inflammation. There was no fluid exudation of either blood or pus in the pericardial cavity, but the heart was covered by a shaggy layer of lymph about one-sixth of an inch thick. The wounds in the heart had healed perfectly.

There were several shreddy, *ante-mortem* clots entangled in the chordae tendineae of the right ventricle and a long narrow clot in the pulmonary artery extending into its right branch, besides the usual *post-mortem* clotting. There was an abrasion of the endocardium of the posterior wall of the right ventricle where the bullet had been lying, but the cavity looked normal otherwise. No wound of entrance was discovered. The heart was sent to the Royal College of Surgeons of England for further investigation.

There were several small clots in the branches of the pulmonary arteries with corresponding infarct areas in the lungs. The right lung had expanded to about two-thirds the size of the left. There were about two pints of blood-stained serous fluid in the right pleural cavity.

The cause of death was judged to be multiple pulmonary infarction from clots derived from the right ventricle.

REMARKS BY COLONEL H. M. W. GRAY.

I should like to add to the notes of Lieutenant Birkbeck and Lieutenant Lorimer that the irregularity of the pulse-rate (65 to 95) without extraneous cause, the occasional dropping of a beat, and the sudden pain and swelling in the right parotid and left leg (due possibly to small emboli) made me decide to operate. The patient was otherwise extraordinarily well, and showed no distress whatever. One did not care to risk postponing operation till the patient could be transferred to England.

The method of using the local anaesthetic was by infiltration of the line of incision and blocking of the intercostal nerves on each side from the fourth to the seventh. No anaesthetic was injected into or around the pericardium or pleura.

Interesting points about the operation are:

1. The complete success of the local anaesthetic. So far as I can gather, this is the first occasion on which any operation on the exposed heart has been done with local anaesthesia alone. The patient was not deeply under the influence of morphine. He responded to questions, requests, or suggestion at once.

2. The evanescent nature of the distress when the right lung collapsed.

3. The absolute absence of sensation of the pericardium, both parietal and visceral, and of the heart itself, to squeezing, pulling, pricking, cutting, or suturing. These manipulations caused, apparently, no interference with the cardiac action. During the extraction of the bullet at least one half of the right ventricle was firmly grasped between the fingers and thumb. The heart missed a beat repeatedly whenever the upper and back part of the interventricular septum was pressed, but began to beat again at once when this pressure was removed. I could not assure myself that the ventricles alone were implicated. The patient denied having any discomfort during these times, or indeed at any time during the operation, except when the right lung collapsed, and when the aspirating needle was being introduced into his chest, when he complained loudly of pain. Even swabbing out the pericardial cavity caused no pain. All these observations are very interesting when one thinks of the effect of similar manipulations of either bowel or parietal peritoneum.

4. There was a little difficulty in being certain of the position of the bullet, owing to its proximity to the interventricular septum, which, when contracted, gave a similar sensation on palpation. Therefore, a straight needle was used to locate the bullet definitely.

5. The method used to obtain rapid distension of the lung at the end of the operation—in the absence of a positive pressure apparatus. On account of commencing respiratory distress, aspiration was stopped after about 25 ounces of the saline solution were removed. It was thought that the remainder would be rapidly absorbed.

6. The possibilities of future successful operations for intracardiac conditions which are conjured up by the virtual success of this one. I understand that a French surgeon recently removed, with permanent success, a rifle bullet which had lain in the right ventricle for five months. Unfortunately, I cannot meantime give a reference to the account of his operation.

OBSERVATIONS ON THE DRAINAGE OF GUNSHOT WOUNDS.

By C. MAX PAGE, M.S., F.R.C.S.,
CAPTAIN R.A.M.C. (S.R.).

ONE of the prominent features of the surgery of the present war has been the necessity for the use of some form of drainage in a large proportion of the wounds met with.

It must at once be admitted that the practice is an undesirable one. Any drain inserted into the tissues has the irritant effect of a foreign body, and in the cases in point, an infective one. However, no means has yet been devised by which the evacuation of discharges and the prevention of the spread of infection can otherwise be secured. This being so, till the ideal method of treatment comes to light, one must employ the type of drain which most efficiently serves its purpose.

In civil practice, when drainage is necessary, standard rubber tubing has been commonly adopted, and in general the same material has been applied in the treatment of gunshot wounds. In this latter work I do not think that simple rubber tubes, either perforated or split, have proved entirely satisfactory, and I propose to describe a type of drain which, when it is a question of maintaining of wound track open in its whole extent, appears to have certain advantages over these.

It is difficult to form a judgement of such an appliance, as the standard of effectiveness does not admit of exact measurement. I will therefore merely attempt to present the reasons which suggested its design.

PRINCIPLES CONTROLLING WOUND DRAINAGE.

The first action of any drain is to prevent obliteration of the cavity by adhesion or apposition of its walls. The introduction of any foreign body effects this purpose, and it is the second action—namely, the evacuation of discharges from the wound track—which determines the surgical value of any particular pattern.

Supposing that no outside hydrostatic or pneumatic force be brought to bear, the movement of wound discharges is effected by two forces—namely, gravity and capillary tension.

1. *Gravity*.—The action and value of gravity in wound drainage is so well accepted that it need not be enlarged upon here.

2. *Capillary tension* is the only force effecting drainage in the reverse direction. Its activity is directly proportionate to the capillary surface in action, and is affected by the viscosity of the fluids in question. The coefficient of capillarity is higher for water than for any other fluid; it becomes lower in proportion to the albuminous material added.

The condition and nature of the surface dressing also controls the movement of fluids in the subjacent wound—thus, when the dressing is completely saturated, no further movement of fluid along the capillary column abutting upon the dressing will occur.

The value of the above forces will vary in respect of different kinds of wound; three main types may be recognized, namely:

1. A cavity—for example, an empyema or a definitely localized abscess.

2. A potential cavity—for example, the track of the wound caused by a missile which has lodged.

3. A potential tubular space—for example, the track formed by the passage of a missile through the substance of a limb.

The method by which drainage is effected in these three types may now be considered.

1. A Cavity.

In the case of a cavity the volume of fluid to be removed will be relatively large, and the drainage of the track from the surface will be usually of little importance. In these circumstances a simple tube placed so as to reach the inner surface of the cavity will, if acting in the direction of gravity, give ideal results.

2. A Potential Cavity.

In the case of a blind track there may be a foreign body or dead material at the end which cannot be completely

removed, and, as far as the drainage of this part is concerned, the above considerations hold good. Drainage of the track, however, is also probably necessary, and the observations made below on the third type of wound will then apply.

3. A Potential Tubular Space.

The track formed by the passage of a missile will contain blood clots and debris; the collapse of its walls will in most cases obliterate the cavity. The injury will have opened up a series of connective tissue planes, and the aim of drainage is to prevent the spread of infection along them. As the exact position of the openings of these planes cannot be determined, the ideal drain should evacuate discharges from the entire inner surface of the wound track. Thus a simple tube lying in the track will permit discharge in the capillary space between its outer surface and that of the wound track; but when, as rapidly occurs, this space becomes clogged by clots or the viscosity of the discharge, the movement will cease. In this instance the action of gravity is acting at a disadvantage in the small capillary surface.

If a rubber tube with side holes be used, its action will not be very different. The perforations are rapidly filled in with granulations and intruded tissue. The discharge which there may be in the direction of gravity from the lumen of the tube will come from these buds of half-strangulated tissue, and satisfactory drainage from the connective tissue planes is impossible. The same observation holds in relation to a perforated metal or glass tube.

A gauze wick acts ideally for a time, but it becomes so rapidly saturated and put out of action that it is of no value in practice.

In general it will be admitted that drainage is rapidly inhibited in all wound tracks, whether a drain is inserted or not, either by the clotting of the discharges or by the obstructive action of the surrounding tissues.

The aim must therefore be to overcome this tendency to stagnation. The hypertonic saline advocated by Sir A. Wright induces a fluid discharge which does not clot. Its use, therefore, facilitates as well as increases wound discharge. But to obtain the best results this solution must be brought into contact with the entire surface of the wound, either by continuous irrigation or by frequently repeated lavage.

The above-mentioned types of drainage tube do not allow this purpose to be fully effected, but I think the form I describe below fulfils this requirement, and also increases the capillary drainage surface in action.

THE GUTTER DRAIN.

The tube should be made of rubber. In section it is star or pinion shaped (Fig. 1). The outside diameter should be the same as that of full-sized ordinary drainage tube.

For certain cases the drain should be provided with a central lumen (Fig. 2). The tube is passed through the entire length of the wound track; the upper projecting extremity is capped by a piece of thin rubber tubing (shown in Fig. 2)—for example, a cut rubber glove finger—which extends just into the entry of the wound.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1.—Section of gutter drain. Natural size.

Fig. 2.—Section of gutter drain with a central lumen. The section also shows the cap. Natural size.

Fig. 3.—Gutter drain extemporized from sections of ordinary rubber tubing sewn together centrally. The cap is not shown. Natural size.

It will be seen that, as a result, a series of gutters lying against the wound surface extend the length of the track. When fluid is syringed into the cap, it passes down each gutter, so as to bring the solution into contact with practically the whole wound surface, at the same time clearing away from the same area all debris. After lavage, the maximum capillary surface in proportion to the size of the drain is in action. When this type of tube is employed

for blind wounds (Type 2), the provision of a central lumen (Fig. 2) allows the fluid to be syringed to the bottom of the track, whence it will return along the various gutters.

Theoretically, it might be expected that this drain would give good results with continuous irrigation, but in practice relatively forceful periodical washing out of the gutters has proved more satisfactory.

It has not been possible to obtain drains quite in the form depicted, but I have for some months used a substitute made from ordinary rubber tubing. The tube is halved longitudinally; three lengths are then lightly sewn together to form the drain. It is capped as described above.

The appearance of a section is shown in Fig. 3.

As stated above, whatever drain is put in the tissues the reactionary tissue formation round it soon leaves only a capillary space between wound surface and drain; for this reason, if it is necessary to leave the drain in place for more than a few days, and, in addition to lavage, periodical movement of the drain of the gutter type is desirable.

Conclusion.

In conclusion, it should be repeated that the above drain has only been used in its extemporized form. It is not suggested that it affords an ideal method of wound treatment, but in two respects it appears to be an improvement on the patterns in common use—namely:

1. The drain forms with the surface of the wound track, in proportion to its diameter, the maximum capillary space, along which the evacuation of fluids can occur.
2. It admits of lotions being brought into general contact with the surface of the wound track while the drain is in place.

REFERENCE.

¹ Magnus, *Hydrostatics and Pneumatics*, p. 89, 1909.

THE RECRUIT'S HEART.

A MEMORANDUM FOR MEDICAL EXAMINERS.

BY

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SINCE the outbreak of the war I have seen a large number of healthy young men rejected as recruits because of some manifestation of the heart which the examiner took to be abnormal and a sign of weakness. I have also seen a number who have been invalided out of the army because of these manifestations.

At the request of the War Office I drew up recently a memorandum upon this subject to serve as a guide to medical examiners of recruits, and as this memorandum may not come before all the examiners, Sir Alfred Keogh has asked me to call attention to it. It is as follows:

THE SIGNIFICANCE OF ABNORMAL SIGNS IN THE RECRUIT'S HEART.

It should be understood that the healthy heart in the young can exhibit murmurs, and variations in rate and rhythm, which are perfectly physiological in origin and indicative neither of disease nor of impairment.

The Functional Efficiency of the Heart.

Before examining the heart, find out the functional efficiency by ascertaining how it responds to effort. This is shown by finding out the amount of exertion the candidate has been accustomed to take in the past in his work or play, and if he can undergo severe bodily exertion without distress.

Murmurs.

The physiological murmurs are always systolic in time, and the situation of the greatest intensity may be at the apex, mid-sternum, or base of the heart. If the candidate's response to effort be normal, and the heart normal in size, the murmur is negligible, for it is manifest that, if the cause which produces the murmur hampers or embarrasses the heart in its work, the size of the embarrassed chamber will increase, and its functional efficiency be impaired.