WAR WOUNDS AND AIR RAID CASUALTIES

The following is one of a series of lectures on the Treatment of War Wounds and Air Raid Casualties recently delivered at the British Postgraduate Medical School

GUNSHOT WOUNDS OF THE CHEST*

BY

G. E. GASK, C.M.G., D.S.O., F.R.C.S.

In the latter years of the great war we saw many changes in the treatment of gunshot wounds of the chest. During the first two years of war very little was done. The usual treatment afforded was to put the patient to bed, give him some morphine and a cough mixture, and hope for the best. If an empyema formed a portion of rib was excised and the pleural cavity was drained by means of a tube. As might be expected, the mortality was great, and in non-fatal cases convalescence was often prolonged.

The reasons for the non-intervention were three. First, experience of the South African War, where the ground was dry and clean and where wounds were largely due to rifle bullets, led our surgeons to the belief that chest wounds were best left alone; secondly, it was believed that it would be fatal to open up the chest cavity without the aid of some form of pressure chamber; thirdly, it was thought that handling of the lung would provoke fast and fatal bleeding. Experience proved these assumptions wrong, and a complete change was made in our practice, not from the discovery of any new method, but by the application to these injuries of the general principles of surgery which govern the correct treatment of all wounds—namely, early mechanical cleansing by operation followed by early closure.

Types of Wounds

The types of wounds commonly met with in a casualty clearing station are as follows: the through-and-through wound caused by a rifle bullet; the through-and-through wound caused by a shell fragment; the lodging wound with retention of a large foreign body; the lodging wound with retention of a small foreign body; and the open sucking wound of the thorax, with or without retention of a foreign body.

Causes of Death and Prolonged Illness

If complicating wounds are disregarded the causes of death from pure chest wounds may be divided into three groups: deaths on the battlefield or in a few hours after admission to a medical unit due to injury to large vessels or an extensive lesion which cannot be aided surgically; deaths after forty-eight hours—these are almost always due to sepsis of the pleural cavity and its contents; and deaths at the base after seven days. In the last group again the cause of death is almost invariably sepsis. Therefore the guiding principles in treatment of chest wounds, as in any other wound, must be the elimination of contamination before organisms have had time to invade the tissues.

Channels of Infection

Granted that the chief danger to a man wounded in the chest is infection, it is necessary to see how organisms reach the chest cavity. The pleural cavity may be

infected: (1) by the missile and portions of the clothing or equipment carried in by it; (2) from the wound of the lung in which a missile, a splinter of bone, or a portion of clothing may be retained; (3) through the wound in the chest wall. A wound that opens direct into the pleural cavity, through which air is constantly sucked, will always lead to infection, and unless dealt with is often fatal. Further, a wound, even of moderate dimensions, through which air is not being sucked, unless adequately dealt with, may suppurate in the course of a few days, and if the thoracic cavity is not sealed off organisms gain entrance to the pleural cavity, where they find the blood a convenient medium for growth. This accounts for many cases which exhibit septic changes only after an interval of five or six days.

Primary Measures

The principle to be aimed at, therefore, is the early mechanical cleansing of the wound, both of the chest wall and of the injured viscera; the evacuation of all foreign bodies and of effused blood from the pleural cavity; the repair or suture of the damaged lung; and the closure of the chest cavity by suture. To arrive at this, when a patient suffering from a chest wound is admitted to a casualty clearing station he should be put to bed and allowed to rest undisturbed to recover from shock. The only exception to this rule is when there is a large open blowing wound of the chest. In such a case the opening is at once closed by temporary skin suture. The relief given is immediate, and it is generally advised that a blowing chest wound should be sewn up at the earliest possible moment in the advanced medical units.

Patients with retained missiles should be submitted to x-ray examination for information concerning the position and size of the foreign body, the existence and extent of haemothorax and pneumothorax, and the condition of the opposite lung, cardiac displacement, and movement of the diaphragm.

Indications for Early Operation

These are as follows: a ragged wound of the soft parts; bleeding from the parietal wound; compound fracture of the ribs; suction of air into the pleural cavity; retention within the chest of a large foreign body; great pain due to in-driven splinters of bone; rapidly increasing pneumothorax due to a valve-like opening into the pleural cavity which allows air to be sucked in and prevents expulsion; and a large haemothorax which cannot be evacuated by aspiration. When none of these indications are present—that is, when the wounds of the chest wall are small and clean, such as those made by a rifle bullet, when the ribs are not splintered, when the foreign body retained is small—the patient is treated on general medical principles.

Treatment by Operation

The best time to operate is as soon as possible after the receipt of the wound, provided the patient has recovered from the initial shock. Patients bear operation well and take a general anaesthetic satisfactorily. It is unnecessary to use any form of pressure chamber.

* The substance of this lecture was presented to the ninth annual session of the Clinical Congress of the American College of Surgeons in 1918, and appeared in *Surgery, Gynecology and Obstetrics* in the following year.

Wounds of Soft Parts of Chest Wall.—Wounds of the soft parts, unless small and clean, should always be excised even if nothing further is done, because otherwise they suppurate and infection is liable to spread along the track of the missile into the pleural cavity.

Fracture of Ribs.—Excision of the soft parts leads the surgeon to the ribs. More often than not the ribs or scapula are broken, and, whether or not the chest is to be opened, the splinters of bone should at least be removed, ragged ends of rib cut cleanly off, and all dead tissue excised.

Thus the first step in the treatment of a chest wound is to make a careful complete excision of the parietal wound. In some cases this is as far as the surgeon should go. Excision of the wound allows a thorough examination, which may reveal either a bleeding intercostal artery or a large hole, hitherto unsuspected, leading into the chest, and a finger introduced into the pleural cavity may discover splinters of bone, either free or sticking into the lung. Such splinters ought to be removed, for they play a great part in the production and maintenance of sepsis.

At this stage the case has been converted into one of open haemothorax. Two courses are now available to the surgeon: he may do what is called the complete operation, opening the chest, repairing the lung, cleansing and closing the pleural cavity; or he may content himself with the excision or with suturing the parietes after evacuation of the blood from the pleural cavity either by rolling the patient or by aspiration. The decision may be difficult. My belief is that if any operation is undertaken for a penetrating wound of the chest it should be done completely, as yielding the best results in the long run.

Retention of a Large Foreign Body

By a large foreign body is meant a shell fragment of about one inch by half an inch. Such a fragment not only injures tissue but carries in with it fragments of clothing which unfailingly cause contamination. Therefore it should be a rule that all large missiles be removed at an early date. The operation may be done either by enlarging the original wound or by a fresh incision, and the surgeon is guided in his choice by the position of the missile relatively to the wound, as seen by the radiograph. Where possible thoracotomy through the wound is preferred, but in any case the original wound or wounds must be completely excised. A fresh thoracotomy may be done by resection of four inches of rib or by an incision in the intercostal space. The easiest route is probably via the fifth rib in the anterior or mid-axillary line; through such an incision with the use of a retractor or rib spreader any part of the pleural cavity can be reached. On looking into a chest thus opened the first thing seen is a quantity of blood, the greater part of which is unclotted—at any rate during the first two or three days after injury. This must be removed by mopping. The cavity of the chest is now visible, the chief objects seen being the collapsed lung, the dome of the diaphragm, and the mediastinum. The missile may be evident at once, but, if not, it may be sought by inserting the hand into the pleural cavity; if it is lying in the lung it can be felt with the fingers, and be removed either through the wound of entry in the lung or by fresh incision into lung tissue.

Lung tissue may be excised without fear, because any fresh bleeding following incision is easily controlled by suture. Continued bleeding from the lung is exceedingly rare. *Arrest of bleeding follows spontaneously from col-*

lapse of the lung; and early operation within twelve hours after injury does not cause recrudescence of bleeding. The wound in the lung itself should be excised, when possible, in the same way as a wound of the soft parts—that is to say, it should be cleaned mechanically and sutured. It should be sutured for two reasons: first, because even if not completely freed from organisms there is evidence that the lung is capable of dealing with a considerable amount of infection, as proved by the rarity of gas-gangrene infection; and, secondly, because restoration of function is hastened.

Abdomino-thoracic Injuries

Injuries involving both the chest and the abdomen are not infrequent, and may be either single or multiple. When a missile has traversed both chest and abdomen the diaphragm is necessarily injured, and abdominal viscera may herniate into the pleural cavity. This is more often found on the left than on the right side, because on the latter the liver affords protection. The diaphragm can only be repaired efficiently from above, therefore it is wise to open the chest first, replace the abdominal viscera, suture the diaphragm, deal with the chest as already indicated, and then, if there is evidence of injury to the hollow viscera, laparotomy may be performed. The passage of a small missile through the diaphragm may not necessitate repair; in such a case, with evidence of injury to hollow viscera, the abdomen is given preferential treatment.

Haemothorax

The question often arises as to the correct treatment for a patient with haemothorax of moderate dimensions and in whom there is no retained missile and no large wound of the parietes—that is to say, a case of uncomplicated haemothorax. The majority of these cases recover with aspiration. A certain proportion, however, become infected. If it were possible to foretell which cases would become infected, then there is no doubt that they would be operated on at an early stage, the haemothorax evacuated, the damaged lung repaired, and the chest closed. So far as is known there is no way of foretelling this; therefore, to prevent any possible infection it would be necessary to operate on every case—a course which is not advocated, seeing that many of these patients get well by themselves. The usual practice is to aspirate the haemothorax as completely as possible and make every effort to detect signs of infection at the earliest moment. The only certain evidence of infection is either a positive bacteriological finding or the removal of stinking fluid. By clinical signs it is often possible to diagnose the existence of infection before organisms can be detected by the bacteriologist.

The essential treatment, as soon as infection is proved or suspected, is to empty the chest of all blood and clots. This cannot be done by aspiration; so open operation must be employed. The common practice has been the resection of an inch of rib and insertion of a tube. Provided the operation is performed within a few days after receipt of the wound it is better to do a wider resection, cleanse the pleural cavity, and close the chest, subsequently keeping the pleural cavity dry by aspiration. This method offers the following advantages: the chest may remain closed; the lung is allowed to expand and adhesions may form which will prevent complete collapse, even if the pleural cavity is subsequently drained; respiratory distress is much less with a closed chest; and if infection persists and the chest has to be drained it is very easy to take

out a few stitches and insert a tube. Drainage of a chest, like amputation of a limb, should be regarded as an admission of surgical failure.

Contraindications for Operation

These are: shock and collapse, such as would be contraindications for any surgical procedure; small clean wounds without evidence of serious intrathoracic injury; and collapse of the opposite lung as indicated by inspirating retraction of the chest wall on the side opposite to the wound—in this case an anaesthetic on opening of the chest may be fatal.

Operative Technique

Thoracotomy through the Wound.—The first essential is the complete excision of the wound, including the skin, muscles, and broken ends of rib. This having been done, the chest should be opened with fresh instruments. An incision is made from the edge of the wound through the skin along the line of the broken rib, either forwards or backwards, to obtain the best access to the cavity of the chest. The muscles are incised down to the rib and retracted, and the periosteum incised along the middle line of the exposed rib. Along this line the periosteum is stripped off with a rugine. A Doyen's periosteal rib elevator is then inserted and the periosteum entirely separated. The bone is now cut through with a pair of rib shears or bone forceps and removed. To allow free access to the pleural contents and insertion of the hand it is necessary to take away four inches of rib. The posterior layer of periosteum of rib with the parietal pleura attached is next incised with a pair of scissors along the middle of the gap. Then a retractor or rib spreader is inserted and the chest opened widely.

Thoracotomy by Fresh Incision.—As previously stated, this operation may become necessary when thoracotomy through the wound will not allow access to the injured portion of the lung—for instance, when the wound is in the lower and posterior part of the thorax and the foreign body near the hilum or in the upper lobe of the lung. Resection of four inches of the fifth or sixth rib in the anterior axillary line gives a good exposure of the thoracic contents, and if there are no other considerations this is probably the best and easiest route to follow. It has to be remembered, though, that if drainage of the pleural cavity has to be performed later on it cannot be done effectively through this incision. Therefore, if the nature of the wound and missile is such as to indicate probable future infection it may be advisable to choose a lower rib and make the incision more posteriorly. A six-inch incision is made along the line of the selected rib and continued down to the periosteum, which is stripped off the anterior surface with a rugine. With rib elevator and shears four inches of the rib are resected. The posterior layer of periosteum with the parietal pleura attached is then incised along the whole length of the middle of the gap, and the retractor or rib spreader inserted.

Procedure within the Thoracic Cavity

After the chest has been widely opened, either through the wound or by fresh incision, it is advisable to remove the blood from the pleural cavity—first, because it is easier to see what has to be done, and, secondly, because removal of the blood relieves respiratory difficulties by lessening pressure on the mediastinum. The blood can be removed by rolling the patient on to his side. Probably, however, it is better to do it by swabbing with gauze and scooping

out the clot with the gloved hand; less disturbance is caused to the patient by this method. This done, the gloved hand should be inserted into the pleural cavity and swept around in order to detect and remove any splinters of bone which may be lying free, or the missile and portions of clothing. These are most likely to be found in the pleuro-diaphragmatic reflexion. Next, the foreign body, if retained in the lung, may be detected by the fingers, and with the aid of two pairs of lung forceps the affected area is brought into the opening of the chest. The lung can be handled as easily as a coil of intestine, and without causing a great fall in blood pressure.

Treatment of the Wounded Lung

A foreign body, when present, seems generally to lie near the surface of the lung, and can easily be removed; if necessary, a small incision may be made through the lung substance. The hole in the lung should now be explored for splinters of bone and shreds of clothing, and cleansed as far as possible by swabbing. When there is a large ragged wound, and it is anatomically possible, a wedge of lung may be removed or the edges of the hole clipped with scissors. In any case, whether the wound is excised or not it should be closed by catgut sutures in either one or two layers, according to the depth of the wound. Bleeding is easily controlled by such suture.

Cleansing of the Pleural Cavity

In most cases it is only necessary to cleanse the pleural cavity by swabbing it dry and clean. If, however, there has been much soiling it is advisable to wash it out with either warm saline or eusol. In any event the chest should be left dry, an essential factor in the early expansion of the lungs.

Closure of the Chest and Post-operative Treatment

Whether the operation has been performed through the wound or by fresh incision, the chest should always be closed. The relief afforded is instant and marked. An attempt should be made to repair the chest wall in layers—pleura to pleura, muscle to muscle, and skin to skin. Where a large hole has been blown through the chest wall it may be impossible to get the edges of the pleura to meet; in that case muscle should be made to cover the gap, even if a flap has to be cut. Finally, the skin should be closed by interrupted sutures. In the majority of cases healing will be by primary union.

Regular post-operative aspiration is generally required to keep the pleural cavity dry, for after a big operation there is usually a fluid exudate, which if not removed may become infected.

C. L. H. Majoor (*Nederl. Tijdschr. Geneesk.*, 1939, **83**, 1725) records a case of agranulocytosis in a man aged 51 following the treatment with prontosil for erysipelas. In the course of thirty days he had in all 52.2 grammes of prontosil album and 10 c.cm. of prontosil soluble. Although examination of the bone marrow—obtained by sternal puncture—and of the blood showed a complete absence of neutrophils, the patient recovered, though in convalescence a leukaemic attack occurred. Treatment was by two injections of pentose nucleotide intramuscularly. Majoor has collected fourteen other similar cases following the administration of prontosil for subacute endocarditis, pyelitis, gonorrhoea, and puerperal fever in patients aged from 11 to 63; of these fourteen patients ten died and four recovered.