WAR WOUNDS AND INJURIES

SECOND EDITION

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WITH A FOREWORD BY
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FOREWORD TO THE FIRST EDITION

A physician, I have had the temerity to accept the invitation to write a Forenote to this compact yet comprehensive collection of articles dealing with war wounds and injuries. In the present state of human emergency the boundaries of medicine and surgery are more fluid than, as a useful convention, we were prone to regard them in peace-time. To-day it is a case of all hands to any and every pump.

Two things are vital in our attitude just now: quick observation and plasticity of mind. Much turns upon our ability to follow up our experiences—to cling to academic and traditional ideas may cost us valuable lives. People who make war, whether offensive or defensive, are constantly trying out new methods; if found to be of no service they are quickly dropped, if found to be good they are elaborated and intensified. So it is in this anomalous field where one set of human beings hastens to mend what another set has marred—these essays hold fast the things that remain and discard those that are only theoretical and merely transient.

The help that this little book can give is urgent; if time did not press so much no doubt a chapter on burns and another on sepsis (other than gas gangrene) would be included. I understand that a second Edition will contain them. It is safe to predict that we shall not be long kept waiting for this increasingly important information.

HORDER

PREFACE

In presenting the second edition of this book we have felt that sufficient experience has now been gained in the treatment of wounds and injuries in the present conflict to call for complete revision. We have been fortunate in getting together a group of contributors, each an expert in his own field, to describe present-day practice. We have felt it best not to fetter the judgment of individual authors as to the scope and presentation of their articles, as most of our readers will be familiar with standard methods of treatment. More space has therefore been allotted to certain specialities in which new work is being done, such as peripheral nerve injuries and fractures.

The suggestions incorporated in Lord Horder's Introduction have been adopted, and chapters on the subjects he mentions are included.

The distinction of the contributors, to each of whom our thanks are due, guarantees that those interested in War Surgery will find in this book authoritative answers to many of their problems.

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WAR WOUNDS AND INJURIES

CHAPTER 1

RESUSCITATION

Resuscitation is a major problem in the management of the wounded, and many valuable contributions have been made since the outbreak of the present war. Early treatment is the secret of success in cases of shock, the patient being transported to a centre where adequate facilities are available without delay. The patient is handled with gentleness, and care is taken when he is lifted on to a stretcher and into an ambulance. Rough transportation must be avoided as far as possible, as this will aggravate the condition. If the patient is conscious he should be reassured and anxiety dispelled. In the presence of restlessness or pain, a moderate dose of morphine is given, the amount and time being recorded on a label attached to the patient. The patient is kept warm in blankets and all unnecessary exposure avoided. The injured part is put at rest, an extremity being immobilized in a splint. Hæmorrhage is controlled by application of a pressure pad, a ligature, or a tourniquet, but the danger of leaving on a tourniquet for too long must be remembered. The presence of a tourniquet should be indicated on the patient's label. An open wound of the chest is closed immediately, an external wound emitting a sucking or whistling sound must be made as air-tight as possible by the application of a firm pad.

Reception of the Wounded. On reaching hospital, casualties are admitted to the reception hall, where they come under the supervision of an experienced medical officer, who makes a quick preliminary survey and decides on their disposal. Patients suffering from shock are admitted to the resuscitation ward. This ward should be situated near the operation theatre and reception hall. It must be of adequate size and possess adequate heating and ventilation systems, but the windows should be bricked up. The lighting must be efficient, and a reserve system is advisable. The ward is under the supervision of a medical officer who is conversant with all modern methods of resuscitation. An adequate number of trained medical assistants, nurses, and orderlies must be available. The equipment should include a plentiful supply of pyjamas, blankets, hot-water bottles, electric cradles, sterile dressings, ligatures, syringes, and sphygmomanometers. Supplies of morphine, nikethamide, antitetanic and anti-gas gangrene sera are provided. Bottles of blood and plasma must be available, together with the apparatus for blood and plasma transfusions. Oxygen cylinders are required and B.L.B. masks

and intranasal catheters for oxygen therapy. Some patients are able to take hot drinks—e.g. sweetened tea, which should be available.

Differentiation of Primary and Secondary Shock. This is easy when the injury is of such severity that immediate transfusion is required, or when no wound is present and transfusion is unnecessary. In intermediate cases, when the problem is more difficult, Whitby and co-workers advise that the patient be kept under observation, and if after one hour the blood pressure is still below 100 mm. mercury, there is probably some degree of secondary shock present and transfusion is required. If the blood pressure rises within one hour and remains above 100 mm., it may be assumed that primary shock is present and transfusion is unnecessary at once but may be required during the operation. When doubt exists as to whether transfusion is indicated, it is wiser to give it rather than to withhold it.

Many important factors in the management of primary shock are also concerned in the treatment of secondary shock and are considered in detail in this chapter, which has the latter condition chiefly in view. It should be stated that no effort must be spared to combat primary shock in order to prevent the onset of secondary shock or to minimize its effects.

SECONDARY SHOCK

Definition. Shock is a syndrome resulting from depression of many functions, but in which reduction of the circulating blood volume and blood pressure are of basic importance, and in which impairment of the circulation steadily progresses until it eventuates in a state of irreversible circulatory impairment (Wiggers).

The Physiology of Shock

The most important factors in the causation of shock are hæmorrhage, pain, cold, loss of plasma protein from the circulation to the tissues, and, in the case of burns, loss of plasma by exudation from the denuded areas. This leads to peripheral circulatory failure from oligæmia, and so produces most of the symptoms of shock.

The Clinical Picture. This varies from case to case, but generally speaking these patients are pale and cold but sometimes sweating. The pulse is rapid, thin and thready, and the blood pressure is frequently lowered. Air hunger is sometimes present. The patients are alert, and occasionally vomit.

This is the fully developed picture, and it is the aim of medicine to forestall its appearance, as treatment is far more effective in the absence of these signs. It is not generally realized that the syndrome of shock may be imminent in a patient who is apparently fairly well.

Oligæmia. The importance of this factor both as a precipitating and

also as a secondary cause cannot be over-stressed. It is in the therapeutics of oligæmia that the chief success of shock treatment resides.

The Rôle of Anoxæmia. The anoxæmia produced is of the stagnant variety, consequent upon the lowered cardiac output, and results from the diminished venous return. It is considered that this anoxæmia has a deleterious effect on the capillary walls, allowing both protein and crystalloids to escape from the circulation and so reducing the blood volume.

Diminution in blood volume caused by plasma loss is more dangerous than the same reduction due to hæmorrhage. Loss of plasma results in a concentration of the cellular elements of the blood which increases the viscosity. The increased viscosity of the blood causes a reduction in tissue circulation over and above that produced by vasoconstriction and fall of blood pressure, and so still further embarrasses the circulation. Under these conditions the patient suffers from oxygen lack.

The Rôle of Dehydration. Although the rôle of dehydration has been amply emphasized in many papers, both official and non-official, it must not be thought that it is a crucial factor in every case. The factor which must always be borne in mind is the time factor. For instance, a bomb casualty brought off the street into hospital within 2 or 3 hours of the incident is usually given sufficient fluid by mouth or intravenously to forestall the period of dehydration, and so in these cases the situation of absolute fluid loss never arises in an acute form. But in the case of a man wounded and lying in the desert for 24 hours, it does arise, and may be, and in fact is very likely to be, crucial.

Pain. Experiments have been performed regarding the association of the central nervous system and traumatic shock. Such experiments were : (*a*) section of peripheral nerves to a limb ; (*b*) section of the spinal cord ; (*c*) destruction of the spinal cord ; (*d*) induction of spinal anæsthesia. O'Shaughnessy and Slome found as the result of such experiments that when an attempt was made to exclude the nervous impulses from the area of trauma the shock syndrome was less marked.

Loss of Plasma in the Case of Burns. This is dealt with in the chapter on burns.

Treatment

The success of shock treatment depends to a very large extent on the stage at at which it is commenced. To illustrate this, a transfusion of 2 pints in the stage of potential shock might avert the whole syndrome, whereas a transfusion of twice this amount a few hours later might be almost useless. So that in " timing " lies the secret of success, and the secret of " timing " is acute observation. The danger signal is a low blood pressure, and should always be regarded as such, but a normal blood pressure does not give any reassurance of safety : it may be due to vaso-constriction in a shocked patient, and in such cases the severity of injury and the estimated amount of blood or fluid loss, are the best guide (Grant and Reeve).

The Induction of Rest. It is of great importance to put the patient at rest both psychologically and physically. All unnecessary noise must be rigorously avoided. The ears may be plugged with cotton-wool and bandaged in order to eliminate any harmful psychical stimuli. The patient is placed in a comfortable position in bed, which should be raised at the foot except in cases of head and chest wounds.

The Administration of Heat. Patients suffering from shock complain of feeling cold, thus heat must be administered and heat loss prevented as far as possible. Warm, dry clothes are substituted for cold, wet ones. The temperature of the ward is kept uniform, adequate ventilation is ensured, and draughts avoided. If the patient is able to take hot drinks, these should be given.

The use of a " Restor " shock cradle, electric blankets and hot-water bottles are recommended subject to the considerations set out below. Blalock's work has recently been the subject of Army Medical Department Bulletin No. 17, and is briefly quoted here.

" It is now accepted that the blood volume nearly always diminishes after severe injuries, because fluid has left the blood vessels, either by hæmorrhage or by oozing into damaged tissues or both. The consequent fall in blood pressure brings into play a vasoconstrictor mechanism which raises pressure again by reducing the capacity of the vascular bed. It is not yet certain which parts of the vascular system are affected by this vasoconstriction, but undoubtedly the cutaneous circulation is much diminished. And the capacity of the cutaneous vessels is very considerable. Even in a normal person warming may increase the blood content of the skin by as much as a pint, and in cases of shock, where the superficial vessels have been constricted and depleted, similar warming might well bring far more than a pint to the surface—diverting it from more vital functions. . . . Theory and experiment thus agree that casualties should be warmed in a conservative manner, e.g., with blankets and hot bottles applied after the removal of wet clothes. More potent means of heating, such as the hot cradle, may be used when the blood volume is being, or has been, restored by transfusion ; but the heat should never be so great as to cause sweating, and limbs with injured blood vessels or gangrene should not be warmed at all. In so far as the " cold " of shocked patients is compensatory, it is a symptom that should not be treated energetically unless its basic cause (reduction of blood volume) can be treated at the same time. Whereas warming plus transfusion gives excellent and prompt results, warming alone may, if carried too far, lead to vasodilatation, circulatory collapse, and death."

The Infusion of Saline and Glucose-saline Solutions. The use of these solutions is very limited in the treatment of secondary shock, but in those cases associated with dehydration they are of considerable value when used in conjunction with protein-containing solutions.

In order to come to a reasonable conclusion on this matter some attempt must be made to estimate the bodily deficit of water. The War Office handbook gives the following rough guide :

" *Amount of Fluid.*—From the symptoms the approximate amounts of fluid necessary for a given case can be estimated. Dry mouth and scanty urine appear

when the water deficit amounts to 6 per cent. of the body-weight—7 to 10 pints for an average man. Low blood pressure, feeble pulse and cyanosis denote a deficit of at least 10 per cent. of body-weight—12 to 16 pints. To this figure must be added the normal output during the period of hydration, i.e., 5 pints every 24 hours. In cases where abnormal losses occur through vomiting, exudation, etc., further addition must be made to the total.

The simplest criterion of adequate hydration is a urinary output of 2 to 3 pints every 24 hours."

Route of Administration. The oral route is used in all cases of shock, even those not associated with dehydration.

In cases of severe dehydration the intravenous route by the continuous drip method is advocated. Isotonic saline and isotonic glucose are given at about 40 drops per minute. Watch should be kept for the onset of pulmonary œdema.

The Administration of Drugs.

Sedatives. Morphine is required if the patient is restless or in pain, and this should be given in doses of $\frac{1}{4}$ to $\frac{1}{2}$ gr. which should not be repeated in less than 4 hours. It is contra-indicated in the presence of a head injury, and in such cases sodium phenobarbital may be given intramuscularly in doses of $1\frac{1}{2}$ to 3 gr. The routine use of morphine may be dangerous in cases of shock, and it is not always indicated.

Stimulants. It has been claimed that nikethamide is a stimulant to the respiratory and circulatory systems in this condition.

Vasospastics. Of the drugs employed to raise the blood pressure it appears that veritol is the most satisfactory. The drug is of low toxicity, but further investigation regarding its value in the treatment of shock is advisable.

Adrenal cortical extract. The synthetic hormone has been tested by Wilson and Stewart in the treatment of shock due to severe burns and intestinal obstruction, and they report that some benefit occurred but the results were neither constant nor dramatic. Rhoads and Wolff found this substance to be of value in the treatment of the fluid shift which occurred in a group of patients with severe burns. When it is effective the capillary permeability for plasma protein is reduced as early as the eighteenth hour after injury. These observers are of opinion that plasma should be given by transfusion at the same time, in order to restore the circulatory plasma volume. They found that chloride retention occurred in patients receiving adrenal cortical extract and state that such patients should not be given sodium chloride unless this is indicated by a chemical analysis of the blood. The writer has used eucortone in a number of patients suffering from shock. It was given intravenously in doses of 5 c.c. followed by 2 c.c. at four-hourly intervals, depending upon the condition of the patient. In less severe cases it was administered intramuscularly, 1 c.c. being the initial dose, followed by 2 c.c. at four-hourly intervals if there is no reaction such as a rise in temperature. The

impression gained is that the preparation is of value, but further investigations should be performed before its use in shock can be advised.

The Administration of Oxygen.

Since one of the most characteristic features of secondary shock is tissue anoxia, oxygen therapy appears to be a rational method of treatment. Wood and co-workers, after experimental investigations, conclude that inhalations of high concentrations of oxygen are beneficial. Blalock is of opinion that oxygen therapy has not received sufficient attention in the preventive and active treatment of the condition. Oxygen therapy should be instituted in the early phase of secondary shock; very little benefit can be expected in the terminal phase. It is unwise to continue the treatment longer than 48 hours at a time; if continuance is indicated, an interval should elapse between the courses.

The Administration of Fluid.

In secondary shock there are changes in the circulating fluid and especially a diminution of the volume of blood in currency. The replacement of the lost fluid in the body is one of the most important measures in the treatment of this condition. This replacement is rendered difficult on account of the increased permeability of the blood capillaries. It is essential that fluid is given as early as possible, and the amount given is fixed according to the requirements of each patient. The object of a Transfusion Service must be to make these fluids available as near as possible to the field of battle, or alternatively the wounded must be transported quickly to centres where transfusion can be carried out. The institution of early, adequate treatment will lead to a greater saving of the lives of wounded men than hitherto. It may be that the aerial transport of wounded will be developed in the future with great saving of life. It has been found that the type of case which received most benefit was the casualty resulting from bombing in the vicinity of a hospital where early treatment was available.

Transfusion of Whole Blood. The transfusion of whole blood is of proved value in secondary shock, and this must be performed as early as possible, a sufficient amount being given. Adequate quantities of blood must be available, and mobile blood transfusion units equipped with the necessary apparatus and staffed with men trained in the latest resuscitation methods are required for modern armies in the field.

Transfusion of Fresh Blood. Donor systems have been organized in large communities to provide fresh blood for transfusion. Many hospitals have developed their own systems. The donors are carefully examined, hæmoglobin estimates are performed together with typing and serological investigations. During war-time when large quantities of blood may be required at short notice this method is unsatisfactory, and other methods must be developed.

Stored Blood. The establishment of the blood bank system possesses important advantages. Large quantities of blood, completely investigated, are available for quick emergencies and easily transported to places where blood is required. De Gowin and Hardin state that when glucose is used in the preservative fluid, blood can be stored for thirty days before use, and Maes and Davis recommend a safe period of three weeks. The transportation of stored blood exerts no deleterious effects and no increased hæmolysis. Blood should be stored in a refrigerator at a temperature of 4° C.

Transfusion of Blood Plasma or Serum. Discussion has occurred concerning the relative merits of plasma and serum, but from the therapeutic viewpoint there are no important differences between these substances in secondary shock. The comparative values of dried serum or plasma and also the liquid forms have been investigated. The dried substances possess certain valuable properties, such as stability and economy of space, and solutions of greater concentration than normal plasma can be used. Wakeley states that the mortality of war burns has been reduced considerably since the introduction of citrated plasma and reconstituted serum. He points out that dried serum can be carried on any warship and is readily converted into fluid by the addition of the requisite amount of distilled water. A disadvantage of the dried forms is the care required to preserve sterility when solutions are made under emergency conditions.

There is considerable evidence that plasma serum is an efficient substitute for blood in cases of burns, secondary shock without hæmorrhage, and even in severe hæmorrhage when whole blood is unavailable. Plasma does not filter through the blood capillaries to the same extent as crystalloid solutions, because of its protein content and high colloidal osmotic pressure. It is readily prepared, can be stored for considerable periods, large and repeated quantities may be given, and it is almost reaction-free. Experience in the management of casualties shows that plasma transfusion is a valuable and important method for the restoration of the depleted blood volume.

The Amount of Blood or Plasma for Transfusion. Whitby and co-workers have formulated useful guides concerning the amount of blood or plasma required by the patient in shock. Both plasma and blood are efficient in restoring the blood volume, whole blood being necessary for patients in which the blood volume is reduced mainly by loss of whole blood. An immediate transfusion is essential in patients with serious injuries and a low blood pressure. In patients where the blood pressure does not rise to 100 m.m. mercury after adequate resuscitation has been carried out for one hour, or where the blood pressure continues to fall in spite of this treatment, a transfusion must be given.

In severe cases of secondary shock large amounts of blood or plasma are required. In our experience, amounts of one pint may be quite inadequate. Transfusion must continue until the blood pressure reaches normal levels, and if it falls subsequently the transfusion must recommence. A rapid transfusion of 1,000 c.c. should be given in about thirty minutes. Unless the blood pressure remains at a dangerously low level, further amounts which may be necessary are given at a slower rate. When the blood pressure reaches a level of 100 mm. mercury the transfusion is given by the drip method at the rate of one bottle in three to four hours. Clinical judgment plays an important part in deciding the amount of fluid which the patient requires and the rate at which it should be given. Whitby and co-workers state that it is possible to lose 3½ litres of blood and live, if reasonable restoration of the blood volume occurs quickly.

In the treatment of secondary shock accompanying burns, Black found that initially about one litre of plasma is required in the average case. After the wound is cleaned a further two to three litres may be required, administered at the rate of 100 drops per minute. He has compiled the following table giving the approximate plasma volume deficit corresponding to a series of hæmoglobin readings. This method of estimating the amount of plasma lost is applicable to patients who were in good health before the injury occurred.

Estimation of Plasma Volume Reduction (Black)

Hæmoglobin Percentage (Haldane).	Blood Volume (litres).	Plasma Volume (litres).	Estimated Deficit in Plasma Volume (c.c.).
100	5·0	3·0	—
105	4·75	2·75	250
110	4·55	2·55	450
115	4·35	2·35	650
120	4·15	2·15	850
125	4·0	2·0	1,000
130	3·85	1·85	1,150
135	3·7	1·7	1,300
140	3·55	1·55	1,450
145	3·45	1·45	1,550
150	3·35	1·35	1,650

Surgical Operation in the Presence of Shock

Unless an immediate operation is essential, surgical interference must be postponed until shock is controlled. It is advisable to defer operation until the systolic blood pressure has become stabilized at a minimum of 100 mm. mercury. Fluctuation in the blood pressure or figures lower than this level make operation hazardous. When the operation is carried out every effort is made to limit the degree of subsequent shock which

may develop. The patient is transported to the theatre with care, and it is advisable to take him in his bed to diminish the amount of movement; in severe cases the operation can be carried out with the patient in bed. The theatre is heated adequately and unnecessary exposure avoided. Preparations for the operation must be complete when the patient reaches the theatre, and no time is lost in carrying out the operation. The transfusion commenced in the resuscitation ward is continued during and after the operation if necessary

With regard to pre-operative medication, enquiry should be made as to the amount of morphine which has been given and the time of administration. Many patients do not require pre-operative medication, and large doses of morphine should be avoided.

At operation the tissues must be handled gently and all unnecessary trauma avoided. There should be perfect hæmostasis and the minimum loss of blood. The patient is not moved or turned unless this is necessary to complete the operation. It may be an advantage to keep the head of the operation table in 15° to 20° Trendelenburg position. All unnecessary exposure of the body must be avoided, and the skin coverings are not allowed to remain in a wet condition. Abdominal and thoracic viscera are exposed as little as possible, and no tension placed upon them. Cavities and viscera should be covered with large swabs wrung out in hot saline. When the dressings and bandages are applied it is necessary to lift the patient instead of turning him from side to side, and he must not be propped up suddenly in order to bandage the chest or back.

If possible the patient's bed is brought to the theatre and he is transferred gently from the operation table. The bed must be warmed and exposure and rough transportation avoided.

Post-operative Care. The patient is kept at rest and given as much sleep as possible. The room is adequately heated, and kept at an even temperature by good ventilation. Sweating must be avoided. Pain is relieved by sedatives and the fluid balance of the body maintained. Careful records are kept showing the intake and output of fluid. Transfusion may be required, and if the patient cannot take fluid by mouth it is given by other routes—intravenously, subcutaneously or rectally. The patient must not be left alone when recovering from the anæsthetic on account of the danger of respiratory obstruction from mucus, vomiting, or spasm of the respiratory muscles. Charts are kept, showing frequent readings of the pulse-rate, blood pressure, temperature, and the respiratory rate. If the blood pressure falls or the pulse-rate rises the surgeon is informed immediately. In the case of injured limbs periodic examination is necessary for signs of interference in the circulation. There may be indications for chemotherapy.

The importance of keeping accurate records of all that happens to a patient from the time of injury to either recovery or death is stressed.