the year after having ably held the office for just over four years, and has been succeeded by Major-General J. B. Hance. It is gratifying that Sir Gordon Jolly has agreed to serve on the Central Committee as a co-opted member.

It is sad to have to record the death of Dr. C. Frimodt Möller, a foundation member and the first Medical Commissioner of the Association. He was connected with India for 36 years. As Lady Linlithgow said in her farewell speech, 'he combined vast knowledge, great powers of organization, strength of character and charm of manner which will be almost impossible to replace'.

R. N. C.

Special Article

WOUNDS OF THE EXTREMITIES*

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THE treatment of wounds has undergone a radical change since the last war. During that period, the rival merits of antiseptics in the control of wound infection were adumbrated to the exclusion of the simpler and original principles of Lister who sought to keep infection from wounds and insisted on the reparative defence powers of the body. This is quite different from endeavouring to destroy infection with antiseptics which result in an assault on the reparative powers of the body and violate the principle of rest. The methods of to-day show no difference from the methods of Lister, though the technique in their application may differ. The mortality in gunshot wounds of the femur in the last war was in the region of 80 per cent, differing little from that which occurred in the Crimea. At the end of the war it was in the region of 20 per cent. Trueta (1939) in the recent Spanish war had a mortality of one case in a series of 101 cases.

The wounds.—Bullets, fragments of shell or bombs travel in the limb in the line of flight of the missile, and the wound track depends on the position of the limb at the time of wounding. This fact must be borne in mind.

The wound of entry of bullet wounds is generally smaller than that of exit, but in uncomplicated through-and-through flesh wounds their entrance and exit wounds approximate each other in size. I have seen a case in which a bullet pierced both thighs behind and it was difficult to tell in either thigh which was the wound of entry or exit.

Where a bone is involved, the wound of exit, if present, may be many times larger than the wound of entry, because of the disruption of the bone or of the turning of the bullet in its long axis.

In the ragged wounds produced by a bomb or shell splinter, it is easier to decide the site of entry. The destruction of tissue, vessels, nerves and bones will be so severe that there may be complete ablation of the limb. In the case of bullet wounds involving bone (this I have found common in Waziristan) there may be no exit wound, and the bullet or disintegrated parts of it will be found in the bones and beyond, buried in the soft tissues. The violent disruption of the bone or bones may lead to a large gap, and fragments of the bone are pulverized and displaced a considerable distance into the surrounding muscles (*see* figures 1, 1*a*, 1*b* and 1*c*, plate XVII).

Through-and-through bullet wounds of the soft tissues are relatively clean, and may be left, but this requires careful judgment as will be subsequently described.

Injuries to arteries and nerves.—Along the course of the missile, for a variable distance depending on its size and velocity, there is an area of necrosis. In this area, blood vessels and nerves may be damaged, the former giving rise to hæmorrhage which may be fatal; damage to the latter will produce the signs characteristic of the various nerve lesions. An incomplete wound in an artery bleeds continuously, causing death if not dealt with; whereas a completely severed artery will bleed profusely for a few moments and then cease, as the elasticity of the arterial wall gradually withdraws the wall from the site of injury and envelops the severed end in a mass of adventitia. In animals (rabbits), I have found that bleeding ceases within three minutes where complete division of an artery is carried out. In incomplete division, death occurs after four minutes without cessation of bleeding. In a divided posterior tibial artery I have seen hæmorrhage cease due to this retraction. Lieut.-Colonel L. K. Ledger, I.M.S., also described to me a case which he dealt with where the femoral artery was completely divided and a similar condition had occurred. The artery was subsequently dealt with successfully.

An artery may suffer from concussion without demonstrable injury, producing local spasm which may disappear. Another type of injury is a localized contusion causing rupture of the intima with thrombosis at the site, which, by extension distally or by the liberation of an embolus, may cause gangrene. Another sequel may be necrosis

*Read before the British Medical Association, Peshawar Branch, on 15th December, 1942.

of the contused wall and secondary hæmorrhage either externally through the wound, producing death from hæmorrhage, or into the tissues around the lesion producing a pulsating hæmatoma leading to the formation of a sacculated aneurysm. Should artery and vein be both involved in the process, a varicose aneurysm may occur.

Infection of wounds.—Whether large blood vessels are damaged or not, blood pours out into the track from the damaged muscle and bone, and pieces of missile, clothing, earth, stone or other foreign bodies may be found; moreover, the area is contaminated with organisms from the skin or area where the wounding has occurred.

For a variable period of time after the receipt of the wound, the limb is numb due to the concussion; as a result the individual suffers from wound shock and hæmorrhage which may be severe. In such a devitalized anoxæmic area full of blood clot and serum, favourable conditions are present for the growth and dissemination of both anaerobic organisms and aerobic organisms, as these latter may be facultatively anaerobic.

Such wounds are regarded as being contaminated up to a period of six hours, and may be dealt with so as to bring about healing by first intention in very favourable conditions. After this period, wounds are to be regarded as being infected; the organisms have established themselves. The virulence with which they do this varies with the amount of trauma which the limb has suffered, the interference with the blood supply, and the soil and climatic conditions where the individual was wounded; in some cases, the injudicious use of a tourniquet will favour infection.

In injuries seen after the first 12 hours, the patient will have fever and a raised pulse rate. He will complain of pain in the affected limb. The affected part will be red, brawny and œdematous, with a sero-sanguineous or frankly purulent discharge. The whole limb may be involved, as the organisms tend to spread rapidly along the relatively avascular fascial spaces. If hæmolytic streptococci are present, a rapidly spreading cellulitis or lymphangitis may occur. The neighbouring groups of lymphatic glands are enlarged, swollen, and tender, and localized abscesses may develop. In severe cases, septicæmia may result. If the bones are involved, there is a concomitant osteomyelitis.

If anaerobic gas-producing organisms have established themselves in such traumatized limbs, the onset of gas gangrene is often fulminating, and may declare itself within a few hours of the injury. In less fulminating cases the infection may not declare itself for 24 to 48 hours, and this commonly occurs where surgical aid is delayed or is ineffective.

Clinically, gas gangrene declares itself by the onset of violent pain in the wound, an increase in the volume of the limb, a sudden rise of pulse rate in relation to the temperature, sunken eyes and a general appearance of grave illness. There is an icteric tinge, and intense thirst. In the affected limb, there is œdema, a brownish discoloration around the wound, and a brownish frothy sero-sanguineous discharge, and a mousy odour which is characteristic. Palpation of the limb reveals crepitation, and on flicking it with the finger a drum-like note is obtained. The presence of emphysema in a wound may excite suspicion of an incipient gas gangrene, but the absence of the other clinical signs should obviate this. In delayed cases, no one can make a mistake.

Treatment

(*a*) *Preliminary.*—As a general rule, all injuries of the lower limb should be placed in a Thomas splint as soon as possible, and those of the upper limb by padded splints and binding to the trunk for transportation.

I have not encouraged the systematic use of the tourniquet because of its misuse in the hands of the inexperienced; damage may be caused which is worse than the original injury. It should only be used if the limb is completely shot away or if the hæmorrhage comes obviously from a main artery. The routine use of a tourniquet causes pain and shock, and predisposes to gas gangrene by causing anoxæmia of the tissues. A firm pad and bandage will in most instances control hæmorrhage. In four years in my area we have never had occasion to use a tourniquet except in the operation theatre.

Three thousand units of anti-tetanic serum and anti-gas gangrene polyvalent serum are given, and if it is likely that the situation will not allow of evacuation within the first 12 hours, a full course of sulphathiazole is given. Free fluids are given unless the injury is complicated by an abdominal injury. Morphia up to ½ grain is given. The problems of evacuation to a suitable surgical base will vary with the situation. These will differ in, say, a city subjected to enemy action compared to the battle front; whatever these problems are, it should be our object to give adequate surgical care to wounded within the first six to eight hours. That is an ideal which may not always be practicable.

(*b*) *The fracture.*—Prior to any operation on a compound gunshot fracture of the limbs, immobilize the limbs in a traction apparatus. Reduce the fracture at once so that the limb is restored to its correct anatomical position. By this means the vicious circle which initiates wound shock is broken. In my opinion it is a misconception that primary treatment should be delayed for the patient to recover from shock, hæmorrhage and swelling. All these conditions may be prevented or relieved by immediate reduction and control of the injured parts in correct position. With reduction of the fracture, there is restoration of the circulation and nerve supply; hence all the physiological functions of the injured part may be expected to improve. In the treatment of shock, an infusion is given of saline

glucose, whole blood or plasma, whichever is needed.

In fractures of the lower limb below the knee, I employ a Bohler's leg traction apparatus with a Steinman's pin through the calcaneus if necessary. For fracture of the femur, an orthopædic table is used, or, if it is not available, a simple pelvic rest attached to an ordinary stout table will do. For the forearm I use fixed traction from a bracket in the wall to which a band is attached, and counter traction is made by an assistant on the forearm which is kept flexed to a right angle and in the mid-position of rest. As a general rule, I find that a minimal amount of traction is required in gunshot wounds, as the muscles are in a state of paralysis, and deformity is easily overcome; fractures of the arm are easily dealt with as the weight of the forearm is often sufficient to secure reduction and prevent displacement.

(*c*) *The wound.*—When the limb has been placed in the required position, the skin is cleansed with soap and water. The wound itself is covered with a dry sterile dressing, and the surrounding skin is thoroughly cleaned, working from the wound outwards. The hair around the wound for a distance of three inches is shaved, and the remainder is left. This is, I consider, important, as the hair is incorporated in the plaster of paris to be sequently applied. It gives an even pull on the skin, and is comfortable. A shaven limb enclosed in non-padded plaster is uncomfortable. After the skin has been cleaned, ether is used; this is necessary often to remove oil or grease which nowadays is by no means an uncommon contaminant of the skin. Finally, any skin antiseptic can be used to complete the cleaning of the operative field. The limb is then draped and the operation proceeded with.

This consists in *excision and débridement.* The excision is the paring away of all devitalized and contaminated tissue around the wound track, as if the affected area was a tumour mass. To achieve this completely is impossible in practice except in the most superficial types of wound. The débridement is the surgical relief of tension by the division of fascia and muscle sheaths. It is not the removal of débris as is sometimes erroneously thought. This latter is more correctly called épluchage.

The skin edge all around the wound is removed for a distance of ½ to 1 cm., if possible in one piece, keeping the knife perpendicular to the surface. Next the subcutaneous tissue and fascia are excised with scissors, leaving a sharp continous edge. When this stage is complete, easy access to the wound should be afforded; if not, the skin opening should be opened upwards and downwards; this is necessary in punctiform wounds. Foreign bodies, pieces of bullet, bomb, clothing loose pieces of bone and blood clot are removed. All ischæmic and necrotic muscle must be excised until contractile and bleeding muscle is encountered. It is here that the débridement is called for; fascial layers and muscle sheaths will have to be divided and opened up to follow up retracted and damaged muscle. This relieves the constriction of the muscle masses due to swelling brought about by the concussion of the limb and subsequent tissue recoil. In the removal of the muscle, excessive mutilation should be avoided. In the deeper parts of the wound it will have to be done carefully lest vessels and nerves should be damaged. These should be seen if possible.

The fracture is next dealt with. All loose pieces of bone are removed. Those attached to healthy muscle or periosteum are left. The wound is completely 'saucerized' from top to bottom. Avoid as far as possible the use of catgut; secure hæmostasis by forceps pressure or a hot moist saline sponge. *Divided nerves and tendons* are not sutured at this operation unless the wound is favourably situated and unless ideal conditions are present for primary closure of the skin wound. It is the rule of the surgery of warfare that *wounds are not closed by primary suture except in special cases.* These are in wounds of joints seen in the first six hours, in fingers, and in cases where the patient is not being moved and is under supervision for at least ten days. If the case has to be evacuated, remove the stitches and pack the wound. Total excision in severe wounds is an impossibility, as it always remains an incomplete proceeding and the end-result is always an infected wound. Short 'gutter' wounds are easily dealt with. Through-and-through wounds must be approached from one end and then from the other.

It is sometimes stated that through-and-through high velocity bullet wounds are relatively sterile and can be left alone. I do not agree that all should be left, as the small skin entrance and exit wounds are no criterion of the damage which may have occurred to the deeper structures. It is wiser to excise the skin wound and prolong the wound upwards and downwards and deal with the deeper layers as described. A good guide is the degree of tension in the limb after such a wound; moreover, if there is any suspicion of vascular damage, intervention is imperative.

In *wounds of blood vessels,* ligature is the procedure of choice under war conditions; such ligation should be performed at two points above the injury and the artery completely divided if it is not already so. Double ligation is preferable to ligature in continuity, since erosion of the vessel wall at the site of ligature is always a danger. When a large artery is ligatured in continuity, complete division permits retraction and shortening of the vessel due to its elastic contents, thus producing a thickened wall. Ligature in continuity also invites reopening of the ligature. Further, unless it is completely divided, it has been observed that vascular disturbances may develop years later, characterized by pain, poor pulse and claudication of the affected limb, symptoms which are completely relieved by division of the fibrous cord at the site of the previous ligature. According to

Leriche it is due to damage to the periarterial sympathetic plexus by the ligature producing a reflex vaso-constriction in the arterial bed distal to the ligature, thus obliterating or closing potential collaterals. The problem of whether ligature of the accompanying vein is desirable whenever a large artery is ligatured is still a subject of controversy. In my opinion the vein should be ligated. In a statistical summary it was found that among 995 ligations of the large arteries alone, gangrene occurred 154 times or 15.5 per cent and among 198 ligations of artery and vein, gangrene occurred 17 times or 8.5 per cent.

Injuries producing direct communication between artery and vein are inimical to the later health of the patient. The injury is accompanied by profuse but easily controlled bleeding, and by the prompt development of a thrill and bruit continuous throughout the cardiac cycles; occasionally these are delayed for several hours or days, due probably to temporary occlusion by a blood clot. The arterio-venous aneurism, if sufficiently large, will lead to cardiac dilatation and decompensation. To prevent this, operate under a tourniquet. Evacuate the hæmatoma and perform an excision and débridement. If the injured vessels are exposed in the absence of infection, a suture of a vessel might be attempted if heparin is available, but results are disappointing. If suture is not possible, the injured portions of the artery and vein are excised and the four ends of the artery and vein are ligatured with quadruple ligature and the wound is left open. Ligature of an artery alone proximal to a fistula is disastrous in that it leads to inevitable gangrene.

In concussion of an artery, localized segmentary spasm may occur. Treatment consists in exploration of the artery; division of the fascial covering and evacuation of a hæmatoma may succeed in relieving the spasm. If not, the intravenous injection of papaverine should be carried out; Griffiths (1940). Peri-arterial sympathectomy is not satisfactory. It is more satisfactory to block the sympathetic fibres to the limb by injecting 10 c.cm. of 2 per cent novocain around the pre-ganglionic fibres by paravertebral injection. In the upper limb this is done into the second and third inter-vertebral spaces; for the lower limb into the third and fourth lumbar spaces. In contusion with localized thrombosis, treat by ligature above and below the site, and excise the affected segment.

After the excision, débridement and reduction of the fracture, if present, the wound is *insufflated with sulphathiazole.* The wound is then *packed with sterile vaseline gauze. No drainage tubes are used and the wound is not stitched even in part.* The wound is packed wide open so that no pockets are allowed to occur anywhere. The pack must be carried to the depths of the wound and the vaseline gauze overflows on the surface of the skin for a distance of one inch so as to carry away the discharge from the wound. This vaseline gauze pack is then covered by a dry sterile absorbent pad of cotton-wool. Trueta uses dry gauze instead of vaseline gauze. I have used this in a few cases but have given it up as I found that the granulations in the healing wound tended to become enmeshed in the interstices of the gauze and its removal at the subsequent change of plaster caused bleeding and breaking down of the granulation tissue.

The *entire limb is then encased in an unpadded plaster of paris case* without a window over the wound, and including the joints above and below the injury.

A similar cast is applied to wounds not complicated by fracture. It may be thought that the application of a plaster cast to the wound is unwise owing to swelling and œdema. On the contrary I find that the swelling and œdema are quickly reduced and pain and muscle spasm disappear.

Infected wounds.—Wounds seen over 8, 12 or 24 hours will be infected, and infection will vary in severity. Some will have mild infection; others will be grossly infected, with cellulitis, lymphangitis and osteomyelitis.

In these cases, reduce the fractures if present at once, so that the tissue planes are restored to their normal balance. The abolition of deformity and mal-alignment prevents pain, shock and muscle spasm.

Then open up the infected area freely, remove sloughing tissue and loose pieces of bone. Pack the wound with gauze after insufflating with sulphathiazole. Give a full course of sulphathiazole by mouth. The infection should be under control in 24 to 48 hours and the limb quiet. Then enclose the limb as previously described in a plaster of paris cast.

In neglected soft tissue injuries alone in which suppuration and cellular infection has occurred, open up the infected area with a liberal incision so designed as to reach the infection area between the muscle planes. If this is not possible, open through the muscle. The limb is then dealt with as previously described. After the first change of plaster in about 10 days or later, the limb is quiet and there are clean granulations. Secondary suture has been recommended, but I do not find it satisfactory, as the stitch tracks tend to become infected and they tear out; but place the limb in a zinc gelatine paste bandage after insufflation of the raw area with sulphathiazole and immobilize in a half plaster shell. Two applications of the zinc gelatine bandage are all that may be necessary (*see* figures 2 and 2*a*, plate XVII).

The *prevention of gas gangrene* depends primarily on early adequate surgery. It is to be remembered that certain predisposing factors give rise to its development, and the organisms of the anaerobic group have been cultured from war wounds in which there was no clinical evidence of gas gangrene infection. These factors are extensive laceration of muscle, circulatory disturbances sometimes caused by prolonged use of the tourniquet, the presence of foreign

bodies or blood clot, and inadequate drainage of deep penetrating wounds.

The argument has been brought forward that the closed plaster technique of Orr (1929) brings about anaerobic conditions. This is not so, as the injured extremity is immobilized in the correct anatomical position. There is restoration of the circulation and nerve supply, and adequate drainage, so that oxygenation of the tissues and the internal respiration of the damaged part is restored to normal.

Where gas gangrene has developed, immediate operation is imperative. The affected limb is opened widely in the longitudinal axis of the limb. If the limb has been sutured, sutures are removed. Two or three other incisions may be needed. All infected muscles are removed. It is sometimes possible if one muscle only is affected to remove it completely. In the removal of such a muscle, care has to be exercised that the blood supply to neighbouring uninfected groups of muscle is not interfered with. The wound is then irrigated with hydrogen peroxide. No dressings are placed in the wound. It is left completely open to the air. A gauze cage covers the area somewhat similar to that shown in figures 3 and 3*a* (*see* plate XVII). Full doses of sulphathiazole are given by mouth, and 10 to 20,000 units of polyvalent gas bacillus antitoxin are also given. In 10 to 14 days the limb can be enclosed in a plaster of paris case and then in a gelatine gauze dressing as described for dealing with cellulitis in the soft tissues. If there is a fracture, continue with the closed plaster treatment.

If the infection is not controlled or if the case is received in a condition in which it is obvious that this treatment will be of no avail, immediate guillotine amputation above the limb of infection will be necessary to save life. In more extensive involvement of a limb, *e.g.* in the lower limb where a case is received with involvement as far as the groin, nothing will avail.

After the guillotine amputation, put one or two tension stitches over the raw stump to keep the skin edges and muscles from retracting, having first applied sulphathiazole powder to the stump; then vaseline gauze is applied and the limb is immobilized in a plaster cast. This prevents fluid loss and avoids painful dressings. As soon as possible, perform a flap operation to make a good stump, as guillotine amputation cases do not do well. It is a life-saving procedure and nothing more. Certain amputations are condemned as unsuitable in Europe, *e.g.* Symes, Lisfrancs. It is however to be remembered that our patients in this country will find a Syme or Lisfrancs amputation more suitable and to their liking than an amputation at the usual site of election below the knee joint.

In *wounds of joints* seen in the first six to eight hours, it is my practice to excise the wound track and remove loose pieces of cartilage, foreign bodies, etc., and the wound is sutured provided that the case is not being evacuated. If it is evacuated, remove the skin stitches and pack with gauze.

The whole limb is immobilized in a plaster of paris case, thoraco-brachial in the case of the shoulder and spica for the hip.

In the *knee joint* I have had satisfactory results in cases seen within the first six hours by closing the joint after stitching and immobilization in plaster.

In *knee joints in which infection is present* the joint should be opened by an incision extending up from the medial side of the patella and a finger's breadth from it so as to open up the suprapatellar pouch. A counter incision is made along and above the tendon of the biceps. The joint is washed out with saline and a limited excision is done. The wound is packed with vaseline gauze and the patient is put on a full course of sulphathiazole. You will know within 24 hours if the patient can retain his limb, by his general condition ; locally the glands in the groin should have subsided and the limb will feel comfortable under the plaster. If not, amputation is indicated.

Wounds of the hands should be treated with extreme conservatism. During the period of contamination, wounds of the fingers are excised, the tendons stitched and bone fragments replaced. Traction is secured by adhesive tape or wire through the pulp. This is attached to Kramer wire incorporated in a plaster splint. No dressings are applied to the wound but a gauze cage is applied to the whole extremity (*see* figures 3 and 3*a*, plate XVII).

In infected cases I apply the vaseline gauze technique as is the case in other regions. In injuries of the carpus, removal of a bone or bones may be necessary. Never be in a hurry to amputate the hand in the more severe types of wound. Any one who has seen an individual without a hand and one with a partial hand or even one finger can have no doubt as to the efficiency of the latter over the former (*see* figure 4, plate XVII).

Wounds of the foot can be very resistent to treatment. Wounds of the talus and calcaneus keep discharging for months as a result of a low-grade osteitis. An excellent operation I have found in dealing with chronic osteomyelitis in the calcaneus is Gaenslen's (1931) which is as follows : The heel is incised in the midline from the attachment of the tendo achillis to the anterior extremity of the os calcis on the plantar surface. The structures are dissected to the bone, the plantar artery, vein and nerve being avoided in the distal end of the wound. With a broad osteotome, the os calcis is divided in half, proceeding obliquely from the posterior and plantar surfaces. The two halves are retracted exposing the interior of the bone. All sequestra and obviously infected material are removed by curettage, the cortex being left as intact as possible. Soft tissue and sinuses on the medial or lateral aspect of the heel are likewise curetted. The wound is packed open with vaseline gauze.

The after-treatment consists of a plaster of paris boot case. As a rule, plantar scars are painful on weight bearing, but this is not true following the Gaenslen incision. After healing is complete, the scar is so deeply placed that the edges of the incision curl inward forming a thick cushion on each side (*see* figure 5, plate XVII).

Plaster of paris

The advantages of the closed plaster treatment over other methods according to Trueta are as follows :—

(1) Rest and immobilization allow local venous and capillary thrombi to form; these prevent and delay the spread of infection and are not broken down by repeated handling.

(2) Rest allows new capillaries to form which are not broken down by repeated dressings of the wound.

(3) The plaster maintains a constant beneficial pressure.

(4) The mixture of organisms on the wound by their mutual antagonism prevents the victory of any one group.

(5) To leave the wound uncovered as advocated by Schede and Bohler is good treatment for superficial wounds, but in deep wounds the dehydration and loss of heat which result from this treatment induce a condition of shock.

(6) The patient does not need constant dressing, adjustment of dressing and splints.

(7) The patient can often evacuate himself. He is mobile.

Finally there are very distinct advantages in mixed traction as against elastic traction. In the latter an amount of movement is impossible to avoid which is an irritant to the injured parts causing muscle spasm. In such a case the fractured surface is never under proper immobilization. Irritation of the wounds and inflammatory complications are common and frequently occur and this when coupled with the constant inspection and dressings of the wound which are carried out, the dice is loaded against the patient's chance of recovery.

With the plaster of paris case, immobilization is complete, muscle spasm is overcome and, if the wound has been dealt with adequately surgically, drainage is satisfactory and secondary infection and repeated assault on the healing tissues are avoided. When this immobilization of the bones and tissues is adequate, accurate and prolonged healing is, in my experience, sure. There has been no case of non-union in my series of 274 cases. Finally the patient is mobile. This is an important point in evacuating a hospital, say, in an air raid. He has no cumbersome splints or traction devices to require constant care and attention, and it is easier to look after in a small hospital with a limited trained staff.

I will not go into the full details of the application of the various plaster cases as these should be thoroughly understood by any one carrying out the closed plaster treatment of wounds, but I would comment on the following points :—

Plaster of paris bandages should be made with gauze of a suitable mesh. If the gauze is too thick in mesh or starchy, it is impossible to prepare suitable cases and they are apt to crack.

The plaster should be creamy and should contain no grit or lumps. One specimen of plaster I was supplied with effervesced on the addition of water.

A good plaster must immobilize well and can only do so if it is skin tight. The hairs of the limbs are unshaven as they are incorporated in the plaster, and an even tension is thus exerted on the skin without discomfort. A shaven limb is uncomfortable in a plaster of paris splint. Padding must be placed over the bony points, on the acromion and iliac crests in the thoraco-brachial cases, on the anterior superior iliac spines and sacrum in hip spicas. A fillet should also be used to protect the gluteal fold, as this area is liable to be cut into by the plaster. A plaster case must also immobilize the joint above and below the injury. I also incorporate, under large spicas and thoraco-brachial cases, four tapes at each quadrant, which can be moved to and fro by the patient or his attendant. It is invaluable as it helps to relieve him of the itching which may occur under the plaster. This tip I have had from Colonel J. P. Huban, I.M.S. I also cut windows in these cases after having strengthened them with metal rods incorporated in the plaster at each quadrant. This is necessary in the hot weather. These windows are of course not over the wound (*see* figures 6, 6*a*, 6*b*, 7, 7*a*, 7*b*, 8, 8*a*, 8*b*, 9, 9*a* and 9*b*, plate XVIII).

Another difficulty in the hot weather is flies. There are few hospitals in India where these can be avoided. They tend to lay eggs under the plaster if the edges are not protected by gauze attached to the plaster edge and the skin, and secured there by sticking plaster. In the very severe hot weather, when the patient is doing well, I transfer him to a higher altitude where the climate is not so trying. He reports to the headquarters hospital once a month for an *x*-ray check or change of plaster when necessary.

After the application of the plaster of paris case, the patient is relieved of severe local pain and shock, and there is a striking difference in his general appearance. The drawn expression disappears. The temperature and pulse rate begin to fall to normal and this generally within from 48 to 72 hours in early cases. In later cases, for five to six days the temperature and pulse will be elevated. Locally the case becomes soaked with pure blood at the site of the wound, assuming a brick-red appearance ; this is a favourable sign. There is no pain or local discomfort. Swelling decreases in the limb, and there is a good circulation and free range of movement in the fingers and toes. In the delayed case so treated, the swelling of the regional lymph glands subsides and the leucocyte count falls. A few days later, an unmistakable smell is noticeable. The elimination of this unpleasant feature has taxed the efforts of many; charcoal bags, lævulose solution incorporated in the jelly, soaking the bandages in perchloride solution have been tried. The latter I use coupled with eucalyptus oil and chlorine water

occasionally sprinkled on the plaster, but so far there has been no satisfactory remedy.

In a case not progressing satisfactorily, what are the signs and symptoms which warn one that all is not well? Despite the fact that the wound cannot be seen, general and local signs will indicate that all is not well. The general signs are a rise of temperature and pulse rate. Before jumping to erroneous conclusions, eliminate malaria. The total leucocyte and polymorphonuclear count is up.

Locally there will be a sensation of heat and tension in the wound, and the discharge from the wound into the plaster will be excessive and finally the local regional lymph glands will be enlarged and tender. An *x*-ray should also be taken; this may show mal-alignment of the bones or perhaps an area of bone necrosis with sequestration causing inadequate drainage. These findings will necessitate the removal of the plaster for re-alignment of the bone or for removal of sequestra for more adequate drainage. Cellulitis may be present and this will need incision and opening up of the tissue spaces. I have found that this occurs oftener in delayed cases. On removal of the plaster, the skin may show a dermatitis which is of no consequence as it is due to irritation of the skin by the discharge. An ointment of zinc oxide can be rubbed on the area. Changes of plaster should be done in the operation theatre and re-dressing done with all aseptic precautions.

A more serious complication is the development of gas gangrene underneath the plaster. This will usually declare itself quite early after the application of the plaster. When this is suspected, the plaster should be removed at once. I have luckily had no case develop.

Secondary hæmorrhage.—I have had one case and a description of this case will more clearly illustrate the signs and symptoms of this.

A sepoy was admitted with a bullet wound of the left calf in March 1939 which guttered the back of the tibia but did not fracture it. It progressed to fracture the fibula. The bullet was of the tribal variety and the casing had disintegrated.

As thorough an excision and débridement as possible was done, hæmorrhage was controlled and all pieces of the metal, as far as possible, were removed, the wound insufflated with sulphapyridine packed with vaseline gauze, and the limb encased in plaster of paris. Progress was satisfactory until the 17th day when the patient complained of a severe tearing pain in the limb which came on suddenly. There was a rise of pulse rate to 120 per minute. The plaster stain showed signs of fresh blood. Within half an hour the patient was removed to the theatre with a tourniquet applied, and the plaster removed. The vaseline gauze plugging had been practically pushed out of the wound. It was removed, the limb was cleaned up and the wound mopped dry and explored. It was seen that the posterior tibial artery was ruptured and ragged in appearance for about ¾ inch. It was ligatured proximally and distally, the wound was repacked and the limb was replaced in plaster. His recovery was uninterrupted with the retention of his limb.

Persistent discharge and sinus formation indicate the presence of a sequestrum or other foreign body. The commonest cause I have found to be a small sequestrum which does not appear to unduly delay union, as the closed method controls the sepsis and the hyperæmia which would militate against calcification of the callus.

Syphilis is a common cause of *non-union* of fractures in this country. In my cases as a routine, a Wassermann test is done. A study of *x*-ray films will often show signs of gummatous periostitis, and treatment should be begun at once.

Avitaminosis.—Many of my civil cases were in an extremely debilitated state as the result of malaria, chronic dysentery and low nutrition. The usual treatment for these diseases was given and, for the avitaminosis, a liberal diet was given. Recently I have given vitamin C by injection and by the mouth in cases in which at the first change of plaster the granulations appear pale and anæmic and there is a little apparent callus formation, or in which obvious signs of subclinical scurvy exist. This vitamin is important in the maintenance of intercellular cement substance so necessary in the healing of wounds. It is also important in calcium metabolism. These two functions are necessary in the repair of bones. One course is given so as to raise the body content of the vitamin if apparent preclinical scurvy is present. A high vitamin diet is then maintained.

Treatment and prophylaxis of infection.—Of the three sulpha drugs generally in use, sulphanilamide, sulphapyridine and sulphathiazole, the latter is by far the most potent against the streptococcus and has some effect on the staphylococcus. Its solubility in wounds is greater than that of sulphapyridine when employed locally. Up to 5 or 10 grains can be implanted locally. Orally 27 grammes can be given over a period of six days. For the past two years I have been using sulphathiazole, for the reason given above, and clinically I find the patients tolerate it better. There were none of the minor toxic symptoms seen which are commonly encountered with sulphapyridine. I found that my cases which were treated in the first six to eight hours were no better off than before I had adopted this treatment, but in delayed cases where a cellulitis was established it was invaluable in controlling infection. A perusal of the literature leaves one in a state of perplexity as to what is the correct procedure. The relative merits of these drugs used in prophylaxis are debated, and at present there appears to be no unanimity of opinion. In laboratory studies, these drugs are proved to have value, but the rather enthusiastic clinical adoption of local sulpha therapy has so far failed to provide conclusive evidence of the extent to which such prophylactic treatment has prevented the growth of organism in wounds. In my cases I use both sulphathiazole and polyvalent anti-gas gangrene serum for the following reasons. The sulphathiazole is bacteriostatic and may inhibit toxin formation, but there is no good evidence to show that the drugs can permanently neutralize or

inactivate bacterial exotoxin in the tissues. For this reason I would give anti-gas gangrene polyvalent serum as well in the treatment of gas infection.

Many authorities are sceptical about the value of gas gangrene serum, notably Bohler and Trueta who do not use it. I believe official opinion in England is sceptical. It is certainly true that the experience of the last war left grave doubts about the value of antisera in the treatment of established cases of gas gangrene. The value of serum when administered to wounded individuals as a prophylactic measure was not tested, and I am afraid this will now not be done owing to the incursion of the sulpha group of drugs. Experimentally the sulpha group of drugs have been proved inferior to antisera in the prophylaxis of gas gangrene. I use both, and administer the serum always by injecting it near the wound. In the present state of our knowledge I consider it justifiable in the interest of the patient to use both.

In my consecutive series of 274 cases in North Waziristan, I have had no deaths, and no case of gas gangrene or tetanus. There was one case of gangrene due to damage of the popliteal artery for which an amputation was done.

Acknowledgments

I am grateful to Colonel J. P. Huban, O.B.E., I.M.S., Inspector-General of Civil Hospitals, N.-W. F. P., for his permission to publish this article and to Dr. Abdul Raziq Khan, for help with the *x*-ray pictures.

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DESCRIPTIONS OF ILLUSTRATIONS
PLATES XVII AND XVIII

Fig. 1.—A gunshot fracture of the humerus showing disruption of the bone with the fragments displaced into the surrounding muscles.

Fig. 1*a*.—Union after 6 months, a small sequestrum present. Sound union occurred at 9 months.

Fig. 1*b*.—Case under treatment in a thoraco-brachial cast in full abduction, necessary as the weight of the limb would have caused distraction of the fragments and non-union.

Fig. 1*c*.—Showing union with a small sinus through which a small sequestrum was removed. Final result gave full flexion of the elbow joint except for the last ten degrees.

Figs. 2 and 2*a*.—Neglected bullet wound of the soft tissues treated by incision and drainage. Healing obtained by zinc gelatine bandage and immobilized on half plaster splint. More satisfactory than secondary suture in this country.

Figs. 3 and 3*a*.—Bullet wound of the thumb with fracture and rupture of the extensor tendon, primary suture and traction. The whole treated in a gauze cage. Stitches removed on the 7th day. Union of the fracture was secured at 4 weeks, final result perfect.

Fig. 4.—Shell wound of the hand causing ablation of the four fingers. Stump trimmed and placed in plaster of paris. More satisfactory than amputation of the forearm.

Fig. 5.—Result of a Gaensien operation for a low-grade osteitis following a bullet wound. Result excellent. Bone healed, and the patient walks and runs without pain.

Fig. 6.—Showing thoraco-brachial cast with four tapes between it and the skin at each corner which can be moved to and fro to relieve skin irritation.

Figs. 6*a* and 6*b*.—*X*-ray of figure 6 showing fracture and healed result after 7 months' immobilization.

Figs. 7, 7*a* and 7*b*.—Gunshot fracture of the femur being treated by the closed method in a hip spica. Fig. 7*a*: *X*-ray showing the fracture on admission. Fig. 7*b*: Healed result 9 months later. Sequestrectomy was performed once during the course of the treatment.

Figs. 8, 8*a* and 8*b*.—Fig. 8 showing a fracture of the ulna with severe soft tissue damage as a result of a bomb. Plaster stained satisfactorily. Fig. 8*a*: Healing edges of the wound after the first removal of the plaster. Fig. 8*b*: Healed result in 10 weeks.

Figs. 9, 9*a* and 9*b*.—Showing gunshot fracture of the tibia and fibula (fig. 9); the case in a walking plaster after 3 weeks (fig. 9*a*); healed result in 16 weeks (fig. 9*b*).

Medical News

MEDICAL EDUCATION IN INDIA

IN India it is not often that we hear of any criticism of the system of medical education, and we therefore welcome Dr. K. V. Krishnan's presidential address on the subject before the Medical and Veterinary section of the 31st Indian Science Congress, 1944. We give below a summary of his main points.

India has a dual standard of medical education—a lower one for the licentiates and a higher one for the graduates. Hoping that the former will be abolished in near future, the lecturer proceeded to say that India with a population of 388 millions has 37 medical institutions and 42,000 doctors, but according to Western standard she should have at least 400,000 doctors, or ten times the present number. As the medical schools and colleges are jointly producing only about 1,700 new doctors in a year, there seems to be no hope of solving this question of inadequacy unless a way is found out to hasten production.

Despite the fact that all medical colleges are affiliated to universities, the outlook of most of them, if not all, is still to produce the 'tradesman doctor' who can prescribe a bottle of medicine or use a surgical instrument for the cure of disease. The majority of the doctors are averse to settling down in rural areas where 95 per cent of the population live and receive little or no medical aid; the few that do are unable to cater to the special requirements of the rural people and to adapt themselves to the condition of the villages for long. Although the majority of our graduates compare well with those of other universities, the average standard of the profession is not as high as it should be, the education of most of our

PLATE XVII

WOUNDS OF THE EXTREMITIES : C. J. HASSETT. PAGE 323.

For description see page 330.

Fig. 1.

Fig. 1*a*.

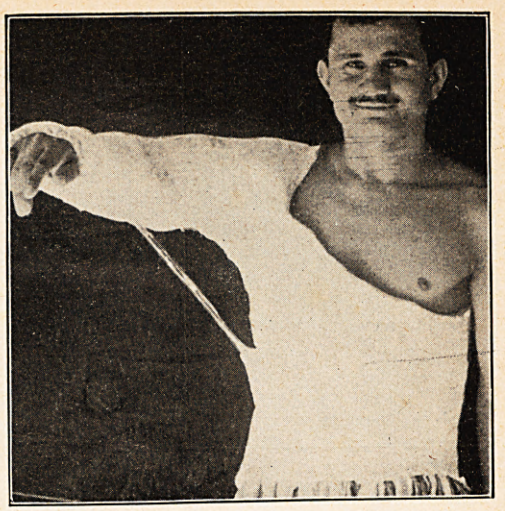

Fig. 1*b*.

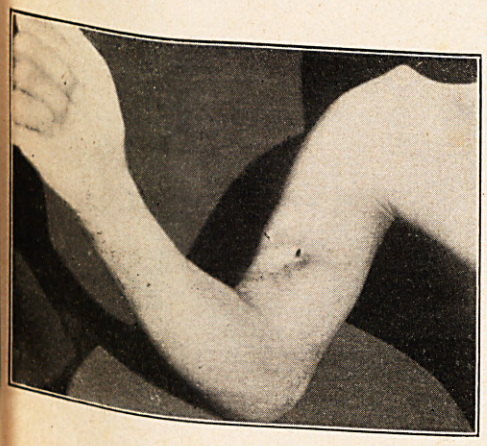

Fig. 1*c*.

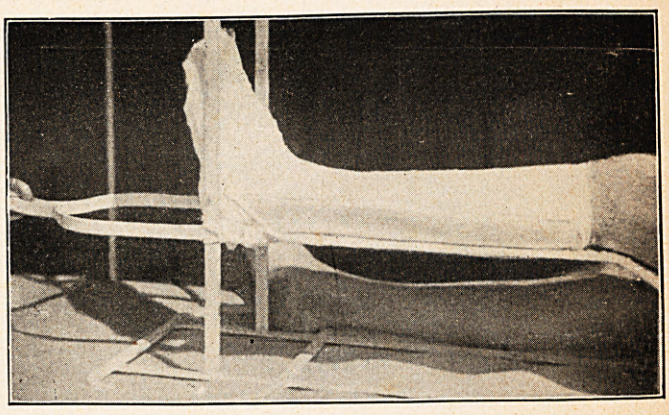

Fig. 2.

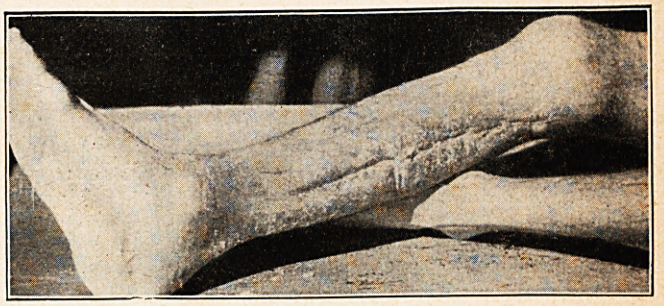

Fig. 2*a*.

Fig. 3.

Fig. 3*a*.

Fig. 4

Fig. 5.

For description see page 330.

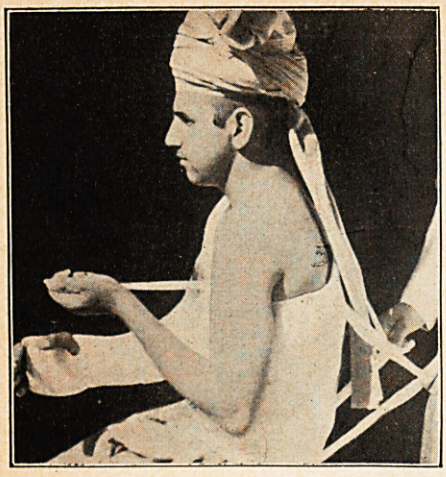
Fig. 6.

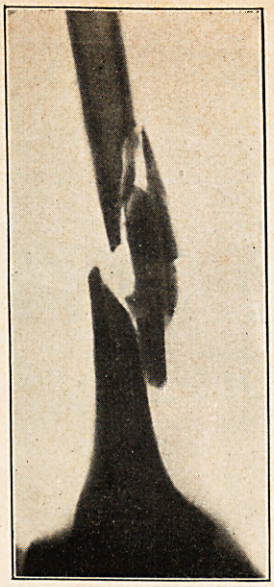
Fig. 6*a*.

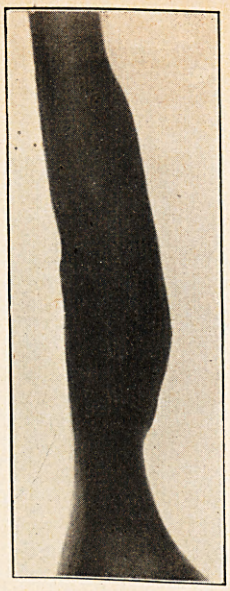
Fig. 6*b*.


Fig. 7.


Fig. 7*a*.


Fig. 7*b*.


Fig. 8.


Fig. 8*a*.

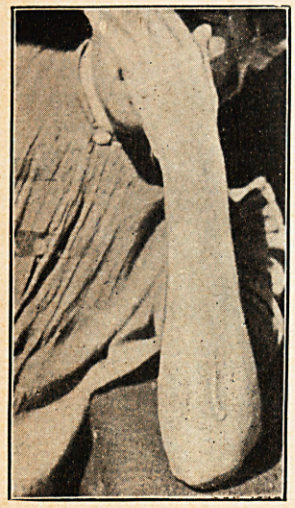
Fig. 8*b*.


Fig. 9.


Fig. 9*a*.

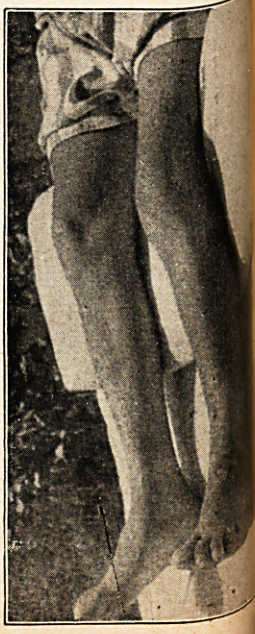
Fig. 9*b*.