CHEST SURGERY IN WAR

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SOME ASPECTS OF CLOSED WOUNDS OF THE CHEST

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An attempt is here made to consider, necessarily from a main theoretical standpoint, the possible effect of advances in knowledge and technique in the treatment of wounds since the war of 1914-18.

Of such advances three are outstanding. They are: chemotherapy for the control of infection; increased understanding of the technique of artificial pneumothorax; and the development of thoracic surgery, including the elucidation of the principles of drainage of the pleura by closed methods.

Principal Dangers

The chief dangers of wounds of the chest are, in roughly chronological order, mechanical dangers, haemorrhage, and infection.

Mechanical.—Open pneumothorax, due to large gaping wounds in the chest wall through which air freely sucks in and out, or "traumatopnoea," is productive of great respiratory and circulatory distress; the necessity for early surgical intervention in such conditions is obvious. Consideration of these cases is outside the scope of the present discussion; but after surgical treatment of the wounds the thorax will often be closed completely, leaving the patient in a position comparable to that of one whose wounds have been "closed"—that is, not permitting the free ingress and egress of air—from the beginning. Closed pneumothorax, unless of large size and under tension, is not in general productive of distress or respiratory embarrassment: this, of course, is abundantly demonstrated by the large number of patients with therapeutic pneumothoraces, even bilateral ones, who are able to lead active lives. A closed pneumothorax in which the pressures are known and controlled may actually prove to be of benefit in the treatment of certain types of chest wounds. The only sort of pneumothorax without external "sucking" wound which is dangerous to life is that which is under tension because of a valvular pleuro-bronchial communication. This requires active treatment. Experience in 1914-18 showed that such a tension pneumothorax is a relatively rare complication of chest wounds.

Haemorrhage.—This may occur from the lung or from the chest wall. Bleeding from the lung may be into the pleura, giving rise to pneumothorax, generally haemopneumothorax; or into the bronchi, giving rise to haemoptysis of varying grades of severity; or into both pleura and bronchi. In either case this form of bleeding may be controlled more or less completely by collapse of the lung by pneumothorax. Bleeding from the chest wall may be either external, through the exit or entrance wounds, or into the pleura, causing haemothorax. Such bleeding can be controlled only by surgery, since the bleeding vessels—generally intercostals—cannot be compressed satisfactorily by any indirect method.

Infection.—Infection is the immediate cause of the late mortality in chest wounds. Its incidence and nature obviously depend to a large extent on the environmental conditions at the time of wounding. During the war of 1914-

18 conditions were so unfavourable that it is surprising that the incidence of infection was not much higher than that actually observed. The following figures may be quoted:

Elliott and Henry (quoted by Duval):

Cases of haemothorax, 500—	
Infected by anaerobic organisms	87 (17%)
Duval (1918):	
Bullet wounds, 49: Infected	0
Shell wounds without retained fragments, 33: Infected	6 (18%)
with	28 (24%)

Conditions favourable to the development of anaerobic gas-producing infections are provided by the presence of large masses of blood and fibrin clot in the pleura. Hence it is probable that early aspiration of haemothorax may lower the frequency of such infections; and while no statistics are yet available, there can be little doubt that prophylactic chemotherapy by sulphonamide drugs can reduce very considerably the incidence of infections in general. These considerations are important in relation to the question of the maintenance of pneumothorax in chest wounds involving the lung; for if the pleura becomes infected the presence of a large pneumothorax may determine the conversion of what might have been a small localized empyema into a large generalized pyothorax, the gravity of the prognosis and the difficulty of treatment being thereby much increased. Thus if infection is to be expected in from 20 to 40% of cases, as in 1914-18, the maintenance of pneumothorax may well be considered to be more dangerous than useful. On the other hand, if the incidence of infection can be reduced by chemotherapy and early aspiration the maintenance or induction of pneumothorax—the possible benefits of which have been outlined—becomes a matter for serious consideration.

Significance of the Intrapleural Pressure

The measurement of the intrapleural pressure is a very simple matter, and in cases of traumatic pneumothorax much useful information may be derived from it.

Any standard type of artificial pneumothorax apparatus incorporates a manometer with which such a measurement may be made; but if this is not available all that is required is a water manometer connected by rubber tubing to a needle. The manometer may consist of a simple glass U-tube, 30 cm. or more in length, with water standing at rest half-way up each limb: it should be remembered that a change in level in one arm of one unit is equal to a change in pressure of two units, since the change is accompanied by an equal one in the opposite direction in the other limb (Fig. 1). If the needle is by error introduced below fluid, the fluid may be sucked into and out of the rubber tubing; the latter should therefore be sterilized. If it is sterilized by boiling care should be taken that water is shaken out of it as completely as possible, since a small amount of water blocking it will prevent the accurate reading of the intrapleural pressure. Though a special needle is a pleasant luxury any needle of reasonable gauge can be used. About 9 s.w.g. is the smallest practicable gauge, and for simple measurement of the intrapleural pressure in an already existing pneumothorax there is no advantage in using a specially stout-gauge needle. The needle should also be dry; this may be secured by taking it out of spirit and carefully flaming it. To measure the intrapleural pressure in a traumatic pneumothorax a convenient area in an intercostal space above the level of any fluid that may be present should be anaesthetized (though in emergency—e.g., tension pneumothorax—this anaesthesia may be omitted) and the needle inserted through this area into the pleura.

The intrapleural pressure is generally expressed in centimetres of water below and above atmospheric pressure; for convenience the symbols - and + are used to denote these

pressures, though strictly, of course, the term "negative pressure" is nonsensical. Thus $-x$ cm. of water is used to mean x cm. of water below atmospheric pressure. Also, the intrapleural pressure normally becomes more subatmospheric in inspiration and less so in expiration. The mean intrapleural pressure is generally taken as the arithmetical mean of the pressures in inspiration and in expiration. The normal mean intrapleural pressure varies from about -5 to -9 cm. of water.

FIG. 1.—Simple water manometer.

The respiratory excursion of pressure varies greatly with such diverse factors as the depth of respiration and the gauge of the needle; thus with a mean intrapleural pressure of -6 cm. the manometric excursion may be -7 , -5 , or -8 , -4 , or -10 , -2 , etc.

As the size of the pneumothorax increases, the intrapleural pressure also steadily increases, at first becoming less subatmospheric, until in a large pneumothorax it exceeds atmospheric pressure, and in "tension" pneumothoraces mean pressures of $+10$ or $+20$ cm. may be attained. The level of intrapleural pressure at which the pneumothorax causes respiratory distress varies greatly, depending upon such factors as the mobility of the mediastinum and the presence and extent of pleural adhesions; most adults are not distressed with an intrapleural pressure equalling atmospheric, provided it is gradually attained, though with an abnormally mobile mediastinum even -2 cm. may be accompanied by distress. In judging the probable effect of a pneumothorax in contributing to symptoms of distress the measurement of the intrapleural pressure must be correlated with the physical signs, especially the position of the apex beat.

Other pathological conditions besides pneumothorax cause changes in the intrapleural pressure. Of these the most important from the point of view of chest wounds is atelectasis of the lung. Atelectasis causes a diminution in the intrapleural pressure—i.e., the pressure becomes more subatmospheric. The phenomenon is observed even in the presence of a pneumothorax: thus if the pressure in a pneumothorax which has averaged -4 cm. suddenly becomes -10 cm., the most likely explanation is that part of the lung has become atelectatic. Depending upon the mobility of the mediastinum, a contralateral atelectasis will cause a greater or lesser change of similar sort in the pressures in a pneumothorax.

Another variation in intrapleural pressure which is of importance in dealing with older persons is that occurring as a result of pulmonary emphysema. In this condition the normal mean pressure more nearly approaches atmospheric the more severe the changes in the lung. Hence in older men all pressures will be expected to be a little above—i.e., less subatmospheric than—those observed in younger men.

Surgical Intervention

It cannot be doubted that the following three conditions are urgent indications for surgical intervention:

Large External "Sucking" Wounds.—The closure of these is a matter of extreme urgency. As a first-aid measure an air-tight dressing must be applied, and surgical closure as early as possible is indicated.

Extensive External Wounds and Haemorrhage from the Chest Wall.—These are to be treated on the ordinary surgical principles of excision of wounds and control of haemorrhage.

Evidence of a Retained Foreign Body.—The influence of this complication on the incidence of infection has already been noted. Although an immediate recovery may be made without undue delay in cases in which there is a foreign body retained in the lung itself, experience has shown that in a large proportion of these cases chronic pulmonary suppuration—chronic abscess and bronchiectasis—develops subsequently.

Opinion may be divided, however, on the extent of the surgical intervention in these cases, on the application of surgical treatment to cases not showing these indications, and on the relative merits of complete closure of the chest after operation or drainage by a closed method.

With regard to the extent of surgical intervention, this must in practice depend very largely upon the available facilities, both of personnel and of equipment. Without the services of a specialist thoracic surgeon it would certainly seem wisest to confine surgical intervention to thorough attention to the three points mentioned above. In favourable circumstances more complete operations on individual cases and the extension of surgical treatment to suitable cases not showing these urgent indications may prove to be advisable. The extent to which such urgent surgery is likely to be required may be exemplified by the figures of Duval (1918), who was one of the first surgeons to advocate the application of the ordinary principles of wound surgery to chest wounds. He reported that of 161 cases he operated on 46 (29%); 29 (18% of the total) of these were urgent operations for haemorrhage or open thorax, and 17 were later operations for removal of foreign bodies or for "direct treatment of the lung wound." Of the 46 cases operated on 13 ended fatally. 102 cases presented no indication for operation; of these only 1 ended fatally. The statistics were complete, with the exception of deaths occurring at regimental aid posts.

With regard to the question of complete closure of the chest or air-tight (under-water) drainage after operation, the latter has become a routine with many thoracic surgeons for a few days at least after thoracotomy. The advantages of this procedure are that it acts as a safeguard against the development of pressure pneumothorax and that it drains away blood and pleural exudate. The disadvantages are that it often requires much attention for its smooth maintenance, and that it considerably diminishes the ease with which a patient can be moved—a matter that may be of great importance under war conditions. Also, the rapid re-expansion of the lung which a properly arranged under-water drainage secures may be actually disadvantageous if there is a wound of the lung itself; clearly this will tend to heal more readily if the lung remains collapsed for a few days. It need hardly be mentioned that in the presence of a free pleura any form of drainage except air-tight under-water drainage is highly dangerous. On the whole, then, it would seem best, after operative treatment of the limited sort mentioned above, to close the chest completely. This leaves the patient in the same position as regards after-treatment as one with a "closed" wound which has not required operation. Of course, these remarks on drainage do not apply to cases treated in special centres where more radical surgical treatment, even involving lobectomy, may be carried out.

(The article will be concluded in our next issue.)