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view of the great interest of the subject and its bearing in military and naval operations, the recent experiments on the effects of the small caliber military rifles, by the Prussian army authorities, show that we must alter our previously formed notions as to the benignant perforation wounds made by these missiles. It is now well known that at various distances these bullets often have a tearing explosive effect on organized tissues, and instead of a small perforation and often aseptic wound we are now likely to see large cavities and explosive effects, at very long distances as well as under 1,000 meters. These varying effects may be due to unusual movements of the bullet in flight, changing shape and breaking of the mantle, heat of the metal, and very much according to the state of or the kind of tissue struck. Against such wounds likely to occur in future battles, from the use of the modern military rifle of small caliber and great power, medical science has, however, the methods of aseptic surgery and wound treatment to oppose.

This whole subject is well worked out in the pamphlet issued by Surg. Gen. von Coler, and Staff Surg. Schjerning of the Prussian army, and presented to members of the military section of the Rome Congress. The results in the main correspond to those of other recent experimenters, Demosthen of Roumania, Kocher, Reger, and others in Germany, Delorme, and Chausee of France, and LaGarde, U. S. Army. More recently still the experiments of Victor Horsley, of England, are also of interest, as the results show the extreme importance of the physical condition of the tissues struck, in explaining the shattering or explosive effects of the missiles as due mainly to force of impact being transmitted equally in all directions when the tissues are in states of tension from fluid or semifluid contents.

Among the literature collected at the Congress bearing on matters relating to the military and naval services will be found a large number of very excellent plates, illustrating the effects of the bullets on various tissues, dead and alive, issued in common with the pamphlet above cited by the Prussian military medical authorities.

REPORT ON FIRST AID ON THE BATTLEFIELD.

By HENRY G. BEYER, *Surgeon U. S. Navy.*

In view of the title of this paper, I feel it incumbent to begin with a few remarks of explanation, for it might be asked with not unseemingly propriety, what have naval surgeons to do with the battlefield? I have on several occasions received the impression from conversation with army medical officers as if they held the opinion that the litter, the ambulance, the tent and field hospital were means of conveying the injured and of treating them belonging exclusively to the army surgeon. This, I may be permitted to state, is indeed a mistake. During the eighteen years of my connection with the naval service the operations of the Navy in which my services might have been called into requisition in an action were operations on land. During such operations, as must be evident, the duties of the naval surgeon are identical with those of the army surgeon. Moreover, on the several naval stations that are connected with permanent hospitals, the litter and the ambulance are in constant use in the process of moving patients to and from these hospitals. Thus it will be seen while the transportation of the sick and wounded in the Navy includes transportation by water, the embarking and disembarking of them from ships into boats and onto the land, and *vice versa*, the naval surgeon is just as much in need of the army litter and ambulance. On the other hand, the army surgeon may be placed in a position in which it becomes necessary for him to move his patients in ships or boats across a lake or river when no cot will serve his purpose so well as would "Dr. Gihon's ambulance cot," the workings of which he has so well explained to us recently. The fact that the naval surgeon is more often called upon to apply first aid on ships or in small boats than the army medical officer may perhaps influence his methods of administering such aid, but can have no essential modifying influence on the principles that must govern both in the administration of such aid.

With these few preliminary remarks, I pass on to the subject of this paper:

The adoption and general introduction of the modern small arm of reduced caliber for infantry, and a thorough experimental study of its effects on the human body, have made a revision of our methods of administering first aid to the wounded and transporting them to a place of safety a necessity.

Thus, one of the first inferences which experimenters in this line of research were led to deduce from the investigations was, that the number of the wounded would be largely increased in a given time during an action on account of the deadly range of the new small arm having been greatly extended. This deadly zone of the new small arm reaches a distance, according to the calculations of Habart, of 5,000 meters from the muzzle of the gun.

In accordance with this result before them, a result based upon a large number of experiments made upon human cadavers, as well as living animals, the Germans have deemed it necessary to increase their sanitary corps, which, without counting reserves, according to Haase, numbers 45,000 men when all the twenty army corps are in the field.

Every company has now 4 bearers and every battery 2, including musicians, who have recently received training as bearers. In Russia the number of litter-bearers has been increased to 6 per company, or 2 more than in Germany. Austria provides the same number as Germany, nearly 4 to the company. As regards the personal wound package supplied to each soldier no change has so far, to my knowledge, been made, and Delorme, one of the foremost French experimenters, states that this package, if necessary before, has become still more unavoidable to-day.

So far, then, a large increase in the number of the sanitary corps is one of the direct results of the introduction of the new rifle. Let us now see what some of our best and most experienced surgeons have to say on the subject of first aid, and how it has been influenced by this change of arms.

First aid, in our opinion, is not only first in time, but should be looked upon also as first in importance, and therefore well deserves the most earnest attention which it has received from the foremost military surgeons of to-day.

Habart, the eminent Austrian experimenter, thinks that nothing much can be done directly in the rear of the line of battle, and that the chief attention must be paid to a safe and easy transport of the injured; that it is not the first bandage upon which so much depends as the first transport.

According to a standing order of the German army, the place where the first bandage and dressing are to be applied must be about 4,000 meters behind the line of fire. Haase, on the other hand, thinks that the transport is possible even during the progress of the battle, and considers that 2,400 meters behind the line of fire is a safe distance for the first dressing station, and his extensive experience in the Franco-German war would certainly entitle him to speak with authority on the subject.

But whether 4,000 meters or 2,400 meters, the question that would have to be asked and that needs to be definitely settled is, what constitutes a safe and easy transport for either distance. A transport that would prove injurious or even fatal to the wounded had better not be undertaken, and certainly every case of injury that is to be assured of a safe transport needs first of all a certain amount of examination if not the application of splints and bandages.

The application of splints to broken bones and perhaps a circular Esmarchs bandage in cases of severe arterial hemorrhage, seems all that is practicable, if we believe with Haase that it is at all possible to act during the progress of a battle.

Fortunately, however, first aid does not end here, but is continued, or rather begins in earnest at the first dressing station.

One of Habart's expressed expectations is that there will be more slightly wounded in the next war than severely wounded. Habart also states it as one of the most important problems to be solved by the military surgeon of to-day, to be able to distinguish promptly and correctly between the slightly and the severely wounded because of the treatment in either case being essentially different.

During the war of 1861-1865, a time when antiseptic surgery had scarcely been conceived, and during that of 1870-71, when it had not yet reached the age of practical application, its influence on wound healing was consequently nil, and all gunshot wounds were attended by what we now know to have been wound infection, showing either merely local symptoms, such as suppuration, or being accompanied by the more general symptoms of septicæmic poisoning. Is it, therefore, to be wondered at that the impression at that time prevailed that all gunshot wounds are primarily and necessarily infected wounds? Is it, moreover, not also rather to be expected that this impression is still the prevailing one in the minds of those who have gone through the experience of those wars and have not only seen but treated thousands of such cases? These same considerations apply also to the open method of treating gunshot injuries.

The first serious step toward a change in regard to our views as to the nature of gunshot wounds and their treatment had been taken when von Bergmann published his experience in the Russo-Turkish war in 1877, more especially that which has reference to the splendid results obtained in cases of his kneejoint injuries under partially antiseptic dressings. From that time on we have gradually become more and more convinced of the fact that gunshot wounds, both severe and slight, are not necessarily always infected ones, as was supposed to be the case in preantiseptic days, and, so far as we have been able to gather from the literature of the subject, the tendency of the best authorities on the treatment at the first dressing station has inclined most decidedly toward the expectant plan of treatment for both the slightly and the severely wounded. Conservative surgery, in other words, has come to the front again.

Thus Langenbuch, having become convinced from experience gained in 1870-'71, and from observations made since that time, that gunshot wounds are not primarily septic in character, and that therefore one of the prime objects being to prevent secondary infection, proposed in 1892, at the congress of German surgeons in Berlin, as a first dressing for the simpler gunshot wounds that they be, temporarily at least, hermetically sealed either by means of properly prepared rubber adhesive plaster, or, if needs be and circumstances demand it, by temporary sutures; this treatment to be applied by first-aid men properly trained for this purpose!

It was hardly to be expected that so bold a proposition, so radical a departure from the preconceived and preexisting methods of treatment would not meet with strong opposition, and no doubt Langenbuch himself did not expect that at the time. I doubt, however, very much if the same proposition made to-day and with two years' additional experience behind us would meet with the serious opposition it met with then.

Even in cases of wounds complicated with fractures we have the high authority of Wagner, who recommends the expectant plan of treatment rather than primary debridement. In cases of wounds complicated by extensive splintering of bones Wagner has used the irrigator for the removal of small fragments of bone and of marrow, poured a 10 per cent solution of iodoform in glycerin into the wound of entrance and also that of exit until the solution reached the seat of fracture and awaited the results under a bandage. This method was the one in actual use in the late Servio-Bulgarian war in 1885-'86, and the results that followed this treatment were as gratifying as they were unexpected; the death rate was the smallest as yet obtained, namely, 1.5 per cent. The death rate in the war of 1870-'71, as you may remember, was 12 per cent. Reyher, of St. Petersburg, at the International Medical Congress, held in London, advanced the most noteworthy arguments against the unconditional debridement, the practicability of which is admitted by him only when large fragments of bone, muscles, and tendons are hanging out of the wound, with unmistakable signs, as gurgling noises, indicative of air in the deeper parts of the tissues, or when it is made certain that the wound is rendered impure by cloth, straw, and feces having been introduced accidentally.

On the other hand, whenever the wounds are small, clean, and show no very great destruction of the soft parts, no air in the deeper parts, then Reyher recommends the encouragement of healing under a scab; he, however, proves by figures that a greater number of deaths has occurred from infection when primary debridement was employed (23.6 per cent) than when healing under a scab was allowed to go on (15.7 per cent). Von Bergmann, also, has declared himself as against the immediate debridement.

The experience of those who are most generally considered as best entitled to speak with authority on this subject would clearly prove to my mind that gunshot wounds are by no means always primarily infected and that the danger from secondary infection is greater by far than that at primary infection and that nature under certain circumstances is well able to take care of a few germs that may have been carried into a wound through the projectile or pieces of clothing, provided that these germs are not of the septic or pyogenic kind.

Does bacteriology furnish us with anything reliable that has a direct bearing upon this point?

Quite recently La Garde proved by experiment that it was indeed possible to carry pathogenic germs into a living animal or into sterilized gelatin by means of an infected projectile and that the act of firing by no means prevented this result. It has been proved beyond doubt that neither the heat produced in the combustion of the explosive material used, nor that produced by the bullet rushing through the atmosphere, nor even that caused by the collision of the bullet with some resisting object is sufficiently great to cause the sterilization of the infected bullet.

In the same manner Meissner, of Wiesbaden, was able to produce all kinds of infection through the medium of an infected projectile fired from the new rifle.

Experiments such as these no doubt establish the fact that gunshot wounds can be, and experience has shown that they are, sometimes infected in this way.

But Capt. La Garde has also shown that sterilized projectiles fired from sterile guns produce no infection, and he has furthermore shown that 53 per cent of all the projectiles are sterile in their original package.

This important fact alone would go far to explain to my satisfaction the healing of simple gunshot wounds produced by the new projectile which has been so frequently noticed of late and in which no sort of reaction of any kind has attended the straight course to recovery.

The notion has always prevailed among surgeons that whenever pieces of clothing are carried and remain imbedded in a wound infectious organisms have certainly been carried into this wound, and the open method of treating that wound was instituted without further hesitation, notwithstanding the fact being perfectly well known that pieces of clothing could and did sometimes heal into a wound and give rise to no

further trouble for ten or twenty years, when, through an occasional injury to the old cicatrix, an abscess would result, the opening of which brought forth the piece of cloth.

Bearing upon this question of infection being carried to wounds through pieces of clothing, Pfuhl, at the suggestion of Prof. Langenbuch, has made recently a series of inoculation experiments that have shed considerable light on it. Pfuhl took pieces of clothing freshly removed from the uniforms of soldiers and immediately buried them under the skin, the muscular substance, in the pleural and peritoneal cavities of both mice and rabbits, both animals being, as is well known, highly susceptible and reacting like man on pyogenic and septic microorganisms. The pieces of clothing were taken from places of their uniforms that were especially exposed to the perspiration and the street dust, and contained, therefore, many bacteria. Of the twenty-six mice that were inoculated in this manner not one showed any signs of wound infection; but whenever a piece of cloth was, previous to inoculation, infected with a culture of staphylococcus aureus or of streptococcus, the usual results followed, namely, either local death with suppuration or septicæmia and death. Identical results were obtained with the rabbits. The pieces of cloth varied in size from a few threads to 3 centimeters square, and were taken from the underclothing as well as from the outside clothing of soldiers.

The results of Pfuhl's experiments are, briefly stated, as follows:

Of the 46 small and 5 large pieces of cloth taken directly from the bodies of soldiers and buried immediately into the tissues of susceptible animals not a single one produced either simple or purulent inflammation or gave rise to an infectious disease. None of the 51 specimens contained virulent microorganisms, although many other bacteria. Pfuhl sees nothing very surprising in these results, because staphylococci and streptococci, the two principal sources of wound infection, could not thrive in human clothing and would soon die if present at any time. Similar experiments with identical results had already been made by Fraenkel in Vienna in 1888.

The danger, then, it would seem, is not so much in the clothing or in the projectile that are carried into the wound, but in the handling of it by the attendants whose hands are infected with pyogenic bacteria, and this must be much more frequently the case in hospitals than in the field.

This whole question, then, in its relation to gunshot injuries and their treatment in the field, more especially, however, to "first aid," may briefly be summed up in the following generalizations:

(1) It is generally conceded by the most experienced military surgeons of Europe that antiseptics at the first dressing station is hardly practicable. This, no doubt, will be readily understood when we try to realize how rapidly the number of wounded will increase for a given time during an action. But this is not necessarily true for smaller expeditions.

(2) Experience so far gained in cases of gunshot wounds caused by the new rifle and bullet, produced either in the field or experimentally, shows that a surprisingly small number of the simple and small flesh wounds, and even some complicated by broken bones, have healed under the first dressing and without showing any signs of wound infection.

(3) These observations, together with those made and recorded during previous wars, would seem to make it pretty certain that the almost general and universal wound infection of all gunshot wounds observed in former wars was more often due to the introduction of germs by human hands rather than by bullets or the cloth which they carried into them.

(4) The small caliber of the new projectile, its great power of penetration, making the manipulation of such wounds, so often necessary formerly, unnecessary to-day, neither digital exploration being possible on account of the smallness of the wound nor bullet extraction required, the indications for the first treatment of gunshot injuries of to-day would most decidedly point toward a rapid hermetic sealing of such wounds, providing a method can be devised that will secure this result with absolute certainty and which will not add insult to injury.

(5) Esmarch's wound package, as has been admitted by Von Esmarch himself, not being absolutely reliable in producing this result on account of the bandage being liable to slip during transport and incapable of such firm application so as to prevent its slipping, the method proposed by Prof. Langenbuch deserves our most careful attention and consideration.

Langenbuch has recommended the hermetic sealing of those of the gunshot injuries that are included under the collective term "slight" (*Leichtverwundete*) either by means of properly prepared adhesive plaster or sutures, this treatment to be applied by "first-aid men," trained especially for this purpose.

Langenbuch has quite recently published a list of 11 cases of gunshot wounds, in 4 of which the thorax had been perforated, and in all of which this method of treatment had been employed without giving a single bad result. In a footnote to his