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MODERN RIFLE BULLETS AND THEIR EFFECTS.

By Brigade Surgeon Lieutenant-Colonel C. H. Y. GODWIN, Professor
of Military Surgery, Army Medical School.

In a paper on "Magazine Rifles in War" published in the Journal of the Royal United Service Institution for the month of November last, the author writes: "We endeavour merely to disable our enemies individually and collectively, but the disabilities inflicted should, under the circumstances, be at least grave enough to prevent the injured from taking any further part in the campaign;" and the argument of the paper, if I rightly understand it, is that the bullet of the Magazine rifle has been so reduced in weight and size that, judging from the two cases reported, it will be inefficient to check men opposed to us in any future war, and also, if they are wounded, the nature of their wounds will be so slight as to scarcely render them ineffective for longer than a few weeks.

I propose to bring forward in reply a series of experiments that have been made in France with the Lebel rifle as against the Gras, as they are very comparable with the two military rifles at present in use in this country, namely, the Martini-Henry and the Lee-Netford or Magazine rifle.

	Bore.	Weight of bullet.	Muzzle velocity.	Rate of spiral.
Martini-Henry	0·450	410 grs.	1,362	1 in 22
Magazine	0·303	217 "	1,850	1 " 10
Gras 11 mm. or	0·433	386 "	1,493	1 " 22
Lebel 8 mm. or	0·315	231 "	2,000	1 " 9·4

The Martini-Henry and the Gras bullet is a solid one of lead, hardened with tin and antimony respectively.

The Magazine bullet has a core of lead hardened by antimony encased in a cupro-nickel envelope.

The Lebel bullet has a core of lead encased in an envelope of mallechort.

The extracts quoted below are taken from a paper published in the "Archives de Médecine et de Pharmacie Militaires" for the month of February, 1891, and headed "A Study of the Comparative Effects produced by the Bullet of the Gras Rifle 11 mm. in diameter, and of the Lebel Rifle 8 mm. in diameter; by M. M. Delorme, Professor of Surgery, Val de Grace, and M. Charasse, Assistant Professor of Surgery, Val de Grace."

Experiments with the Gras and Lebel Rifle in France.

In a paper read before the Academy on 29th May, 1888, the authors, after a series of experiments most carefully conducted, reviewed the lesions produced by the bullet of the Lebel rifle, and came to the conclusion that the type of fractures caused by this small-bored rifle 8 mm. (0.315 inch) were, with some slight differences, almost the same as those that had already been described as caused by the Gras rifle 11 mm. (0.43 inch). Since then a further series of experiments have been conducted, and the effects produced by the two bullets have been compared—

1st. By firing the bullets at equal ranges.

2nd. By firing the bullets so that they should possess the same velocity at the moment of impact, which of course was only possible at very dissimilar ranges, owing to their different initial velocities.

The authors state that a condition of the first importance with respect to the value of the results was to fire at exactly similar parts of the limbs and of the bones of one subject, and, notwithstanding all their previous experiments, they have only taken account in the present paper of the occasions where the conditions in each case were absolutely fulfilled; they add, it is not any exaggeration to say that the results obtained present a high degree of accuracy.

Impact.—The shock impressed by the force of the projectile on a fractured limb was always shown to be much more considerable with the leaden bullet of the Gras rifle 11 mm. than with that of the Lebel rifle 8 mm., whatever might have been the distance, the velocity, or the points of bone fractured. The difference, however, was infinitely less marked, almost absent, in fact, when the soft parts alone were traversed. This fact was especially remarkable in firing from such ranges as 400 metres, and at certain bones, as the humerus or femur. These long bones, when struck by a Lebel bullet 8 mm. at ranges such as 300 or 400 metres, did not seem to have received a sufficient shock to lead the surgeons to believe that there was a fracture, which was discoverable only after a direct and close examination; whereas, when the bullet was from the Gras rifle 11 mm. the fracture could always be recognized at once by the oscillation of the limb. This absence of shock in limbs struck by the Lebel bullet appeared to be due to the greater power of penetration, to its smaller diameter, and to its preserving its shape unaltered.

The authors conclude from these experiments that the general shock, as well as the local shock, will be less with these new enveloped projectiles, especially when fired at distances over 400 metres.

Explosive Effects.—The bullets of the Lebel rifle 8 mm., as also those of the Gras 11 mm., produced, at distances relatively short, effects on the tissues which have been termed *explosive*. Under ranges of 300 metres, especially at ranges of 200 metres, with the Lebel rifle explosive effects were observed in wounds of the skin and muscles; the muscular tracks were very large, sometimes enormous, whether the bones were fractured or not. Indeed, with both the Gras and the Lebel rifle bullets, when they met a long bone capable of offering

some resistance, the lesions were so much the more considerable according as the velocity was greater; in a word, the shock, the destruction of the soft parts, and the comminution of bone increase with the velocity. With the Lebel bullet these effects were obtained almost regularly up to ranges of 280 metres, and sometimes in ranges of 300 and 320 metres, when the bullets encountered a hard resisting bone. With the Gras rifle 11 mm. such injuries were not produced much beyond 100 or 150 metres.

Examples of the so-called explosive effects are illustrated by the following experiments:—

Experiment I.—Gunshot wound from a Lebel rifle at 280 metres. The bullet hollowed out deeply the middle part of the right tibia, near its internal border a little obliquely. The wound of entrance had a diameter of 10 mm.; the wound of exit looked like a longitudinal bursting open of the skin 11 cm. in length, through which the muscles protruded; the fracture was very comminuted.

The gunshot wound of the Gras rifle at the same range produced a large hollowing out of the middle part of the left tibia, in all respects comparable in type to the preceding one, with detached splinters from the posterior face of the bone; moreover, a single fissure of 0.13 mm. in breadth split the external face of the bone. The wound of exit of this bullet had only the dimensions of the index finger. The lesion was grave, but it did not present by any means the degree of attrition, the extensiveness, or the comminution of the preceding injury.

Experiment II.—Gunshot wound of the middle part of the right thigh by a Lebel bullet at 280 metres. Fracture very comminuted of the femur, wound of entrance measured the same in diameter as the bullet, wound of exit was as broad and as long as the hand. The Gras rifle bullet only made a wound of exit on the opposite limb of the size of the top of the thumb, at the same range. The seat of fracture was, like the preceding one, 8 cm. in extent, but it was a less clean one than the other, although the amount of splintering was about the same. Fissures in the ends of the bone extended up for 6 cm.; but none were found in the right femur.

Experiment III.—In a third case, a gunshot wound of the middle part of the thigh due to a Lebel rifle bullet at a range of 320 metres, the following lesions were noted, which were very remarkable. At the side of the wound of entrance, which was clean and regular, and scarcely larger in diameter than the bullet, was a tear through the skin 0.12 metre in length, widely gaping, through which the mangled muscles could be seen. The vessels, apparently intact, but bruised, crossed the cavity. The wound of exit looked like a large square chasm 14 cm. in length, of tattered flesh held together in part by some filaments of the sciatic nerve. There was a clean fracture of the femur, with a loss of substance 9 cm. in length between the ends of the bone, which were not fissured. Such an injury as this had never been met with, the authors say, at such a range with the Gras rifle.

These kinds of injury explain what is meant by the explosive

effect of a solid bullet; it is just as if the wound had been made by an explosive bullet.

On the spongy and articular ends of the long bones, the destructive effects of the Lebel rifle at ranges of 200 and 280 metres were sensibly less than those of the Gras, but at closer ranges the effects of the two rifles were very similar and very severe.

To repeat, up to 100 metres, the two rifles produced occasionally the same kind of explosive effects. From 100 to 200 metres, the Lebel rifle continued to produce wounds of this kind when striking the shaft of a long bone, but at other ranges in the case of joints the Gras rifle was the more destructive.

From these experiments one fact is evident, that the severity of the injury is in direct proportion to the velocity of the projectile, and the amount of resistance it meets with. The Lebel rifle bullet presents a marked inferiority to the Gras rifle bullet, which is so easily altered in shape, when we consider its weight and the little tendency it has to become deformed.

At 1,600 metres, the Lebel bullet made a wound of entrance no larger than its own base, while at short ranges, both bullets made openings in the skin as large as the tip of the little finger. The wounds of exit in the case of both bullets when they had only passed through the soft parts presented no peculiarities.

Injuries to the Shafts (Diaphyses) of Long Bones.

The lesions produced on the shafts of the long bones by bullets possessing the velocity of the Lebel rifle for ranges up to 280 or 300 metres, and up to 100 or 150 metres for the Gras rifle, have been noticed under the heading of explosive effects.

At ranges from 300 to 800 metres.—The lesions of compact bone caused by either bullet were always most serious, but became less so as the range increased. The size of the splinters of bone increased, while the pulverization and scattering of the fragments of bone diminished, with the distance. The general characters, however, of the wounds caused by the two bullets were much alike, but with some differences.

The Lebel rifle bullet, on striking compact bone at these ranges, produced a pulverization, or a great shivering into pieces of the compact bone which were scattered with force in all directions. Of these particles of bone, some were free, and others remained adherent to periosteum; nothing like this was seen with the Gras rifle.

It often happened that fissures extending from the seat of fracture were less extended in the case of the Lebel bullet than in the case of the Gras. At these distances, however, the differences of action of the two bullets did not appear to be of great importance.

From 800 to 1,200 metres.—The Lebel bullet caused a less amount of comminution of bone than the Gras; there were fewer loose splinters of bone, and the extent of the fissuring was less; hence, the fractures of the Lebel bullet were, at this distance, less severe than those of the Gras.

Beyond 1,200 metres.—The Lebel rifle bullet appeared to produce more comminution of bone than the Gras; fractures of this kind were met with up to 1,500 and 1,800 metres.

Effects upon Joints (Epiphyses).

In the case of wounds of joints (epiphyses) beyond the range of 300 metres, the effects of the two bullets were very much of the same character, except that, owing to the difference in size and the maintenance of its proper shape, the Lebel bullet did not force so widely asunder the fragments of the articular ends of the bones.

Results obtained for the two Bullets with equal Velocities.

Some experiments were made with the two bullets when possessing the same velocities; to do this the range of the Gras rifle had to be lessened and that of the Lebel increased.

In these experiments the lesions produced by the Lebel rifle were less grave than those of the Gras; the general character of the types of fracture, however, varied but little.

In the case of the smaller and enveloped bullet there was a less-marked lateral displacement of the splinters attached to periosteum, and the loose, or nearly loose, splinters were not so forced into the surrounding muscular tissues. On the other hand, the Lebel bullet, with its great and mean velocities, was attended with more crushing or pulverization of the more compact bone at the wound of entrance, and with a greater breaking into small pieces of the loose splinters.

The differences observed in the two series of experiments are easily explained, the authors say. In firing with equal velocities, the weight and size of the Lebel bullet accounts for the less severe kind of lesions; but, at equal distances, this deficiency of weight and diameter is compensated for by the increase of velocity.

MM. Delorme's and Chavasse's Conclusions.

The writers of the paper, in their conclusions, say that the new projectile (the Lebel), owing to its increased velocity, possesses a greater power of penetration. It, in common with the Gras rifle bullet, at short distances produces explosive effects; between 300 and 800 metres the differences in effect are only of a slight character; both inflict very severe wounds; at 800 to 1,200 metres, owing to its small size and regular shape, it does not cause such severe injuries on bones as the leaden bullet of 11 mm., which so readily undergoes changes of shape, but thereby loses some of its force. Beyond 1,200 metres the bullet of the Lebel causes more comminution in the fractures it produces than that of the Gras rifle.

On the epiphyses and short bones, fractures and perforations of the same type and character are made by both bullets, but the smaller one causes generally less extended and less widely separated fissures,

the splinters from it are smaller and less broken up, and simple perforations are more often met with. In short, the wounds of joints by the Lebel rifle bullet are in general less comminuted and less severe.

If the envelope of the Lebel bullet broke, lead and possibly the deformed and empty case will be retained in the track.

Both bullets often carried in with them pieces of clothing.

Professors Chauvel and Nimier, of the Val de Grace, who have also made many experiments, do not altogether agree with the above conclusions, and are not inclined to give the Lebel rifle credit for more than an increased range with a consequent increase of penetrative power, which is in part due to the hard envelope, which does not usually undergo any change of shape.

Results of Experiments in this Country.

In some experiments carried out in this country with the Magazine rifle, a series of shots with the Metford bullet 0.303 were fired at the carcasses of horses at short ranges, viz., 100 yards. In all these instances, the so-called explosive effects upon tissues, whether hard or soft, were most marked, the bones were frightfully shattered, and the splinters and particles of bone were scattered far and wide in amongst the surrounding pulped muscles. In several instances, the envelope of the bullet had yielded when striking some hard resisting part of bone; the lead had then escaped, leaving an empty doubled-up case in the track. In such a case crushed bone and particles of lead were found in the pulped muscle. Unfortunately, no experiments were made at longer ranges. At the distance, however, of 100 yards hard compact bone was split into pieces, joint ends of bone were completely smashed, and such injuries were inflicted as would have been of the gravest character. Since these experiments were made, the cupronickel envelope of the bullet has been strengthened, and is consequently less liable to yield; the charge used was the ordinary service charge of compressed powder, and, in some instances, cordite or smokeless powder.

Conclusion.

In estimating the power of such rifles on the human body for purposes of warfare I do not think the wild game theory quite comparable. The sportsman's object is to bag his game; hence, in dealing with fierce animals, he must so stun them, if they are not killed outright, that they cannot offer any more resistance; again, in the case of deer, &c., it is well known that breaking the leg only is tantamount to losing the animal, unless a second shot is more successful. In fighting with Western nations there is very little fight left in a man once wounded by a rifle bullet; other reasons come into play; though there may be but little shock, the tendency of men when hit

is to fall out. Against some Eastern nations, especially when fanaticism exists, doubtless a stopping power is a desideratum.

It seems to me that some other lessons are to be learnt from the so-called Aldershot case referred to at length in the paper published in the November number of the United Service Institution Journal. The man was hit at a distance of 1 mile behind the 800 yards range, or at a range of 2,500 yards, by a bullet which, after encountering two ricochets and traversing 2,500 yards, had still sufficient energy to go right through the thick of a man's thigh, and bury itself afterwards in the ground.

If one may be allowed to conjecture, it is only fair to say that supposing the bullet had struck his chest or abdomen, it would have penetrated, if not perforated, these cavities, and so probably have caused the man's death; or, again, if the bullet had struck a joint, it would undoubtedly have split the bones forming it. At this distance of 2,500 yards would the Martini-Henry rifle have been able to touch him, and, if so, could it have caused more harm than a slight contusion without any breach of surface? Yet this small bullet, 0.303, not only hit the man but perforated his thigh, and, as the chance was, it merely created a slight flesh wound, whereas, if it had struck him in a vital part, it was quite capable of causing his death, or some serious injury to bone or joint that would have been the cause of a lengthened illness.

My object, however, is not to criticize, but to bring forward some experimental results, which, in my opinion, go far to prove that not only will a greater number of wounded fill our hospitals in the future, but that the character of the wounds produced by these small enveloped bullets are likely to be of a nature that will try the Surgeon to the utmost, and will not be conducive to the soldier's speedy return to a military life.