Operation. — The method of reduction will be made clear by the following diagram (Fig. 1):

FIG. 1. Diagram of upper surface of lower vertebra, arrows indicating movements for reduction.

This diagram shows the upper surface of the lower of the two vertebrae concerned, that is, the one in normal position. The articular processes of this vertebra are marked XX. The left articular process of the vertebra above having slipped into the intervertebral notch (Y), the situation of the spinous process of the dislocated vertebra will be indicated by the dotted lines. The direction in which the head must be tilted for reduction is indicated by the line Z (in other words, if the patient is facing north the head must be tilted southeast). Slight rotation in the direction of the short curved arrow on the right of the diagram may be necessary to free the process. After the articular process is freed, rotation into place in the direction of the long curved arrow on the left of the diagram will complete reduction. In case the right articular process is displaced by the dislocation, these movements must be reversed.

The patient should be in the sitting position for the operation, and the head should be rocked without traction, for traction only lessens the effectiveness of the fulcrum necessary to reduction.

LESIONS THAT AUGMENT THE DEVELOPMENT OF TETANUS AND OTHER INFECTIONS IN GUNSHOT WOUNDS.

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THE object of this paper is not so much to discuss the lesions that predispose to infection in gunshot wounds as it is to point out the histological anatomy of such wounds as revealed by microscopic sections.

Gunshot wounds are often referred to as punctured, penetrating or perforating wounds, such as are apt to be inflicted by any blunt instrument wielded with sufficient force. This idea is correct only within limits. A punctured wound from a blunt instrument exhibits lacerations and contusions in and immediately around the area of injury, while a punctured wound by a bullet propelled by a certain degree of velocity will

exhibit loss of tissue and lacerations, not only in the immediate vicinity of the channel made by the projectile, but lesions will appear in the parts beyond to an extent dependent upon:

- (1) The sectional area of the bullet.
- (2) Its velocity.
- (3) The resistance encountered on impact.

The greater the velocity or sectional area of the bullet, the greater will be the lesion in the surrounding tissues; and in those instances when the velocity is great, and the resistance on impact is unyielding, as in the case of a ball colliding with the shaft of a long bone like the tibia or femur, the destructive effects are enormous. These effects are so extensive that the wounds produced in this way are referred to as explosive wounds, or wounds showing explosive effects. It is not necessary to resort to the latter class of wounds to study the lesions that are thus created; in fact, microscopic sections of gunshot wounds in soft parts reveal all the characters of gunshot wounds sufficiently for the purpose of study.

Aside from the microscopic studies of the contused area, we know that the tissues are injured beyond the track of the bullet by certain appearances, which reveal themselves in the history of such cases. Thus slough often occurs in the skin beyond the margins of entrance and exit. Later, when healing is well along, a cord marking the track of the bullet running in the soft parts between the two external wounds is easily discernible to the sense of touch.

In recent studies upon the character of the various tissue lesions Strick has shown that hematوماتа especially predispose to the development of infections. He was able to show that hematوماتа in wounds increase the susceptibility to infection from tetanus a thousand times more than exists in a clean incised wound. More recently we have demonstrated that burn, as in toy-pistol wounds, adds to the susceptibility, and that animals infected in a cut made by a red-hot knife, with a certain spore mass of tetanus, died in every case, while animals similarly infected in incised wounds made with a cold knife lived in every instance.

Dr. Lardy, in the Greco-Turkish war, in commenting upon the conditions found in 95 infected gunshot wounds out of a total of 469 cases, gives the following:

Pieces of cloth in wound carried by the ball	13
Hematوماتа	3
Fragments of bone acting as secondary missiles	29
Lodged balls	22
Cause of suppuration undetermined	28
Total	95

In this estimate we must conclude that the percentage of cases showing hematوماتа is small in view of the twenty-nine cases which presented fragments of bone lodged as secondary missiles. Each one of these fragments was displaced by the force of impact, which of necessity possessed energy enough to rupture the tissue about it, and there was doubtless a corresponding degree of hematوماتа.

That suppuration should have been so seldom attributed to the lodgment of either the ball or the pieces of clothing seems to accord with the observations of Strick, who experimented with a known spore mass of tetanus with which he contaminated his bullets before firing into rabbits. The animals died of tetanus in every instance. In order to estimate the influence of implantation of foreign bodies in wounds devoid of the lesions which come with the mechanical effects of a missile while traversing tissues, he experimented with four different kinds of foreign bodies; namely, bullets, splinters, cloth and paper. Out of seven rabbits in which the ball was infected with a tetanus culture and implanted in a simple incision in the muscles of the thigh five recovered and two died. Six rabbits inoculated with splinters similarly treated and planted in clean cuts all got well. When placed on cloth and buried in clean incised wounds, the tetanus killed two rabbits out of six; and but one rabbit out of six died when the culture was placed on filter paper which was buried in a clean wound. These results, compared to those of Strick, in which every animal died when shot with infected balls, show that the lodgment of foreign bodies *per se* adds but little to the susceptibility to infection, and that the special lesions from a ball animated by a certain degree of velocity as it passes through tissues are necessary to augment the susceptibility to infection. As already stated, these lesions partake of the nature of hematmata.

The influence of velocity in creating hematmata in soft tissues was the subject of certain experiments that prove of value. We fastened a rusty nail of thirty-two calibers to the end of a board, and, using the board as we would the handle of a hammer, a perforated wound was inflicted in the thigh of a cat by delivering a sharp blow. In the other thigh we fired a thirty-two caliber bullet at a distance of one foot. After death a block from each wounded area showed no gross appearances of hematmata about the perforation caused by the nail, while hematmata extended in the interstices of the muscle fibers for a distance of 5 mm. about the bullet wound in the opposite thigh. The influence of velocity was again shown by firing into cats with the Krag-Jorgensen service rifle. We give below the measured distance of the hematmata as observed away from the channel made by the bullet:

Krag-Jorgensen bullet, cal. 30, v. 835 f. s., hematoma, 8 mm.
Krag-Jorgensen bullet, cal. 30, v. 1138 f. s., hematoma, 12 mm.
Krag-Jorgensen bullet, cal. 30, v. 2200 f. s., hematoma, 23 mm.

The areas, as influenced by this bullet in the order given, would, therefore, be as follows:

Velocity 835 f. s.	201 sq. mm.
Velocity 1138 f. s.	453 "
Velocity 2200 f. s.	1664 "

See Fig. 1 and 2. The extent of hematoma is marked by the darker areas.

It is thus seen that the extent of the hematoma increases with the velocity of the projectile to

a marked degree. The fact that destructive effects in the hard bones increased with velocity from the dispersion of the energy of the projectile was always appreciated, and the same factor doubtless accounts for the extent of the lesion in the soft parts.

Again, we know, as far as bone tissue is concerned, that the destructive effects increase with the sectional area of the bullet. That the same is true of the soft parts is shown below. The experiments were conducted by firing into the

FIG. 1. — Krag-Jorgensen bullet, cal. 30, vel. 835 f. s.

FIG. 2. — Krag-Jorgensen bullet, cal. 30, vel. 2,200 f. s.

gluteal region of cats with the Springfield and Krag-Jorgensen rifles, the velocity of the bullets remaining approximately the same. The measured distance of the hematmata from the channel of the bullet is:

Springfield rifle ball, cal. 45, v. 1301 f. s., hematmata, 30 mm.
Krag-Jorgensen rifle ball, cal. 30, v. 1138 f. s., hematmata, 12 mm.

The thoroughness with which tissues are often infected by the energy of an unclean bullet has a great bearing upon the susceptibility to infection. This is well shown by firing bullets of varying velocities and calibers into animals in which the skin has been well rubbed with finely powdered charcoal. The numbers in millimeters

represent the distance the charcoal particles were found in the tissues away from the channel caused by the bullet:

Pistol ball cal. 32, v. 300 f. s., 3 mm.
Krag-Jorgensen bullet. cal. 30, v. 2200 f. s., 10 mm.

FIG. 3. Springfield rifle bullet, cal. 45, vel. 1,301 f. s.

FIG. 4. — Krag-Jorgensen bullet, cal. 30, vel. 1,138 f. s.

If we compare the distribution of carbon particles as influenced by the sectional area of bullets, the velocity being about the same, we find the following:

Krag-Jorgensen bullet. cal. 30, v. 1138, 6 mm.
Springfield bullet cal. 45, v. 1301, 17 mm.

This result corresponds closely with that obtained by Koller and Karlinski, who found that foreign bodies (such as carbon or particles of cloth) were driven at a distance of $\frac{1}{2}$ to 2 cm. from the channel track while experimenting with the Swiss model reduced caliber rifle.

Among the lesions of gunshot wounds which predispose to infection another important factor (aside from the hematoma) is the fissuring, ex-

tending laterally from the channel track, and the disturbance of the muscle or tissue fibers, which is apt ultimately to lead to necrosis of the same. Microscopic sections show the muscle fibers torn, twisted, and otherwise distorted at a distance of 3 mm. to 10 mm. from the channel, varying with the velocity and sectional area of the projectile (see Fig. 5).

The foregoing has a very important bearing upon the rational treatment of gunshot wounds. In view of the extent to which extraneous matter

FIG. 5.

containing bacteria may be driven into tissues, it is hopeless to attempt to disinfect the channel made by a bullet. Extended experiments were conducted by Muller and Koller, in which they essayed various methods of treatment of the channel track in gunshot wounds caused by projectiles that were primarily infected, namely:

- (1) Controls, for which nothing was done.
- (2) Those treated with a glass drain.
- (3) Those treated with an iodoform gauze drain.
- (4) Those irrigated with a 5% solution of carbolic acid.
- (5) Those treated by rubbing with a cotton mop soaked in tincture of iodine.
- (6) Those treated by cauterizing the wound.

However treated, all the wounds were dressed with a clean sterile dressing.

The results showed that the animals treated by a simple dressing did best of all, and that all those treated by radical measures, such as swabbing with iodine and the application of the thermocautery, gave evidence of suppuration in every instance.

THE PLAGUE OF ATHENS.

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If one consults mythology the origin of the first great epidemics, so called, will there be found, but leaving aside the myths, it may be said that it is more than probable that the pathology of the