formed in the lower part of the common carotid, which was treated expectantly for some days, but the rapid daily enlargement compelled operation on the fourteenth day. By this time the aneurysm had attained the size of an orange, filling up the interval between the clavicle and the upper border of the thyroid cartilage, extending across to the line of the common carotid of the left side and overhanging the subclavian on the right. Its approximate measurements were $4\frac{1}{2}$ in. in breadth by 4 in. in height. Hoarseness developed in the later days, pointing to pressure on the recurrent laryngeal nerve. The respirations were 24; the temperature varied from 100° to 101.8° , and the pulse from 100 to 112. Both entrance and exit wounds suppurated moderately.

Operation.

The artery was exposed by a rectangular incision in the mid-line and along the clavicle. After detachment of the sternal head and part of the clavicular head of the sterno-mastoid and partial division of the sterno-hyoid and sterno-thyroid muscles, it was found that no space was available between the clavicle and the aneurysm. Therefore, one and a quarter inches of the inner end of this bone were resected. The apex of the lung, with its uninjured pleura, appeared in the dissection. The inferior thyroid veins and the larger veins were retracted without damage; in fact, no artery or vein was clipped or ligatured throughout the operation. The innominate artery was found behind the middle of the manubrium, and in tracing it upward it became apparent that the common carotid was so incorporated in the aneurysm that the placing of a ligature upon it was impracticable, and therefore the innominate was tied with a single strand of No. 4 thirty-day catgut. The muscles were repaired with catgut sutures and a small drain tube left in for forty-eight hours.

The question of a distal ligature was now debated in obedience to the commonly accepted principle that the wounded artery should be doubly ligated and the contents of the sac turned out, or the sac excised, but these measures were advisedly omitted in this instance lest a copious bleeding from the sac in a markedly anaemic subject, or the prolonging of an already lengthy operation, should jeopardize the patient. It was felt that a distal ligature should be placed on the carotid some days later, should the progress disappoint. Fortunately, the need for this step did not arise.

The subsequent course was uneventful: no septic changes from the original bullet track were propagated to the operation wound; and the patient was evacuated to the base on September 16th, 1916.

Three months after operation (December 13th, 1916), an examination of the patient showed that no cerebral deterioration had resulted; his mental functions were normal. The vision of the right eye was perfect, though the vessels in the fundus were slightly reduced in size. There was no giddiness or disturbance of equilibration. The thrill, bruit, and pulsation could not be detected, and the aneurysmal swelling had entirely disappeared. A degree of muscular atrophy and the absence of the end of the clavicle rendered this examination more easy and convincing. Radial and ulnar pulses had not returned at the wrist; the circulation and sensation in the hand were good, but some feebleness with stiffening at the fingers remained, due, probably, to the prolonged disuse of the extremity rather than to tropho-neurotic changes. No doubt massage and exercises will remedy this temporary disablement. A satisfactory pseudo-arthritis had formed with the first costal cartilage, and active shoulder and elbow movements were good.

The chief anxieties, apart from the immediate risks at the time of the operation, are secondary haemorrhage, septic complications in the neck and chest, embolism, and cerebral softening from ischaemia. Disastrous cerebral changes, which may begin in forty-eight hours or be delayed for a fortnight or longer, are more likely to arise in patients over 40 with arterio-sclerosis; but acute anaemia from recent haemorrhage may render even young persons liable. Detachment of emboli may, of course, occur under any condition, or at any age, but in the case here recorded the acceptance of some extra risk in this respect by omitting a distal ligature of the carotid, which shuts off useful reflux circulation through subclavian branches, was considered justifiable, in the expectation that the cerebral ischaemia might be rendered less profound and sudden in a very anaemic subject.

Surgeon-General Sir George H. Makins, in his admirable paper on "Vascular lesions in war," lays it down that, "In certain conditions a proximal ligature at the seat of election suffices to cure a false aneurysm; but the method is uncertain, and should not be adopted in any situation where the sac and the opening in the vessel can be dealt with locally." In a later paragraph, dealing with carotid aneurysms in particular, he says: "Still I think the more extensive operations must be used with judgement, since they are obviously more risky procedures if a large sac is present."

It is noteworthy that cerebral complications are more frequent after ligation of the common carotid than after ligation of the innominate artery. Delbet estimates their

incidence at one-fifth and Jordan at one-fourth under modern surgical technique. Burns of Memphis in 1908, in a record of fifty-one innominate cases with eleven recoveries, speaks of six dying from shock, six from cerebral complications, and the balance from septic wound infections and secondary haemorrhage.

Various methods of exposing the innominate artery have been devised: Trephining the manubrium; vertical splitting of the manubrium; clipping away the upper margin of the manubrium, with resection of one or both sterno-clavicular joints—even the first costal cartilage has been resected; temporary displacement of the clavicle; resection of the sternal end of the clavicle. The last-mentioned plan was adopted and gave ample access. It was deemed better than temporary displacement of the bone, which, by its dangerous traction on the aneurysm and the subsequent difficulty of retaining it on replacement in its old socket, did not commend itself in this instance.

Major Gask, Captain Chubb, and Captain Manford kindly assisted at the operation, and took charge of the case after it; and the later treatment in London was carefully supervised by Mr. Laming Evans.

EARLY TREATMENT OF COMPOUND FRACTURE OF THE LONG BONES OF THE EXTREMITIES.

By BASIL HUGHES, CAPTAIN R.A.M.C.(T.F.).

THE early treatment of compound fracture of the longer bones of the extremities forms a large and important branch of military surgery. Upon what is done for men suffering from such wounds in the hours immediately following their infliction depends to great extent their subsequent utility, and often their life.

There are points of difference between these fractures and compound fractures seen in civil life. In the latter there is not the same quality of damage to bone and the soft parts, and we have not the same type of infection to deal with. Further, in civil life men are not injured under the conditions which obtain in war.

In the case of a man wounded in action, we must consider (a) fatigue; (b) shock (specially in fractures involving the femur); (c) local tissue stupor; (d) infection.

Fatigue is a powerful predisposing cause to wound infection and to other trench ailments. I have pointed this out in connexion with "trench feet" and "trench pyrexias." Life in trenches under the conditions that exist there, with lack of sleep, are potent causes in producing trench fatigue. It is noticeable how rapidly rigor mortis occurs in men killed in the trenches.

Shock.—With severe wounds of soft parts, specially the thigh with fracture of the femur, shock is immediate and severe. It is not necessarily associated with loss of blood. It is much increased by motor transport if the limb is not securely immobilized.

Local Tissue stupor.—This condition is brought about in the muscles and other soft structures as a result of injury caused by a piece of shell. The naked-eye appearance of such tissue is characteristic. The muscle looks dry and lifeless, it is quite insensitive, does not bleed when cut, and does not contract when stimulated. This tissue, though not dead, is very apt to die, and while in this stunned state is very prone to infection. If a tourniquet be applied to the limb above such tissue, or if antiseptics be used, gangrene is almost certain to ensue. Under these conditions, if necessary, a limb can be amputated quite painlessly. This I have done on more than one occasion in the trenches, and the cases have done well.

Infection.—All shell wounds are bound to become infected, whatever care be taken. This statement is clear to those of us who have had experience in the front line. Predisposing causes are fatigue, exposure to wet and cold, nerve strain, and tissue stupor. The bacteria most to be feared are: (a) *B. perfringens*, (b) Vincent's bacillus, (c) *B. tetanus*, and (d) *Streptococcus faecalis*.

It is therefore important as early as possible to follow out the rules applying to open wounds—namely: (1) Prevent further infection; (2) get rid, as far as is possible, of infection already carried in; and, in cases of fracture, a third may be added: (3) Prevent what infection has

already been carried in from becoming further disseminated by thoroughly immobilizing the limb.

Quite a number of wounds, chiefly in men who have lain out, though not always so, have become fly-blown, and within a very short time contain an abundance of maggots. The presence of maggots in such wounds seems to exert an inhibitory action on the growth of the more virulent bacteria, and so acts beneficially. Maggots only thrive in dead tissue, and seem to hasten its removal. Two of the worst buttock wounds that I saw became accidentally fly-blown, and from the time of the appearance of the maggots both cases started to improve.

Question of Transport.

From the battlefield these wounded men have to be carried to the regimental aid post or the advanced dressing station. From the latter place they go by motor transport to the field ambulance. This part of the journey has, as a rule, to be as rapid as possible, owing to enemy shell fire.

This necessitates shaking, and brings into consideration other complications—namely: (a) Embolism (pulmonary); (b) increased shock; (c) increased damage to tissue and so further dissemination of infection; (d) haemorrhage.

Embolism has happened frequently, and I have seen it occur between the firing line and the regimental aid post, and on several occasions it has occurred in the motor ambulance.

Increased shock has been occasioned by the pulling on large nerves of the fractured limb, and increased damage to tissue has taken place owing to the fractured ends of the bones having too free play amongst the soft parts.

Haemorrhage has also occurred during motor transport from divided vessels and from the fractured ends of the bone.

Early Immobilization.

From the field ambulance these men proceed by motor to the casualty clearing station, often a considerable journey. The condition of their wounds on arrival will depend upon the length of time they have been wounded and the manner in which the fracture has been immobilized.

If, therefore, the immobilization of the fracture be imperfect, especially in cases involving the femur, extensive and often irretrievable damage may happen both to limb and patient during motor transport. Perfect immobilization, as early as is possible, in the position in which the fractured limb is found, whether in trenches or in the open, is the first essential to success.

The earliest treatment falls to the lot of the regimental medical officer. When active fighting is in progress he has more than he can do, hence the importance of instructing stretcher-bearers and additional combatants in the first aid treatment of fractures.

This work has usually to be carried out under heavy fire, often for hours on end. It is this that makes the task of the regimental medical officer the most arduous and difficult of all. It calls for unlimited resource and endurance. Some cases have reached the clearing stations direct from the front line with serious compound fractures of the thigh perfectly immobilized, having travelled painlessly for some miles over rough roads. In other cases the splint has slipped, despite the time taken and patience exercised in fixing it. These latter cases suffer much pain during motor transit, shock is increased, infection is further disseminated, more damage is done to the soft parts, and haemorrhage has often taken place. If a limb is hopelessly shattered, with vessels and nerves divided, it is wiser to amputate at once at the regimental aid post, and tie the main vessels. Owing to tissue stupor the operation is painless, and the risk of shock and fatal haemorrhage during transport is avoided.

Tourniquets for transport should not be used. They tend to slip; they are painful, and increase shock; and they cause irretrievable damage to the tissues they constrict. From what I have seen of cases arriving at clearing stations with tourniquets applied, I am convinced that earlier amputation is the correct procedure, for such amputations do well.

The all-important part of conservative treatment in the line is a perfect immobilization of the fracture as it exists. There should be no attempt to reduce these fractures in

the line, as infection is only further disseminated. This should be left until the casualty clearing station is reached and the wound can be disinfected.

Fractures of the bones of the forearm and leg do not usually show much displacement. For the leg the rifle makes a good temporary splint if padded with sandbags, and the limb so fixed is bandaged to its fellow of the opposite side. Sandbags rolled and stiffened with cardboard make excellent splints. For the forearm a clean sandbag rolled up makes a comfortable and efficient splint, and the arm is put in a sling.

Femur.

When the femur is the bone involved I have found the following method give good fixation for motor transport. A rifle padded with sandbags or a great-coat is placed with the butt end in the axilla. A strip of wood four or five inches broad broken off a ration box and rolled in another sandbag is fixed between the leg and the lower end of the rifle. The rifle is firmly secured around the chest with puttees, and is fixed to the leg below the knee with another puttee, the padded piece of wood intervening. Another strip of wood six or seven inches broad, broken off a ration box and padded with sandbags, supports the thigh behind, while a third piece, similarly padded, and reaching from the perineum to as far down the leg as possible, supports the thigh internally. The thigh, with its internal and posterior supports, is now fastened securely with puttees to the rifle. The limb so splinted is now securely bandaged to its fellow of the opposite side. Cases so treated have always travelled well.

Some fractured femurs have, on their way to the clearing stations, been put upon Liston's long splints, Page's splints, and the like, but invariably these splints have slipped, and have not proved efficient for motor transport.

Humerus.

Fractures of the humerus can be immobilized with rolled sandbags strengthened with entrenching-tool handles. The arm should be put in a sling and bandaged to the side. The bandages or puttees fixing the splint should not be applied too tightly, as the circulation is thereby impeded, and serious consequences result.

TREATMENT AT CASUALTY CLEARING STATION.

At the casualty clearing station these men are divested of their dirty clothes and provided with thick woollen pyjamas without disturbing the fracture. If the case is urgent and requiring amputation it is dealt with at once, but if not it is better to wait two or three hours. Chloroform induction, followed by open ether, has been the anaesthetic used, and if the case is severe subcutaneous saline, two or more pints, are slowly run in during the operation.

Not until the patient is anaesthetized is the splint removed and the wound examined. The skin is shaved, cleaned with petrol, and painted over with iodine. The edges of the wound are clearly cut away with all dead and stunned tissue in the wound itself. Foreign bodies are removed. Foreign bodies carried in the trouser pocket are apt to be driven into the thigh by a missile. I have extracted coins, buttons, a pencil, and even a piece of a miniature New Testament, from the soft tissues of the thigh.

After free removal of bad tissue with foreign bodies, the wound is thoroughly disinfected with hydrogen peroxide, and gauze wrung out of it is placed over the wound. Detached fragments of bone have been left if not too badly soiled and still attached to periosteum. Small spicules and completely detached pieces only have been removed. All bleeding vessels have been twisted off and not ligatured.

Traction is now made in the long axis of the limb by an orderly, while the fractured ends with detached fragments are manipulated into position by the surgeon. The splint is then applied with the extension apparatus before the final dressing of the wound, and the surgeon should satisfy himself that such a splint is adequately keeping up the reduction of the fracture before he adjusts the final dressing. Suture of a wound after excision has not been practised in wounds complicated by fracture of the long bones of the extremities.

Femur.

If the fracture be not too high up and complicated with wounds of the buttock, the perineum, or its immediate vicinity, then Thomas's knee splint gives the best fixation. Fracture of the shaft of the femur is often complicated with haemarthrosis of the knee, making extension and adequate fixation all-important as a safeguard against extending sepsis, which in a fissured bone progresses at the rate of about one inch a day.

Extension between the tuber ischii and the lower bar of the splint is maintained by strapping from the leg (Fig. 1). The lower free ends of the strapping are turned back, and through the loops so formed a piece of wood (A) is inserted. A stout piece of rubber tubing (B) passes round this piece of wood, and is fixed, after being put on the stretch, to the lower bar of the splint. This gives an excellent uniform extension, and is proof against jars that may happen during the journey to the base.

The thigh is supported behind by troughs of perforated zinc fixed to the bars of the splint, and a back splint

FIG. 1.

extending from just above the knee to the foot further steadies all. In the absence of perforated zinc, three-corner bandages have answered well.

The final dressing is now applied, and the lower end of the splint is suspended to the support bar provided with the service stretcher. The wound can now be inspected without disturbing the splint. Fig. 1 shows the apparatus applied, and the wounded man on the stretcher ready for transport to the base hospital.

If the fracture is high up and complicated with wounds about the perineum or buttock, the splint illustrated in Fig. 2 will answer all requirements. It consists of a leather-padded ring for the axilla. The space from A to B can be varied by two adjustable screws, C. At D is a hinge allowing of abduction only. Four narrow strips of metal, E, project from the frame, and from their extremities leather straps are attached. Two of these encircle the chest and two the leg. Extension by rubber can be taken from the stirrup, F, at the bottom of the splint. G is an adjustable footpiece. The splint is further secured to the chest by a roller towel. The thigh is supported behind by a convenient back splint. The framework does not touch

FIG. 2.

the thigh and allows of attention to the wound without disturbing the splint. This splint is also useful for fractures and wounds involving the hip-joint, allowing, as it does, of extension and abduction.

The Leg.

For fractures of the bones of the leg the splint illustrated in Fig. 3 will be found useful. It consists of two bars, A, ending behind in a broad-based stand, B, and connected behind by a curved bar, C; D is an adjustable foot-piece. The space between C and D is made good by adjustable troughs of perforated zinc, E. On the foot-piece is fixed an iron strap, F, to keep the foot in position. Dressings can be changed without disturbing the splint,

and the stand, B, not only steadies the splint during transport, but, with the adjustable footpiece, affords

FIG. 3.

slight flexion at the knee, which adds to the patient's comfort.

Humerus and Forearm.

One of the most satisfactory splints for fractures of the humerus is the principle of Thomas's knee splint applied to the arm by Colonel Robert Jones. It is, however, not an easy splint for travelling, and is apt to get knocked.

Fig. 4 shows a splint which is useful for all fractures involving the upper extremity. It consists of a bent, leather-padded piece of iron, A, hinged on to a horseshoe-shaped piece of iron, B. This is again hinged so as to rotate horizontally at C. From this point a bar of iron passes down below to D and is here bent. This bar of iron, which is of adjustable length between C and D by means of a screw E, is hinged to a trapezium iron frame at F and G. Thus abduction and

FIG. 4.

rotation are allowed to the humerus, and flexion is allowed for injuries about the elbow-joint. Extension for a fractured humerus is taken between the axilla and the bar H. Extension for the forearm is taken between the bars J and K. The forearm rests in adjustable troughs of perforated zinc, L. By bending up the distal part of the horizontal portion of the splint dorsiflexion for the wrist may be acquired.

The splint is efficacious, light, and easy to adjust, and answers all requirements for fractures of the upper extremity.

The Dressing.

If the wound be extensive, the dressing used for the first few days before sending these cases to the base has either been a salt pack or Carrel's tubes with Dakin's solution. The latter method requires more time, and can only be undertaken when there is not an undue rush of casualties. The salt pack has given good results, and does not require the same amount of attention.

After-Treatment.

This consists in treating the general condition and the wound. Plenty of fluid (water), nourishment of all kinds, with a brisk purge, are the main essentials, combined with rest in bed. Fatigue and shock are the conditions which militate against success for the day or two following the

operation. Saline given subcutaneously helps very much to combat these. If the temperature rises and there is pain, disinclination for food, and vomiting, the wound should be examined, and fresh spread of sepsis looked for. Should such be present and threaten life, amputation by the rapid circular method should be performed without delay.

If infection still persists in the wound, and is spreading, though not sufficiently to threaten life, treatment will depend upon the organism present. If *B. perfringens* and *S. reptococcus faecalis* (for these two organisms generally coexist) be the cause, then a barrier of hydrogen peroxide or potassium permanganate (strong solution) injected into sound tissue above and below the infected area, and completely encircling the limb, has done good in some cases and sufficed to arrest further spread. Further incision and drainage of the affected part may be needed, and this can be combined with continuous irrigation of the wound with normal or slightly hypertonic saline solution, alternating with eusol.

If the infection be pyogenic, hot antiseptic fomentations, or charcoal and carbolic poultices, will often limit the process.

In a few desperate cases I have tried intravenous injections of eusol, as recommended by Fraser and Bates, but have had no success from its use.

Stimulants may be freely given, and do good in these cases. As soon as possible these men are sent to the base hospital, where more perfect conveniences for subsequent treatment exist.

It must be clearly understood that what has been said in this article refers only to the treatment of fractures between the firing line and the clearing stations. Many cases of serious compound fractures arrive at the clearing stations in a very septic and foul condition. The general condition of such wounded men is grave, and amputation is their only hope of salvation. Attempts to save such limbs have, time after time, ended in disaster, owing to the rapid spread of infection in these fatigued and worn-out men. This will explain the number of cases of amputation reaching the base hospitals from the clearing stations. Further, these amputations have to be performed exceedingly rapidly, as the condition of these men is often desperate. Such operations are purely life-saving operations, and so the same finesse cannot be looked for as can be obtained in later operations when the patient's condition warrants a longer anaesthetic; hence the crude appearance of some amputation stumps when the base hospital is reached.

I am indebted to Mr. R. Brown, of the Kensington "War Hospital Supply Dépôts," for the manufacture of these splints and for valuable suggestions; to Miss Hope and to my wife for the illustrations.

AN APPLIANCE FOR THE AMBULATORY TREATMENT OF FRACTURES OF THE THIGH.

By C. MAX PAGE, M.S., F.R.C.S.,
CAPTAIN R.A.M.C.(S.R.).

THE importance and value of the ambulatory treatment of fractures of the femur at the earliest period practicable is well recognized. The restoration of full function of the limb; the union of the bone, and the repair of any wounds present are all favourably influenced by such treatment. Hardly less important is the improvement in the moral of the patient which occurs once he is able to move about again independently.

The apparatus which I propose to describe is made and applied by the surgeon from inexpensive and readily available material. Its chief advantage over the calliper type of splint is that at a certain period it leaves the knee-joint free.

DESCRIPTION OF THE APPLIANCE.

The appliance in its simplest form consists of two plaster-of-Paris collars; the upper one surrounds the thigh at the level of the great trochanter, and abuts on the tuber ischii; the lower is moulded on to the two condyles of the femur just above the level of the knee-joint. These two points d'appui are united by two

extension screws, which lie just behind the central coronal plane of the femur.

The extension screws, when adjusted, procure long axis extension of the femur, and pass the weight of the body taken on the foot from just above the knee direct to the pelvis.

The principle employed is similar to that of Hackenbruch's "Distraktion-klammer."¹ The fixation at the knee is that used by Professor Delbet² in his spring splint for the thigh.

As indicated above, the appliance leaves the knee-joint free. If it is used in a case where little or no union is present, fixation of the knee-joint and an extension of the lower point d'appui to the ankle should be effected for a short period.

DETAIL OF MATERIAL.

The upper collar or ischial saddle is made from tarlatan. This material (cost about 3d. a yard) is usually sold 65 cm.

wide. All descriptions below will be based on this size. It is formed as follows (Fig. 1): About 5 metres of tarlatan are folded so as to make a parallelogram 65 cm. by 25 cm., and containing twenty thicknesses of the material. This is then cut as shown in Fig. 1.

The raw edges of the boomerang-shaped section are then roughly tacked. It has merely to be dipped into a plaster emulsion before use.

The lower collar is made from one five-yard quick-drying plaster bandage 3 in. wide.

The extension screws are similar to those used for the wooden type of Macintyre splint. The most useful size for adult thighs measures 10 in. when screwed home, and 14 in. when fully extended. The two screws are attached to arches of perforated zinc by means of split rivets (Fig. 2). The zinc collars are cut for each case. The screws should lie symmetrically both above and below, about half an inch behind the coronal plane of the femur shaft.

Tailed Pieces for Attaching the Extension Unit.—These are made from tarlatan. The one for the ischial attachment measures 110 cm. by 4 cm.; the lower one 90 cm. by

FIG. 1.—Ischial saddle, diagram of tarlatan section required; scale 1/10. It should contain twenty thicknesses of material.

FIG. 2.—Extension unit, consisting of two screws attached to zinc arches by means of split rivets.

FIG. 3.—H tail-piece for attaching extension unit to the collars. The one illustrated measures 90 cm. and is for application to the supracondylar collar. It should contain twelve thicknesses of tarlatan.

4 cm. (Fig. 3). Both should contain twelve thicknesses of material. They are cut like an elongated H, and the margins afterwards roughly tacked.

APPLICATION OF THE APPARATUS.

Preparation of the Skin.—The skin around the ischial area and above the condyles should be rubbed with spirit, dried, and powdered daily, for a short period before the application. The thigh should be shaved.

An anaesthetic is only necessary in the case of very recent fractures.