THE MANAGEMENT OF MULTIPLE INJURIES IN AIRCREWS *

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Three types of injury result from the hazards of operational flying in war: (1) gun-shot and missile wounds; (2) burns; and (3) fractures and fracture-dislocations.

1. Gun-shot and Missile Wounds

In a paper dealing with aircrew casualties these wounds by themselves need no special mention. They present no inherent problem and have no peculiar feature to distinguish them from similar wounds inflicted under other circumstances. As isolated injuries they are relatively insignificant, and two readily understandable factors aid the surgeon in their repair. There is seldom a long interval between the wounding and the admission of the patient to hospital, and gross contamination of the wounds is not common. Efficient early treatment reduces the incidence of serious infection, and gas gangrene is very rare. Two of the gravest complications of missile injuries are therefore almost eliminated. The main difficulties are found among the second and third types of injury especially when, as so often happens, they are mixed.

2. Burns

In the Royal Air Force the problem of the burn is very specialised and of first-class importance. It is specialised because practically always the same areas are burnt. Even a light layer of clothing affords very considerable protection against burning by flame. The trunk and limbs which are covered by heavy flying clothing are rarely burnt, but the hands and face which are not so protected commonly suffer. Having indicated what areas are affected, I do not need to emphasise further the importance of the problem which treatment presents. Unless the burnt areas heal rapidly with minimal contracture serious disability must result. Even extensive burns of the trunk and upper limbs may heal with quite considerable scarring, but the effect upon the function may be only slight unless joints are involved. This is not so with burns of the hands and face.

The longer an area granulates, especially when it granulates in the presence of infection, the more fibrous tissue is laid down in its base, and the deposition of fibrous tissue in a healing wound inevitably leads to contracture. The problem, therefore, in the treatment of

* A Honyman Gillespie Lecture delivered in the Royal Infirmary, 18th May 1944.
burns of the hands and face is that of covering the burnt area with skin without avoidable delay. In addition, in the case of the hands function must be preserved throughout. If joints are opened, tendons destroyed, and prolonged granulation is inevitable, measures must be taken to ensure that the function of the hand is not further impaired by preventable contracture.

When this war began the treatment of burns by the application of tannic acid or some other form of coagulant was almost universal. This was and still is adequate treatment for many burns, though I do not believe that it is the best treatment for any burn. Very early in the war it was realised that the results of the treatment of burns of the hands and face by this method were disastrous and that, especially in the hands, coagulation of the burn could and did produce consequences more serious than those of the original trauma.

The coagulant treatment of burns depends for its success on the maintenance of sterile conditions under the coagulum. Then and then only can it be used without causing harm except in burns of the hands. But burns of the face treated with tannic acid are inevitably infected under the tan from the eyes, the nose or the mouth; and all burns in which there is actual destruction of tissue, so-called "third-degree" burns, must become infected at some stage. In any case there is no good reason for coagulating with chemicals that which has already been destroyed by heat. In burns of the face even without tissue destruction some degree of infection must occur, and treatment should be directed to its control. In third-degree burns of the face and elsewhere controlled infection is a valuable part of the healing process, for without it sloughs separate much more slowly.

Though infection serves a useful purpose while the sloughs are separating, it must be eliminated at the stage of re-epithelialisation of the burn. The recent popularity of the closed plaster treatment of wounds and compound fractures, and the undoubted and amply proved value of this method of treatment for this type of wound, have led to some confusion of thought about its applicability and the indications for its use. It is true that infected compound fractures heal in a closed plaster, and that if drainage is adequate the associated soft tissue wound, benefiting also from the plaster splint, granulates readily; but that is the point: the wound granulates. Granulations grow well in a wound enclosed in plaster even in the presence of infection, and the exuberant heaped granulations which are so produced are a familiar sight. Epithelium will not grow well under these conditions. Growing epithelium thrives best on flat sterile granulations and is inhibited by infection in a wound bathed in pus under a plaster or a coagulum. There is no need to "stimulate" epithelial growth by the use of coloured lotions of great repute but of no proved value. Epithelium will grow with amazing speed if the obstacles to its growth are removed. The usual obstacles are infection and irregular granulations.
Face.—Burns of the face are best treated by daily saline irrigation, if possible in a saline bath, though this is not obligatory, and dressings of sulphonamide powder, tulle gras and saline packs until any slough has separated. As soon as infection is under control the remaining raw areas are covered with a split-skin graft. Thus contracture is minimised, the need for subsequent plastic repair of the face is reduced, and such repair as may be needed is facilitated. Particular attention must be paid to the areas around the eyes, and every possible measure must be taken to minimise contracture here. Contracture around the eyes causes exposure of the cornea, and this in the presence of infection results in corneal ulceration with loss of the eye. The treatment of burns of the face must centre around the preservation of the eyes. In all cases in which the eyes are in danger penicillin is now instilled into the conjunctival sac, and I have seen eyes saved by this means which would otherwise certainly have been lost. This is by far the most valuable single contribution which the introduction of penicillin has made to the treatment of burns.

Hands.—The coagulant treatment of burns of the hands may do dreadful damage even in the absence of infection. Burnt hands must swell, and often the swelling is greater with the lighter degrees of burning. In the hands œdema acts like glue, and unless swollen hands are kept moving serious stiffness will result which may last for months or may even be permanent. Fingers and hands clothed in a glove of inelastic coagulum cannot be moved and must stiffen. Hands should be treated with daily saline baths and with sulphonamide, tulle gras and saline packs bandaged on so that the fingers can be moved and exercised from the beginning to preserve their function. So treated they need never become stiff.

The granulations are covered with a split-skin graft as soon as they are ready to receive it. There is always a temporary deterioration in finger movement after the skin-grafting of a burnt hand. It is directly due to the fact that the hands have to be immobilised so that the grafts may take, and it is soon overcome only because the period of immobilisation does not exceed four or five days.

Coagulants used on burnt hands may cause greater disaster than prolonged stiffness. The unyielding coagulum acts as a tourniquet and strangulates the swollen hand and fingers even to the degree of producing gangrene. Those who wish to read the account of one who suffered the appalling calamity of the loss of his fingers in this way may find it set out in his own words in One of our Pilots is Safe. Surely no book ever had a more sadly satirical title. Even if the coagulum does not cause gangrene the vascular supply of the splinted fingers is seriously impaired, and this state of affairs continuing for more than a few days produces what has been aptly described as a "frozen hand." The fingers are spindled, the skin is shiny and atrophic, and there is no more than a shiver of movement in the finger-joints. Though the fingers are still there the hand is functionally useless.

When the burning is so deep as to destroy tendons and open joints,
another consideration must guide the surgeon in his treatment. Severe limitation of movement will result from a burn of this degree, and what movement remains must be facilitated by the functional position of the hand and not hindered by preventable contracture. In the Royal Air Force the hands are usually burnt worst on the dorsum, and the characteristic contracture of a severe burn of the dorsum of the hand fixes the metacarpo-phalangeal joints in hyper-extension. Once this contracture has become established there is no known means of restoring any function whatsoever to the affected digits. The rarer burns of the palm produce a flexion contracture which is equally disabling. Hands thus gravely burnt must be splinted, preferably in plaster, in the optimum functional position with the metacarpo-phalangeal joints in mid-flexion until a fibrous ankylosis occurs. Then the patient is encouraged to develop such movement as he can. It may not be much, but it is useful movement in the position of function and not the pathetic flicker of a subluxated joint.

The rules governing the treatment of burns of the hands are quite simple and are in exact accord with surgical first principles: control infection; promote healing; prevent contracture; above all, preserve function. Unless the hands are in plaster active movements are practised hourly. Patients are encouraged to perform for themselves the everyday routine of life, such as feeding, dressing and lighting cigarettes. Not long ago I saw a new arrival offer a light to a boy with badly burnt hands who was having difficulty with a match. The offer was refused with "Don’t you know better than that? Never help a ‘burns’ patient." That must be the attitude of all who are dealing with patients with burns of the hands. There is no lack of practical sympathy, but it is not openly expressed, and it is always remembered that misplaced sympathy will delay recovery.

3. Fractures and Fracture-dislocations

In contra-distinction to the stereotyped burns of aircrews the fractures and fracture-dislocations which they sustain are characterised by their multiplicity and extraordinary variety. This is understood when the degree of force producing the injuries is remembered, and when it is realised to what terrible stresses machines and men are subjected in aircraft crashes. The horse-power developed by the engine of a single-seater fighter exceeds that of the locomotive which pulls the Flying Scotsman, and the speed of impact in aircraft crashes to-day is seldom less than 100 miles per hour. It is often more. It is not surprising that these accidents produce more than one injury in the same patient, or that the injuries commonly show severe displacement and are frequently compound. They are often associated also with head injury; this may dominate the immediate picture and delay the treatment of other injuries.

These are some of the difficulties. On the credit side of the balance there are two factors which help greatly in the treatment of aircrew
THE MANAGEMENT OF MULTIPLE INJURIES IN AIRCREWS

Casualties. Firstly, they occur in young fit men whose morale is high. Secondly, they usually come under treatment within a few hours. Thus in the Royal Air Force we have had the opportunity of treating with success combinations of injuries which must under other conditions have proved fatal.

The treatment of a patient with multiple injuries is divided into two phases: (1) the immediate; (2) the remote or definitive. In the immediate phase the general considerations consist mainly in the control of shock, and the local considerations are those of prevention of wound infection and primary reduction and splinting of fractures. The treatment of the fractures themselves occupies a very secondary place in the immediate phase, and care must be taken that it is not given undue emphasis. Definitive treatment is concerned with the management of wound healing, the replacement of skin loss and the accurate realignment of fractures. In this phase all possible methods of fracture treatment should be available. Often the programme which would otherwise be considered most suitable for the treatment of an individual injury is made impossible because of unavoidable delay in starting it, because of infection, or because of other injuries in the same limb or elsewhere.

A. IMEDIATE TREATMENT—Shock.—The treatment of shock may be epitomised very briefly as the use of measures to restore to normal the volume of the circulating blood. As soon as a patient with multiple injuries comes under treatment, a blood-pressure reading is recorded and a plasma transfusion is begun. This blood-pressure reading is not made for diagnosis, for it can be assumed that a patient with one or more major fractures is shocked. It is made to afford a baseline against which further readings can be compared. Plasma can be used without any typing or cross-matching, and is as efficacious as blood in restoring the blood-volume in the initial stages of resuscitation. McMichael has shown that, in the stage of haemo-concentration, transfusion of up to two pints of plasma not only restores the blood volume but brings again into active use red cells which were stagnant in dilated capillaries.

Massive plasma transfusions are not desirable for three reasons:

(1) A transfusion of more than two pints of plasma causes haemodilution, and then plasma becomes much less effective in controlling shock than whole blood.

(2) The administration of large amounts of plasma is followed in two or three weeks by a very troublesome and intractable secondary anaemia.

(3) Large amounts of blood are lost into the tissues in closed fractures and without any external bleeding. One and a half to two pints of blood may be extravasated into the muscles of the thigh with a closed fracture of the femur.

Blood, therefore, is used for massive transfusions.
Three or four pint transfusions are relatively common, and an empirical limit must not be set to the amount of blood which should be given to any patient. The largest transfusion of which I have had experience was used in the treatment of a dispatch-riding who was gravely injured in a collision with a tank. He was moribund when he reached hospital, and he received two pints of plasma and twelve pints of blood before operation was successfully undertaken. I was recently asked to see a soldier who had suffered an accidental gunshot wound of the leg with a gross compound shattering of the tibia and a closed fracture of the femur on the same side. When I saw him he had been under treatment for about three hours. He was desperately ill, with a systolic blood-pressure of 80 mm. and a diastolic pressure which I could not estimate. There had not been much external blood loss, and he was then having his fourth pint of plasma, which was being used "because it is just as good as blood in pure shock." The surgeon in charge of him was concerned at his lack of response. Not only was treatment based on a false premise but the fact that there was, in addition to what he had lost externally, a blood loss of two pints into the muscles of his thigh had escaped notice. He needed blood, and he needed it urgently. In the following thirty-six hours he had ten pints of blood, and during this time the injured limb was successfully amputated at mid-thigh. He ultimately recovered.

Gravely shocked patients should be lifted and moved as little as possible. They are adversely affected by lifting and should always be taken from the ward to the theatre in bed and not on a trolley. One lift from the bed to the table is enough, and they should be lifted with scrupulous care and gentleness. Any alteration of position on the table or alteration of the tilt of the table itself should also be made very carefully and gradually. Further, severely shocked patients should not necessarily be moved to hospital as soon as they are seen at the site of the incident. A patient may stand a short journey to a nearby place of shelter where he can be given plasma and blood and left to recover till he is fit to move further, when he would have died in the ambulance had he been taken straight away on an hour's journey.

Estimation of Degree of Shock.—The blood-pressure is the most valuable indication of the condition of a shocked patient and of the effect of resuscitation. An estimation of the state of the peripheral circulation by observation of the rate of return of surface blood to the lobe of the ear or the nail bed is a much less accurate indication and is open to wide personal error on the part of the observer. This sign is of little use to the inexperienced, and though it is of some value to those with experience, even they use it only as an adjunct and place by far the most reliance on the behaviour of the blood pressure. I do not believe that any dependable assessment of a patient's condition can be made by counting the pulse or by estimating its "quality" with the finger.

One blood-pressure reading is not enough. Shock is one of the most treacherous and deceitful conditions in the whole of surgery,
and if reliance is placed on one blood-pressure reading alone errors are inevitable. An accurate estimate of the patient’s condition can be made only by a determination of whether the blood-pressure is stationary, rising or falling. There is a stage of vaso-constriction in shock when the blood-pressure is high, and sudden and dramatic alterations may happen without warning. A patient, whose general condition did not give rise to anxiety and whose blood-pressure was 140/90, was left without transfusion. Two hours later he was obviously profoundly shocked and his pulse was impalpable. He had been in the vaso-constrictive phase of shock, and the single blood-pressure reading had given an entirely erroneous impression of his condition. In point of fact the slight elevation of the blood-pressure might have roused suspicion, but this indication was missed and a grave degree of shock was not recognised until the point of extreme danger was reached.

Transfusion, therefore, is started immediately, for once the needle is in the vein shock is largely under the control of the surgeon. So that sudden deterioration of the patient’s condition may not escape recognition, the blood-pressure is recorded and charted at fifteen-minute intervals while the preparations for operation are being made and every ten or even five minutes during the operation. The medical officer in charge of the case must keep most careful watch so that he may promptly counter sudden worsening of the patient’s condition by speeding up the transfusion.

Anaesthesia.—Great importance attaches to the anaesthetic and to the method of its administration. The anaesthetist is a key member of the surgical team. In my opinion there is no field of surgery in which administration of the anaesthetic needs more precise judgment or greater care. The anaesthetist and the surgeon must work in the closest co-operation. It is my practice to discuss with the anaesthetist what I would like to do, to estimate with him what will be possible, and to plan my procedure accordingly. There is always an understanding between us that I shall be entirely guided by him about how long I may continue to operate and that I am prepared to stop immediately at his request.

Type of Anaesthetic.—Spinal analgesia is never used. The drop in blood-pressure which it produces and the fact that its effect once established is not readily reversible combine to make it too dangerous. Many fatalities from the use of spinal analgesia in shocked patients have been recorded, occurring before operation had even begun. Rear-Admiral Gordon-Taylor truly says, “If you want to practise euthanasia in war surgery use spinals.”

Local anaesthetics are usually excluded by the technical difficulty of the multiple infiltrations needed and by the potential or actual infection of the wounds, but sometimes regional blocks may be used with advantage. Brachial plexus block is particularly useful both in immediate and in definitive treatment.

Intravenous soluble barbiturates are valuable for induction but
must be used with great care. They act very rapidly and in very small doses in shocked patients as, incidentally, they also do in patients with established sepsis. Pentothal should not be used in a solution of greater strength than 2.5 per cent., and a shocked patient may be completely anaesthetised by 3 or 4 c.cm. of this solution who would ordinarily need 12 or 15 c.cm. of the usual 5 per cent. solution, or about twelve times as much Pentothal.

Gas and oxygen given by an expert anaesthetist with especial care to avoid any increase in tissue anoxia is the best means of maintaining anesthesia. A little ether or cyclopropane is added if necessary. If an expert is not available, the less experienced anaesthetist is probably safest with ether. This is best given by the Oxford Vapouriser introduced by Air-Commodore R. R. Macintosh.

**Immediate Local Treatment.**—The most important object of the immediate local treatment of patients with multiple injuries is control of infection. This is effected by two means: (1) by careful and thorough excision of wounds; and (2) by the prevention of skin necrosis due to gross bony displacement.

**Wounds.**—The principles governing the primary local treatment of wounds have been enunciated many times and do not need further repetition. I would emphasise just one point. As my experience of war wounds grows I become more and more convinced that primary suture is never indicated. I feel very strongly that the introduction of penicillin has as yet added nothing to the arguments in favour of primary closure. I have never seen anything but a little time lost by leaving a wound open. It is easy to do a delayed primary or a secondary suture if the wound remains clean. The ill-advised primary suture of a wound may precipitate grave infection which will endanger life or limb. I now never suture war wounds primarily, however favourable the conditions may appear to be.

**Fractures and Fracture-dislocations.**—I have already indicated that bony injuries are usually severely displaced. If they are not compound when first seen the skin is often so stretched over the underlying bone that it will necrose in a few hours. This is particularly true of fracture-dislocations of the ankle and foot. In the immediate treatment the displacement should be clinically reduced so that the skin is preserved and the complication of sepsis is not added to the existing lesion. As soon as the skin is safe, further time should not be spent in X-ray check and possibly remanipulation in a gravely ill patient. The necessary adjustments can be made when his life is no longer in danger.

**Plaster.**—A limb in which there is a fresh or a recently manipulated fracture or a recent wound due either to accident or to operation must not be enclosed in a complete plaster. The plaster must be split in its whole length, and the dressings under it split down to the skin so that reactionary swelling cannot endanger the blood supply of the limb. A patient arrived at a Royal Air Force hospital two days after he was injured. Both legs were in full-length unsplitted plasters
and both feet were gangrenous. The plasters were removed at once, but both legs had to be amputated below the knee. His primary injuries were minor closed fracture-dislocations of both ankles and moderate second and third degree burns of both legs.

The following case illustrates most of these points.

R. B., a rear-gunner, was injured when his aircraft crashed on take-off. He sustained a compound fracture of the shaft and a simple fracture of the neck of the left femur, a grossly compound severely comminuted fracture-dislocation of the left ankle and a fracture-dislocation of the right ankle. After he had been given a pint of plasma and two pints of blood he was well enough for some operative treatment, but it was obvious that he could not stand much, and that the operating time available had to be carefully apportioned. Blood transfusion was continued throughout the operation. Anaesthesia was induced with dilute Pentothal (he was asleep when he had had 3 c.cm. of a 2.5 per cent. solution), and maintained with gas and oxygen.

The two ankles were the most urgent injuries, the left because it was grossly compound, and the right because the skin would obviously slough if reduction were delayed more than a few hours. The fracture of the femoral shaft was only slightly compound from within and there was no gross muscle damage.

The left ankle wound was rapidly excised, the displacement was corrected clinically, the wound was packed open with vaseline gauze and a padded split plaster was applied up to and including a transfixion pin which my assistant had meantime inserted through the tibial tubercle. The gross displacement of the right ankle was corrected clinically, making the skin safe from further pressure from within, and a padded split plaster was applied. The thigh wound was excised and packed open. A Thomas's splint was applied to the left lower limb, and the patient was returned to bed with the femur controlled by fixed extension from the tibial pin.

In a few days, when the general condition had improved, the displacement of the femoral shaft fracture was corrected by weight extension and by adjustment of the posterior and lateral splints till adequate alignment had been achieved. Ten days later, at three weeks from the accident, the reduction of the fracture-dislocation of the right ankle was completed by further manipulation with open replacement and screw fixation of the internal malleolus. Complete reduction of the internal malleolus by manipulation alone was not possible because, as so often happens, torn and displaced periosteum was interposed between the fragments.

Five days later the fracture of the femoral shaft was already sticky, and the realignment of the limb was completed. The patient was slung in a Hawley table and the two femoral fractures were accurately aligned under X-ray control. A double plaster spica was applied down to and including the tibial tubercle pin. The plaster was removed from the left leg and foot below the tibial pin. The compound wound
was clean and granulating; it was redressed with sulphanilamide and tulle gras. The residual ankle displacement was corrected clinically and radilogically till the foot lay squarely under the tibia in good weight-bearing alignment and the foot and leg were again immobilised in plaster which extended up to meet the upper plaster. Now as the ankle wound heals the joint may fuse spontaneously in satisfactory position. If fusion is not sound, an operation to produce firm ankylosis is relatively simple. The femoral fractures will not need any further adjustment and will be held in plaster till they are firm.

The primary operative treatment of this patient took only forty-five minutes, but by the time it was finished his condition, in spite of blood transfusion, had begun to deteriorate and he would not have stood much more. In the definitive treatment the manipulative and operative reduction of the right ankle occupied one hour and a quarter, and the realignment of the left lower limb and application of plaster took nearly four hours. But these adjustments were undertaken on a patient who had recovered from his shock and was in good general condition. They upset him hardly at all.

B. DEFINITIVE TREATMENT—Wound Healing.—When there is no skin loss, wounds of almost any size will heal with remarkable rapidity under a closed plaster if infection is adequately controlled. Granulations soon fill up any defects in a properly excised wound, and in a very short time what had been a saucerised cavity is flush with the skin surface under the plaster. Final healing soon follows. If infection persists in such a wound, it is maintained either by inadequate drainage of the wound and consequent pocketing, by the sequestration of infected bone, or by a retained foreign body. The wound needs further exploration with provision for free drainage and the removal of any foreign body or separated sequestrum. In this connection it must be remembered that not all foreign bodies in wounds are radio-opaque, and that an X-ray which does not show a sequestrum or a piece of metal does not exclude the presence of a piece of wood, cloth, leather or perspex. But if infection is controlled a wound will granulate rapidly inside a closed plaster up to the skin level and will then heal if there has been no skin loss.

Skin Replacement.—When skin has been lost the picture is different. Any tissue loss under the skin is made good by granulations which fill the defects and contract into a firm scar, but until the granulation tissue is covered with skin the wound is not healed. It has already been noted that increased fibrosis and consequently greater contracture are a direct result of prolonged granulation. There is also another disadvantage connected with delay in wound healing when there is an associated fracture, for any definitive operation to an underlying or neighbouring fracture must wait till the wound is healed. It is most tantalising to have to watch a fracture which is not amenable to any other treatment than operation become more and more difficult to handle because operation must be postponed.
Again, therefore, the problem of promoting rapid healing of a
wound arises, and again, as in the burn, the answer lies in the control
of infection and the replacement of lost skin by a skin graft. Usually
quite simple forms of skin-grafting, which are well within the com-
petence of the surgeon without special training in plastic methods,
are enough. When flaps or pedicled grafts are needed, the aid of the
plastic surgeon should be sought. For wounds of the trunk or limbs
pinch grafts or "postage stamp" grafts of split skin are used. These
are by far the easiest and safest methods of skin replacement, and a
sheet of split skin (a very much more difficult graft to cut and implant)
has only a cosmetic advantage over them. Split skin grafts the size
of the area to be covered are used on the face, but pinch grafts or
"postage stamp" grafts may be used with advantage anywhere else.

Just as in the case of a burn defect, epithelium will grow only over
flat uninjured granulations, and its growth is inhibited by pus and
by irregularities in the surface of the granulations. The wound should
be covered in plaster till the granulations are flush with the surface.
Then the raw area is prepared for the reception of skin by exactly the
same method as that used in the treatment of burns. The wound is
irrigated daily with saline, preferably in a saline bath, and dressed
with sulphonamide, tulle gras and saline packs till the granulations
are ready to receive new epithelium. This stage is reached when the
granulations are flat, pink and shiny, when there is little or no purulent
discharge, when the culture shows no growth of haemo-lytic streptococci
or of staphylococcus aureus, and when the new epithelium can be seen
creeping in from the edges of the defect. This last is the best indica-
tion of all. If skin is growing over the granulations then a skin graft will
take without trouble.

The rapidity with which skin defects heal, when treated in this
way, has to be seen to be believed. Wounds, which are indolent and
in which it looks as though healing had come to a standstill, can be
changed in a very short time into responsive healing areas, and very
large defects can be reclothed with skin by pinch grafting.

J. E. was an air-gunner whose horribly mangled leg was almost
completely severed in an aircraft crash. He had also a severe fracture-
dislocation of the spine, and a formal amputation of the limb was out
of the question. The removal of the leg was rapidly completed through
the fracture of the tibia without any attempt to fashion flaps, and the
stump was enclosed in plaster. When his spinal fracture had been
reduced and immobilised in an extension jacket the plaster was removed
from the stump, the granulating area was prepared with daily saline
irrigations, and pinch grafted. The subsequent amputation at the
site of election in the thigh was safely made through sound skin and
above a healed wound.

E. S. was injured by a heavy vehicle which ran over his leg and
degloved an encircling area about a foot wide just below the knee.
He was treated in another hospital for a month and came to us with
an extensive grossly infected wound which showed no sign of healing.
After ten days of saline bath treatment the area was pinch grafted and seven weeks later it was all but healed.

The method can also be used on a wound under plaster by cutting a window. Some considerable ingenuity is often required of the nursing staff, but I have yet to see a wound in which the method was indicated and was found to be impossible because of technical difficulties.

When the defect involves a joint, a weight-bearing surface like the heel, or an area where tendons are superficial like the back of the hand, a whole-thickness flap of skin must be used to take the strain of constant movement or weight-bearing without breaking down, and to prevent the adhesion of tendons to the scar. Skin defects over the tibia may need a whole-thickness replacement because they often heal very slowly and with a very unstable scar, but even these wounds can be healed in the first instance by pinch grafts if for any reason the immediate application of a pedicled flap is not possible. Flaps may be used in two ways:

(1) by immediate application to a fresh wound, particularly an abdominal flap to a wound of the hand;

(2) a delayed flap such as a cross-leg flap to replace an unstable scar of the tibia.

These are not simple procedures and should be left to the surgeon with special plastic training.

**Bone and Joint Injuries.**—The treatment of these follows the ordinary lines and is unusual in aircrew injuries only in the severity and multiplicity of the deformities which have to be corrected. Massive bone grafts are often needed to replace lost bone or to provide internal fixation for a fracture the alignment of which could not be controlled by external splints and which could not be treated by early operation because of a wound. A bone graft is essential for the first of the two purposes; it is much better than a metal plate for the second, for it promotes union in addition to providing internal fixation of the fracture.

A. M. lost 4 inches of his lower femoral shaft in a crash. The wound healed cleanly after excision and delayed primary suture, and the length and line of the limb were held by extension and splints till a slender involucrum bridged the gap. This was then reinforced by a massive onlay graft from the tibia together with a graft of iliac bone to encourage more rapid bone regeneration.

C. A. had compound fractures of both bones of the right forearm and humerus, a plateau fracture of the right tibia, a simple fracture of the left femur, and a compound fracture of the left tibia and fibula. The forearm fractures could not be controlled by any means other than open operation and internal fixation, and this was not possible till fourteen weeks after injury. Then with great difficulty the displacement was reduced and the radius was fixed with an onlay bone graft. During the operation the humerus was accidentally refractured. As he was already in a hip spica, a thoraco-brachial spica in addition was out of the question, but the necessary fixation of the humerus was
provided by joining the arm cast to the body of the hip spica with plaster struts. The refracture of the humerus healed in anatomical alignment in six weeks.

**Fractures of the Spine.**—The variety of the combinations of fractures which are seen in injured aircrews is almost endless, and I make no attempt to cover the whole field, but one common type of injury must be mentioned—fracture of the spine. Specific search must always be made for injury to the vertebral column occurring alone or as an associated lesion in patients involved in aircraft crashes even when no complaint is made of pain in the back. Also, the spines of patients with fractures of the os calcis or astragalus, no matter how they were injured, should always be examined as a routine. Severe pain in the foot often masks minimal discomfort in the back.

A. B. was a physical training instructor who wished to become a paratrooper. He was accepted for training and came to see me after he had completed his initial course of jumps. He was complaining of "a pretty constant ache in the back." He had had this for some time but "had not liked to complain about it" lest he was taken off training. On clinical examination I found a tender lumbar kyphos, and X-ray showed a compression fracture of the first lumbar vertebra. Further questioning elicited the history that he had landed heavily from his first jump and had "jarred his back." He had done five subsequent jumps with this compression fracture of the spine. A complaint of pain in the back after an aircraft crash or a parachute descent must always be thoroughly investigated.

R. A. was admitted from another hospital with a fracture dislocation of the talus. He did not make any complaint of pain in the back, but he was found to be tender on pressure over the lumbar spine and X-ray showed compression fractures of the bodies of three lumbar vertebrae.

I have already made reference to J. E.'s spinal injury when I discussed his leg. On admission to hospital he was gravely shocked, but when he became co-operative enough to be examined he was found to have a tender lump in the lumbar region and X-ray showed a gross fracture-dislocation of L. 1 on L. 2. A spinal extension jacket was applied as soon as he was well enough and before any local treatment to the primary amputation stump was begun. Later when the secondary amputation stump was healed the spine was fused.

There may be an obvious, gross and dramatic injury elsewhere, but the spine of a patient injured by severe violence must always be examined before a course of treatment is planned.

And so I finish. I have tried to present a broad picture and have not entered into great detail on any one point. Maybe I have been too discursive. But I have failed in my object if I have not shown that the management of multiple injuries in aircrews is, if I may slightly modify the words of Robert Louis Stevenson, "a task for all that a man has of therapeutic skill and delicacy."