WAR WOUNDS AND AIR RAID CASUALTIES

The following is one of a series of lectures on the Treatment of War Wounds and Air Raid Casualties recently delivered at the British Postgraduate Medical School

WOUNDS OF THE PERIPHERAL NERVES AND BLOOD VESSELS

BY

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In war surgery it must be realized that when injury affects either the blood vessels or the peripheral nerves the wound of the surrounding tissues which will undoubtedly accompany the injury must be taken into consideration. The severity of this wound will in many cases render unnecessary any doubt as to either the diagnosis of the extent of the injury to or the treatment of any individual nerves and vessels. It cannot be emphasized too strongly that prompt and thorough excision of the wound track must be in all cases carried out. In doing this the condition of any damaged nerves and vessels may be ascertained and such lesions as are present may be dealt with.

In wounds of peripheral nerves suture should be carried out in all cases provided this can be done without tension on the divided ends; the limb must then be splinted so as to support paralysed muscles in a position of relaxation.

Where blood vessels are injured they should, as a general rule, be completely divided and ligatured above and below. Attempts made to reconstruct the lumen are dangerous, and are likely to result in severe secondary haemorrhage should the wound become infected; moreover, the ultimate results of such a procedure are unsatisfactory.

Injuries to Nerves

Wounds and injuries to the peripheral nerves are commonly met with in war surgery, and, as excision of the wound is required in all cases, failure to recognize the lesion should not occur, as the divided nerve ends will then be apparent; but examination of the limb should not be neglected because excision has to be performed, and it is helpful to the surgeon to know what damage he is likely to encounter. The limb should therefore be examined for any evidence of muscle paralysis or anaesthesia. The following lesions of nerves may be found complicating a wound: (1) contusion; (2) division; (3) partial ablation, where a greater or less extent of the nerve trunk is destroyed and missing.

Contusion of Nerve

In these cases the nerve looks slightly swollen, with its sheath reddened or actually infiltrated with blood. There is no obvious loss of continuity of the nerve fibres, though in most cases loss of conductivity can be demonstrated clinically.

Treatment.—In cases of contusion with no loss of continuity no surgery should be attempted on the nerve trunk, as recovery is the rule, but in the meanwhile the limb should be so splinted that paralysed muscles will be in a relaxed position; if these react to faradism that form of electrical treatment should be employed to stimulate them daily until voluntary contraction reappears. In severe cases in which no faradic response can be obtained galvanic stimulation must be carried out daily until a faradic reaction can be elicited.

Division of Nerve

The trunk of the nerve may be cut clean through as if divided by a knife, but more commonly the ends are ragged and bruised; occasionally the nerve may be only partly divided, often with a portion of metal embedded at the point of injury. In these wound cases, owing to the pulping and damage of the surrounding muscles, the nerve ends are not separated to any great extent and are easy to identify, pick up, and approximate. Anaesthesia of the skin and paralysis of muscles in the area supplied by the nerve below the point of section will of course be present, though they are often confused by the extent and results of the accompanying wound.

Treatment.—In every case the nerve ends must be carefully pared with a very sharp knife till the trunk is clean and unbruised. The nerve sheaths of the peripheral and distal ends should be gently freed by dissection from the surrounding tissues (all damaged muscles having been excised) and approximated by a series of catgut sutures passed through the perineurium, always provided this can be carried out without any undue tension being exerted on, and without rotation of, the nerve ends. When the suture is securely accomplished the nerve at the point of operation should be embedded, if possible, in healthy muscle, but if this is not feasible it should be enwrapped in fascia or fat to prevent adhesions. When completely excised the wound should be closed, with drainage if necessary, and the limb splinted so as to rest the wound and relax any paralysed muscles. In many cases it will be found that infection has already occurred in these wounds before they are seen by a surgeon; in this eventuality it is a common practice to leave the nerve ends unsutured until such time as the infection has cleared up, when they are united by a subsequent operation on the lines already indicated. My own practice, however, is to suture those nerves in the presence of moderate infection, and I can report good results in the majority of cases, with the saving of much time in recovery.

Partial Ablation of Nerve

This is a common condition, seen in most lacerated wounds, and is important not only because the ends of the nerve are widely separated but also because the surgeon may overlook the nerve ends unless careful search is made for them when the wound is excised.

Treatment.—In cases where a gap of several inches is left between the nerve ends it is useless to attempt to carry out any form of primary suture; all that it is advisable to do, in addition to excising the wound, is to clean the cut ends of the nerve and, if possible, pull down and ligature the perineurium over the divided nerve filaments, so as to prevent the formation of a large neuroma and its adhesion to surrounding structures. Subsequently the distal end of the nerve may be implanted laterally into a neighbouring nerve trunk, if one exists, or suitable means, such as tendon transplantation or arthrodesis, undertaken to ensure a useful limb.

Prognosis of Nerve Injuries

It must be realized that further treatment will be necessary for many months in all cases of nerve injury. This

treatment consists in the daily application of the galvanic current and massage to paralysed muscles until such time as they react to faradism, which may then be employed. At the same time it is very necessary to protect the limb from external trauma and, in cases of injuries in the upper extremity, to warn the patient of the danger of holding lighted cigarettes or matches between partially insensitive fingers.

With all nerves the nearer the body they are divided the longer will be the period before recovery is complete; thus when a sciatic nerve is divided in the upper part of the thigh an interval of from two and a half to three years is to be expected before recovery takes place. In the case of a similar wound in the upper limb this period is usually a year or eighteen months, but may be slightly longer.

The prognosis is always best after primary suture where no sepsis has intervened. It is never so satisfactory in the case of delayed suture or sepsis, and no really good results are to be expected after nerve grafting or implantation. The end-results are much better with some nerves than with others. An almost perfect end-result may be anticipated with the sciatic and musculo-spiral (radial) nerves where primary suture has been successful, but with the median and ulnar nerves muscle weakness and sensory disturbances persist in nearly all cases.

Injuries to Blood Vessels

Injuries to blood vessels are extremely common, and, of course, occur in every wound seen, but it is particularly with injuries to the larger vessels of the limbs that we are concerned. In respect to damaged small vessels, which will be encountered in all kinds of wounds, it cannot be emphasized too strongly that in excising any wound it is necessary to remove tissue until spurting vessels are met with in place of the ooze first seen on a wound surface; and, moreover, it should be remembered that the *per primam* healing aimed at by excision is possible only if adequate haemostasis is secured before the wound is closed.

As to damage to the large vessels, it is evident that the cutting off of the blood supply to a wounded limb will not only increase the risk of its death but will also greatly favour the occurrence of infection, and especially those forms due to anaerobic organisms (gas gangrene and tetanus). It is therefore justifiable in many cases where damage has been done to the main vessels of the limb, especially if accompanied by gross muscle-crushing or fracture of the bones, to perform immediate amputation with the object of saving the patient's life.

As with nerve lesions so also in the case of blood vessels we meet with (1) contusion; (2) division; (3) partial ablation. It must be remembered that Nature, by a general fall in blood pressure, the coagulability of the blood (especially in the presence of damaged muscle tissue), and the torsion of the vessel wall which occurs in all severe wounds, does much to arrest haemorrhage, and is often successful even where main vessels are torn across. It is not, however, safe for the doctor to rely on this natural arrest of haemorrhage, as the rise in blood pressure consequent on treatment and the occurrence of infection of these wounds are sufficient to loosen the clot and cause severe reactionary and secondary haemorrhages.

FIRST AID

In such cases the first-aid treatment is of great importance in saving the patient's life. All personnel engaged on first-aid duty must be taught to look for haemorrhage

cases first and to give immediate treatment. A pad, improvised or otherwise, is pressed into the wound and held firmly until a dressing and bandage can be applied. If an artery is bleeding pressure is applied to the appropriate "pressure point" until the dressing is in place. All wounds of the lower limbs are to be treated as stretcher cases. The tourniquet is not to be used indiscriminately, but only when it is certain that a large artery is bleeding or when a limb has been torn off, when it *must be applied as close above the wound as possible*. A simple type must be chosen, and one that can be efficiently and rapidly applied even in the dark.

THE TOURNIQUET

Many kinds of tourniquet exist, but probably the improvised types are the most useful. Careful judgment is required in their use; unless a large artery is obviously injured the tourniquet should be applied only after the simpler forms of treatment have failed. The tourniquet should always be put on as far down the limb as possible—that is, near the wound—so that the blood supply of uninjured parts is not interfered with. The rule of relaxing the tourniquet after fifteen minutes should be observed, but it should be left *in situ*, with an orderly ready to tighten it up again if necessary. When a tourniquet has been applied a note must be made of this fact, together with the time of application, on the casualty card; should this not be available the fact of application must be recorded on the patient's forehead. It should be noted that where a tourniquet has been applied and it is subsequently decided that immediate amputation is to be carried out this should be performed without removal of the tourniquet, and immediately above it; this procedure saves the patient very considerable shock.

CLINICAL INDICATIONS

Though haemorrhage is visible to the naked eye it may sometimes be difficult in the case of a penetrating wound to be sure whether deep vessels are damaged or not. In this respect examination of the distal pulse, the possible presence of a pulsating swelling, or deep tension in the limb should be looked for. In other words, with a small penetrating wound internal haemorrhage occurs in a limb just as in the coelomic cavities, and will present the same general signs, though to a lesser extent. As a rule the presence of a persistent tachycardia is an indication that there is vascular damage, usually with arteriovenous communication, unless the patient is developing or has developed gas gangrene, which is the other common cause of continued rapidity in the pulse rate in patients recovering from the effects of wounds.

TREATMENT

Subsequent treatment should aim at ligation of the damaged vessels, and, as Makins pointed out in 1917, simultaneous ligation of the artery and vein leads to retention of more blood in the limb and further improves the conditions necessary for the preservation of its vitality. The surgeon will soon become acquainted with the main arterial trunks, and in the early stages of his career may attempt to carry out operations for the repair of vessel walls and the re-establishment of circulation. This line of treatment is not justified in the majority of cases, as it means submitting the patient to a lengthy operation, the results of which are usually to produce thrombosis at the suture line with obliteration of the vessels; and, where the circulation is maintained, subsequent examination after several months has shown that the majority of these patients develop arterial or arteriovenous aneurysms.

Following ligation of the vessels the limb should be elevated and, if necessary, splinted to secure rest, while

the patient is to be encouraged to contract the muscles gently and massage may be given to aid the circulation. I must repeat that a sharp eye should be kept for gangrene, which is more likely to occur in the lower limb, being very rarely seen in the upper even after ligation of the axillary vessels. Infection also must be watched for. As already stated, it will be ill resisted in the devitalized tissues, so that its appearance is of serious significance and calls for immediate and drastic surgical treatment. In cases in which gas gangrene manifests itself prompt amputation will offer the best chance of saving the patient's life.

Traumatic and Arteriovenous Aneurysms

One of the results of failure to recognize damage to blood vessels in a wound is the subsequent and usually gradual appearance of some sort of traumatic aneurysm. It is not in large wounds that vessel damage is likely to escape notice, but in small penetrating wounds where the exit and entry of the missile are situated at some distance from the lines of the blood vessels.

These small wounds frequently heal without complications, but the patient gradually notices a feeling of fullness and tiredness developing in the limb, especially after use, while in some cases a definite bruit may be detected by him and pulsation be present in the veins distal to the wound. In the early stages the surgeon should be led to suspect the development of such a vascular lesion by the presence of a persistent tachycardia in a patient in whom no obvious cause for this can be demonstrated. As will be seen from the above description, the onset of these aneurysms is usually gradual, and it is several weeks before they are clinically obvious. There are occasions, however, when, just as the wall of an artery may give way and cause secondary haemorrhage, so an arteriovenous communication may manifest itself suddenly. In this case the patient shows all the signs of collapse and internal haemorrhage, while the affected limb will be found distended, with tortuous pulsating veins.

Traumatic Aneurysms

Following an undetected wound in an artery the resultant traumatic aneurysm enlarges gradually in the surrounding tissues, the pressure of which limits the extent of the sac. In superficial vessels such a lesion presents itself as a rounded swelling with expansile pulsation in the course of the vessels, while in deeper tissues a sense of fullness and discomfort is all that is usually manifest. Pressure on the artery above the aneurysmal sac of course obliterates the pulse in this. There may be pain and oedema distal to the aneurysm from pressure on surrounding nerves and veins.

Treatment consists in exposing the sac, ligaturing the main trunk both above and below it, and, where practicable, excising the sac itself, though this is not essential and should not be carried out if it involves any risk of damage to important structures in the sac wall.

Arteriovenous Aneurysms

These occur where a wound involves contiguous vessels such as in the subclavian and axillary regions in the upper limb, the thigh and popliteal regions in the lower limb, and the carotid region in the neck. As already stated, these communications develop gradually in most cases, though rarely they may have a sudden and dramatic onset; it is usually not until at least six weeks or more after the wound that the condition can be diagnosed with certainty, though a persistently rapid pulse in any patient

should lead to the suspicion of a developing arteriovenous communication. As a rule the patient is aware both of discomfort and pain and of a bruit in the affected limb. This bruit may often be heard when near the patient and can always be detected on palpation and on auscultation, while the superficial veins below the lesion may generally be seen to be tortuous, distended, and pulsating. It must not be forgotten that such a communication may complicate a fractured skull and occur in the cavernous sinus, between the internal carotid and that blood space, giving rise to distressful cerebral symptoms and a pulsating exophthalmos.

TREATMENT

From the point of view of treatment it makes little difference whether an aneurysmal varix or a varicose aneurysm is present, for, as already enunciated, ligation of both the artery and the vein above and below the communication offers the best opportunity of cure. Unless the patient is seriously inconvenienced by the communication it is wise to defer this ligature of the vessels for at least three months from the time of the wound in order that a collateral circulation may be well established. The operative treatment, however, should not be delayed unduly, since this increases the involvement of surrounding structures and makes operation far more difficult.

Only very rarely is it justifiable to attempt repair of the vessel wall at the point of communication, but where operation has to be undertaken very early, and especially in the lower limb, where doubt may exist as to the efficiency of collateral circulation, such repair may be carried out at times. Even should an aneurysm subsequently occur, the initial procedure will have permitted the patient's collateral circulation to develop in the meanwhile. As stated elsewhere, such repair operations are disappointing in their results, in that in many cases immediate thrombosis arises at the site of operation, and in the vast majority of the remainder the giving way of the scar results in the subsequent formation of an aneurysm.

Conclusion

As will be gathered from the foregoing remarks, injuries of the peripheral blood vessels and nerves are in themselves often unimportant compared with the grave damage that is likely to be caused by aerial bombs. Experience has shown that the most severe wounds may be expected, and these will quite overshadow any vascular and nerve lesions. On the other hand, it is important to recognize and treat these conditions in minor wounds: in the case of injuries of the blood vessels the recognition of damage to the main vessels of a severely wounded limb may often cause the surgeon to determine upon immediate amputation—a step which will save the patient a long and painful convalescence with the chance of a useless and painful limb, and will often be life-saving in its effects—while in the case of a slight wound the recognition and prompt treatment of vessel involvement will avoid the inconvenience and danger of a traumatic or arteriovenous aneurysm.

The third International Congress for Microbiology will be held in New York City from September 2 to 9, 1939. Those who want to attend this congress are asked to send their names to Dr. R. St. John Brooks, secretary of the British National Committee (Lister Institute, Chelsea Gardens, London, S.W.1). Some knowledge of the numbers likely to make the journey will greatly facilitate arrangements for securing advantageous terms of transport from shipping companies.