MAUSER BULLET WOUNDS OF NERVES—A SURPRISING LESION.

By Major S. F. Freyer, C.M.G.
Royal Army Medical Corps.

In the late war in South Africa lesions of the nerve trunks seemed by far the commonest of all complications of Mauser bullet wounds, as they undoubtedly were one of the chief causes of invaliding home for wounds received in action.

This prevalence, as compared with that of former wars, was, of course, only apparent. It was due to the fact that the ordinary Mauser wound healed by first intention; and, as a consequence, the more slowly recovering nerve was left a long way behind the other tissues, so to speak, in the race for repair. Thus the nerve lesion came very prominently into notice, even in those cases where graver, if less lasting, complications existed as well.

What struck one most, perhaps, about these nerve lesions—as met with at a General hospital—was the incompleteness of the paralysis in the parts supplied below the site of injury, either as regards sensation or motion, or both. For my own part I can say that, in aseptically healed normal Mauser wounds, I did not see a single case in which some part or other of the nerve below the lesion did not retain its normal function. Consequently, although it would seem that others have met with complete division of the nerve in such a bullet track, I am inclined to think that this condition must be extremely rare. The following three cases, given in detail, in which nerves were actually seen to have been perforated by bullets of much larger diameter than the nerves themselves, go far to bear out this view; while the degree of recovery of function eventually attained in them may afford some satisfaction as well as interest to those who, like myself, saw little or no improvement take place in nerve lesions generally, during the few weeks they remained under our observation in South Africa.

Here I would remark that, while some authors who have contributed to our knowledge of Mauser bullet wounds in this war allude to the possibility of nerve perforation, they do not give any details of cases. This omission is all the more unfortunate, inasmuch as the lesion is evidently quite new in military surgery. At least, if it existed in former wars, it seems not to have been noticed, though apparently its existence was not even suspected.
So that, although, as will be seen further on, there are some grounds for believing that this must have been a rather common nerve lesion in the recent war, I can find no case recorded other than those given here, which came under my own observation very early in the war, in which, on exploration, the perforation was actually seen.

No doubt, subsequently, there were some cases noted by other surgeons in which the great sciatic, and even the internal popliteal nerves were found traversed by scar tissue in such a manner as to suggest to them perforation by the bullet. But with such large nerves the condition would naturally not occasion much surprise. It is a different matter altogether when nerves of smaller diameter than the bullet are so perforated, instead of being cut right across, as one would expect. It is this class of cases that provides food for reflection, and that makes the lesion one of the most interesting, perhaps, to be met with in modern military surgery.

**Case 1.**—Pte. A., Bethune's Mounted Infantry, wounded at Tugela River, January 15, 1900; transferred to No. 4 General Hospital, Mooi River, seven days later. Entrance (normal Mauser) in front, half an inch above centre of axillary fold; exit in kink of posterior axillary fold; both small and healed by scab. Drop-wrist, but triceps not paralysed, nor sensation entirely lost on backs of fingers.

Operation undertaken to repair the nerve January 26, eleven days after receipt of wound. Incision made across axilla and bullet track, in the line of the main artery. In following, with the finger alone, the musculo-spiral nerve, as it wound under the artery, it was found glued to the latter, in the bullet track, by a small, tarry-looking blood clot, the disturbance of which gave rise to profuse haemorrhage. There was a rent found here in the axillary artery half an inch long, where it had been adherent to the nerve—the vessel was on the stretch now, with the arm drawn from the side. The artery was tied above and below, and divided between the ligatures. When the divided ends retracted, a small round perforation in the underlying nerve came fully into view. It was only just big enough to allow the blunt end of the ordinary pocket-case silver probe to drop through, and was occupied by blood clot previously. On cleaning up the traces of clot, the sides of the nerve were seen to be sound, and in continuity. The perforation in the nerve was partly punched out, though the edges were contused, leaving some severed and frayed ends of nerve fibres above and below, and it involved about one-third of the diameter of the nerve.
trunk. The question now arose as to whether we should approximate these divided fibres, by hitching up the nerve with a suture or two, placed vertically across the opening, or leave things alone. As it would be a matter of some delicacy to remove the contused parts only, and as it seemed that the sound parts of the divided fibres could not be more than a quarter of an inch apart, the latter alternative was adopted. The nerve was merely cleaned, and replaced in its bed, and the wound closed. Healed by first intention; wrist-drop improving slowly, under massage, when, fifty-one days later, patient was invalided to England. At Netley, June 7, one hundred and forty-four days from receipt of wound, the official record says, "musculo-spiral paralysis has disappeared." Patient then went to America, and, in answer to my enquiry, I received a letter dated California, February 15, 1904. He says that he has perfectly recovered, that previously, when he was in a colder climate, his hand used to become a little numb at times, but not now, and adds, "I can hardly tell that my hand was ever crippled at all."

CASE 2.—Sergt. X., admitted to No. 4 General Hospital, Mooi River, January 24, 1900, about a week after receipt of wound. A normal Mauser bullet had traversed the middle of the arm, crossing in front of the humerus. Wounds had healed by scab, but "there was numbness in all the area supplied by the median nerve, though the numbness was not complete. The muscles supplied by this nerve were weak and sluggish in action, but not actually paralysed."

On January 29,—about ten days after being wounded—Mr. F. R. Martin (now Captain S.A.C.) made an incision across the cicatrix, in the course of the nerve. The nerve trunk was found pierced in the track by the bullet, just as in the former case. The perforation was central, and admitted a large sized probe. The nerve was replaced in its bed, without further interference, and the wound closed. Healed by first intention; when invalided to England two months later "it was doubtful if any improvement had taken place." Now (1904) serving; Lieut. Ievers, R.A.M.C., says "great improvement . . . finger joints are not stiff . . . no cicatrix to be felt in bullet track," but it appears that he has not yet quite recovered, from the further remarks: "there is some wasting of the small muscles . . . says he cannot clench his fist."

Remarks.—These are, it seems, the first cases of nerve perforation by a bullet on record, and lest there should remain any doubt in the reader's mind, as to the correct interpretation of the condition seen, I would add, that, in each case, we made a very careful examina-
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dition of the bullet-track, in relation to the nerve. Mr. Sidney Hulke, and Mr. F. Pope assisted in the first case, and, at both operations, there were many other officers present, who were no less astonished at this peculiar lesion than we were. How the Mauser bullet makes its way through a nerve trunk that is not more than half its diameter was, and still is, a puzzle.

This observation, however, so early in the war, prepared us, I think, for the similar, and scarcely less curious perforations which we afterwards met with in blood-vessels, as well as for the trifling symptoms that followed perforating Mauser wounds of the contents of the chest, abdomen, and even cranial cavity, in quite a large proportion of the cases.

It can only be surmised, either that the nerve spreads out like a ribbon on impact of the bullet, or that, on account of the conical shape of the Mauser point, it partly splits up the nerve trunk. The latter assumption seems negatived by the next case, which was not due to a Mauser, but to the ordinary Service pattern revolver bullet, with blunt leaden nose.

CASE 3.—Sergt. M., wounded January 24, 1900; transferred to No. 4 General Hospital, Mooi River, nine days later.

Entrance one and a half inches above, and a little outside, internal condyle of left arm; no exit, but a short and thick bullet seen by X-rays to be lying over deltoid muscle—a long raking wound of arm, due to his revolver going off accidentally. Tense haematoma all over arm; oedema of forearm and hand; partial anaesthesia of median supply, but the flexor muscles appeared to be unaffected.

On February 5, twelve days after injury, we cut down on the brachial artery by a rather long incision, as, from the very oblique course of the bullet and great swelling of the arm, it was impossible to tell where the vessel was wounded. Basilic vein found bleeding into haematoma, and tied; laceration found in lower third of brachial artery, half an inch long, and severing the vessel across except for a slender shred on the inner side; the latter divided after tying the vessel above and below.

When the clot was washed away, a slit-like aperture was found in the median nerve, which left three-quarters of the trunk sound, on the outer side, but only a small strand of fibres on the inner,—less than a quarter of the nerve being thus cut across by the perforation.

Nerve replaced and wound closed. Healed by first intention; invalided to England March 20. At Netley, April 19; official
record says, "sensation was lost in median, but is now returning." Still serving, and Dr. Power in medical charge of the unit certifies February 24, 1904, "sensation and motion normal."

**Remarks.**—The three cases here given are the only ones in which a deliberate examination of the nerve lesion in the bullet-track was made at our hospital, at an early stage in the lesion. Indeed, when the second case was found to be like the first, we came to the conclusion that partial lesion of a nerve trunk did not require operation in a wound that had healed by first intention, whether the lesion was due to mere contusion, or to notching, or perforation as well; and, as already stated, no case of complete severance in such a wound presented itself. As a consequence of this policy of non-interference, we had little further opportunity for studying the nature of the nerve lesions in the numerous cases that passed through the hospital. This, it will be noticed, is the reason that, in the other cases here given, the nerves were only examined in the course of an operation for aneurysm.

The nerve cases that require operation at a later stage are those that heal slowly, by granulation, in a septic wound. These latter were, as a rule, invalided home, before any pressure symptoms from cicatricial contraction set in, and frequently before the wound had closed. I do not remember operating on any case of this kind of bullet wound. Moreover, either notching or perforation of the nerve would be difficult to recognise at this stage, on account of the other deformities, caused by the strangulating tissues around it. Mr. Stanley Copley, however, on July 13, 1901, operated on the internal popliteal nerve in one of these cases. He told me, some time afterwards, that he found a string of cicatricial tissue leading across from the entrance to the exit scar, through the nerve trunk, in such a manner as to suggest that the nerve had been perforated.

It would be obviously unwise to draw general conclusions from these four cases only, amongst the large number of nerve cases that would be met with in the 2,800, or so, "wounds in action" treated by us, even occurring as they did in the only four cases deliberately explored at Mooi River. The experience of others who had opportunities, during the war, of observing the early stage of Mauser lesions may yet throw some light on the relative frequency of perforation to other lesions of the nerve.

Meantime, it seems certain that, if the lesion here described is not the commonest of all nerve lesions where the small bore mantled bullet is concerned, it is at least sufficiently frequently met with to deserve consideration in gun-shot wounds of nerves in future.
Fortunately, however, from the point of view of treatment, the nature of the partial lesion does not matter in the least; and the following rather typical case, in which the brachial plexus was traversed, possibly contained, in different cords of the plexus, illustrations of all three kinds of partial lesion.

Before describing this last case, it seems necessary to say something about a nerve lesion that has occupied a rather prominent place in military surgery hitherto, namely, "concussion" of the nerve trunk. It would be difficult, perhaps, if not impossible, from the classical symptoms attributed to this condition, to separate it from slight contusion of the nerve, either alone, or in association with the compression of extravasated blood. Besides, the more opportunities one has of exposing the nerve to view, at an early stage in the lesion, the more sceptical one becomes, perhaps, as to the existence of the condition at all. Moreover, such a condition of the nerve trunk itself, as distinguished from a nerve "centre," would hardly seem to be in accordance with present physiological knowledge. However this may be, the existence of "concussion" has still the support of the highest authorities. It was therefore necessary to make passing allusion to it; but as we entertained no suspicion of this lesion in the cases which reached our hospital, on account, perhaps, of their being nearly always some few days old, it will not be further considered here.

Case 4.—Lieut. the Honourable ——, wounded March 15, 1902, transferred to No. 4 General Hospital, Mooi River, twenty-eight days later. Left arm paralysed, hand scalded—the result of lost sensation, and dipping it into very hot water (which he did not feel), to relieve intense pain in the arm after receipt of wound. Entrance (normal Mauser) on front of arm, just at junction with axillary fold, from which protruded a nipple of dried blood clot; exit long healed, over chest, on same side, one inch and a half from fifth dorsal spine. A large, tense, pulsating aneurysm filled the axilla; face blanched, and history of severe recurrent haemorrhages from the entrance wound. With the arm drawn from the side, an incision was made across the axilla, in the line of the main artery; the aneurysm was rapidly emptied of clot and the vessel seized. In this procedure I had the advantage of the kind assistance of Lieut.-Col. Lucas, C.B., and Lieut.-Col. Hackett, of the R.A.M.C. The rent in the artery, which was situated high up between the heads of the median nerve, at the junction of the lower and middle third, was three quarters of an inch long. The vessel was ligatured above and below, and the space flushed out. No divided nerve was seen;
but, as the patient was very weak, *there was no time for a deliberate examination of the plexus for other lesions.* The wound was closed, and it healed by first intention. Pain was much relieved by the operation, and when the sutures were being removed he could move his arm away from the side; but he regained little further power in the limb up to May 21, when invalided to England.

On arrival home, acting on our advice he saw Mr. Anthony Bowlby, who, amongst other things, prescribed a rigorous course of massage, with electrical treatment of the limb. Progress slow, but steady, for twelve months, afterwards much more rapid.

During this time he suffered from *"trophic" disturbances; Weir-Mitchell "glossy skin," swelling and stiffening of joints, hyperaesthesia, wearying pain, and mental depression.* After eighteen months, when he appeared before the last Board, there had been remarkable progress; arm and forearm practically normal; wrist-drop, pain and mental depression disappeared; skin healthy looking. The fingers were still paralysed, and sensation below wrist was impaired. The thumb, however, was beginning to recover, so that he could hold a stick between it and the hand. Allowed to rejoin his regiment.

*Remarks.*—Although contusion alone, or with perforation, or notching of more than one cord of the plexus, must have occurred here, the prognosis of ultimate recovery of the fingers—of the coarser movements at least—would seem justified by the results obtained in the first three cases.

This is to be deduced from the fact that perforation, which occurred in all the others, was the severest form of any single lesion that could be caused by the bullet in this case. Mr. Bowlby, evidently relying on the description sent home, of the appearances of the nerves in the open wound, did not consider any further operation indicated. Otherwise, on account of the complexity in origin of the individual nerve trunks affected, it would probably have been impossible, without exploration, to exclude total transverse section of one or other of the cords of the plexus.

This question of operative interference, so difficult to settle in a complicated case like the last—in view of the fact that nerve trunks have been found completely divided, it is said, by the normal Mauser bullet—is, where single nerves only are concerned, decided, it would seem, by the results obtained in the previous three cases. The inference to be drawn from the latter is undoubtedly, that, in partial lesion of a nerve trunk, where the wound has healed by first intention, any operation on the nerve is unnecessary. The only
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Apparent exceptions to this rule are really cases with complications, such, for instance, as where adjacent bone has been damaged and the nerve is, in consequence, being tied down by callus.

It is true in all these cases a string of cicatricial tissue is left behind in the bullet-track for many months after the wound has closed. This is unavoidable in all wounds causing loss of substance, and thus healing under scab, as do bullet wounds. After normal Mauser wounds, at least, this cicatricial string is very fine. But whether the young fibres grow through, or round it, remains to be demonstrated.

All we know about the matter clinically is, that this sort of cicatrix does not seem to materially interfere with their growth; and, until the results to be anticipated from nerve suturing generally are more definite and certain than they appear to be at the present time, it is not advisable to interfere with these partial breaches of continuity.

Our knowledge of the mode of healing of nerve injuries generally may be said to be as yet in its infancy, notwithstanding the recent interesting contribution of Messrs. Ballance and Purves Stewart ("Healing of Nerves"). The method of reproduction of the axis cylinder, the behaviour of the cicatrix, and even the time required for repair in the human subject, after a simple and clean section of a nerve trunk, are all very obscure still.

Mr. Bowlby, in his work on "Injuries and Diseases of Nerves," insisted on a term of years, not of months, being allowed for anything like complete restoration of function. The history of the few cases here given entirely bear out his view, as far as they go, and I have had opportunities on Medical Boards of seeing many other such cases which showed little improvement in the first six months or more, though eventually recovering completely to all appearances.

Should it be definitely shown yet, that better, or even quicker results are to be got from surgical interference with suture, in these aseptic cases, than the results in the cases here detailed, then of course the above conclusions will require modification.

It is probable that the differences in tension on this scar string, set up during muscular action, may cause irritation of the nerve. In some of these cases the pain during the long healing process has been found almost unbearable, an observation made long ago by Drs. Weir-Mitchell, Morehouse and Keen, in their work on "Gunshot Wounds and other Injuries of Nerves." If, in a very exceptional case, an operation be undertaken for its relief, it is
as well to remember, that, no mere division of the cicatricial string is likely to be followed by anything but temporary alleviation of that symptom.

Whatever misgivings we may have on theoretical grounds, as to the wisdom of leaving this string of scar tissue alone, rather than attempt to hasten the reparative process in the nerve by its removal, it is important to note here, further, that in these cases no compression of the nerve demanding operation can arise later. This follows from the fact that the cicatricial string does not envelop, but merely runs through the nerve in perforation, thus leaving the sides free; while, in notching, and contusion, it is confined more or less to one side of the nerve only.

On the other hand, where the wound becomes septic and so heals slowly by granulation, with formation of pus, the nerve trunk is in great danger of being embraced in the large amount of scar tissue left behind in such a wound. In the latter case strangulation of the nerve will certainly follow, unless it is relieved by operation. As already mentioned, these patients were usually invalided to England before the stage of compression declared itself. On arrival home there were, no doubt, few of these cases in which operation for the release of the nerve was not imperative. When the wound has closed, so that the part can be rendered aseptic, then obviously the sooner this operation is done the better.

It will have been noticed, perhaps, that no mention is made of "neuritis" in the cases described. This is because there was no naked eye sign of inflammation in any of the nerves exposed. Contrary to what is usually taught, I do not think that there is any tendency to inflammation of the nerve in the ordinary sense, as a direct result of injury from the bullet. The hyperaesthesia, pain and trophic disturbances generally, which arise later, even in aseptic wounds like that of Case 4, although attributable perhaps to the irritation of the cicatrix as already explained, would seem to be clinical manifestations of repair only, rather than of inflammation. At least I know of no observations made on nerves in that stage, in which, apart from cicatricial strangulation of the nerve, the ordinary evidences of inflammation were found on exposing the latter. This is a point which might, perhaps, be cleared up by those who were operating at home on the invalids returned from South Africa; for there is reason to believe that the distinction here drawn between Mauser wounds that healed by first intention, and otherwise, as regards suitability for operation, was not recognised, at least in civil hospitals and in private practice. Meantime, it is highly probable,
that "neuritis" also, strictly speaking, is for the most part confined to septic wounds.

Altogether, then, it will have been gathered from the foregoing, that, in nerve wounds, the importance of obtaining primary union in the bullet-track can scarcely be exaggerated. It is on this question that, as a rule, the whole prognosis of the case turns. Fortunately, in the South African war, this result was attained without any trouble in the immense majority of cases. It was, in fact, astounding how readily these Mauser wounds closed and scabbed over when not interfered with. Even when implicating the large body cavities it was quite an exceptional experience to find that a normal Mauser wound was not scabbed over on removal of the "first dressing."

This unusual experience, in the case of wounds exposed to what would be considered at least an ordinary amount of septicity, has led to some speculation as regards its cause. It is not that the "first dressing" has not been credited with its full share of praise in contributing to the desired result; nor that the influence of the pure air of the South African veldt on the vital, as distinguished from the physical and chemical factors of repair in wounds, has been overlooked. But, having admitted the excellence in many ways of the regulation dressing, it is obvious that the circumstances under which it has to be applied at the Front are anything but those that would satisfy a surgeon nowadays, in the closure of an operation wound for instance. Besides, we have most of us seen odd cases, in which, on an emergency, a "puttie," or anything to hand, was improvised into a first dressing, with what appeared to be an equally good result as regards aseptic union.

There is just a danger, at the present time, of our attributing more than a due share of the success attending the treatment of wounds generally to "asepticism," or to some one or other of the rival "antiseptic" systems. Or rather, perhaps, the danger lies in neglecting the physical factors acting upon the wound, which are common to them all, and which are pre-eminent in the healing process, in our excessive solicitude for the mere minor aiding factors introduced in the complicated details of any particular system.

This view of the matter was brought home to us forcibly by M. Preobajensky, in an article in the Annales de L'Institut Pasteur, in September, 1897—an article which by the way would well repay the attention it seems not to have attracted in this country up to the present time. M. Preobajensky in this paper, demonstrated conclusively, from the results of physical experiments, and experi-
ments on animals, the overwhelming importance of the physical, as compared to the chemical qualities of a dressing. Briefly, he shows that the forces of evaporation, osmosis, and capillarity in a wound, when intelligently assisted by an absorbent dressing, can set up such a fluid current from the depths of the wound to the surface, that ordinary infection of the wound is practically impossible, and that even the deliberate infection of it by such a highly virulent microbe as that of anthrax is a matter of some difficulty.

Our experience with Mauser wounds in South Africa amply testify to the soundness of this view. To take, for example, Case 4, here given, which, although an exaggerated instance of the kind, will well illustrate the importance of these physical forces which keep a wound aseptic in spite of untoward surroundings. Here the large cavity, containing clotted blood—a very suitable pabulum for microbes—was in free communication with the air, for nearly a month, without the slightest sign of infection resulting.

We are not surprised at this, because it is notorious that these cases of recurrent haemorrhage, unlike those of secondary haemorrhage, do not lend themselves to infection. No satisfactory explanation of their immunity, however, can be given, except the physical one, namely, that there is such a constant current kept up by the blood pressure, from the depths of the wound to the outside, that the inward growth of microbes into the wound is effectually barred.

Of the same nature, if in lesser degree, is the current that saves ordinary Mauser, and indeed all well-planned operation wounds from infection, provided that it is not interrupted by tampering with the wound, or by an impermeable dressing, or one that becomes so from neglect. The wound falls together in its depths, so as to leave no cavity containing stagnant blood; and whatever little fluid exudes between the raw surfaces is kept in constant motion outwards, until the wound is healed dry from the bottom. The dry climate of South Africa peculiarly lent itself to aiding in this process, which would thus explain the unprecedented success obtained in the primary treatment of gunshot wounds in the late campaign.

As regards dressings M. Preobajensky found that, provided a sufficient "molecular adhesion" existed between the dressing and the fluid in the wound, the efficiency of the former, practically speaking, entirely depended on its permeability and capacity for absorption. For the absorption of blood serum from a recent wound nothing has been introduced into practice since the date of his experiments that stands higher than gauze, such as is used in
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the regulation "first dressing," and generally speaking in every system of dressing in common use at present. So that, if we except that method of hermetically sealing wounds, in which appeal to all outside help is discarded, it may be said that gauze, or a gauze substitute, is the only thing common to all "aseptic" and "antiseptic" systems.

In this way it was that M. Preobajensky reconciled the results obtained by successful surgeons from what superficially appeared to be widely different, and more or less antagonistic, systems of dressing operation wounds. To some of us, perhaps, his conclusions may not have any the less significance in that they strikingly recall Mr. Herbert Spencer's generalisation with regard to the similarly various and antagonistic systems of Religion, "There is a soul of truth in things erroneous."