drained freely into the bladder, and the gauze packing was almost dry when removed on the fourth day. Uninterrupted recovery.

REFERENCES.

- ¹ *Exploration radiographique de l'appareil urinaire*, Paris, 1913.
² Newman; BRITISH MEDICAL JOURNAL, April 10th, 1900, and March 24th and 31st, 1906. ³ Newman: Calculi impacted in Ureters, *Lancet*, April 21st, 1900, Case III.

(To be continued.)

REMOVAL OF A BULLET FROM THE RIGHT VENTRICLE OF THE HEART UNDER LOCAL ANAESTHESIA.

REPORTED BY

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With Remarks by

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PRIVATE A. was admitted to a general hospital on July 19th, 1915, having been wounded eight days previously. The bullet had passed through and killed a man in front of him. A. was knocked down, but did not lose consciousness, and had not had any discomfort other than slight pain from the wound. There was a small dirty wound ($\frac{1}{2}$ in. diameter) just below and to the right of the xiphi-sternal junction, and also a painful swelling of the right parotid gland, which disappeared next day. The patient showed no other symptoms during the first few days. He was kept in bed. The heart appeared to be normal and regular. The pulse varied between 80 and 90. The evening temperatures rose to 100° to 101° F.

X-ray Report by CAPTAIN S. F. McDONALD, R.A.M.C.

July 21st, 1915.

"There was an entry wound in the right epigastrium, but on examination no shadow could be seen in the abdomen.

"The lungs and pleural cavities were normal. The diaphragm moved well and evenly on both sides. The heart was normally situated, but there was some slight increase of cardiac shadow on the right side. In the lower portion of the heart shadow was a very sharply defined dark shadow moving with the heart, and also apparently laterally in relation to the heart. This last movement suggested that the object was free in the pericardial cavity, but on turning the patient over it was seen to lie quite definitely in the substance of the heart. It had a distinct rocking movement. No antero-posterior movement was visible in relation to the heart.

"The object seemed to be in, or close to, the lowest portion of the wall of the right ventricle. Its shape and size, so far as could be made out, were those of a rifle bullet. Attempts to take radiograms were unsuccessful."

Colonel Gray, consulting surgeon, saw the patient first on July 25th, and again on July 26th, on which day a sharp pain developed suddenly in the left leg. As the pulse during the night of July 26th had shown some irregularity, rate 65 to 95, and the heart had occasionally dropped beats, an operation was decided on and performed on the morning of July 27th. Veronal, gr. v, was given on the evening before, and three doses of morphine, amounting in all to $\frac{1}{2}$ gr., during the morning before operation. The patient was not unduly under the influence of morphine. He was screened again just before the operation and conversed, sat up, and turned himself smartly when asked to do so.

Operation.

Under local anaesthesia (eucaine 1 per cent., potassium sulphate $\frac{1}{4}$ per cent., and adrenalin) Colonel Gray made a wide horseshoe-shaped incision, convexity upwards, extending along the sixth costal cartilage on each side and across the sternum at the level of the attachment of the fifth cartilage. This incision was used so as to make an

exposure of the track of the bullet in the depth. The perichondrium was separated from the left sixth cartilage, which was cut across at the costo-chondral junction and used as a lever to elevate the sternum while the triangularis sterni, pericardium, etc., were being separated off the posterior aspect of the flap. A small portion of the right sixth rib was removed close to the costo-chondral junction. The sternum, at the lower border of the fifth costal cartilages, was grooved deeply with a gouge and divided with bone forceps. The soft parts were then separated from the sternum and ribs so that the flap could be turned downwards and forwards. When the flap was pulled forwards a hole about an inch long appeared in the pleura on the right side, in the track of the bullet. The right lung collapsed. The respirations became laboured and quick, the patient coughed jerkily; he became anxious and complained that he was breathless. The colour remained good, and he settled down in about one minute, after being reassured by the surgeon. Except for this disturbance there was apparently no discomfort during the entire operation.

The flap was held forward by hooks, and the pericardium opened obliquely from the base to near the apex of the heart. About a drachm of slightly bloodstained fluid was noticed in the pericardial cavity. The heart looked normal. No wound could be seen. On digital exploration the bullet was felt to be lying, apparently fixed, at the back of the heart, either in the wall or cavity of the right ventricle. The point of the bullet was near the apex of the ventricle. During the manipulations the heart was noticed to miss a beat occasionally—when touched at the upper and back part of the interventricular septum.

The right ventricle was seized with a pair of catch forceps near the apex. When it was seen that this caused no disturbance a suture was passed through the muscle adjacent, and by these the heart was held forward. This in no way agitated the patient. On further exploration the bullet was definitely located by probing with a needle, and was thought to be fixed in the right ventricle near the posterior coronary vessels. After manipulation, the bullet was felt to change position and to be free inside the ventricle. It was worked away as far as possible from the coronary vessels and grasped between the thumb and finger. Two stitches were inserted into the muscle wall over the bullet. The wall of the ventricle was incised for half an inch, and the bullet removed with forceps. While the wall of the ventricle was still being held firmly between the finger and thumb the stitches were tied.

On removing the catch forceps there was brisk bleeding, which was stopped quickly by an under-running stitch. The pericardial cavity was wiped free of blood-clot and was filled with normal saline to expel the air; it was then sewn up. The right pleural cavity was next filled with saline and the injured pleura sewn up. While the wound was being closed the chest was aspirated to remove the saline. This aspiration was the only part of the operation which seemed to cause the patient any pain.

The patient was wonderfully comfortable on being taken back to bed, but about four hours after the operation the respirations rose suddenly to 48 a minute, and remained at about that level till he died, except for part of the day of July 29th and 30th, when, the patient being deeply under the influence of morphine, they dropped to 28 a minute.

He was much troubled after this occurred by mucus collecting in large quantity in the throat and the upper part of the trachea. Various remedies were tried for this, with little avail. He took nourishment fairly well. Cardiac stimulants were used after the first two days.

On July 29th his mind began to wander, and he was often delirious till the time of his death on July 31st. He lived nearly four and a half days after the operation.

There was never any indication that the operation on the heart had interfered with its action, which, though quick (average 120 to 130), was wonderfully strong up to within a few hours of his death. No dropping of beats was noticed after the operation.

Necropsy.

At the *post-mortem* examination it was found that the external wound had healed well; there was no sign of any

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