WAR WOUNDS AND AIR RAID CASUALTIES

The following is one of a series of lectures on the Treatment of War Wounds and Air Raid Casualties recently delivered at the British Postgraduate Medical School

COMMON INFECTIONS OF WOUNDS: TETANUS AND GAS GANGRENE

BY

CLAUDE FRANKAU, C.B.E., D.S.O., M.S., F.R.C.S.

It is obvious that any wound produced by a missile, whatever its nature, will be potentially an infected wound. Simple perforating wounds of an exposed portion of the body, not involving the carrying in of infected clothing, may heal by first intention, but such an outcome is rare. Wounds in which the projectile is retained and in which fragments of clothing, etc., are embedded are of necessity infected, the degree of infection depending on the extent of injury to soft parts and bone and the condition of the clothing and skin of the patient. A wound sustained by a soldier dressed in mud-stained uniform in the well-manured fields of Flanders inevitably became heavily infected unless treated energetically within a short time of wounding.

The bacteria which may be found in wounds are of many types, and may be divided into two groups. Group 1 consists of the following organisms, any or all of which may be present at the time of wounding: anaerobic spore-forming bacilli—for example, *B. welchii*, *B. sporogenes*, and *B. tetani*; pyogenic cocci—for example, staphylococci; streptococci (haemolytic and non-haemolytic); and organisms of the *B. coli* group. At a later date Group 2, consisting of staphylococci and streptococci, predominates, and may be the cause of septicaemia; in addition such organisms as *B. pyocyaneus* may be found as a secondary infection.

The spore-bearing anaerobes produce two conditions which are of extreme gravity and require special treatment—namely, gas gangrene and tetanus—conditions which will be dealt with in detail later. The pyogenic cocci and organisms of the *coli* group, etc., are more amenable to simple treatment, have mainly a local effect, although they may be the cause of a septicaemia, and, with one exception, require no special measures apart from the routine treatment* for all wounds. The exception is the haemolytic streptococcus, which in the great war was the cause of septicaemia in innumerable cases and was then found difficult if not impossible to combat. At the present time the introduction of the sulphonamide group of drugs has entirely altered the picture, and it seems probable that the use of sulphonamide as a prophylactic, as is the case already in civil compound fractures, etc., and for treatment when infection is established, will be of extreme value provided the drug is employed with care.

TETANUS

The incidence of tetanus fell to such a very low figure in the great war after it had been decided that anti-tetanic serum should be given to every wounded man, however trivial the wound, that it is clear that the disease is largely preventable. Infection is by means of spore-bearing anaerobic organisms which, if able to develop in a suitable environment, produce a toxin which eventually invades the central nervous system via the motor nerves. The

organism may be present in a wound without producing the disease: any type of wound, even the most trivial graze, if infected, may be the cause of tetanus; but punctured wounds, and wounds in which other organisms, which use up oxygen, are present, are particularly favourable to the development of the disease.

Prevention

Experience in the treatment of wounds shows, first, that the more carefully the wound is treated in the early stages the less the liability to infection by *B. tetani*; and, secondly, that the use of anti-tetanic serum in suitable doses is of indisputable value.

Dosage of Antitoxin.—The customary prophylactic dose for the majority of wounds is 500 U.S.A. units—a larger dose of 1,000 to 1,500 units being given in the case of severe wounds or when a wounded man has not been within reach of assistance for a considerable time after being wounded. A larger initial dose was advocated towards the end of the war, and it seems probable that a first dose of 1,000 U.S.A. units in all cases would be preferable to the smaller standard dose of 500 units. Tetanus spores are very resistant, and may lie dormant in wounds for long periods; hence it is essential to repeat the injection of serum weekly for four weeks, and in addition a dose should be given subsequently if any further operation is to be performed involving the original wound area. This dose should be given eighteen to twenty-four hours before the time of operation. The danger of anaphylaxis is very small, and will be still less now that the antitoxin is concentrated in a smaller bulk of serum.

Incubation Period

The incubation period in cases which have not been given a prophylactic dose of serum shows considerable variation: onset of symptoms within twelve hours has been recorded, and the first symptoms of the disease may be delayed for as long as twenty-eight days. Taking an average, it appears that in cases untreated by serum the onset of symptoms usually occurs in from seven to ten days. In cases treated by serum the onset is always delayed, its average time of appearance being approximately fourteen days. The severity of the symptoms varies directly with the date of onset: if symptoms begin within seven days of the injury a fatal result is almost inevitable; the mortality diminishes with the delay in onset.

Symptoms

I do not intend to describe fully the symptoms of a developed case of tetanus; these will be known to anyone who has seen such a case, and they are adequately depicted in all textbooks. Certain of the early and premonitory symptoms require mention.

One of the earliest signs is anxiety: the patient looks worried, his face is pinched, the pulse is quick, the tongue tremulous, and there is obvious deterioration of his general condition. The next phase is slight spasm of the facial and masticatory muscles, slight stiffness of the neck, and at times some spasm of the vesical sphincter. With this there is often difficulty in swallowing fluids as well as solids. Finally, well-

marked trismus and risus sardonicus appear, with subsequently all the well-known generalized spasms of fully developed tetanus.

In some cases, especially those with a delayed incubation period, the condition known as local tetanus may be observed. In this condition there is localized stiffness and spasm of muscles in the neighbourhood of the wound. Generalized spasms may follow, but in a considerable number of these cases generalization of symptoms does not occur provided additional serum treatment in large doses is instituted at once. Another type of infection is cephalic tetanus, the cranial nerves being affected as a result of a wound of the face or head. Facial palsy with spasm of the facial muscles is the principal feature: generalization of the disease is uncommon, and recovery is the rule.

Treatment

Immediate isolation of the patient in a quiet room that can be darkened is essential. Any sudden auditory or visual stimulus may invoke a spasm. Doubts have been cast on the efficiency of serum once the disease has started, but my own feeling is that in large doses given subcutaneously, intramuscularly, intravenously, and intrathecally serum is definitely beneficial by its action in neutralizing further toxins liberated from the infected area. Very large doses should be given in the following way: On the first day, (1) intrathecally; (2) intramuscularly; (3) subcutaneously; (4) intravenously—15,000 U.S.A. units by each route. This dosage should be repeated daily—with the exception of the intravenous dose, which it is safer to omit—until symptoms begin to abate. The dose may then be reduced, but treatment by the subcutaneous and intramuscular methods should continue until all stiffness has disappeared. The injection is comparatively small in bulk, there now being 1,500 U.S.A. units approximately in 1 c.cm. of serum in the concentrated preparation. This reduction in the amount of serum given diminishes the risk of anaphylaxis, but this danger must always be borne in mind when administering antitoxin by the intravenous route.

The wound should receive the minimum of treatment. It may be necessary to establish better drainage or to remove bone fragments, etc., but in doing so the tissues should be disturbed as little as possible. Major operative intervention should be avoided unless haemorrhage or other condition necessitates a life-saving operation.

Control of the Spasms

The intense spasms of tetanus kill by producing spasm of the diaphragm and by the patient's exhaustion from want of sleep and inability to take food. Many drugs have been used to control the spasms, but at the present time practically all have been supplanted by avertin, given per rectum in full anaesthetic doses. Avertin controls the spasms for periods up to six hours, during which time fluid food can be taken and the patient is able to rest. It may be given in severe cases every eight hours, and can be continued for six or seven days if necessary. In the later stages, when the symptoms are regressing, bromides, chloral, chloretone, and nembutal are of use.

Mortality

It is almost impossible to give an exact figure representing the true mortality, but from a study of a number of statistics of cases of tetanus occurring in war wounds

it appears that in patients who have received a prophylactic dose of serum the mortality is 50 per cent., while in unprotected cases it is nearer 80 per cent.

GAS GANGRENE

The organisms which produce gas gangrene are of two types: the saccharolytic, of which *B. welchii* is the commonest, which decompose carbohydrates and produce acid and gas; and the proteolytic, which digest protein and produce alkaline (ammonia) bodies. In the latter *B. sporogenes* is the commonest organism. Both organisms may be present in a wound, *B. welchii* being the most common, and it is probable that a certain amount of interaction occurs—that is, *B. welchii* produces acid to such an extent that its action is inhibited and only starts again after *B. sporogenes* has produced enough alkali to neutralize the excess of acid. Infection by gas-forming organisms occurs, in almost every instance, primarily in muscle, and the virulence and extent of the infection depend on the integrity of the blood supply to the part. Gas-forming organisms may develop in the pleural cavity or in a joint when blood is present, but under such circumstances show much less virulence. Invasion of the blood stream is uncommon, and is usually a terminal event.

The Clinical Picture

From the clinical point of view a case of gas gangrene presents the following picture:

The onset may be very rapid: the earliest case I saw developed not more than three and a quarter hours after the receipt of the wound. The average time of onset is probably about thirty-six hours, and development at a much later date has often been recorded. The appearance and condition of the patient are characteristic: the skin is yellowish, the expression pinched, and the tongue dry; the pulse is rapid and poor in volume, and the blood pressure as a rule is low. The condition of the patient may be far graver than the nature of the wound would indicate.

The wound itself presents certain definite features: a characteristic smell resembling acetylene gas is to be noted on removal of the dressings; the skin edges show no reaction; and a thin discharge often containing gas bubbles is seen escaping from the wound.

If a limb is affected swelling is present and a tympanitic note may be obtained on percussion. In the late stages crepitation may be felt in the subcutaneous tissue. In the early stages the skin of the limb is pale as a result of the swelling. As the condition progresses the skin becomes yellow; purple patches then develop, with blebs containing blood-stained serum, and finally, when death *en masse* has occurred, the limb assumes an olive-green colour.

When a wound is opened up or an amputated limb is examined after removal, naked-eye changes in the muscle may be observed. The earliest change is in colour, the normal purple-red of healthy muscle changing to a dusky red: in more advanced cases the muscle becomes a brick-red, is friable and non-contractile, and gas bubbles may be seen or felt in it. In the last stages the muscles become pultaceous and greenish-black. The fact that at operation on a wounded limb non-contractile brick-red muscle is found should at once suggest that gas gangrene is present even if it had not been suspected before. On microscopical examination it can be seen that the muscle fibres are at first coagulated and separated from their sheath by a space presumably containing gas and toxic exudate, and in the later stages both sheath and fibres are completely disintegrated.

The gangrene may be of two types: (1) Massive gangrene involving the whole limb and practically always associated with injury to the main vessels of the limb. (2) Group gangrene, where a muscle or a group of muscles

are affected, the main blood supply being unaffected. It is of interest that in this type of case the infection does not readily tend to spread from one group of muscles to another.

Treatment

Prophylaxis by means of anti-gas-gangrene serum or the use of this serum after the infection has been established is in my opinion of little or no value, though it is obviously difficult to substantiate this statement fully in the case of prophylaxis. The giving of anti-gas-gangrene serum at the same time as anti-tetanic serum is advisable therefore, and though it may do no good it can do no harm. The best form of prophylaxis is the early and careful débridement of the wound, all dead tissue, especially muscle of doubtful vitality, being removed and the wound being left open for some days if there is obviously risk of severe infection. In established cases the line of treatment depends on the nature and extent of the infection: where there is massive gangrene in a limb with damage to the main artery early amputation is essential. Such amputations should be well above the limits of the infected area; if flaps can be fashioned they should be ample, and it is advisable that they should not be sutured for some days. Exposure of the stump to the air with the minimum amount of dressings is also of extreme value. The immediate amelioration in the patient's condition after amputation for gas gangrene is most remarkable.

In group gangrene, where a muscle or a group of muscles are attacked, resection of the affected area will often cut the infection short and save both limb and life. I will give two examples of such cases to illustrate the method:

Case 1.—This patient was wounded at 1 a.m., the right leg being shattered in the lower third. He was admitted at 3.30 a.m., and a primary amputation was performed by equal lateral flaps in the upper third of the leg at 4 a.m. The flaps were lightly sutured and provision was made for continuous eusol irrigation. All went well for twenty-six hours; the pulse then ran up to 120 (it had previously been 80 to 90), the tongue became furred, and the patient was drowsy and obviously very ill. On examination of the limb the front of the leg showed mottling of the skin, with swelling and a tympanitic note on percussion. The patient was at once anaesthetized and the wound was opened up, when it was found that the entire anterior tibial group of muscles in the stump were brick-red in colour and non-contractile. They were removed *en masse*, and the wound was left open and treated by continuous eusol irrigation. After twenty-four hours the patient's condition improved steadily, and he was evacuated to the base nine days later. At the first operation it was noted that the anterior tibial artery was occluded but that the anterior tibial muscles were apparently healthy and contractile: the arterial occlusion clearly predisposed to the development of the gangrene at a later date. In this case it is doubtful whether the patient would have survived an amputation through the thigh. Local excision of the infected muscle group gave him a useful stump with a normal knee-joint.

Case 2.—This patient was wounded at 4 p.m. by a rifle grenade fragment and admitted three and a quarter hours later as a walking case. When he arrived he was clearly very ill: his pulse was 120, of poor quality; the tongue was furred and the face pinched. There was an irregular entry wound the size of a threepenny-piece on the posterior aspect of the right arm just above the internal condyle of the humerus; there was no exit wound. The whole arm appeared swollen and was crepitant to the touch; there was a tympanitic note on percussion. He was operated on at once, when it was found after excision of the wound of entry that the projectile was lying to the inner side of the vessels in the

lower third of the arm. A second incision was made over the site of the projectile, and subcutaneous tissue was found to be oedematous and the biceps muscle showed signs of gangrene. The whole biceps was therefore exposed by a long incision and the inner half was found to be changed in colour and non-contractile: the outer half of the muscle appeared to be normal. As the infection seemed to be localized to the inner half of the muscle this portion was excised in its entirety. The wound was left open for seven days, and was then closed by secondary suture. The ultimate result was extremely satisfactory.

BIBLIOGRAPHY

- Cole, L. (1936). *British Medical Journal*, 1, 1191.
 — (1938). *Proc. roy. Soc. Med.*, 31, 1205.
 Frankau, C. H. S., Drummond, H., and Neligan, G. E. (1917). *British Medical Journal*, 1, 729.
 Wallace, C. (1917). *Ibid.*, 1, 725.

THE ORGANIZATION OF OUT-PATIENTS AT A TEACHING HOSPITAL

BY

WALTER HOWARTH, M.A., M.B., F.R.C.S.

Surgeon to the Ear, Nose, and Throat Department,
St. Thomas's Hospital

It has for a long time been a reproach that at the large London hospitals, in which very considerable numbers of out-patients are dealt with each day, the patients may have to wait, and indeed often do wait, many hours before their case is finally attended to and they are free to go home. A considerable period of waiting may also be entailed when patients come up regularly for treatment, and it is sometimes the case that a patient may wait several hours before being seen. If the patient is at work and time is valuable, a visit to the hospital may well mean the loss of half a day, and if this has to be repeated at frequent intervals it may give rise to some dissatisfaction on the part of the employer as well.

From time to time attempts are made to expedite the examination of patients, either by having a continuous "sorting" system or by the appointment of senior officers qualified to deal with the cases as they arise and so obviate the necessity for the patient to wait to be seen by the visiting surgeon or physician at a later hour. Improvements have undoubtedly been effected by these and other means, but the lot of the patient who comes for regular treatment (and these form the bulk of the hospital out-patient attendances) has not improved very much. In my department at St. Thomas's Hospital a scheme has been worked out and has been put to a practical test with such satisfactory results that it seems worth while to draw attention to it in the hope that others may think it worthy of a trial. The details of the scheme have been largely worked out by the lady almoner to my department, Miss Turner, and by my colleague, Mr. Bateman, and the greatest credit is due to them.

The System at St. Thomas's

In a teaching hospital, not only have the patients to be examined, diagnosed, and treated, but some also have to be reserved for teaching purposes and examined by the students. A certain number of those who attend for regular treatment have also to be examined with the students, so that the results of treatment may be followed up and demonstrated. This necessity for teaching—of vital importance, I think, from the student's point of view—naturally complicates and often delays the actual treatment of the patients, so that any plan that ensures a more even distribution of time is an advantage for everyone concerned. A careful examination of the time-sheet will show the method that has been adopted, and a mere glance at the accompanying typical daily time-sheet that has