THE MEDICAL ASPECTS OF INJURIES OF THE CHEST

(Being a Lecture delivered to the members of Sector 3 of the E.M.S.)

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When I was asked to give a lecture in this series and was told that the title that had been chosen was "The Medical Aspect of Chest Injuries," I was in some doubt what exactly it meant. Even now I am not quite sure what it was intended I should talk to you about. The advantage, however, of being asked to give a lecture with an ambiguous title is that one is left with a fairly free hand in the choice of one's method of dealing with the subject.

It seems to me that a consideration of the medical aspects of injuries of the chest should include a reference to the different varieties of thoracic injuries that are met with, together with the methods of dealing with them which come within the scope of the physician; some mention of the complications that may ensue on such injuries (how they may be recognised and how they may be treated); and finally an indication of the occasions on which the assistance of a surgical colleague should be sought, and what he should be asked to do.

DAMAGE TO LUNG BY BLAST

The blast from a bomb dropping in the near vicinity of a victim may result in severe injury to the lungs without producing any external injury to the chest wall. In such an event, in the absence of sudden death, which is very liable to occur, symptoms very similar to those of acute pulmonary oedema develop. The patient is usually rendered unconscious and there is severe dyspnoea, cyanosis and expectoration of the characteristic frothy blood-stained sputum. On physical examination râles of all types are heard scattered widely over the chest. The majority of the cases die within a few hours of the injury. The common post-mortem findings are pulmonary and pleural haemorrhages of varying size and extent.

At one time it was throught that these results were produced by the alterations in the intra-bronchial pressure either by the positive wave that accompanies the bursting of the bomb or the negative wave that succeeds it. More recent experiments in animals, however, suggest that it is rather the alterations of pressure acting on the outside of the chest wall that causes the damage.

Treatment.—In the absence of any more definite knowledge of the mechanism by which bomb blast produces its effect on the lungs, little save symptomatic treatment is available. Morphia and possibly atropine should be given, though the efficacy of the latter is open to considerable doubt. Oxygen should be administered in the presence of cyanosis, and coramine injected to stimulate the heart.

FRACTURE OF RIBS

Crushing injuries of the chest may cause fracture of the ribs without any trauma of the overlying skin or the underlying lung. More rarely the sternum may be fractured. The treatment of such injuries consists in the application of overlapping strips of adhesive plaster extending from the mid-line in front to the mid-line behind, special care being taken in the application to avoid the ends of the fractured ribs penetrating either the skin or the lungs.

High-Tension Pneumothorax.

The end of a fractured rib may lacerate the underlying lung, producing a broncho-pleural fistula and a resulting pneumothorax. In many such cases, owing to a valvular action of the opening in the lung the air enters the pleural cavity during inspiration but is unable to escape during expiration, so that with each breath that the patient draws the intrapleural pressure rises.

Symptoms.—The chief symptoms of this condition are severe and increasing dyspnoea and cyanosis.

Physical Signs.—The physical signs of a high-tension pneumothorax are: on inspection, some prominence with deficient movement of the chest on the side affected; absent voice conduction; a hyperresonant or tympanitic percussion note and absent breath sounds. In addition the heart and mediastinum are displaced to a variable extent to the contra side. The extent of this displacement is dependent not only on the height of the intra-pleural pressure but also on the mobility of the mediastinum. This mediastinal mobility appears to vary considerably

in different individuals, so that the degree of shift of the structures within this compartment caused by air or indeed by fluid in the pleural cavity on one side also varies within considerable limits.

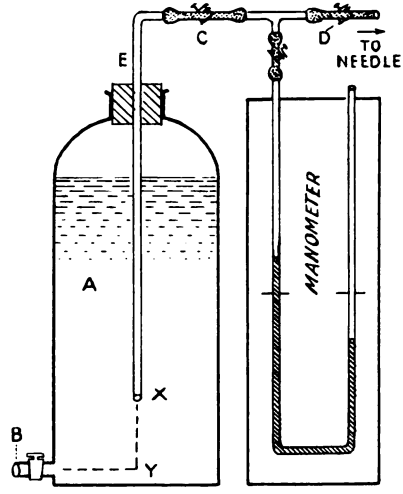
Treatment.—The treatment of high-tension pneumothorax may be considered under two heads:

(1) The immediate relief of the more urgent symptoms.
(2) The subsequent measures that may be employed to assist the re-expansion of the lungs.

The circumstances under which injuries producing a high-tension pneumothorax are sustained are usually such as to preclude the employment of any elaborate apparatus immediately in their treatment. It is, however, necessary to relieve promptly the urgent symptoms. This can be effected by the insertion of a hollow needle into the pleural cavity through an intercostal space. A large bore needle is preferable, but any needle that happens to be available will suffice. By this means the air is able to escape from the pleural cavity and a high positive pressure is converted into an atmospheric pressure. The lung will, of course, remain completely collapsed as long as the needle is in the chest, as re-expansion cannot take place till the intra-pleural pressure becomes negative. The reduction, however, of a positive to an atmospheric pressure is sufficient to relieve to a great extent the urgent symptoms.

(2) When the patient has been removed to a hospital further measures may be taken to assist the re-expansion of the lung. If the needle that has been inserted between the ribs be removed, it will be found, if the opening in the lung is of a valvular nature, that the intra-pleural pressure soon rises and the dyspnoea returns. This contingency may be met by the removal of sufficient air (generally about 1,000 c.c.) to leave a negative pressure. As this procedure may have to be repeated for some time, and often at frequent intervals, some method of continuous air suction is preferable. Dr. Foster-Carter, the R.M.O. at Brompton, has devised a simple and efficient apparatus for this purpose.

The apparatus consists of a large bottle, A, capable of holding at least 80 oz. of fluid and having at the bottom an outlet, B, provided with a tap (see figure). This outlet tube must



be straight and not curved downwards, otherwise it may act as a siphon. The neck of the bottle is closed with a rubber cork, pierced by a tube, E, which dips below the level of the water in A and can slide in the cork, so that its height may readily be altered. When tap B is opened water will flow from bottle A, and air will be drawn in through tube E. If E is closed, or if it communicates with a closed cavity, a negative pressure will develop within it, proportional to the height of its lower end, X, above the level of the outflow, Y. Thus, if the distance X–Y is 10 cm., a negative pressure of 10 cm. of water will develop in E when tap B is opened.

When this apparatus is used in the treatment of spontaneous pneumothorax, the suction tube E is connected by rubber tubing with a pneumothorax needle strapped in position. It is also convenient to incorporate a water manometer in the system to measure both the intra-pleural pressures when clip C is closed and the negative pressure developed by the apparatus.

when clip D is closed. Bottle A should be refilled, with clip C closed, before the water falls below the level of X.

Massive Collapse of the Lung.

Another result of thoracic injuries, both in the type we are considering now and also those associated with external wounds, is massive collapse of the lung. The collapse may be either on the same side as the injury or on the contra-lateral side. It may involve the whole lung or only one lobe. Various explanations of its mechanism have been put forward, but it is probably true that it is caused in most cases at all events by obstruction of the bronchus by mucus or blood.

Symptoms.—The symptoms associated with massive collapse of the lung will naturally vary according to the extent of the lung affected. When it is the only pathological condition resulting from the injury and the whole of one lung is involved (a rare condition) there will be dyspnoea, cyanosis, pain in the chest and a non-productive cough associated with signs of shock. When a smaller area is affected similar symptoms of a lesser degree will be observed. When the collapse supervenes on other results of thoracic injury there may be an intensification of already existing symptoms or the condition may go unnoticed. For this, as well as many other reasons, an X-ray picture of the chest should be taken with a transportable apparatus in all cases of chest injury.

The physical signs of massive collapse are deficient movement, a dull percussion note, absent voice conduction and absent breath sounds over the area affected. The apex beat and possibly the trachea are displaced towards the affected side. It is only by this displacement of the mediastinum to the homo-lateral side that it is possible clinically to distinguish between massive pulmonary collapse and fluid in the pleural cavity. In the latter the heart is either in the normal position or displaced to the contra-lateral side, and in the former it is displaced to the homo-lateral side.

The radiological appearances of massive collapse are characteristic. In the case of involvement of a lower lobe, for instance, the skiagram will show a uniformly dense opacity at the base. The upper limit of this opacity is sharply demarcated and runs downwards and outwards from the hilum, and is formed by the interlobar septum, which is shifted downwards.

Prognosis.—Left to themselves these cases may terminate in one of three ways: (1) The plug of mucus may be coughed up and the lung re-expand. (2) Infection of the lung distal to the obstruction may occur, with a resulting lung abscess. (3) The lung may remain permanently collapsed, and though no infection occurs, undergo fibrotic changes with secondary bronchiectasis.

I am confident that many of the cases of that relatively common condition of bronchiectasis in collapsed lobes is the result of the blocking of a bronchus by mucus following an operation; pneumonia or trauma, and could have been obviated if the obstruction had been recognised and removed at the time of its occurrence.

Treatment.—It is true that in many of these cases the plug of mucus is coughed up, but as it is impossible to forecast in which cases this will not happen I am sure that it is wise, if there is no sign of re-expansion of the lung in a week's time, to pass a bronchoscope and suck out the obstructing material. This operation can be performed under a local anaesthetic and in the hands of a skilled operator, with very little strain even on a seriously ill patient.

Haemothorax.

Blood may be poured into the pleural cavity either as a result of crushing accidents or of penetrating wounds of the chest. In either case, as far as the haemothorax is concerned, the treatment is the same. In addition to the blood, air may escape into the pleural cavity, either through the external wound or as a result of laceration of the lung, producing a haemo-pneumothorax.

Physical Signs.—A small effusion of blood into the pleural cavity may produce dullness to percussion, bronchial breathing, and increased voice conduction without any displacement of the apex beat. Failure to recognise this fact frequently leads to an erroneous diagnosis of pneumonia. A large effusion will produce absolute dullness or flatness, and absence of voice and breath sounds, with displacement of the heart to the contra-lateral side. When, in addition to the blood in the pleural cavity, there is a massive collapse of the lung beneath, the heart will be either in the normal position or even displaced to the same side. In such equivocal cases the diagnosis can always be arrived at from the radiological appearances.

In the case of a haemo-pneumothorax the physical signs will be a flat percussion note, with absent breath and voice sounds over the fluid below and a hyperresonant note and absent voice and breath sounds over the air. This is of course in the erect position. In addition a splash may be elicited on shaking the patient, and rarely the physical sign known as metallic tinkling may be detected.

Radiological Appearances.

Haemothorax.—A skiagram will show a diffuse uniform opacity, of varying extent according to the amount of blood present. The density is greatest at the base and gradually lessens as it approaches the upper limit. The upper limit is therefore not clear cut and extends outwards and upwards from the mediastinum to the axilla.

Haemo-pneumothorax.—When fluid and air are both present the fluid presents a uniformly dense opacity which in the erect position has a clear-cut horizontal upper limit, the so-called fluid level.

In cases of both haemothorax and of haemo-pneumothorax it is advisable to have lateral as well as antero-posterior pictures taken.

Treatment.

In all cases of traumatic haemothorax I advise early and complete removal of the blood by aspiration. In cases of tuberculous serous pleural effusions it is my custom to leave them alone in the absence of certain clear-cut indications. When, however, we are dealing with traumatic haemorrhage into the pleural cavity certain additional factors are present which call for the invariable removal of the blood.

The chief considerations which justify this method are:

(1) In view of the properties of blood as a culture medium there is a grave risk of infection through the external opening when one is present and via the blood stream or the lung in compression injuries.

(2) It is much easier, if the blood is aspirated, to determine whether the bleeding has stopped.

(3) The presence of blood in the pleural cavity for any length of time is very liable, as a result of the deposit of fibrin on the pleural surfaces, to initiate a pleural fibrosis and thickening which may seriously mitigate the chances of the lung eventually regaining its full functional capacity. In this last connection it may be mentioned that, contrary to what might be expected, although a certain amount of fibrin is deposited on the pleural surfaces, the blood in the pleural cavity does not form clots to any considerable extent. Though various theories have been suggested, no entirely satisfactory explanation of this has been put forward.

Method of Aspiration. Air Replacement.

When the haemorrhage is due to laceration of the lung, the accumulation of blood in the pleural cavity will collapse the lung and so tend to check the bleeding. This consideration has been advanced as an argument against aspiration, and indeed it is a very valid reason against permitting a *sudden* re-expansion of the lung. It is an objection, however, which is completely overcome by aspirating the blood by the method of air replacement. A detailed description of this operation can be found in *Modern Treatment of Diseases of the Respiratory System* by Punch and Knott.

Infected Haemothorax.

As already mentioned, a sterile haemothorax may produce a temperature as high as 103, which, however, usually falls to normal in the course of two or three days. In unaspirated cases the blood may remain sterile for many days, infection occurring quite suddenly. In such cases the temperature again rises and assumes a septic character, the fluid in the thorax increases, the pulse rises, the tongue becomes dirty, and the patient develops a toxic appearance. Examination of the fluid in the chest removed by exploratory puncture reveals the presence of pus and pyogenic organisms. In all save the very mildest cases, which may possibly clear up with the administration of sulphapyridine combined with aspiration, immediate *intercostal drainage* is indicated. It cannot be too strongly insisted that resection of a rib and open drainage, at all events at this stage, will not only greatly increase the mortality in these cases but is also contrary to the elementary principles of thoracic therapeutics.

Continuous drainage by this method for a prolonged period will, in favourable cases, result in re-expansion of the lung and obliteration of the empyema cavity. In the course of time the pus may become too thick for adequate drainage to take place through the intercostal tube. In these circumstances it will be necessary to get a surgeon to resect a *small* portion of rib and to insert a Tudor Edward's tube, which fits tightly through the chest wall into the empyema cavity. This should again be connected to the bottle and drained under water. Re-expansion of the lung may be assisted by the application of a continuous negative pressure of 5 cm. of water by means of a suction pump attached to a Robert's bottle fitted with a special manometer.

It is most important that the tube shall not be removed till the empyema cavity has become completely obliterated. The retention of even a small pocket in the thorax after the wound has closed will almost inevitably give rise to a recurrence of the empyema at a later date. The progress of the obliteration should therefore be assessed from time to time by skiagrams taken in the lateral and antero-posterior views after injection of neohydriol into the empyema cavity through the external wound.

Infected Haemo-pneumothorax.

In cases of injury to the chest resulting in laceration of the lung and the escape of blood and air into the pleural cavity, pyogenic infection is even more liable to occur than in simple haemothorax. The treatment for these cases also is intercostal drainage under water. The need for strict adherence to the closed method of drainage should be even more apparent. The collection of air and fluid in the pleural cavity results, in the absence of adhesions due to previous disease, in complete collapse of the lung away from the chest wall towards the mediastinum, and when infection occurs the whole of one side of the thoracic cavity is converted into an enormous abscess cavity. The only hope of obliterating this abscess cavity is to establish drainage under such conditions as will allow of re-expansion of the lung. With open drainage, where air is sucked into the chest with each inspiration, the intrapleural pressure will always remain at that of the atmosphere, there is no hope of any re-expansion of the lung ever taking place. It is only by the establishment of closed drainage, possibly assisted by suction, that a negative pressure can be produced in the pleural cavity and the lung induced to re-expand and by adherence to the chest wall eventually obliterate the abscess cavity. Where this obliteration remains incomplete it may be necessary to perform some form of plastic operation to bring about the desired result.

WOUNDS OF THE CHEST

So far I have dealt with most of the intra-thoracic conditions resulting from injuries of the chest, both those without and those with external wounds. The management of such wounds themselves is, of course, a surgical matter, and a detailed description of them is beyond the scope of this lecture. A brief reference to the general principles of their treatment, however, is permissible for the sake of completeness.

Small penetrating wounds of the chest may give rise to no symptoms and therefore require no treatment beyond the application of a sterile dressing.

When either the entrance or exit wound is sufficiently large to allow air to be sucked in with inspiration and expelled with expiration, an open pneumothorax is produced. This state of affairs is associated with signs of marked shock, intense dyspnoea and cyanosis. Such wounds should be sewn up at the earliest possible moment. When facilities for immediate suture are not available, the opening should be made as air-tight as possible by a pad held firmly in position by adhesive plaster.

When the patient has been admitted into hospital, the question of the advisability of surgical interference will arise. Tudor Edwards has laid down certain indications for thoracotomy in such cases. Since I agree entirely with them I cannot do better than quote his words.

(1) A penetrating wound which is accompanied by signs of persistent bleeding into the pleural cavity.
(2) Wounds associated with fractures of ribs or scapula where in-driven fragments of bone are probable.
(3) Wounds with large retained fragments of missile.
(4) Abdomino-thoracic wounds.
(5) In view of the presence of phosphorus in incendiary bullets it may be advisable to remove all retained bullets.