THE CLOSED PLASTER METHOD OF TREATMENT

AN ACCOUNT OF ITS USE DURING THE SPANISH WAR

BY

Colonel J. D'HARCOURT, M.D.

Formerly Chief Surgical Consultant to the Spanish Republican Army

A. FOLCH, M.D., and A. ORIOL, M.D.

Professors in the Faculty of Medicine, Barcelona

The Spanish War of 1936-9 provided a very wide field of experience in the treatment of war wounds by the occlusive method. Trueta published his first results in the treatment of the victims of aerial bombardments, and we here record our own results when applying the technique to the Republican Army. During the latter period of the war we were personally responsible for the treatment of 7,500 fracture casualties, and followed up a further 17,000 cases treated in other centres specializing in fractures. As a result of our clinical experience the use of the closed method was extended to the treatment of injuries to soft tissues in cases in which there was much loss of substance. Below we describe its application to those wounded in battle.

To make it possible to employ this technique it was essential to standardize the methods of those surgeons who were dealing chiefly with fractures and to establish special centres of treatment so that the same method might always be adopted in the various surgical units of the Army. The closed method can be applied both at an early stage—that is, within six or eight hours of the infliction of the wound—and at a later stage, when the wound has already begun to granulate. We dealt with cases in both stages: the slight variations in technique required in each will be described later.

General Results

Although the total number of casualties is not available, we can quote some statistics in connexion with fractures which indicate the importance of this technique—a technique which permits a very high degree of conservative treatment. For instance, in the Battle of the Ebro a surgical unit dealt with 120 casualties, and in only five cases—in which there was very extensive local damage—were amputations necessary. At the Vallcarca Hospital, Barcelona, out of 5,000 wounded treated by us in one year (almost exclusively fracture cases) only twenty-six secondary amputations were performed, and very few serious complications were encountered. We had twenty cases of gas gangrene, twelve of which showed vascular lesions. In the course of the year the number of deaths among the 5,000 was thirty-seven, fifteen of these being due to gas gangrene, seventeen to septicaemia, and five to secondary haemorrhage.

We have not seen any instances of non-union or mal-union resulting from a faulty position of the callus of the fracture, despite the fact that in a certain number of cases of comminuted fracture there were a great many broken pieces that had lost all nutrient connexion. The few cases of non-union have been in the forearm, when we were faced with extensive loss of substance due to the shattering of the bones. On the other hand we have had cases of osteomyelitis connected with fracture. These

have not been serious, but they were very persistent. In our opinion the use of the closed method of treatment did not have any marked effect, one way or the other, on this complication, which is a well-known sequel of gunshot wounds.

Cases for which the Closed Method is Indicated

(a) *At an Early Stage.*—The closed method is recommended for cases in which it has been possible to clean out and excise the whole wound thoroughly within six hours of the time it was received. The more extensive the wound the greater the advisability of using the closed method. The wasting that follows evaporation and dehydration is in our experience a very serious matter. If the wound has been sutured, either partially or completely, it is important before enclosing the limb to make sure that there is no tension in any of the wound strata. Contused tissues tolerate tension very badly, soon become gangrenous, and afford an excellent focus for infection. Care must also be taken to ensure that haemorrhage has been controlled before the limb is enclosed. Haematomata, whether visible or concealed in muscular tissue, afford an excellent site for the formation of a serious anaerobic infection supervening on an aerobic infection of little importance. Early and complete immobilization of fracture wounds after thorough excision of the wound avoids the risk of secondary haematomata and prevents the muscles from being damaged by the action of fragments of bone on the soft tissues. The closed method must not be used in the following cases: (1) when there is any risk of extensive necrosis, due to the severity of the contusion and inadequate circulation; (2) when the wound is unsuitable for saucerization; (3) when a vascular lesion or the slightest suspicion of the existence of such a lesion is present; (4) when there is severe crushing. The method can be applied far more readily to the limbs of the upper extremity than to those of the lower. The greater vitality of the upper limbs, due to their more vigorous circulation, is well known, and explains this difference. Extreme caution must be exercised in dealing with wounds situated in the bend of the knee and in the buttock.

(b) *At a Later Stage.*—Infected wounds or wounds in which there is much dead tissue should be enclosed in plaster provided that they have first been submitted to débridement and saucerization. The use of this method obviates the following: (1) the ordeal of dressings; (2) the risk of secondary infections developing as a result of repeated handling of the wound; (3) the absorption of proteins from tissues devitalized by antiseptics; (4) the absorption of toxic products distributed by constant movement during treatment; (5) the destruction of bacteriophages or trephones; (6) the risk of injury to granulation tissue and the formation of unhealthy granulations (see below). Enclosure at a later stage is also indicated for fractures of the femur treated by extension once the correct position has been secured and granulation tissue is being formed beneath the slough. The same method should be used for stumps of limbs after guillotine amputation has been rendered necessary by gas gangrene or septicaemia and all risk of secondary infection is over. The appearance of oedema, either at a window made in the plaster over the wound or throughout the whole limb before any attempt has been made at immobilization, does not indicate that the closed method is inadvisable for such a case. Strict immobilization of the limb or a preliminary postural treatment will quickly cause the oedema to disappear.

Technique

The cavity of the excised wound should be lightly packed with sterile gauze: petroleum jelly is used on the gauze in Orr's technique, but Trueta omits this. A plaster bandage applied direct to the skin then immobilizes the limb. The plaster should be moulded carefully over all bony prominences to ensure the greatest possible immobilization and should enclose the two joints nearest to the wound. In cases of wounds in soft parts, with destruction of tissues but no fracture of bone, the same technique should be used.

As a general rule, provided that there are no obvious signs of trouble, every plaster should be retained in position for a period of from three to six weeks without any window or opening being made in it. If the plaster has to be removed it should be opened in two halves and the wound exposed to the air for three or four days so that the dermatitis which sometimes appears may be dealt with. This dermatitis is of no importance, being simply due to irritation of the skin caused by the discharge. If it is acute the scabs can be treated with Alibour water and the lesions with a salve of red oxide of lead (Pb_3O_4). After this interval, when the condition of the lesions permits, a new plaster is applied.

Throughout the whole period during which the plaster is in position a very careful watch must be kept on the patient's general and local condition. Attention must be paid to all symptoms experienced by the patient, especially to any feeling of tension or of movement in the region of the wound and to any local sensation of heat. On the other hand, undue importance should not be attached to a very free discharge from the wound, which may stain the plaster and even ooze through to the outside. It is only the characteristic and unmistakable smell of putrefaction which indicates the presence of a focus of necrosis and demands an immediate modification of treatment. If maggots should appear in the plaster it is a matter of no great significance, and Baer's method of treatment is sometimes unintentionally introduced in this way. We have never noticed any bad results in such cases; on the contrary, the wound generally healed well.

From the clinical point of view the most important local indications are a good circulation and range of movement in the fingers and toes, the absence of oedema, a normal temperature in the region of the wound, and freedom from all discomfort. As to the general condition of the patient, the temperature, the blood count, and the leucocyte count should all be closely watched, as explained in more detail later. Systematic radiographs should be taken to make sure that the fracture has been correctly reduced.

Minor Difficulties that may be Encountered

First, there may possibly be faults in the make-up of the plaster cast, particularly along the edges. Bony prominences may suffer undue pressure, and sores may develop and distress the patient. The most frequent cause of trouble lies in inadequate drainage of the wound. In such cases, and particularly if there is an abscess, the wound must be opened up more drastically, thoroughly excised, and a fresh plaster applied. Impetiginous infection of the adjacent skin was in our experience very rare, and always yielded to the standard treatment employed for such cases—namely, exposure to the air and the application of Alibour water and red oxide of lead. Erysipelas was also rare, and in spite of this unpleasant feature the prognosis in such cases was very good.

Complications

The chief complication that may follow fracture wounds is septicaemia. (See our work on the chemotherapy of this condition, *Revista de Sanidad de Guerra*, Barcelona, 1939.) Septicaemia does not occur when the granulations are completely impervious. Occasionally, however, one sees a low form of septicaemia in which both the fluctuations of temperature and the indications of toxæmia are only slight, but there is a stubborn diarrhoea which slowly weakens the patient and does not yield to any known form of treatment. In many cases there is no obvious cause of infection, such as an underlying abscess or a very sinuous wound; but the diarrhoea, accompanied by mild albuminuria and slight signs of toxæmia, gradually debilitates the patient, chiefly by dehydration, under the helpless doctor's eyes. In some of these cases a positive agglutination of bacteria of the *Salmonella* group was found in weak dilutions, although there was nothing in the previous history to account for this. This diarrhoea could not be attributed to the closed method of treatment, as it occurred with the same frequency in wounds treated by the open method, which ran an equally distressing course.

Examination of the Wound

In cases progressing satisfactorily the wound is found to be granulating freely when the plaster is removed. The well-defined granulations, which are deep red in colour and bleed very readily, offer a marked contrast to those of wounds treated by the open method and antiseptic irrigation, which are pale red in colour and do not bleed. The circumference of the wound will be found to be considerably smaller than it was when the plaster was applied. Epithelium forms far more quickly than it does in wounds treated by the open method. The discharge, which is sometimes considerable, comes out through the granulation tissue without in any way affecting its formation. The disadvantage of this treatment is the repulsive smell—sour and butyric—given off by the discharge. If, however, a smell of putrefying tissues is noticed—and this is an entirely different smell from that just mentioned—the plaster must be removed, as the trouble which then has to be faced is certainly necrosis. In spite of the smell the patient stands this treatment excellently. A slight skin irritation may be experienced if treatment is considerably prolonged, but the patient is otherwise comfortable, his general condition is excellent, and his temperature is normal or is so slightly raised as not to affect his appetite or prevent his being up and about. When the treatment is well tolerated there is no glandular reaction.

The first indication that the clinical picture is not satisfactory is a deterioration in the patient's general condition, followed by pain and a sensation of tension in the region of the wound. The plaster becomes hot and a stubborn diarrhoea often sets in. These adverse symptoms find their parallel in the results of laboratory tests.

Results of Various Investigations

Temperature.—In the first few days after the application of the closed plaster the temperature rises, even if the patient has previously had no fever. It then falls by lysis in the course of the next four or five days. A similar rise of temperature follows each application of a new plaster after a break in the treatment. This fever is probably due to the reabsorption of products of dis-

integration in the wound, which has been stimulated by the movements involved in applying the plaster.

Sedimentation Rate.—We noticed that the sedimentation rate is always very high, at whatever period it is recorded, and even when the patient's clinical condition is excellent. We attribute this to the persistent lack of balance in the blood proteins during the whole period of healing, which causes an abnormal local metabolism. This finding is consequently not a matter of any significance from either a prognostic or a diagnostic point of view.

Total and Differential Leucocyte Count.—The total leucocyte count is very high at the beginning of treatment or if sepsis is present. In the initial feverish period the number of leucocytes rises to about 12,000 to 15,000, to fall again correspondingly with the temperature until normality is reached. The differential count, which first indicates a state of suppuration, soon changes. Polymorphonuclear leucocytes, after a preliminary increase to 80 per cent., decrease to a normal number and Arneth's deviation disappears. The appearance of lymphocytosis and monocytosis indicates that the wound is cooling. The formula at once reveals any sign of infection which can be recognized at an early stage, especially if serial tests are made on the slightest suspicion of trouble. Nearly all cases suffer from a mild anaemia, particularly when there has been sepsis for any length of time.

Permeability of the Granulations

Great importance has been attached to a factor which is regarded as a sign of good clinical progress—namely, a decreasing permeability of the granulations that necessarily reduces the absorption of toxins at the surface of the wound.

We carried out some systematic experiments with methylene-blue (using Melchior's technique) and verified the fact that the degree of permeability in the granulations decreased in direct relation to the healing process. On the other hand, unhealthy pale granulations rapidly absorbed the colour. To avoid the difficulty of possible interference in the results by the action of the liver and the kidneys we used phenolsulphonephthalein as the dye. The medium was applied to the surface of the wound in a slightly alkaline solution (6 mg. per c.cm.) such as is used for testing the action of the kidneys. When this method is used elimination takes place very quickly and is easy to measure. The dark red granulations of wounds treated by the closed method allow of little infiltration, but, on the other hand, those of wounds treated by the open method permit the colouring matter to pass through freely. We consider this to be a factor of prime importance in demonstrating the physiopathological mechanism of the closed method.

The Discharge

The discharge has been submitted to systematic analysis, both chemical and bacteriological.

pH Determination.—Contrary to our expectation, based on some articles we had read, we found that there was, in fact, an increase in acidity, a feature also noted by Trueta. Measurements with an electrometer showed an average pH, which fluctuated round 6, reaching 5.6 in some instances; but in no case did we find the alkalinity which other workers claim to have met. We took the measurements as accurately as possible, and were careful to prevent the specimens from coming into contact with the air. To achieve this we made holes in the plaster and extracted the fluid under a covering of paraffin wax. At all events we are of the opinion that the

discharge has a high buffering power, as it resists vigorously and persistently all attempts made *in vitro* to modify its acidity.

Bacteriology.—The bacilli found have principally been the staphylococcus, the streptococcus, the common saprophyte, and often the *B. pyocyaneus*. In no case was there only one type of bacillus. In taking a field count on each successive application of plaster we noted a decrease in the number of bacteria as time went on. We noticed also that the streptococcus and the staphylococcus lost their Gram-positive character and came to look like *Neisseria*. We concluded that the *B. pyocyaneus* did not appear in smears, although it was found in cultures and reappeared in greater numbers, but with signs of degeneration, in the specimens taken towards the end of treatment, without taking up the stain. Occasionally the discharge was completely sterile, and it was impossible to obtain any cultures. This sterility is difficult to account for, and the only two logical explanations we can offer are either a deficiency of nutrient matter in the wound or the presence of bacteriophages. We have so far been unable to determine which of these two factors is responsible for the sterility. It has not been possible to measure the virulence of the bacteria, as we have not been in a position to keep and feed laboratory animals.

Conclusions

The advantages of this method of treatment may be summarized as follows:

The period of healing, and particularly that of the preliminary stage of disintegration, is greatly reduced.

In wounds of the limbs a very high degree of conservative treatment is possible, with a consequent striking reduction in the number of amputations.

Strict immobilization of the wound ensures a faster growth of epithelium and obviates the non-union and the ill-positioned calluses which so often occur after extensive and infected open fractures.

The treatment eliminates the painful process of daily dressings and prevents the distribution and absorption of products of disintegration resulting from movements involved in the constant handling of the wound.

Above all, secondary infections, which appear so readily in cases treated by the ordinary method of violent antiseptic irrigation, do not occur; nor does proteolysis, another common result of the use of antiseptics in the standard treatment. In short, the closed method does not interfere with the natural process of healing by the application of antiseptics, which, however destructive they may be to bacteria, are also destructive to those biological products whose function it is to promote healing (? trephones).

Finally, dehydration due to evaporation at the surface of large wounds is considerably reduced, and this is in itself a very important factor both in the healing of the wound and in the restoration of the patient's health.

According to a circular recently issued by the International Academy of the History of Sciences, the fifth International Congress of the History of Sciences will be held at Lausanne in September, 1940, if the political and social conditions of Europe permit. M. Aldo Mielli, the perpetual secretary of the Academy, having now settled at Santa Fé in the Argentine Republic as director of the history of sciences at Santa Fé University, M. J. A. Vollgraf of Leyden has been appointed assistant secretary for Europe and the Mediterranean countries. The review *Archeion*, the official organ of the Academy, will henceforth be published at Santa Fé, instead of at Rome as hitherto.