ON A CASE IN WHICH A MACHINE-GUN BULLET WAS EMBEDDED IN THE WALL OF THE HEART, WITH OBSERVATIONS ON THE CARDIAC MOVEMENTS OF THE BULLET DURING SYSTOLE AND DIASTOLE AND THE TRANSLATION MOVEMENTS DURING RESPIRATION AND CHANGES IN BODILY POSITION.

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Pte. J. W. H. was wounded on September 29, 1917, while lying on his back, by a bullet from the machine-gun of an aeroplane. The healed wound of entrance is small and situated 1\(\frac{1}{2}\) inches below and 1\(\frac{1}{2}\) inches internal to the left nipple.

An X-ray examination of the chest taken in January, 1918, at the 5th Northern Hospital revealed the presence of a bullet at a depth of about five centimetres from the surface of the body apparently embedded in the wall of the left ventricle near the apex and moving with systole and diastole and with the respiratory movements of the diaphragm. The bullet lies with its point directed towards the mid-line slightly backwards, and during normal respiration somewhat upwards (see fig. 1).

On deep inspiration the point of the bullet travels downwards so that in addition to lying on a lower level the bullet assumes a horizontal position, while in deep expiration it returns to the vertical position with the apex pointing upwards and slightly inwards. These respiratory translation movements are quite independent of the to and fro systole and diastole intrinsic movements which will be described later.

The composite diagrams, figs. 1 to 7 represent actual tracings on the fluorescent screen drawn under the same conditions of position of tube and screen and on the same scale. In each of the diagrams the letter B represents the shadow of the bullet, H the left border of the heart, D the left crest of the diaphragm. The suffixed letters I and E represent the position at full inspiration and expiration respectively. Where the right border of the heart is indicated the line is traced in the inspiratory position. A mid-position of the bullet between systole and diastole is indicated by the broken line. N represents the position of the left nipple. The borders of the vertebrae are outlined in correct position but the rib shadows have been omitted for the sake of clearness. The relation of the ribs to the heart and bullet were determined by X-ray photographs.

The alternating cardiac movements somewhat blur the outline of the cardiac shadow and that of the bullet, but in as much as the diastolic interval considerably
exceeds in the aggregate that of systole the shadows formed by the bullet and the heart correspond approximately to the position assumed during diastole.

We may now consider all observed movements of the bullet under three heads:

(1) **The Effect of Alterations in Bodily Position on the Position of the Heart.**

The level assumed by the bullet with the body in the erect position is lower by half the depth of the eleventh vertebra than the level assumed with the body in the supine position. The bullet shadow also approaches the mid-line in the erect position. The effect of forced inspiration causes the apex of the bullet to point somewhat downwards in the erect position while it is practically horizontal in the supine position. The alteration of outline of the left hand border of the cardiac shadow and its distance from the nipple line roughly coincide with these changes in the position of the bullet shadow in the erect and supine positions.

![Figure 1: Erect Position](http://militaryhealth.bmj.com/)

The greatest difference in lateral deviation of the bullet shadow is obtained by placing the patient on his right and left side respectively. When lying on the left side the bullet shadow closely approaches the nipple line, whereas when lying on the right side it almost reaches the left border of the spine.

(2) **The Effect of Respiratory Movements on the Bullet Shadow.**

During expiration the motion of the bullet has three components: (a) A translation upwards; (b) a rotation clockwise, as viewed from the front, in which the excursion of the apex of the bullet is greater than that of the base in each case; (c) a lateral motion of translation. This lateral movement is (on expiration) outwards away from the mid-line when the patient is standing or lying on his back or left side (see figs. 1, 2, 3), so that, neglecting any antero-posterior
Fig. 2.—Supine.

Fig. 3.—Lying on Left Side.
FIG. 4.—PRONE.

FIG. 5.—LYING ON RIGHT SIDE.
component that may be present the resultant movement is of the same type in these three positions. On the other hand, this lateral movement (also during expiration) is inwards towards the mid-line when the patient is lying on his face and on his right side (see figs. 4, 5), the excursion is greater in the latter than in the former position. In the prone and right-sided positions the movement of the bullet which accompanies the descent of the diaphragm in deep inspiration may be described as a dive downwards and outwards. The intermediate positions
taken correspond to those assumed by a diver when passing through the water from the vertical, through the horizontal to the reverse vertical position. The base of the bullet represents the head and the apex the feet of the diver. In the erect, supine, and left-sided positions, on the other hand, the bullet movement may be described as a fall into the water with the diver in the horizontal position with a tendency for the feet to travel backwards. An attempt was made to observe the respiratory movements of the bullet with the patient in the inverted recumbent position, both prone and supine. In the inverted supine position the respiratory movements of the bullet are practically the same as in the level supine position (see fig. 2), while in the inverted prone position the movement is much more restricted. In both inverted positions the heart shadow and the crest of the diaphragm assume a higher level.

It will be noticed that the upward movement of the bullet shadow during full expiration is in all positions less than that of the crest of the diaphragm. This is due to the fact that the bullet lies in the portion of the ventricle which occupies the angle between the diaphragm and the wall of the chest and not that portion which rests on the summit of the diaphragmatic dome.

(3) The Intrinsic Movement of the Bullet during Cardiac Systole and Diastole.

The continuous lines marked D in fig. 7, are copied from an X-ray photograph. They represent the relative positions of the left border of the heart and the bullet during moderately deep inspiration in the erect position. They approximate to the positions marked, H1 and B1 in fig. 1. The position of the left hand border of the heart and the bullet at the instant of cardiac systole are shown by the broken lines S. It will be seen that the excursion of the point is greater than that of the base of the bullet and opposite in direction to that of the left border of the heart. Thus the apex of the bullet and the left border of the heart tend to approximate during systole. The movement of the base of the bullet is very small and as far as can be observed is opposite in direction to that of the apex. It is probable that the diastolic and systolic relationship in the bullet motion is roughly the same in all positions of the heart as no observational evidence was obtained to the contrary.

REMARKS BY COLONEL C. J. BOND.

The evidence obtained in this case on the whole confirms the earlier observations carried out by the late Sir Victor Horsley and myself on animals at the Brown Institution in 1882, and by myself on the human subject by means of an air bag inserted into the oesophagus connected up with a tambour and recording drum. By this means records were obtained of the base beat of the heart and of the effect of variations in bodily position on the position of the heart and on intra-auricular pressure. These observations were published in the British Medical Journal on December 12, 1885. The evidence in the present case shows that the heart sits upon and by its under surface moulds itself to the convex dome of the diaphragm, at any rate during the uncontracted diastolic phase. It also occupies the angle between the thoracic wall and the rising diaphragm. The bullet lies apparently in that portion of the ventricle which occupies this angle. The chief movements of the heart in the chest brought about by changes in bodily position are lateral side to side movements and up and down alteration in level movements. Direct observation of the bullet shadow on the screen reveals
the great amplitude of these lateral movements when the patient turns from his right to his left side. The upward and downward movements are more complicated and differ in different bodily positions and in alternating phases of respiration.

Thus in the erect, the sloping supine, and the left sided positions, in all of which the heart moves freely, the effect of the descent of the diaphragm in inspiration is to cause the apex of the heart to fall, and while falling to pass a little inwards towards the mid-line. The heart assumes a more vertical position in the chest. Whereas in the right sided position, and partly in the lying prone position, the heart apex falls on inspiration, but it also passes somewhat outwards towards the nipple line. The heart lies more horizontally than in the other positions. In seeking for some explanation of this change in direction of heart movement during respiration according to bodily position we find that in forced expiration the bullet shadow passes through the same phases of movement in the reverse order. We know that with the patient in the right sided position the heart tends to recede from the chest wall in the nipple line and to fall back on its base on the spine. In these figures a larger area of cardiac shadow appears to the right of the spine and at the same time the extension of the left border of the heart on deep expiration is much less in the right sided than in the left sided or the erect positions (compare fig. 5, Hé and H¿ with fig. 3, Hé and H¿). The same thing occurs to a less degree with the patient lying on his stomach, this is probably due to the pressure of the abdominal viscera on the diaphragm.

What happens then in forced expiration during the rise of the diaphragm and the falling in of the chest wall is this:

In all bodily positions the portion of the heart which lies on the diaphragm is raised, but while in the erect, the sloping supine, and the left-sided positions this elevation is accompanied with a spreading outwards to the left, in the right-sided position the heart falls backwards and to the right on its own base, and when the diaphragm rises in forced expiration the portion of the heart resting on the diaphragm and the apex, which in this patient contains the bullet not only rises but passes inwards towards the spine.

The physiological and pathological effects on the function of the heart brought about by changes in bodily position both in man and animals were described in the paper previously published (see British Medical Journal, December 12, 1885).

A series of electro-cardiograms was taken but no change referable to the presence of the bullet was observed.

I wish to record my thanks to Sir James Mackenzie for his kind advice in this case, and especially to Mr. Jevons for the skill and care with which he has traced and recorded the cardiac movements.