RESUSCITATION IN THE FIELD

BY

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Many young surgeons, at the beginning of the Second World War, had at their fingertips all the current theories on traumatic shock in laboratory animals. When suddenly confronted with battle casualties they found great difficulty in applying these theories in practice. Guided by senior colleagues, they gradually gained practical knowledge of resuscitation in the hard school of experience at the expense of their patients. When John Derry's aeroplane disintegrated, on exceeding the speed of sound, at Farnborough in 1952, it was, once again, very obvious that many medical officers were quite unable to assess casualties. The following article includes the generally accepted views on resuscitation, in a practical form for everyday use, as a guide for those who may have to assess mass casualties in the future.

In an atomic war the medical services of the nation will be confronted suddenly with large numbers of surgical casualties. These will consist of injuries from high and low velocity missiles, burns, blast and crush injuries from collapsed buildings. Many of the casualties will suffer from multiple injuries caused by varying combinations of these factors. This mixture of lesions is well illustrated by the experience of a corporal in a tank crew. The tank was knocked out of action by an anti-tank shell. The corporal sustained a fracture of his right tibia and fibula just above the ankle joint, but his foot was immovably jammed on the tank floor. When the spare petrol caught fire, he escaped from the burning tank after cutting off his own foot with a jack knife.

One of the main problems will be to recognize, select and treat those casualties who are suffering from traumatic shock and are in need of transfusion. Adequate transfusion should aim at rendering the casualties fit to stand anaesthesia and surgery, which must be regarded as a second period of trauma.

The clinical assessment of traumatic shock in war wounds has been greatly simplified by the observations of Grant & Reeve (1951). No reference will be made in this article to the burn casualty, as this, in itself, is a vast problem.

LIMB INJURIES

Blood loss and tissue damage are the two most important factors governing the onset and degree of traumatic shock in limb injuries. The total blood volume in an average adult male is about eleven pints, but in a rough clinical assessment, such as is made on the field of battle, it is sufficiently accurate to accept the average as ten pints for simplicity. After the sudden loss of three pints of blood, the blood volume reaches its critical level of 70 per cent. of normal, which
is about seven pints. Nature's defence mechanism then comes to the rescue and the blood pressure collapses in an attempt to stop the bleeding.

A systolic blood pressure of 100 mm. of mercury is thus a very useful rough guide to the amount of blood which has been lost. Other factors being equal, a systolic blood pressure of 100 mm. of mercury, or over, means that less than three pints of blood have been lost, while a systolic blood pressure of under 100 mm. of mercury means that more than three pints of blood have been lost.

Tissue damage is the second important ætiological factor in the production of traumatic shock. This varies directly with the velocity, type and momentum of the missile. Low velocity missiles, such as the bayonet and flying glass, only damage the tissues they actually cut and shock is produced by blood loss only. This was well illustrated at the battle of Sidi Barrani when the 4th Indian Division pursued the retreating Italian Arabs with fixed bayonets. Some of the Arabs had multiple wounds of the buttocks and yet had succeeded in running considerable distances in the interval between receiving the first and last wounds.

High velocity missiles have an explosive effect in passing through the tissues. They create a momentary cavity many times the diameter of the missile. This results in extensive damage at a considerable distance from the missile track. Small vessels are ruptured, causing interstitial haemorrhage and œdema which provides an ideal site for the growth of bacteria. Much fluid escapes into this damaged tissue to cause swelling. From this area proteolytic break-down products are absorbed and within a few hours their effects appear in the clinical picture.

It is therefore essential in assessing battle casualties to estimate accurately by observation and deduction the amount of tissue damaged. The readiest unit of measurement of volume for this purpose is the human hand, which is just under one pint in volume. Depending on the nature of the wound, the hand may be used open, or closed as a fist.

**WOUND CLASSIFICATION**

The following classification of wounds is based on the amount of tissue damage present in the wounds and is a useful means of forecasting the onset of traumatic shock.

- Small wounds ... Less than one hand of tissue damaged.
- Moderate wounds One to less than three hands of tissue damaged.
- Large wounds ... Three to less than five hands of tissue damaged.
- Very large wounds Over five hands of tissue damaged.

When a large artery such as the common femoral is divided, the resulting severe haemorrhage will bring on traumatic shock rapidly, irrespective of the tissue damage. When no large vessel has been cut it is usually possible to correlate blood loss and tissue damage. A small wound loses one to two pints of blood and a moderate wound two to three pints. With this amount of blood loss the casualty is usually still able to maintain the systolic blood pressure above 100 mm. of mercury, as the blood volume is still above the critical level of 70 per cent. of normal. A large wound loses from three to four pints, whereas a very large
wound loses five to seven pints, which is more than half the total blood in the body. In the latter two types of wounds, the blood volume is below the danger level and the systolic blood pressure drops so that transfusion is required to restore the blood volume.

It is important to stress that large, gaping, incised wounds, although they may look ghastly, do not contain much damaged tissue and do not cause traumatic shock, apart from haemorrhage due to divided large vessels. With traumatic amputations the damaged tissue in the stump only is measured as the severed limb is discarded. With multiple wounds the wound classification depends on the sum total of damaged tissue in the various wounds.

**Secondary factors.**

On the field of battle, primary traumatic shock caused by haemorrhage and tissue damage may be simulated or modified by neurogenic shock due to secondary factors such as anxiety, fear, painful movements, dehydration and morphia poisoning. For example, at a regimental aid post, a soldier with a small wound of his hand which has had only a small haemorrhage may appear to be at death's door, yet he is not in need of transfusion. The problem that presents itself is how to distinguish quickly those who need transfusion to save their lives from those who need some minor form of resuscitation, such as sal volatile and a mug of hot sweet tea. It may seem ridiculous to compare these, but on superficial examination they look exactly the same.

**Circulatory patterns.**

Four simple circulatory signs can be relied on to make a differential diagnosis:

- The systolic blood pressure (normal 100-140 mm. of mercury).
- The pulse (normal 70 to 99 beats per minute).
- The temperature of the distal extremities (warm or cold).
- The colour of the face (pale or rosy).

It is well known that when a soldier after wounding presents the normal pattern of normal blood pressure, normal pulse, warm limbs and rosy lips, he is fit for evacuation and is fit to stand an anæsthetic because his blood volume is near normal.

The four abnormal patterns are not so well known. In each the casualty has cold limbs and pale lips, and they differ only in the blood pressure and pulse as follows:

1. **The cold tachycardia pattern.** Here the blood pressure is normal, the pulse is rapid, the limbs are cold and the lips are pale. The key to this pattern is the normal blood pressure and fast pulse. Since the patient can maintain his blood pressure, this pattern means that his blood volume is above the critical level of 70 per cent. of normal and that his blood loss is less than three pints. In all probability he has a small or moderate sized wound. He can be evacuated safely without transfusion once the haemorrhage has been controlled. He will need a prophylactic transfusion of about two pints before operation.
2. The vaso-vagal pattern of neurogenic shock. Here the blood pressure is low, the pulse is slow, the limbs are cold and the lips are pale. The key to this pattern is the slow pulse. This pattern is due to secondary factors already mentioned, such as anxiety, fear and pain. It is not due to blood loss or tissue damage. The casualty does not need blood transfusion. An excellent form of resuscitation is to lower the head end of the stretcher for five minutes. That should restore the blood pressure to normal. If the blood pressure again falls on restoring the patient to the horizontal, further clinical examination is indicated.

3. The cold hypotension pattern. Here the blood pressure is low, the pulse is fast, the limbs are cold and the lips are pale. The key to this pattern is the low blood pressure and the fast pulse. This means that the casualty, through blood loss and tissue damage, can no longer maintain his blood pressure. His blood volume has therefore fallen below the critical level of 70 per cent. of normal and his blood loss is greater than three pints. His tissues are suffering from acute anoxia. Resuscitation is an urgent matter and varies with circumstances. It is best to lower the head end of the stretcher, control all external haemorrhage and evacuate the casualty towards surgery without delay. He will stand a short, speedy, smooth journey under the influence of morphine, reasonably well. He is in urgent need of rapid transfusion to restore his blood pressure, but this is best delayed until surgery is at hand. The volume transfused should equal the quantity estimated to have been lost.

4. The extreme cold hypotension pattern. Here it is impossible to record the blood pressure, the pulse is not palpable, the limbs are like ice and the lips are ashen. The apex beat is very rapid. There is severe dyspnœa with great restlessness and profuse sweating. This pattern is seen in casualties who have suffered severe haemorrhage from multiple large wounds. Such a patient will not stand evacuation. He requires urgent transfusion where he is or he will die.

If there is still any doubt about the degree of blood loss, the following additional signs of severe haemorrhage may be noted: mental alertness, urgent and quenchless thirst, intolerable discomfort and extreme vasospasm so that it may be impossible to get a needle into the lumen of the superficial veins.

If the blood pressure cannot be recorded, through lack of a sphygmomanometer, the rate and quality of the pulse beat and the response of the nail bed capillaries to digital pressure are the most reliable signs indicating the state of the blood pressure.

THE CRUSH SYNDROME

During the blitz this syndrome was commonly seen after people had been partially buried for some hours or when limbs were severely crushed by collapsed buildings. When the limbs were released from pressure the general condition did not show the signs of traumatic shock. The limbs presented an unexplained erythema, blisters, loss of sensation, paralysis and gross swelling.
After a latent period varying from half an hour to a matter of hours, plasma poured from the circulation into the crushed tissues. The blood volume soon fell below the critical level of 70 per cent. of normal, and this produced the clinical pattern of cold hypotension. Later the crushed limb became ischaemic with tense œdema and impending gangrene. This coincided with the passage of a diminished amount of urine containing blood and albumin. About two-thirds of these casualties died in less than a week from renal failure. A persistently acid urine caused irreparable damage to the kidneys. Even early amputation made no difference to the prognosis.

With these casualties treatment is required urgently to restore the circulation and blood pressure by plasma transfusion. A good output of alkaline urine should be aimed at, to ensure the excretion of myoglobin and toxic metabolites without their precipitation. In the field and during evacuation, oral fluids should be given at the rate of six pints daily. To each pint two teaspoonfuls of sodium bicarbonate should be added. Many patients, because of vomiting, will only be able to retain small quantities of fluid given frequently.

CASUALTIES FROM ATOMIC EXPLOSIONS

The bulk of casualties who survive an atomic explosion will suffer from burns and injuries due to ante-mortem burial and flying missiles such as fragments of glass. Sublethal radiation effects will not be an immediate surgical problem. The brunt of the blast effects will fall on air-containing organs such as the middle ear, lungs and gut. It is thought that the damage inflicted on these organs in survivors will be less severe than that inflicted by high explosive blast, such as was seen in the last war, as the human body is said to resist over-pressures of a high degree. Whether or not this is so will probably be proved in the future when statistics become available for publication.

CHEST INJURIES

Traumatic shock is again due to the reduction of blood volume from hæmorrhage and tissue damage, but in chest injuries the tissue damaged is the specialized lung tissue. When fluid escapes into the lung tissue, cardio-vascular embarrassment ensues. The resulting clinical features are three in number, chest pain, dyspnoea and cyanosis.

These clinical features should be added to the clinical patterns of traumatic shock already described under the heading of limb injuries.

In addition to the general picture of traumatic shock in chest injuries, there are three specific lesions of the chest which produce profound traumatic shock and require prompt treatment if life is to be saved:

The "sucking wound" must be sealed with an air-tight dressing held in place with overlapping layers of elastoplast.

The "stove-in chest" requires oxygen by B.L.B. mask plus fixation of the lower chest wall with elastoplast.

A tension pneumothorax needs urgent aspiration through a wide bore needle in the second intercostal space.
A shock-producing "silent chest lesion" in the presence of some gross wound is easily missed if a routine general examination of the casualty is omitted. For example, the lungs may not have been examined in an obvious G.S.W. of the buttock, yet they may have been damaged and a blood transfusion may be fatal. The location of the apex beat of the heart is a useful guide to the diagnosis.

Tissue damage within the lung results from high explosive blast without evidence of external injury. The blast wave drives the chest wall inwards momentarily. This causes multiple haemorrhages of varying degrees of severity to be scattered throughout the lung tissue. The pulmonary capillaries are torn and blood escapes into the alveoli and into the lung parenchyma. Clinically the casualty appears to be dazed and to be suffering from traumatic shock due to blood loss. Yet there may be no external wounds to account for it. The persistent dyspnœa, cyanosis and extreme restlessness should focus the attention of the medical attendant on the chest. The patient usually complains either of constant, deep, central pain from mediastinal haemorrhages, or of superficial pain from contusion of the chest wall.

The cold hypotension pattern of traumatic shock is present in addition to the signs of cardio-vascular embarrassment. The pulse is very rapid and of poor volume. The jugular veins are prominent. There is no impairment of the percussion note, but the breath sounds are weak and moist rales are audible all over the lungs. Any sputum is usually blood-stained. One or both ear drums may be ruptured.

Treatment. All casualties suffering from chest wounds must be treated as stretcher cases, right from the regimental aid post. This lessens the strain on the cardio-vascular system. In the excitement of battle, some casualties resent being carried on stretchers, as they feel fit to walk. This was well illustrated in the case of a young Turk from Cyprus. He was wounded in the chest during a Stuka dive-bombing attack while he was delivering shells to the guns. A bullet passed across his chest, tearing open his left second intercostal space. It emerged through his left biceps. He completed his task, making light of his injuries. On his return journey to the ammunition dump, he stopped at the C.C.S. to get a dressing on his wounds, to keep out the sand. He was most indignant when he was admitted as a casualty. Within an hour of his admission he collapsed while on a stretcher, from grave cardio-vascular embarrassment.

In addition to complete rest, oxygen should be available for administration by a B.L.B. mask. Morphia should only be given with extreme care and in physician's dosage of one-eighth or one-sixth of a grain. Early administration of antibiotics does much to lessen the incidence of later septic complications. Transfusions and anaesthetics should be avoided if at all possible, but if a transfusion is essential, plasma or plasma substitute is preferable to blood.

ABDOMINAL WOUNDS

Because the course of missiles in the human body is not predictable, all wounds in the vicinity of the abdomen, especially buttock and perineal wounds, should be
kept under observation as abdominal wounds until proved to be so or exonerated. A silent abdominal wound can very easily be overlooked.

Traumatic shock is again due to the reduction of the blood volume from hæmorrhage and from tissue damage. The peritoneum is specialized tissue which when irritated or damaged reacts by secreting fluid into the abdominal cavity. This reduces the blood volume and produces traumatic shock, but only after the passage of some hours. It is thus possible to distinguish traumatic shock due to severe hæmorrhage from that due to tissue damage by noting the time of onset in relation to the time of wounding. This is of great practical importance in the management of these two different varieties of casualties.

Each group includes about half of the casualties wounded in the abdomen. The first group of casualties, suffering from severe active hæmorrhage, very quickly presents the clinical picture already described as cold hypotension. The majority of this group will die within two hours of wounding from blood loss unless the hæmorrhage is controlled by surgical measures.

The second group of casualties includes all those with perforations of the gut. Over a period of some hours, they develop acute peritonitis. The majority of this group lose less than two pints of blood in that time. If they lose more blood they would probably have been included in the first group.

Severe blast waves may injure the gut, as it contains gas. The injury consists of submucous and subserous hæmorrhages. The clinical picture shows a sudden onset of acute spontaneous abdominal pain, just as if the patient had been kicked in the abdomen. This spontaneous pain persists and is accompanied by nausea, vomiting and a desire to defecate. Very often there is blood on examination per rectum. There is a great danger of perforation of the gut. If this happens the patient slowly develops the clinical picture of cold hypotension with board-like abdominal rigidity and loss of liver dullness.

In the management of these blast casualties, a sequence of brief, accurate, clinical notes, such as the presence or absence of bowel sounds, muscle guarding, etc., recorded during the evacuation of the patient, is of the greatest assistance to the surgeon who will have to decide whether or not laparotomy is necessary.

**Treatment.** All these patients require very gentle handling. No fluids should be given by mouth. Morphia should not be given unless it is obvious that laparotomy will be essential. Antibiotics should be given in such dosage as one million units of procaine penicillin and half a gramme of streptomycin. Both groups of casualties require rapid evacuation towards surgery. They first need immediate pre-operative transfusion followed by urgent surgery. Those who are bleeding very rapidly may die before reaching a surgeon unless they receive a transfusion. Only in such cases is it justifiable to delay evacuation so that a transfusion may be started. The second group of casualties who are bleeding less actively do not need quite such hurried evacuation provided antibiotics have been given early. In fact in emergencies they can be evacuated beyond the C.C.S. before laparotomy, provided gastric suction and an intravenous drip have been set up. They stand a better chance of survival if they travel before rather than after operation.
THE MANAGEMENT OF CASUALTIES IN THE FORWARD AREA

First-aid measures and early surgery to stop haemorrhage and to minimize infection are the keystones of surgical treatment. By early is meant within six hours. It is generally accepted that pathogenic organisms require that time to multiply sufficiently to establish infection in damaged tissue. Infection can be held at bay by the early administration of antibiotics, so long as the infective organisms are susceptible to their action. Unfortunately antibiotics cannot penetrate dead tissue where anaerobic organisms can multiply and give rise to potent toxins which, unaffected by antibiotics, are absorbed into the circulation to kill the patient.

Transfusion can mitigate the effects of delayed surgery, but every effort should be made for the two to be used together. Prolonged periods of unrelieved anoxia, the absorption of metabolites and excessive amounts of potassium from injured tissues will cause death from renal failure during the post-operative period, despite adequate surgery.

The French Medical Services in Indo-China have used, with some success, what they call "artificial hibernation." This state of suspended animation is induced on the battlefield by means of drugs and cold, in severely wounded men, to eliminate traumatic shock. It is claimed that the patient can be evacuated safely without delay. One day this method of combating traumatic shock may revolutionize the management of severely injured soldiers, but at present it is still too experimental to be put into general use in war.

The cardinal points in the early resuscitation of surgical casualties are described below.

1. Maintain a clear airway. A tracheotomy may be necessary, but positioning the patient on the stretcher is usually successful. An unconscious patient should be placed face downwards on a stretcher with his forehead resting on a strong bandage between the handles and his chin clear of the canvas.

2. Arrest external haemorrhage without delay by any of the following methods: digital pressure, elevation, pad and bandage, artery forceps or ligatures. Tourniquets should only be used temporarily in emergencies or as a last resort.

3. Seal "sucking wounds of the chest" with a pack and elastoplast to stabilize the mediastinum.

4. Relieve pain by giving morphia. The usual dose is one-quarter of a grain given intravenously or half a grain intramuscularly. This drug should never be given by the subcutaneous route to a patient suffering from traumatic shock, because it is not absorbed until the blood pressure has been restored by resuscitation. It then takes effect when it is no longer required and interferes with the recovery of the patient. The dosage given should be recorded legibly along with the route used and the time of administration. Morphia given by tank crews to their wounded companions is often not recorded. This drug should not normally be repeated within
four hours, because of the very real danger of morphia poisoning. It depresses thirst and can therefore contribute considerably to the dehydration of battle casualties. Its administration is contra-indicated in severe shock, in head wounds, chest wounds and in undiagnosed abdominal injuries, unless pain is very severe. While waiting for morphia to soothe a restless patient, ensure that he is not left unattended on a stretcher supported by trestles.

Do not rush to give such a powerful and dangerous drug as morphia for the relief of fear, anxiety or apprehension. Take time to reassure the patient. Three grains of phenobarbitone given intramuscularly is a very effective sedative and induces sleep. An alternative drug is sodium amytal given in three-grain doses intramuscularly. This is especially useful in head injuries.

5. **Dress wounds** with sterile gauze, such as a "shell dressing," to prevent contamination.

6. **Give antibiotics** as soon as possible after wounding to combat or suppress infection. Ideally they should be given with the first dose of morphia. The dosage of penicillin should be half a million units intramuscularly twice a day, because the *Clostridia* responsible for gas gangrene are not inhibited by low concentrations. With abdominal wounds and perineal wounds it is a wise precaution to give, in addition, one gramme of streptomycin twice a day intramuscularly.

7. **Relieve respiratory embarrassment** causing anoxia in chest wounds and in blast injuries to the lungs by giving oxygen through a B.L.B. mask.

8. **Immobilize fractures.** Support and immobilize efficiently all fractures and large wounds to prevent further tissue damage, which will most certainly increase traumatic shock. Injured tissues must be handled with the greatest care. The cardio-vascular system may be so unstable that sudden elevation of a limb may be sufficient to precipitate the onset of profound traumatic shock. This is especially so in the young wounded soldier who is maintaining his vital circulation by intense vaso-constriction. A severely wounded patient should never be turned over to inspect his back unnecessarily. It is much safer to lift him off the stretcher, well supported by orderlies.

No patient suffering from a fracture of a long bone should be evacuated until the fracture has been adequately immobilized. The fractured femur is particularly dangerous in this respect. Even a simple fractured femur may be a fatal injury if evacuated without immobilization.

At the same time the various methods of obtaining immobilization are not without their dangers. In using the Thomas splint care must be exercised to avoid excessive pressure on the ischial tuberosity and the dorsum of the foot. To maintain extension, the outer part of the ring must be padded adequately to prevent the ring from slipping on to the urethra. The distal end of the splint must be fixed firmly to the stretcher to prevent bumping of the injured limb during transportation.
If plaster of paris is used for splinting, every plaster, with the special exception of the Tobruk plaster, must be split for transportation from end to end and from the outside surface down to the underlying cotton wool, because of the ever-present dangers of further hæmorrhage and of the inevitable swelling following high velocity missile wounds.

9. *Maintain blood volume.* Avoid any form of treatment which will lower the blood volume of the patient. After blood loss in any quantity, nature initiates intense peripheral vaso-constriction which results in general pallor and coldness in the limbs. This aims at maintaining an adequate blood supply to the vital centres. It is therefore absolutely wrong to try to heat the patient externally with hot-water bottles, stoves and electric blankets. These measures cause reflex vaso-dilation with a fall in blood pressure and accentuation of the traumatic shock. At the Farnborough air disaster in 1952 many medical officers, both military and civilian, helped to attend the injured. Electric blankets were used by a number of these officers to apply external heat to severely shocked patients. One patient suffering from extreme blood loss suddenly collapsed and died while a blood transfusion was being set up. It was then discovered than an electric blanket had been put over him a quarter of an hour earlier.

By all means preserve the body heat with blankets, but do not heat the patient. Be guided by the patient’s feeling of comfort. Heating causes sweating which leads to dehydration. So long as the casualty does not complain of cold he is usually comfortable. A slightly subnormal temperature in a shocked or bleeding patient is harmless and beneficial. During the war at sea it was found that wounded immersed in cold sea water for a time were in much better condition when rescued than could have been expected from the nature of their wounds.

10. *Combat dehydration* by giving fluids orally except in those casualties suffering from abdominal wounds, blast injuries of chest and those who will receive a general anaesthetic within four hours. The dehydrated patient is thirsty and feels weak. He has a dry, dirty, leathery tongue and an inelastic skin. His renal function has already been depressed so that the amount of urine secreted has diminished and the non-protein nitrogen in his blood has begun to rise. In the tropics the risk of dehydration is even greater. This is a very common condition in battle casualties, especially as morphia suppresses the desire to drink. With the above-mentioned exceptions every casualty should drink at least six pints of fluid daily. To each pint, a teaspoonful of common salt should be added to ensure an adequate intake of the sodium ion which plays such a large part in maintaining the osmotic pressure of the blood along with the plasma proteins and other electrolytes.

After attention to these ten points the casualty should be ready for evacuation towards surgery. The journey should be as expeditious as circumstances will permit. It should be estimated in hours and not in miles.
PRE-OPERATIVE RESUSCITATION

When the casualty arrives at the unit where surgery is available, the real problem of resuscitation must be tackled. Everything must be directed towards making the patient fit to stand an anæsthetic and operation. The main therapeutic measure available for this purpose is intravenous transfusion to restore the blood volume. In the last war about 10 per cent. of all the surgical casualties required transfusion. The effects of blast in an atomic war may lower this figure. This estimate excludes burn casualties.

The pre-operative resuscitation ward must be big enough to accommodate a large number of casualties. It should be run by an experienced transfusion officer who is always in close contact with the surgeon and anaesthetist. This can only be done efficiently if the ward is close to the operating theatre. A mobile radiograph machine should be at hand to save moving the patient unnecessarily. The officer in charge of reception should be proud of the expeditious manner in which the 10 per cent. requiring transfusion are passed without delay from the ambulances to the resuscitation ward.

On arrival at the resuscitation ward the patient should be handled very gently. His clothes should be cut up the midline to facilitate examination. They should not be removed until the patient is anaesthetized unless they are wet. Many units fail to provide an adequate number of scissors for this purpose. The transfusion officer should then make a full and rapid examination to determine the nature and extent of the injuries. Very few casualties are so desperately ill that this examination can be justifiably omitted. The systolic blood pressure should be recorded and tourniquets should be looked for. A generous supply of sphygmonanometer cuffs saves much valuable time.

Transfusion

The transfusion officer should then decide what fluid to transfuse, how much the casualty will probably require and how fast it should be given. Close liaison with the anaesthetist must be maintained so that the optimum time for operation is not missed.

Transfusion is contra-indicated in head injuries and blast injuries, and should only be given in chest injuries when there is very severe haemorrhage. In these circumstances small amounts of blood should be transfused very slowly because of the risk of pulmonary œdema.

Over a large number of transfusions given during the last war, the average amount given was four pints, made up of two and a half pints of blood and one and a half pints of plasma.

Since the great majority of the casualties suffer from blood loss, the best fluid to use for restoring the blood volume is blood, so long as its state of preservation can be relied on. During the last war the Army Transfusion Service provided Group O blood, of unknown Rhesus group, of the highest standard. Transfusion reactions due to mis-matched blood were almost unheard of.

When blood is not available, the blood volume can be made good with plasma or serum or with plasma substitutes, such as dextran or plasmosan. The
majority of casualties do not stand operation well when their hæmoglobin level is below 70 per cent. of normal. Nevertheless, the use of these substances enables the circulation to use to the maximum the remaining hæmoglobin for carrying oxygen to overcome anoxia. Lack of blood should never prohibit the use of substitutes. An embarrassed circulation responds better to a less viscid fluid than it does to blood, so that plasma and serum produce a better response when used for the first three pints of a transfusion. These fluids are easier to give than blood and the transfusion runs more rapidly. They can be kept in the resuscitation ward and are available for immediate use in an emergency while blood is being collected from the refrigerator. If the first three pints of a transfusion are not given quickly the response is delayed and disappointing, whereas if the transfusion is given quickly the response is usually dramatic, but if not it should be marked within an hour.

Unfortunately, plasma transfusion has a considerable risk* of infecting the recipient with the virus of homologous serum jaundice. For that reason many authorities disapprove of using it. To a lesser extent blood and serum both carry the same risk. In atomic war it is likely that the supply of these fluids will be far from adequate, so that dextran and plasmosan will be the fluids available.

In a number of instances the average transfusion of four pints will be inadequate. Casualties suffering from profound traumatic shock due to severe and continuing hæmorrhage causing prolonged anoxia can sometimes be revived by massive transfusions when supervised by very experienced transfusion officers. Heroic efforts are required, and the outlook should be that there is no such thing as a corpse until the funeral. So long as there is blood to pour in and a vascular system to receive it, a man can be kept alive and reasonably fit until his injuries are repaired, if they are repairable.

When the estimated blood loss has been transfused, the systolic blood pressure should be rising. On average, one pint of blood raises the systolic blood pressure about 10 to 20 mm. of mercury. If the blood pressure has not responded, no time should be lost in further transfusion without surgery. The transfusion should be kept running and the patient taken to the operating theatre as soon as possible to find out what is wrong, otherwise he will die.

Fast transfusion. The rate of transfusion may be either fast or slow. By fast is meant a pint in five to fifteen minutes, using every possible means to speed it up, such as pressure and multiple giving sets. The fast rate should be used in general for all those casualties where the systolic blood pressure has fallen below, and remains below, 100 mm. of mercury, because their blood volume is below the critical level of 70 per cent. of normal. This, of course, does not include those suffering from the vaso-vagal pattern of shock. The intravenous route should be used except when the heart is failing or has stopped. In these circumstances intra-arterial transfusion may be effective in resuscitating the patient. A large artery is selected, and if blood is not at hand when the emergency occurs, normal saline or dextran is used for the first three pints. Many pints of blood will be

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* The use of small pool plasma has now reduced this risk very considerably.—Ed.
required, and because of the pressure used to keep the flow going there is a great risk of air embolism. There is also a risk of distal gangrene in the limb.

Reactions. Unfortunately, fast transfusion usually brings on varying degrees of transfusion reactions which have nothing to do with incompatible blood. If the blood is unfortunately incompatible, the well-known signs of dyspnea, nausea, vomiting, rigors and lumbar pain usually appear whenever a few cubic centimetres of blood have been given. Such a transfusion must be stopped immediately. The reactions due to the rapidity of the transfusion take longer to develop and appear after larger quantities of blood have been given. They occur in two phases. The constrictor phase appears first and is followed about an hour later by the dilator phase.

The onset of the constrictor phase is marked by an intense spasm of all the superficial veins. This stops the running of the drip. The patient becomes very excited and restless. He complains of pain in his limbs and in his back. Severe rigors may follow. These rigors may easily displace the transfusion needle from the lumen of the vein. The patient becomes very pale. His limbs become cold. His pulse is impalpable and the apex beat may reach 140 beats per minute.

His blood pressure begins to rise. The rise of blood pressure is due entirely to the intense vaso-constriction and does not mean that sufficient blood has been given to restore the blood volume to normal. This is a trap for the unwary. If the drip has not stopped, the rigors usually improve if the rate of the drip is reduced, but this delays the recovery programme. It is better to give 1 ml. of 2 per cent. procaine solution into a vein. This is usually sufficient to relax the spasm. After that the transfusion is restarted with the aid of pressure, but care is necessary to avoid a fatal air embolism from faulty apparatus.

The dilator phase follows in about an hour. The restlessness subsides and the patient is at peace. He usually breaks out into a profuse sweat, with a flushed face and a bounding pulse which maintains a beat of over 100 per minute. His blood pressure falls, but if the transfusion has been adequate it remains above 100 mm. of mercury.

Slow transfusion. The second standard rate of transfusion is the slow one. By that is meant one pint in half an hour. This speed is used when the systolic blood pressure has risen again to 100 mm. of mercury. This indicates that the blood volume has been restored above the critical level of 70 per cent. of normal. The patient should be marking time, waiting for his turn to be taken to the operating theatre, having his blood volume in the vicinity of 90 per cent. of normal. He will then stand the anaesthetic and operation with a much greater margin of safety.

The slow rate of transfusion is also used as a prophylactic transfusion in patients suffering from the pattern of traumatic shock already described as cold tachycardia. In this pattern the blood loss is less than three pints. Many casualties in this category may improve gradually without transfusion and appear to be in surprisingly good condition. Unfortunately, they usually collapse suddenly when an anaesthetic is given, because the blood volume is too near its
critical level. The safest method of treating these casualties is to transfuse them prophylactically in spite of their improvement. Sudden collapse is even more likely to take place in fit young men with limb injuries if the systolic blood pressure is over 140 mm. of mercury.

In spite of apparently adequate transfusion, some casualties either show a poor response or fail to respond at all. This may be due to a number of causes such as continuing active haemorrhage, the presence of a fulminating infection such as gas gangrene, fat embolism, morphia poisoning, unsuspected lung damage from the effects of blast, prolonged anoxia after wounding from lack of resuscitation and surgery, or from release of a tourniquet which has been in position for a long time. A proportion of these casualties will survive operation, but they, along with all those who have suffered prolonged anoxia, run the grave risk of dying post-operatively from post-traumatic renal insufficiency when the kidneys stop excreting adequately.

Transfusion should not be divorced from surgery, because with massive injuries the need for operation is just as urgent as the need for transfusion. Transfusion should only be used alone as a life-saving measure when the casualty would not reach the surgeon alive. Even a small transfusion may tide a patient over a critical period of traumatic shock, but giving a transfusion in such desperate circumstances is usually exceedingly difficult and time-consuming because of the intense vaso-constriction which is invariably present. Although the transfusion needle may be well within the lumen of a vein, the fluid will not run into the vein. Dextran, being less viscid than blood, runs more easily. The difficulty of giving such a transfusion was well illustrated at the battle of the Rhine crossing in the last war. A keen young medical officer wasted forty-five minutes trying to get a plasma drip running into a casualty showing the pattern of wound shock already described as cold hypotension. He failed and had to evacuate the patient untransfused to the surgical centre, which was sited alongside an excellent, empty road fifteen minutes' journey away. The casualty arrived safely in spite of the delay.

The policy of providing blood in advance of the surgical centres has been mooted from time to time. The disadvantages far outweigh the advantages. The refrigeration difficulties are very great and the use of blood far forward without refrigerators is too dangerous. The availability of blood at that level is very liable to delay evacuation of serious casualties through the enthusiasm of keen young medical officers in their efforts to do their utmost to help the casualties. Attempts to restore fully the blood volume in the forward area are pointless, as the patient's general condition will only deteriorate during his evacuation until surgery is provided. Once a transfusion has been started in the battle area it must be maintained during evacuation to prevent relapse. Ambulance transfusions are all very well in theory, but good nursing orderlies can seldom be spared and only too often the patient arrives at the surgical centre with the needle out of position or with the drip bottle empty. On arrival at the surgical centre, further resuscitation will be required. Secondary transfusion is always less effective and more difficult than primary transfusion. Experience
has shown that blood must be used for this secondary resuscitation; the optimum time for surgical interference may be missed through bad timing and it is lost for ever.

The views expressed in the above article are personal. I was employed as a surgical specialist in the forward area throughout most of the 1939-45 war and formed these opinions as a result of practical experience, discussions with my colleagues and senior consultants, and through reading publications in the Press of the day.


REFERENCE