into an open gutter; further, the cleansing of the wound can be hastened by invaginating its edges and sewing them perhaps even several inches from the wound. If this be done it will be found easy to remove these stitches and to bring the edges together when the wound is clean. The same principle is made use of in amputations. In the hospitals of the lines of communication amputations are recommended usually