INFECTION OF HAEMOTHORAX BY ANAEROBIC GAS-PRODUCING BACILLI.

BY

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(Continued from p. 418.)

THE MAIN CLINICAL TYPES.

THE forms in which infections of a haemothorax by anaerobic gas bacilli may present themselves fall clinically into five distinct groups, which are differentiated by the predominance of toxic symptoms or of the features of gas formation respectively. These cannot, so far as we know at present, be correlated with particular varieties of the infecting bacilli, though they are to some extent governed in their development by the admixture of anaerobes with streptococci and other organisms.

The groups comprise the following:

Acute or Fulminating.

These may develop to a fatal issue two or three days after the wound.

1. The *acute pneumothorax type*, in which gas is formed with overwhelming abundance, and to some extent overshadows the toxic features of the illness.
2. The *fulminating septic type* with jaundice or delirium.

Progressive.

In these the infection becomes evident from the fourth or fifth day onwards.

3. The *pneumothorax type*, in which the chief feature is a localized or free collection of mal-odorous gas within the pleural cavity, while the toxic features are relatively mild.

4. The *toxic forms* are characterized by: Jaundice, epistaxis, and fever; restlessness, pain, and delirium; tachycardia, fever, and a hectic flush of the face.

Chronic.

5. These develop simply as an ordinary empyema, without marked features of sepsis or the liberation of much gas.

The cases described below as illustrations of these various clinical types were all seen, by the courtesy of the various medical officers concerned, in the military base hospitals at Boulogne.

ACUTE PNEUMOTHORAX TYPE.

CASE I.—*Early Death from Infection which was Wrongly Regarded as a Simple Pneumo-haemothorax.*

Pte. T. April 25th, 1915. Wounded in chest by shell.

Second day: Admitted to base hospital; cyanosed and collapsed. Temperature 98.6°, pulse 118, respirations 28. Heart displaced two inches to the left, and signs of extensive pneumo-haemothorax on the right side.

Third day: Heart not displaced any further. Constant irritable cough. Temperature 98.6°, pulse 120, respirations 36. Slight tendency to mental wandering. Death.

Autopsy found very foul gas and blood in the pleural cavity. The middle lobe was perforated by a ragged wound, and the lung was covered with septic clot which was pitted with rain-drop markings from the development of gas within its substance. (Specimen in War Office collection.) There was early suppurative pericarditis and a necrotic laceration of the liver.

The clinical opinion, on account of the absence of fever, was that the haemothorax was sterile and that the wound had caused death by progressive haemorrhage and escape of air into the chest. The rapid pulse and the tendency to delirium should have corrected this wrong diagnosis. Probably the infection was so serious that the man's life could not have been saved. Without an autopsy to prove the infection, opinion would naturally have regarded this

early death as due to an ordinary pneumo-haemothorax, which had been aggravated by the journey to the base on the second day.

CASE II.—*Septic Case, Mimicking Acute Pneumo-haemothorax; Rib Resected: Recovery.*

Sapper H., R.E. June 5th, 1915. Wound of right chest by rifle grenade.

Seventh day: Moved to base hospital. Dyspnoea increased rapidly in the train, and the patient arrived almost pulseless.

Eighth day: Very ill, but perfectly conscious. Slight cyanosis. Body bathed in icy cold sweat. Tongue clean, but tremulous. Temperature 100°, pulse 132, respirations 40. Heart displaced 2½ inches to left and signs of large pneumo-haemothorax on right. Except for the toxic sweat, the patient's condition was exactly what would have been expected from a supposed leak of air and blood caused by the journey. Explored: Foul gas and dark purple blood, which was teeming with *B. sporogenes*. Intercostal drainage at once, since the patient was too collapsed to endure a fuller operation.

Tenth day: Rib resected.

Twenty-fourth day: Recovered well. No secondary fever. Heart back to normal position, but right lung still much collapsed. Patient discharged to light duty at end of three months.

CASE III.—*Large Gas Pneumo-haemothorax: Recovery by Drainage, but Death from Secondary Haemorrhage.* (See Chart 1.)

Pte. B., Shropshires. June 4th, 1916. Wounded in back of chest by shell fragment. Haemoptysis.

Eleventh day: Arrived at base, extremely collapsed. Temperature 97°, pulse 120, respirations 40. The orderly officer on night duty at once aspirated 20 oz. of foul blood. A few hours later, the patient was still desperately ill, and slightly delirious, but not jaundiced. The left side of the chest was immobile, and bulged outwards by an enormous intrapleural collection of gas. The heart was displaced beyond the right nipple, and the veins of the neck were distended. Part of a rib was now resected under local anaesthesia, and clots of blood had to be pushed aside in order to liberate the foul gas from within. The organisms were not identified.

Fifteenth day: Heart almost back to normal position.

CHART 1.—From Case III, commencing on the fourth day after the wound. The pulse-rate per minute is shown on this and all succeeding charts by the heavily dotted line, and the readings of this curve are given by the numbers on the right hand side of the chart. The paper upon which these charts are drawn gives slightly wider spacing vertically, and therefore a greater magnification of the curves than that given by the ordinary Army Form B 181.

Patient very comfortable and looking well. Temperature 100°, pulse 110. Eusol lavage of pleural cavity.

Twenty-second day: Patient so well that evacuation to United Kingdom was promised in a couple of days' time.

Twenty-third day: A little fresh blood appeared in the sputum. Temperature rising to 102°. Patient complained of "gassy smell in his mouth and a feeling like a football in his chest."

Twenty-fifth day: Haemoptysis of 2 oz.; then sudden blanching and collapse of patient, with death in half an hour.

Autopsy found that the empyema cavity was filled with a completely moulded massive clot from recent haemorrhage. There was blood in the left bronchus, and the stomach was filled with blood. An irregular piece of shell, 1 in. in length, was found in a septic cul-de-sac in the lung, which expanded into a gangrenous cavity about 2 in. across. This was lined by pyogenic membrane, and was full of most offensive pus. From the cavity a channel opened on to the pleural surface of the lung, and a small aneurysm in the wall of the latter had ruptured. (Specimen in War Office collection.) The wound in the chest wall was cleanly healed throughout its track, although the head of the tenth rib had been comminuted.

The retention of the foreign body within the lung was undoubtedly the cause of this secondary haemorrhage and of death. It will be observed that in this case, where the bleeding occurred into a relatively immobile empyema cavity, the blood formed a clotted mass without that separation of fluid which is seen in the ordinary traumatic haemothorax. Also it should be noted that the bleeding was so rapid that the blood had drained down the oesophagus and filled the stomach. Had death not occurred, this distribution might later have led to haematemesis and melaena with difficulty in deciding whether the blood was derived from the lung or from a traumatic gastric ulcer. (Cp. Elliott and Henry, *BRITISH MEDICAL JOURNAL*, April 8th, 1916, p. 523.)

ACUTE TOXIC TYPE.

CASE IV.—Early Jaundice and Delirium: Shell Fragment Embedded in the Lung.

Pte. C., Notts and Derbys. October 7th, 1915. Penetrating shell wound of left chest. No haemoptysis.

Second day: Arrived at base hospital; restless and slightly delirious. Jaundice commencing; dyspnoea and pain in side; signs of large left haemothorax, but patient so ill that no exploration was attempted. He died on the following day.

Autopsy: Left lung in contact with anterior chest wall as far down as the fourth rib in front. Below that level lay a malodorous collection of blackish-purple blood, in which abundant bacilli were found. There was no free gas and no obvious pus. Shaggy clot covered the lung. A shell fragment surrounded by foul-smelling clot lay inside the lung, which was widely infarcted. (Specimen in War Office collection.) The base of the right lung was very oedematous. The body showed signs of universal septicaemia by gas bacilli and the liver veins were blown out with gas.

PROGRESSIVE PNEUMOTHORAX AND TOXIC TYPES.

CASE V.—Slow Development of Large Gas Pneumothorax, Non-toxic Type. (See Chart 2.)

Pte. W., Royal Fusiliers. August 6th, 1916. Shell wound of left chest, through first space in front with foreign body lying deeply below left edge of sternum.

Third day: Arrived at base hospital.

Thirteenth day: Continued fever, but no marked tachycardia. Patient looks and feels well. Physical signs of simple haemothorax, which was aspirated, yielding 40 oz. of fluid with deep haemolysis and a purulent deposit on centrifugalization. No gas was found. A few degenerated bacilli were seen in films, and anaerobic culture revealed a stout Gram-positive bacillus which resembled but was not identical with *B. perfringens*.

Nineteenth day: Almost afebrile and feeling very well; but the physical signs now indicated a large collection of gas extending up to the second rib in front with a very little fluid behind. The gas was found to be offensive. Rib resection, and drainage tube sewn in by Captain Fitzmaurice Kelly. Suction applied up to -4 cm. mercury for five days, so as to expand the lung.

Twenty-sixth day: Ordinary tube drainage.

Thirty-eighth day: X ray showed that the empyema cavity was now quite small.

At the eleventh week the patient was up and about in an English hospital, but the sinus was not yet closed.

CHART 2.—From Case V. The figures at the top of the chart give the day after the wound. It will be noted that the pulse-rate was low relatively to the temperature, but that it remained near 100 when the temperature sank to 99° after the first aspiration.

This case illustrates the slow development of gas by the action of an unknown anaerobe that was relatively non-toxic. The chief disadvantage of the infection was that resulting from the collapse of the lung, and for such a case suction drainage was particularly well adapted. The foreign body was left *in situ*.

CASE VI.—Rapid Displacement of Heart: Localized Collection of Gas.

Pte. A., Scottish Fusiliers. March 12th, 1915. Shell wound of right chest.

Third day: Heart displaced half an inch, and signs of moderate haemothorax. Tongue lightly coated with creamy fur. Temperature 100°.

Fifth day: Flushed and cyanosed; slight icterus. Temperature swinging, 99° to 102°. Increased dyspnoea. Pain in right axilla. Cardiac impulse much more displaced, two inches to left of nipple. Patch of tympanitic percussion note at angle of scapula behind, where previously it had been dull. Exploration over this resonant area yielded gas that smelled like rotten eggs, and purple blood infected with *B. perfringens*. Rib resected at once. No pus found, but only blood clots and dark fluid which coagulated to a jelly as it escaped from the chest. Except for the smell and the dark venous colour, what was found at resection resembled the contents of an ordinary sterile haemothorax.

The patient acquired secondary infections of the cavity, and recovery was delayed until the fifth week, but ultimately was satisfactory.

CHART 3.—From Case VII. The early tachycardia despite the absence of fever or of clinical features of collapse is the notable feature.

CASE VII.—Mixed Infection by Anaerobes and Cocci; yet Clinically a Non-toxic Type. (See Chart 3.)

Pte. R., Royal Warwicks. June 27th, 1916. Wound of left chest by shell.

Seventh day: Arrived at base hospital. Afebrile, but always a rapid pulse, 100 to 110.

Ninth day: Looks well. Clean tongue. Pain and tenderness of left side of chest, which was associated with traumatic herpes zoster over the eighth thoracic skin segment, and was therefore of uncertain indication. Temperature rising to 100°. Heart displaced nearly to right nipple, and physical signs of large and complete pneumo-haemothorax. The clinical appearance suggested that this was sterile. Aspirated; pressure -5 cm. water. Foul gas removed, and haemothorax fluid with a heavy deposit of pus containing anaerobic bacilli, staphylococci, and streptococci. Resected same night.

Fourteenth day: Temperature higher, but the patient remained very well, and never exhibited a toxic aspect. Normal recovery.

Combined infections of streptococci and anaerobic bacilli are often most virulent and grave. Yet the only features indicative of sepsis in this case were the tachycardia and the pain in the side.

CASE VIII.—Toxic Type. Localized Gas at first, and later a Haemolytic Jaundice developing while the infection was being treated by Ensol Lavage without Rib Resection. (See Chart 4.)

Gunner H., Northumbrian R.F.A. February 13th, 1916. Wounded in back of right chest. Shrapnel ball removed from under skin of right axilla next day.

Third day: Arrived at base hospital.

Sixth day: Typical clinical picture of moderately severe infection of haemothorax by anaerobes. Flushed face. Pulse 100, respirations 40. Heart displaced half an inch to the left; "cracked-pot" percussion note just below angle of scapula. Explored: Foul gas; reddish blood, not purple, and a little purulent deposit with abundance of *B. perfringens* in films. Aspirated: Pressure -0 cm. volume, 10 oz. of blood and also some foul gas. Washed out with 0.25 per cent. ensol. The cavity was small, for when the contained volume of ensol was reduced by aspiration from 18 to 8 oz., the intrapleural pressure fell from +7 cm. to -5 cm. water.

Seventh day: Aspirated: 10 oz. offensive fluid containing abundant bacilli. Flushed out with 0.5 per cent. ensol, which did not cause any phenomena of pleural irritation.

Tenth day: Tongue clean; appetite fair. No pain in side. Heart apex beat back to nipple. Aspirated: pressure found to be -5 cm., volume about 6 oz. of inoffensive reddish fluid,

Thirteenth day: Rib resected behind; blood clot not dislodged, and tube introduced only a short distance.

Twenty-second day: Afebrile and very well. Heart apex beat back to nipple. Draining only bloody serous fluid and no pus.

The ball was never removed. The sinus did not close until the seventh month, and the patient was discharged unfit for service; ultimately a poor result.

Since the free fluid below the pneumothorax was sterile, it seems almost certain that this anterior collection was caused by an air leak from the lung. *B. sporogenes* always produces an offensive smell in its growth. The case illustrates the advantage of a preliminary aspiration, for by this means the lung was expanded and the spread of infection over the whole pleural cavity was avoided.

CASE X.—Toxic Type without Jaundice. Death due to Postponement of Resection on Account of Delay in Bacteriological Proof of Infection. (See Chart 6.)

Pte. U., R.A.M.C. April 18th, 1915. Shell wound perforating left chest.

Third day: Arrived at base hospital.

Fifth day: Looks well. Fresh red haemoptysis. Signs of moderate left effusion.

Ninth day: Effusion larger. Pain in left side. Pulse 110, and persistent fever at 100° to 101°.

Twelfth day: Flushed face; feels ill. Temperature rising to 102°, pulse 120. Aspirated posteriorly below the angle of the

CHART 4.—From Case VIII. The pulse-rate fell together with the temperature during the time of closed lavage.

containing numerous bacilli. Flushed out with 0.5 per cent. esulol.

Fourteenth day: Severe epistaxis. Patient shows definite icterus. Serum of blood withdrawn into capsule exhibits yellow tint. Rib at once resected.

Nineteenth day: Icterus vanished. Straightforward recovery, though on the fifteenth and sixteenth days the patient was gravely ill.

The case is of particular interest. The toxic features of haemolytic jaundice developed from a septic haemothorax, which was found by repeated aspirations to contain nothing but anaerobic bacilli.

CASE IX.—Delayed Proof of Bacteriological Infection. Air Pneumothorax Lying Above and Separated from a Septic Haemothorax Clot. (See Chart 5.)

Pte. L., D.L.I. December 26th, 1915. Wound of right chest behind by shrapnel ball, which remained embedded close to hilum of lung. Walked one hundred yards, and then felt urgent dyspnoea. Haemoptysis next day.

Fifth day: Arrived at base hospital, under care of Captain Stratton.

Tenth day: Temperature rising. Physical signs at left base (P.N. dullish, V.R. increased, B.S. almost tubular, but no râles) of either contralateral pneumonia, which might have caused the fever, or of massive collapse. On the right side a large mobile pneumo-haemothorax. Explored at right base: Dark-red odourless haemothorax fluid, containing many pus cells, but sterile in films and on culture.

Twelfth day: Fever increasing. Tongue clean. No tachycardia. Aspirated: well forward in axilla; pressure = 0 cm.; inoffensive air removed and 25 oz. reddish turbid fluid, which

CHART 5.—From Case IX. The low pulse readings are a striking feature when taken in contrast with the high fever.

contained polymorphs and gave a full secondary gelatinous clot, but was sterile. The trocar was then pushed through an area of resistance at the back, when it drew off 6 oz. of purple-red offensive blood, which was full of *B. sporogenes*.

icterus. Temperature 101°, pulse 108. Says that he feels well, but talks as though verging on light delirium. Explored at once on left side; dark purple blood infected by *B. perfringens* and *B. sporogenes*. Resected a few hours later.

CHART 6.—From Case X. The rapidity of the pulse, out of all proportion to the temperature, should have been recognized as indicative of sepsis and should have led to earlier and more successful treatment of this case.

scapula; 30 oz. odourless, dark carmine fluid with crimson clot. Polymorphs in excess, but no organisms seen in films. The clinical opinion desired resection, but this was delayed on account of the bacteriological report.

Fourteenth day: Tongue dry in centre. Pulse 126; face very flushed. Said that he felt ill, and shortly afterwards died. *B. perfringens* was found on this day in the cultures from the twelfth day sample.

Autopsy found a pool of malodorous blood in the left rib hollow, and the posterior aspect of the lung was covered with shaggy septic clot. No pericarditis; no retained foreign body.

The delay in bacteriological proof of infection that has been discussed earlier in this paper is sufficiently illustrated by Cases IX, X, and XII, in which *B. sporogenes* and *B. perfringens* were both proved to be capable of lying hidden in this way.

CASE XI.—Toxic Form. Jaundice and Epistaxis: Death.

Pte. H., 67th Canadians. September 5th, 1916. Shell wound over sixth dorsal spine, and x ray subsequently showed a fragment close to vertebral column in the seventh intercostal space on left side.

Second day: Arrived at base hospital.

Sixth day: Epistaxis commenced. Temperature upheld at 101°.

Seventh day: Jaundice noticed.

Eighth day: Renewed epistaxis. Very yellow icterus. Temperature 101°, pulse 108. Says that he feels well, but talks as though verging on light delirium. Explored at once on left side; dark purple blood infected by *B. perfringens* and *B. sporogenes*. Resected a few hours later.

Ninth day: No vomiting. Now a waxy-white colour, and extremities very cold. Temperature 98°, pulse 108 and very small. Ensol was injected intravenously, and produced a temporary recovery with each injection, but apparently only as a result of the volume of fluid infused. Death took place on the following day.

Autopsy showed that the left pleural cavity was perfectly drained, while on the right side contralateral massive collapse was found in its usual anatomical distribution throughout the middle sector of the lower lobe. The heart was normal.

The importance of epistaxis and of jaundice as a danger signal was not recognized as soon as these features appeared in this case. Consequently, exploration and rib resection were delayed for two days, and the patient passed beyond the chance of recovery. In other septic cases with similar features of toxic jaundice earlier resection was followed by a perfectly satisfactory recovery.

CASE XII.—Toxic with Inoffensive Gas; Semi-delirious, but of the Rarer Pallid Type. Delayed Bacteriological Proof.

Cpl. J., Gloucesters. July 3rd, 1916. Septic shell wound of back of right chest; did not bleed much externally.

Third day: Arrived at base.

Fourth day: Ill, restless, and semi-delirious; but of pallid white aspect, being neither cyanosed nor flushed. Temperature 100° to 102°, pulse 90, respirations 32. Physical signs of contralateral collapse of left base, and a fairly large effusion on right side with tympanitic percussion note close to angle of scapula amid the area of dullness. Explored behind: Inoffensive haemothorax fluid, yielding a slight excess of polymorphs on centrifugalization and no organisms in films. Abundant growth of *B. perfringens* in twenty-four hours' culture.

Fifth day: Pain in right side; more restless. Clean tongue; pulse 90. Neither jaundice nor hectic flush. Explored: Inoffensive gas; more pus in fluid, but still no organisms in films. Rib resection.

Eighteenth day: Heart back to normal position. Pulse never rose above 90 throughout the illness. Recovery was delayed because the drainage hole was too high.

These septic cases with pallor are very rare in our experience. The semi-delirious state and the pain indicated the infection before it could be proved bacteriologically. It is noteworthy that the pulse never rose above 90, though the infection was so serious and the temperature raised. Probably the gas was an odourless product of the growth of *B. perfringens*, and not ordinary air.

CHRONIC TYPES.

CASE XIII.—Slow Development of Empyema by Infection with *B. perfringens*, though the Shell Fragment which Introduced the Sepsis was Aseptic in its Final Resting Place.

Pte. M., Gordons. May 10th, 1915. Shell wound penetrating back of left chest at angle of scapula; fragment could be palpated deeply in second space in front below left costo-chondral junction. No haemoptysis.

Twenty first day: Fever rising to 103° for last week. Pulse 120, respirations 28. Tongue clean; not very ill. Explored at base behind; no collection of fluid found.

Thirty-sixth day: Fever still persisting, but at lower level and now swinging from 99° to 102°; pulse 94 to 100. Feels and looks well. Heart displaced to the right, and evident physical signs of effusion at base. Explored: Offensive gas and pink purulent fluid with heavy infection of *B. perfringens*.

Thirty-seventh day: Resection. A little gas and much pus found between diaphragm and lung. The shell fragment was removed at the same time from the front of the chest, where it was found to be lying in a perfectly clean aseptic bed. The patient's temperature fell at once to normal, and he made a straightforward and rapid recovery, being able to join a reserve battalion in five months after his wound.

This is the fifth case quoted in this series (Cases VI, VIII, X, XII, and XIII) in which *B. perfringens* was identified as the chief infecting anaërobe. It will be noted that the clinical features were different in every case. One had jaundice; one was pallid and delirious; two showed the usual hectic flush and febrile aspect; and the fifth was a mild chronic suppuration.

CASE XIV.—Apparently an Ultimate Extinction of an Infection which had Caused the Development of Foul Gas and Chronic Suppuration.

October 31st, 1914. Penetrating shell wound posteriorly over the tenth right rib. Under the care of Captain Clementi-Smith, R.A.M.C.

Eleventh day: Persistent fever, 102° to 103°; pulse 120. Aspirated 30 oz.; no examination made.

Twenty-third day: Aspirated 15 oz.; no examination made.

Thirty-eighth day: Physical signs of pneumo-haemothorax. Aspirated 10 oz. brown purulent fluid and some offensive gas. Pus abundant, but no organisms found.

Forty-fifth day: Aspirated 30 oz. of same character as before. A few Gram-positive bacilli were found in the purulent debris, but they could not be grown.

Fifty-seventh day: Afebrile, but of pallid, wasted appearance. Sent to England. Rib resected shortly afterwards at home, and cavity drained. The patient then rapidly regained health, and the sinus closed in the seventh month after the wound.

GENERAL TREATMENT.

Diagnosis.

The chief need is for a greater readiness to suspect sepsis, and a prompt action in putting this suspicion to the test by exploratory puncture. Even a day's delay in order to watch the development of the case may in the most virulent types of infection mean that the patient is allowed to pass into a state of such gravity that surgical treatment is almost without hope.

If the needle has obtained an honest sample of the haemothorax—lung or liver blood can always be recognized by the fact that it clots massively in the syringe or test tube, whereas haemothorax fluid never does so—and if this fluid is found under the microscope to be sterile, then it is generally safe to wait and watch developments. It is never justifiable to resort at once to rib resection and drainage merely because the patient presents all the clinical appearances of severe sepsis. If the patient does not improve, a second exploration in a different place should be made on the following day. A later exploration is nearly always required if the fluid first withdrawn yields an unusually rich field of polymorphonuclear cells on centrifugalization, but is none the less sterile. Such an increase of polymorphs has again and again been noticed to be a premonitory feature in cases of delay in the dissemination of bacilli through a haemothorax.

An offensive odour in the sample withdrawn justifies surgical treatment at once without waiting for a bacteriological report.

In all infected cases, except those of a simple through-and-through wound, a skiagram should be taken, if the patient's condition will permit it, so as to localize any retained foreign body. For this purpose the patient should be lying down and not in the sitting posture that is needed for screening a haemo-pneumothorax.

Principles of Treatment.

The ideal treatment of an infected haemothorax would succeed in satisfying all the following conditions:

1. Removal of the gas and infected fluid from the pleural cavity.
2. Removal of the septic blood clot.
3. Extinction of the infecting organisms.
4. Removal of the foreign body.
5. Provision to induce rapid re-expansion of the collapsed lung, and to prevent secondary infection of the pleural cavity by other organisms that might be introduced by methods adopted to secure the first four requirements.

In practice this complete ideal has not been attained, and the surgical treatment of these cases still remains near the primitive level where it is perforce content merely to save life.

Many of these examples of anaërobe infection show a long latent period, during which the bacilli introduced with a shell fragment are seeking to establish their foothold and have not yet burst throughout the haemothorax. The organisms do not flourish in fresh blood or in contact with uninjured live tissues. Hence it would appear to be possible in some cases to open a wounded chest at once, wash out all the clot, remove the foreign body, and close the chest again, in the hope of eradicating the infection before it obtained the mastery over the resistant powers of the vital tissues. Major G. E. Gask has planned such a line of treatment, and already proved it to be practicable in certain selected cases. But the conditions of military surgery make it unlikely that this preventive method of treatment will be found to succeed in general, and therefore the problem to be dealt with, at the base hospitals at any rate, must be accepted as that of a fully established infection in a haemothorax.

Attempts have been made by us to avoid opening the pleural cavity, and to treat the infection by repeated aspirations combined with lavage by some antiseptic agent. This might appear to be a hopeful method, because many of the anaërobes tend to die down in body fluids. Oxygen was tried as an intrapleural injection, but with no good result. Ensol was also used for closed lavage (see Case VIII), and it was equally useless. Probably most of such attempts are foredoomed to failure, because they

cannot deal with the masses of septic clot lying in the pleural recesses. The latter have become foreign bodies just as much as is a shred of clothing or a fragment of metal; and all these, if septic, must be removed.

In a few cases the infection that is reported to be present by the bacteriologist is not a vigorous or extensive one, and the purulent reaction is slight. The body may overpower the organisms if it is aided by aspiration of the dead fluid and if the blood clot chances to have escaped infection. In such cases simple aspiration may suffice to cure.

We were particularly struck by the power of the pleura to dispose of infection, in an example of pulmonary actinomycosis which came under our observation. The left pleural cavity was widely infected, and it had to be emptied by aspiration on three occasions, the last evacuation amounting to nearly 80 oz. of thick pus, which contained abundant actinomyces, but no other organisms. The patient made a slow but complete recovery without drainage, and the chest ultimately showed no abnormal physical signs. French writers¹ have laid stress on the possibility of this simple method of treatment for infection of a haemothorax by cocci when the aspirations are commenced at an early date.

Each chest wound must be judged on its own merits, and in the milder forms delay in drainage is admissible, provided that the patient is continually watched for the development of toxic symptoms. But drainage is the rule for safety, and we regard it as an unavoidable necessity in the vast majority of cases because the clot is infected.

The pleural cavity must be opened, clots detached or washed away by very light manipulation, and the foreign body removed if it is accessible. After such cleansing it is conceivable that it might be possible in certain cases to douche the cavity with an antiseptic agent, and then close up the chest completely, trusting that the natural powers of defence of the body will combat what is left of the infection. But no satisfactory means of arriving at this result has yet been found, and for the present it still appears to be necessary to provide for continual drainage away of the suppurative fluids.

This drainage must be planned so as to empty the lowest recesses of the cavity. When a rib has been resected at too high a level, and a long tube is introduced in an upward direction, while the patient is kept propped up in bed, an offensive cesspool, with all manner of secondary infections added to it, is likely to be established in the bottom of the pleural cavity, and this will continue to poison the patient until it is properly emptied.

In cases of large empyemata, when the toxic features are not very marked, it is an advantage to employ airtight drainage, so as to avoid secondary infections and help in the re-expansion of the lung by suction upon it. The parietal pleura is sewn together tightly around the tube, and the muscles and skin are also sewn together in successive layers. This procedure adds at least fifteen minutes to the time taken for the operation, for it is not an easy matter to sew up the inelastic pleura. The free end of the tube may dip below the surface of a bottle of weak disinfectant fluid placed on the floor, so as to maintain a slight negative pressure after each cough. Or the tube may pass into a collecting flask for the pus, upon which suction is steadily maintained at a known pressure by an automatic aspirating bottle.

These methods are occasionally an advantage, and they add to the comfort of the patient for the first week until the sutures break down, because the dressing on the wound remains dry, and does not become a pus-soaked mass that requires frequent changing. The suction helps a little towards the expansion of the collapsed lung; but the respiratory movements of the patient will do far more in this direction if they are deliberately practised.

So soon as open drainage is resorted to, it should be the aim of the surgeon to get rid of the tube as early as possible. If sloughing clots have been removed there is little need to keep the tube in place for more than a few days. An offensive discharge requires daily lavage with eusol or some other antiseptic, such as carbolic acid combined with weak hydrogen peroxide, in order to dislodge clot if the cavity could not be emptied at the time of the operation. Any retained piece of metal should be removed if it is accessible. Those within the substance of the lung in septic cases may ulcerate their way to the surface without harm, but there is real risk of their opening up a vessel in

this process, and causing death by secondary haemorrhage. We have, however, met with only three fatalities of this nature (cp. Case III) out of all the number of chest wounds that have been seen by us, which must aggregate well over a thousand, so that the danger is not a serious one in the first stages of recovery after such wounds. We have not enough experience to enable us to state whether the danger attendant upon searching in the presence of a septic haemothorax for a foreign body embedded in the lung will outweigh the advantage of avoiding a chance secondary haemorrhage by its early removal.

The Treatment Appropriate to Various Clinical Types.

1. *The Acute Pneumothorax Type.*—These patients are suffering from extreme mechanical disturbance of the thoracic contents by the accumulated gas, and they are so critically ill that they cannot tolerate much surgery. It is sufficient to insert a tube through an intercostal space in the axilla under a local anaesthetic, and then to complete the drainage by rib resection at the lowest possible place behind as soon as the patient has recovered a little. The prognosis is good.

2. *The Acute Septic Type.*—These cases are generally hopeless on account of the overwhelming effect of the poisons, and many of them are subsequently found to have been suffering from complicating wounds of abdominal viscera, which made their chances of recovery still more desperate. Rib resection may none the less succeed in saving life.

3. *The Gradual Pneumothorax Type.*—A preliminary aspiration may be made so as to expand the lung if the collection is very large. Sooner or later the pleural cavity must be opened and cleansed. In mild infections airtight drainage and suction may be employed with advantage, and in some cases (cp. Case IX) it may be possible to deal separately with a sterile collection by aspiration, and with a localized clot abscess by rib resection.

The points which determine immediate resection are the development of jaundice in the patient, or an abundant deposit of pus in the fluid withdrawn. The presence of only a few anaerobes and the absence of other organisms from the fluid may be allowed to justify a vigilant delay, for under these conditions the patient will not suffer if the fluid collection is kept small by repeated aspirations. But in our experience it has always been necessary in the long run to drain chests with purulent infections.

We have tried the method of drainage through an intercostal slit without introducing a tube, in the hope that it would facilitate the expansion of the lung. It was not generally satisfactory, and was little more than a safety valve allowing gas to blow off and prevent its accumulation under pressure.

4. *The Progressive Toxic Type.*—In the jaundiced or delirious forms of intoxication the pleural cavity should be explored without an hour's delay and opened as soon as infection has been found. It is most important to resect at the lowest rib that will give access to the collection. On account of the possibility that the diaphragm may be fixed up in a high position, the exploring syringe must always be used again in the operating theatre as a preliminary to rib resection in order to ascertain the lowest limit of the haemothorax, and the pleura should be incised carefully for fear of cutting through an adherent diaphragm.

The forms with simple fever admit of a little longer consideration, for these clinical features may be caused by many other conditions than that of infection of the haemothorax. But if contralateral pleurisy or pericarditis are detected, these signs should be regarded as presumptive evidence of a dangerous infection, and exploration should be followed as soon as possible by rib resection, if the supposition is proved to be true.

5. *The Chronic Type.*—These cases recover so smoothly after rib resection, that one regrets that it is not possible to leave all septic cases to pass into this chronic state before surgical interference.

PROGNOSIS.

Life can be saved in nearly all cases except those with complicating wounds of the abdomen, or with virulent and mixed infections. A dry tongue is indicative of the latter. So long as the tongue remains moist the patient ought to recover.

Death from sepsis practically never occurs after the end of the second week following the wound. There is no long drawn-out fight with an ultimate and inevitable surrender, such as may be seen at times when the abdomen, the brain, or shattered bones are infected. Out of the last fifteen cases of death among examples that we have seen of haemothorax infected by anaërobie bacilli, fourteen died simply from the sepsis. One, the case related as No. III, died from a late secondary haemorrhage from a deep lung abscess round a retained piece of shell. Pericarditis was proved to be present in eight of the other fourteen fatally septic cases. Jaundice was noticed in seven, of whom two died without pericarditis. There were no instances of death from purulent bronchitis in this series.

None the less purulent capillary bronchitis with thick greenish-yellow airless sputum is a dangerous complication; and it appears to develop with greater severity in infected cases that have been left for many days without drainage. It may be the exacerbation of a cold that was present before the man was wounded; and a history of exposure on the battlefield after the wound is often given by patients suffering from this complication. The bronchi of the uninjured lung are more extensively infected than those on the wounded side, where collapse and immobility tend to restrict the spread of infection along the air tubes. Autopsy reveals thick plugs of green pus rising up from the orifices of every cut bronchiole, and there is sometimes a bronchopneumonic spread of the infection into surrounding lung tissue.

So soon as this character of the sputum is recognized stimulating expectorant medicines should be given freely, for this condition demands a treatment contrary to that usually practised in order to lessen cough in chest wounds. Its presence requires that the haemothorax shall be aspirated or drained away as soon as possible, so as to throw more lung tissue into active respiration. There is no evidence that such treatment introduces further danger by extending the bronchial infection along tubes that were previously collapsed.

Fever that continues for more than a week after rib resection, if not due to purulent bronchitis, is usually caused by inadequate drainage of the empyema. The pleural cavity should be explored by the finger to ascertain whether pus is accumulating in any recess below the level of the drainage tube. If this is found to be the case, a piece should be resected from a lower rib to improve the drainage, or a large catheter should be inserted and suction applied to it by some apparatus, such as the Sprengel pump. Drainage is improved by keeping the patient recumbent in bed.

Sooner or later the lung expands fully in practically all the cases, and the sinus closes without the need for any elaborate surgery. We have learnt the after-histories in England of thirty of our cases, whose chests were drained for infection of a haemothorax, some for anaërobie infections, and others for streptococci, etc. The sinus became closed in the majority during the third or fourth month after the original wound, and some of the men were at once classified as fit for duty. In only eight of the cases was the sinus open as late as the sixth month. There was only one case of chronic empyema cavity in which at the fourth month a minor Estlander operation was performed for its obliteration; and there were two cases in which small operations were needed for the drainage of a loculated collection of pus.

SUMMARY.

1. Infection by anaërobie bacilli occurs in about 10 per cent. of all cases of haemothorax from gunshot wounds of the chest that are seen in base hospitals in France.

2. The infection leads to the development of malodorous gas which may occasionally be so abundant as to simulate a large air pneumo-haemothorax, while the toxic features of the infection for the time being remain in the background.

3. In the majority of cases the septic features are much more prominent than gas formation. The most serious of these features are jaundice, a rapid pulse (which may be the index of commencing pericarditis), and semi-delirious restlessness. Less dangerous is the febrile type with a brilliant hectic flush on the cheeks.

4. Diagnosis depends on exploratory puncture. In cases with the clinical aspect of sepsis it may be necessary to

repeat the exploration on successive days, because it is a characteristic of anaërobie infection that the bacilli frequently fail to spread at once throughout the haemothorax, so that their presence is often missed at the first searching.

5. Life can be saved in at least four-fifths of the cases if the infected blood is promptly drained away. A day's delay in putting such treatment into force, when once the infection is well established, may mean death to the patient.

6. The clinical pictures caused by the sepsis vary widely in the individual cases of infection, but these differences cannot yet be correlated with the various forms of anaërobie bacilli that are proved to be present in each particular case.

REFERENCE.

¹ E. Foisy: *La pratique de la chirurgie de guerre*, Fascicule II, 1916, p. 185.

A CASE OF SPIROCHAETOSIS ICTERO-HAEMORRHAGICA.

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LITTLE evidence of epidemiological importance could be obtained from the patient whose case is here described. No previous case of jaundice had occurred on the boat, to his knowledge, and, since the boat does not call regularly at this port, no later information is available. Questioned as to the presence of rats, he was not able to state that they had been more noticeable than is usual on a ship.

A steward on H.M.T. —, aged 27, complained of vomiting for four days, vague epigastric pain and tenderness, and headache. The tongue was coated, and his mental condition was not clear. His replies to questions as to onset and present condition were vague and rambling. The temperature was 99.8° and the pulse 100, with no special characters. There was no jaundice.

On the morning of December 1st, 1916, he was markedly jaundiced, and his mental aberration was more noticeable. There was no vomiting; his tongue was brown and very furred (centrally disposed). Temperature 97.8° and pulse 86 in the morning; temperature 98° and pulse 90 in the evening. A guinea-pig inoculated intraperitoneally with 2 c.cm. of blood on this day remained healthy for the ten days it was under observation, having no pyrexia, and increasing steadily in weight.

On December 2nd the symptoms were more marked, the patient being delirious and of a deep orange colour, which apparently varied in depth from one part of the day to another. Small cutaneous haemorrhages were present on the limbs and trunk. There was also a small amount of haemorrhage from the mucous membrane of the mouth. He had incontinence of urine and faeces. There was no gross change in the size of the liver. *Tache cérébrale* was present. Herpes was not present. The faeces showed no special characteristics. The urine contained albumin, bile, and casts, mostly granular, but no leucin or tyrosin. He did not complain of any irritation of the skin.

A guinea-pig inoculated intraperitoneally with 2 c.cm. of urine showed fever (temperature 104°) on the sixth day, jaundice on the seventh day, and died with subnormal temperature and signs of collapse on the ninth day of observation. At the *post-mortem* examination haemorrhages of various sizes were found throughout the lung tissue on the right side; at the base was a considerable area of consolidation. The liver showed small patches (2 to 3 mm. in diameter) of a brick-red colour throughout its substance. Spirochaetes were present in the liver and blood, demonstrated by prolonged staining of smears with Giemsa, by silver nitrate, and Indian ink methods. In sections of the liver and kidney treated by Levaditi's method the organism was plentiful.

A second guinea-pig was inoculated with an emulsion of liver from the first animal, and the disease ran a very similar course. On the tenth day it was markedly jaundiced (with bile in the urine), and very dull, with loss of appetite, and a subnormal temperature. It was killed on this day. The *post-mortem* examination showed the usual haemorrhage into the lungs, and the liver was enlarged, very congested, and soft in consistency. The spirochaete was present in the liver and blood as before.

A third guinea-pig, inoculated from the second, died on the eighth day, and the liver showed the same bright red areas as were observed in that of the first animal.

The patient, on the fifth day after admission (probably the ninth day of the disease), showed marked improvement, the tongue cleaning, the degree of jaundice lessening, and his mental condition becoming normal, with return of control over both sphincters. No treatment was attempted. He took nourishment well throughout, the bowels moved freely, and the pulse was always good in quality. He subsequently developed some bronchitis, and had an evening temperature for some days