Thorax (1950), **5**, 116.

FINAL RESULTS IN TRAUMATIC HAEMOTHORAX: A REPORT OF 230 CASES

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The reports and studies of large numbers of cases of traumatic haemothorax, both during the 1939–45 war and at its termination, were of value from two points of view: they were immediately reflected in the treatment of patients, and they provided a record of developing treatment, which will enable future generations of physicians and surgeons to start where those of 1945 left off, should the need unfortunately arise. Indeed, the medical records of the South African war, the first world war, and the second world war, if studied in association, provide a continuous story of development in this field, both from the medical and from the administrative aspects.

In the main, however, these were interim reports, since the patients were for the most part still under treatment at the time. Many of them were transferred to other hospitals to complete their treatment in order to make room for new casualties direct from the battle front. Indeed, some patients were treated in as many as four hospitals in the course of their illness.

The Chest Surgery Centre at Shotley Bridge was one of those hospitals where patients remained until final recovery. The complete records were therefore available, and it has seemed worth while to study and analyse the cases so as to present a relatively complete picture of the factors influencing the course of recovery and its duration.

The literature of all three wars has been carefully studied, but has been referred to only for purposes of comparison and to provide authority and illustration where this seemed to be essential. The object has been simply to present the experience of the 230 cases, and not to attempt an exhaustive survey of the whole subject.

Traumatic Haemothorax

It is generally agreed that haemothorax is the commonest complication of a wound of the chest, although the incidence varies from one series to another, and in the present series is rather lower than usual. For example, Bradford and Elliott (1915) reported 156 haemothoraces in 170 cases (92%), and Kay and Meade (1946) 455 in 500 (91%). Price Thomas and Cleland (1945), on the other hand, found only 520 in a series of 750 thoracic injuries (70%).

In the present series, haemothorax has been diagnosed in 230 out of 400 cases (58%).

These differences are probably due, to a great extent, to varying criteria of diagnosis. In the present series, blood was actually proved to be present, either

by aspiration or at operation, in all but nine of the haemothorax cases; and in these nine the presence of blood was regarded as certain on less direct evidence. Selection of cases was another factor tending to reduce the incidence of haemothorax in this series. More than half the patients reached the Chest Surgery Centre only after more or less prolonged treatment at other hospitals and centres. Hence it is likely that relatively few of those with the smaller effusions reached us. Of those in whom the evidence of haemothorax was regarded as inadequate, many were referred only with a view to the removal of a foreign body from the lung or mediastinum.

The natural history of haemothorax is now reasonably well understood. Bleeding, usually from the lung, occurs until the intrapleural pressure is sufficient to check it. The size of the resulting haemothorax will usually depend upon the degree of collapse of the lung and upon the mobility of the mediastinum. In some cases pre-existing adhesions may perhaps tend to increase haemorrhage by traction upon the lung, and other factors may operate in special cases, but generally speaking it seems we may accept the above statement as correct. The blood at once clots, but as a rule this clot is broken up as it forms by the movements of the lungs and heart (Elliott and Henry, 1916; Melick and Spooner, 1945). The blood is thus defibrinated, and the fibrin is deposited upon the pleura, although if any larger fibrin clots are formed these sink down to the bottom of the pleural space. The pleural cavity is thus transformed into a blood cyst lined by a more or less incomplete and irregular layer of fibrin. The fibrinous layer is much thicker on the parietal than on the visceral pleura for fairly obvious reasons (Melick and Spooner, 1945).

The fluid occupying this cavity is blood with a very low fibrinogen content, and is incoagulable. The irritant effect of this foreign material causes an inflammatory reaction and an outpouring of serous fluid. The blood is thus diluted, and in time becomes again coagulable. Sellors (1945) noted a steady fall in haemoglobin concentration in the fluid, and as steady a rise in fibrinogen over the period of seven days after injury, by which time the clotting time had returned to normal.

In due course in the "normal" case, fluid, fibrin, and clots are all absorbed, leaving a normal pleura. In actual practice this natural cure does not always occur, and in any event it varies in speed. It is the general experience that the very small haemothorax almost invariably proceeds to spontaneous cure, unless infected, and that infection of a small haemothorax is uncommon.

In the case of the large haemothorax, natural cure when it occurs is often delayed and not infrequently interrupted. Interference with the normal process of natural cure is usually due to infection of the pleural contents. But even in a sterile haemothorax things may go wrong. Occasionally the effused blood clots massively and defibrination does not occur to an important extent. If the blood is not completely or almost completely removed within a reasonable time, say a week, clotting is liable to occur as the secondary rise in fibrinogen takes place. In either case the re-expansion of the lung may be greatly delayed, and the clot may organize, thus effectually preventing cure. Rose Bradford (1917) believed that massive collapse of the lung was a common occurrence in all chest injuries, and it is easy to see that if this occurred in association with a large haemothorax an organized

pleural lining might prevent the re-expansion of the lung when otherwise it would have taken place.

Both open and closed pneumo-haemothorax have been advanced as causes of delayed recovery.

Finally, very extensive pulmonary laceration is likely to hinder that early re-expansion upon which the natural cure of haemothorax depends, although Elliott (1917) did not find that this was frequently the cause of a delayed or interrupted recovery.

In a study of the results in traumatic haemothorax, it will obviously be necessary to discuss all these causes of interference with the cure of haemothorax, and the extent to which the treatment received by the patients minimized or abolished their influence. All predisposing factors must also be considered, if we are to obtain a reasonably clear idea of the processes involved.

Infected Haemothorax

It will be simplest to study the infected haemothorax first. Infection is not only the most important, but also the most frequent, cause of interruption of natural cure.

Infection of a traumatic haemothorax may be primary or secondary. This means that infection may be directly introduced from without, or it may arise later from the lung itself, perhaps from an abscess due to the injury or from a more general pulmonary infection. It is also possible that the pleura may be infected by way of an infected wound, or even by the aspiration needle. Bradford and Elliott (1915) found 20% to be due to respiratory organisms, and 80% to external infection.

The Nature of the Missile.—In 1915 Bradford and Elliott noted a significantly higher infection rate in shell wounds than in bullet wounds, and this they naturally attributed to the greater size and irregularity of these missiles (Table I).

TABLE I

Type of Missile in Relation to Pleural Infection (Bradford and Elliott, 1915)

Missile	Number of Haemothoraces			Percentage Infected
	Sterile	Infected	Total	
Shell splinters	55	56	111	50
Bullets	121	47	168	28
Total	176	103	279	37

Table II, prepared from the present series, may be compared. It can be said that the two series are comparable, in that the smaller unproven "haemothoraces" have been excluded from both. There are two points of interest. One is the reduction of the rate of infection from 37% to 22%. The other is the absence of any significant difference in the incidence of infection according to the missile in Table II. The infection rate of bullet wounds is only slightly reduced, but the rate for splinter wounds is more than halved. It does not appear from these figures

TABLE II

CAUSE OF INJURY IN RELATION TO PLEURAL INFECTION IN PRESENT SERIES

Agent	Number of Haemothoraces			Percentage Infected
	Sterile	Infected	Total	
Shell splinters, etc.	105	27	132	20
Bullets	54	15	69	22
Bayonet	0	1	1	—
Non-penetrating	4	2	6	33
Nature of missile uncertain	17	5	22	23
Total	180	50	230	22

that in this series the nature of the missile played any part in determining the rate of infection in haemothorax.

The Nature of the Wound.—Mann in 1919 found that 30% of sucking wounds became infected, and as the incidence of infection in his whole series was only 23%, there was probably a slightly higher infection rate in the "sucking" cases. He noted no difference in this respect between penetrating and perforating wounds.

TABLE III

NATURE OF WOUNDS IN RELATION TO PLEURAL INFECTION IN PRESENT SERIES

Type of Wound	Number of Haemothoraces			Percentage Infected
	Sterile	Infected	Total	
A. Penetrating	146	39	185	21
Perforating	30	9	39	23
Non-penetrating	4	2	6	33
Total	180	50	230	22
B. Sucking	50	13	63	22
Non-sucking	126	35	161	21
Non-penetrating	4	2	6	33
Total	180	50	230	22

Table III shows the incidence of pleural infection in various types of wound—penetrating and perforating, sucking and non-sucking, and non-penetrating—in the present series. There is no significant difference between one group and another, and no indication that the nature of the wound exerts any influence upon the incidence of infection in traumatic haemothorax is to be observed.

Site of Wound.—A study of the situation of the wounds in this series failed to reveal that this played any significant part in determining the incidence of infection.

Size of Haemothorax.—Table IV shows the incidence of infection in large and small haemothoraces. It will be observed that the large haemothorax is more than twice as likely to become infected as is the small haemothorax. The size of the original effusion has of necessity been deduced in most cases from the record. If

TABLE IV

SIZE OF HAEMOTHORAX IN RELATION TO PLEURAL INFECTION IN PRESENT SERIES

Size	Number of Haemothoraces			Percentage Infected
	Sterile	Infected	Total	
Large	123	43	166	26
Small	57	7	64	11
Total	180	50	230	22

the amount of liquid aspirated was more than 30 oz. (850 ml.), the haemothorax was classed as "large." If the amount was less than this, and clinical and radiological evidence indicated that all, or nearly all, had been removed, the haemothorax was regarded as "small." If after aspiration, however, it appeared that an extensive effusion still remained within the chest, the haemothorax was classified as "large" even if less than 30 oz. had been removed.

Treatment.—It is widely stated that delay in aspiration, or inadequate aspiration, favours infection of a traumatic haemothorax. Nicholson (1946) stated that "conservative treatment favours infection." Kay and Meade (1946) assessed causes of pleural infection in 455 cases. They found that 144 empyemata occurred. Of these 41.2% were regarded as inevitable, but they considered that the remainder were due in part to faulty treatment. In 18%, in their opinion, infection was directly due to inadequate aspiration. Holmes Sellors (1945) believes that the chances of infection are increased by delayed re-expansion of the lung, and an analysis of the 230 cases under review supports this conclusion.

Table V sets out the incidence of pleural infection in relation to the adequacy of early treatment. "Adequate treatment" means that emergency treatment when required was prompt and effective, that aspiration was begun early, and was thereafter regular, productive, and well controlled. It means that complications hindering aspiration and so preventing pulmonary expansion were quickly recognized and treated correctly, but it does not mean more than that. In other words, the definition does not demand an unreasonably high standard. It is as much a matter of organization as of the attention of the individual doctor. It will be observed that the

TABLE V

TREATMENT IN RELATION TO PLEURAL INFECTION

Estimate of Treatment	Number of Haemothoraces			Percentage Infected
	Sterile	Infected	Total	
Early and adequate	117	6	123	5
Late and inadequate	55	32	87	37
Inadequate records	8	5	13	38
"Inevitable" infection	—	7	7	—
Total	180	50	230	22

incidence of infection in the cases with inadequate records is much the same as in those cases with inadequate treatment. It might even be justifiable to group these 100 cases together, as inadequate records and inadequate treatment often go together.

Of the total of 50 empyemata, seven could be said to have become infected during the first week, and of the others six appeared to have had fully adequate treatment, although infection occurred later. These 13 patients can therefore be regarded as "inevitable" empyemata, in whom pleural infection could not have been prevented. In five cases defective records prevented the expression of an opinion, but in the remaining 32 there was reason to think that an empyema might possibly have been avoided. In most of these infection was late, arising after the third week in more than half. Aspiration was not started before the second week in 17 cases, and in one of these it was omitted altogether. Once aspiration was begun, two tendencies appeared. In a few cases aspiration was productive, but was stopped after one or two tappings, although it seemed clear that the pleura was far from empty. In others, and these were in the majority, aspiration was regular and persistent, but the amounts obtained were small, and little progress towards the twin objectives of a dry pleura and an expanded lung was made. This was due, it would seem, either to faulty technique or to clotting with loculation within the thorax. It is of course impossible to state certainly which of these factors operated in a given case, but clots were noted during aspiration in only a few cases. And of course the longer a bloody effusion is allowed to remain within the chest, the greater is the opportunity for it to coagulate and to cause loculation.

Thus we see that the incidence of pleural infection in traumatic haemothorax is inversely related to the rapidity and completeness of pulmonary expansion, and bears little, if any, relation to the nature of the wound or of the missile which caused it.

Bacteriology.—In 39 of the 50 empyemata bacteriological records were available. Twenty-four of these were pure infections. *Staphylococcus aureus* was the predominant organism, being responsible, or partly responsible, for 15. Streptococci, colon bacilli, and *Clostridium Welchii*, were also frequent infectors. In six cases the pus was sterile on culture. No tests of penicillin sensitivity were made, but in 18 of the 33 positive cultures the organisms were of types which might have been presumed to be sensitive.

The records of these cases show that intrapleural penicillin was administered, in varying dosage, to 18 of the 39, but that in only seven of these could the infecting organism be presumed to be sensitive. It appears, therefore, that only one-third of the "favourable" infections were treated prophylactically, and that one-half of the "unfavourable" infections were so treated.

It seems unlikely that routine sensitivity tests could be made available in any future war. It certainly appears that unless such routine testing is employed, intrapleural penicillin cannot exert any significant influence on the incidence of traumatic empyema under the conditions of active service unless given to every case.

RESULTS

Table VI summarizes the final results of treatment in the 230 haemothoraces. From these figures it appears that the sterile case does very much better than the

TABLE VI
FINAL RESULTS IN HAEMOTHORAX

Result	Number of Haemothoraces			Percentage Infected
	Sterile	Infected	Total	
Cured	125	23	148	16
Satisfactory	53	23	76	30
Fair	2	3	5	60
Dead	0	1	1	100
Total	180	50	230	22

infected case, although the final results in the 50 patients with empyemata could reasonably be regarded as good.

Results of Treatment of Infected Haemothorax.—Twenty-three of the 50 patients with empyemata were considered to be completely cured. In other words, their wounds were firmly healed, their respiratory function was normal judged clinically, radiologically, and by measurement of vital capacity, and their general health was excellent. In a further 23 cases the result was regarded as " satisfactory." This means that, although the wound was firmly healed and the general health was excellent, respiratory function was not fully restored to normal. The defects were not at all gross, and consisted of impairment of percussion note on the affected side, some loss of translucency and sluggish diaphragmatic movement radiologically, and slight breathlessness on exertion. The general opinion, when these patients left hospital, was that they would continue to improve. In three patients the result was only " fair " ; in all decortication had proved necessary and bronchial fistulae gave trouble. The wounds healed, but there was evidence of pulmonary damage with persisting infection, and the men were breathless on quick walking or running.

One man died of a haematemesis due to multiple gastric erosions.

TABLE VII
DURATION OF ILLNESS IN RELATION TO PLEURAL INFECTION

	Number of Haemothoraces	Average Duration of Illness (Days)
Sterile	180	50
Infected and surviving	49	126
Total	229	66

Table VII shows that the duration of illness in the infected cases was two and a half times as long as in the sterile cases.

A few further details of interest may be recorded.

In six cases the empyema occurred in a clotted haemothorax.

In 12 cases one or more bronchial fistulae were present. This incidence may be regarded as fairly satisfactory. Kay and Meade (1946) reported 36 such cases in 144 traumatic empyemata, and Collis, Davison, and Smith (1945) noted 15 in

44 infected haemothoraces. Nevertheless, the records indicate that in three, and possibly four, of the 12 examples in the present series, a fistula might have been avoided by earlier recognition and treatment of the empyema. For example, two empyemata were not drained until 10 weeks after they had been proved, and one of these was aspirated once only. This latter patient's condition on discharge was only fair, and he is unlikely to be restored to health. The others, however, gave better results, though only three could be regarded as completely cured. The average duration of illness in the 12 cases was 131 days, which is much the same as for the 49 surviving empyemata, as a whole.

Only three of the 50 empyemata were associated with thoraco-abdominal injuries. There were eight thoraco-abdominal injuries in the whole series, and they seemed to do no worse than the ordinary run of cases. The illness lasted no longer, the duration depending entirely on the presence or absence of pleural infection. In two cases bile was present in the pleura. One of these was infected with *Clostridium Welchii*, but the other remained sterile throughout.

The Sterile Haemothorax

It is generally agreed that early and adequate aspiration is essential to secure rapid and complete recovery from all except very small traumatic haemothoraces. The object of all treatment in these cases, however, is full expansion of the lung. In most cases, aspiration alone suffices, but careful clinical and radiological control is necessary. The most conscientious persistence in the ritual of aspiration is worse than useless if little or no progress towards an early restoration of full respiratory function is being made. The danger of intrapleural infection has already been emphasized, but even if this does not occur disability may still follow, with remote effects.

The average duration of illness in the 180 cases of sterile haemothorax in the present series was 50.7 days. This is shorter, and the results are better, than in the infected cases, as was to be expected. But they are not as much better as might have been expected. What is the explanation of this? Is it due to some defect in treatment, or in part to other factors, and to that extent inevitable?

To examine these questions, the sterile haemothoraces were classified according to the adequacy or inadequacy of the treatment they received, and the results assessed in the two groups (Table VIII).

The definition of adequate treatment, as it has been accepted in the present series, has already been given. It should be mentioned that unnecessary treatment such as a thoracotomy undertaken without cause, has been classed as "inadequate."

TABLE VIII

Duration of Illness in Relation to Treatment of Sterile Haemothorax

Treatment	Number of Haemothoraces	Average Duration of Illness (Days)
Adequate	117	37.5
Inadequate	55	67.5
Insufficient records	8	135.8
Total	180	50.7

Table VIII indicates that efficient treatment greatly shortens the illness in the sterile cases. It is now necessary, to determine the duration of illness in the uncomplicated sterile case, adequately treated, to exclude those with gross and obvious complications.

Of the 117 cases efficiently treated 29 were complicated in various ways. If these are excluded, the average duration of illness in 88 cases of uncomplicated sterile haemothorax, adequately treated, is 27.8 days. The average duration of illness in the complicated cases was 66 days.

The complications in these 29 cases were as follows:

Persistent atelectasis	9
Severe lung injury	7
Early massive clotted haemothorax	4
Large pneumothorax	2
Severe abdominal wounds	3
Bronchopneumonia	2
Very large bilateral effusions	1
Severe hepatitis	1

These complications may be regarded as inevitable causes of delay in the recovery from sterile haemothorax. The diagnosis of atelectasis rested on clinical and radiological evidence. The main diagnostic criteria of severe pulmonary injury were repeated severe haemoptysis and radiological signs.

In 55 of 172 cases of sterile haemothorax in which the records enable an opinion to be confidently formed, the treatment appeared to be inadequate in one or more respects. Aspiration was sometimes too long delayed, or was abandoned too early. In other cases, however, though aspiration was begun early, and regularly continued, the amounts of fluid removed were very small, and it was obvious from the records that a large amount remained in the chest. A number of such cases eventually recovered without further treatment, but recovery was greatly delayed and was apt to be incomplete. In others, thoracotomy was necessary for removal of the clots, and usually for decortication.

In a few cases, the instillation of large doses of penicillin intrapleurally over a long period, in spite of slow or negligible expansion of the lung, seemed to delay recovery by favouring loculation and thickening of the exudate, and the formation of a fibrinous pleural jacket. This was also noted by Sellors (1945), who found an abnormal rise in the fibrinogen content of the effusion in cases where intrapleural penicillin had been used.

In one case a torn diaphragm remained unrepaired until the one hundred and second day of the illness. The patient made a satisfactory recovery within nine weeks after the operation, and it is hard to resist the conclusion that an earlier operation would have shortened his illness very considerably.

One patient was subjected to thoracotomy on the second day, apparently for the purpose of evacuating clots. The lung was, however, found to be well expanded. A small sized foreign body was removed from the right lower lobe, and thereafter a large haemo-pneumothorax occurred, which slowly cleared with aspiration in about nine weeks. The operation in this case appeared to be unnecessary, and was considered to have delayed the recovery of the patient.

TABLE IX
DEFECTS IN TREATMENT IN 55 INADEQUATELY TREATED CASES OF HAEMOTHORAX

Treatment	No. of Cases
Incomplete aspiration	33
Delay in beginning aspiration	23
Aspiration abandoned too early	18
No aspiration performed	1
Delay in performing a necessary operation	1
Performance of unnecessary operation	1
Inadequate suture of sucking wounds	1

An analysis of the 55 cases in which the treatment was considered to be at fault is given in Table IX. In a number of cases more than one defect in the treatment was noted.

These 55 cases were, it appears, less frequently complicated than the 117 cases with adequate treatment, as far as can be ascertained. Severe laceration of lung occurred in two cases, and torn diaphragm in one, making a total of three cases with recognized inevitable complications. The number may be inaccurate, as it has proved impossible to exclude atelectasis as a contributory factor in the slow recovery of some of these, for obvious reasons. When the chest is full of fluid, neither clinical nor radiological examination can exclude atelectasis. Of course, atelectasis may not be the only complication which has been overlooked, although the study of the early records of the patients, and observation subsequently at the Chest Surgery Centre, failed to reveal any such complication, either clinically, radiologically, or at operation. This uncertainty somewhat reduces one's confidence in the absolute value of the figures given in Table VIII. It cannot, however, affect their relative value. Even if we assume that a number of complications occurred equal in proportion to those recognized in the former group, and that these prolonged the illness similarly, the average duration of illness in the uncomplicated cases "inadequately" treated would still be 49 days as against 27.8 days for the uncomplicated cases with "adequate" treatment.

The psychological effects of a prolonged chest illness, particularly when this is due to a battle wound, must be remembered. They are of equal importance in both the infected and the sterile case, and may prevent a complete restoration to health even if the technical result is good. The word "cured" in the present series refers to physical cure only. No account is taken of the emotional reaction of the patient to his illness, as this has been difficult to express accurately. But the difference between a man with a relatively short straightforward recovery, and the man with a prolonged irregular illness, has been a striking feature of the series. The man with a vital capacity of 3,500 or 4,000 ml., and perfect pulmonary expansion, who has to stop for breath frequently on an incline, or who cannot swing a golf-club or lift a weight, is physically cured, but is not restored to health. Prolongation of the illness is in itself an important hindrance to full recovery.

TRAUMATIC HAEMO-PNEUMOTHORAX

Air was present in significant quantity in 44 of the 230 cases. In other cases small pockets of air were noted, but in the majority none was present as far as

could be judged from the records. These 44 cases have been studied in an attempt to decide what part, if any, the presence of air of itself played in the course of the illness. Table X shows that haemo-pneumothorax was not especially associated with injury of the upper lobe in this series, although it occurred rather more frequently in these cases (Cheale, Qvist, and Rusby, 1945).

TABLE X

SITUATION OF WOUNDS IN TRAUMATIC HAEMO-PNEUMOTHORAX

Site of Wound	Air Absent or Negligible	Air Present	Total	Percentage with Pneumothorax
Upper lobes	41	16	57	28
Lower or middle lobes	145	28	173	16
Total ..	186	44	230	19

TABLE XI

TYPE OF WOUND IN RELATION TO HAEMO-PNEUMOTHORAX

Type of Wound	Air Absent or Negligible	Air Present	Total	Percentage with Pneumothorax
Sucking	46	17	63	27
Non-sucking	134	27	161	17
Non-penetrating	6	0	6	—
Total ..	186	44	230	19

Table XI shows the incidence of haemo-pneumothorax in relation to the type of wound. The figures are based on the condition found on admission ; nevertheless there was evidence from the records in most cases which showed that only in those included under the heading " pneumothorax " had there been found a significant amount of air in the pleura. Air may have been present in the majority of cases in the very early stage, and of course it must have been present in all of the 63 patients with sucking wounds. It had, however, absorbed very rapidly and was not to be observed on radiological examination except in the special group which is under discussion at the moment. On admission, the incidence of pneumothorax was slightly higher in patients whose wounds had originally been of sucking type.

Haemo-pneumothorax was found to carry a high rate of infection ; exactly double that in those without air (Table XII).

Apart from pleural infection, haemo-pneumothorax does not appear to affect the rate of recovery as a general rule. In only five cases did the rate of recovery appear to be related to the amount of air in the chest. In one of these the injury was so severe that recovery was bound to be slow in any case, and in two others a persistent atelectasis was present. The average duration of the illness in these five patients was 53.5 days, and so it seems that haemo-pneumothorax of itself caused some delay in recovery in a small minority of cases.

TABLE XII

HAEMO-PNEUMOTHORAX IN RELATION TO INFECTION

	Air Absent or Negligible	Air Present	Total	Percentage with Pneumothorax
Sterile	152	28	180	16
Infected	34	16	50	32
Total ..	186	44	230	19

CLOTTED HAEMOTHORAX

The definition of a clotted haemothorax accepted in this series has been "any haemothorax in which massive or extensive coagulation of the pleural contents, sufficient to hamper or prevent adequate aspiration, occurs."

While it is recognized that in such cases organization of the clot commonly occurs, organized or organizing haemothorax is not discussed under the present heading. The aim has been to consider only those cases illustrating intrathoracic clotting and its effect upon the recovery of the patient. Organizing pleuritis is to be considered separately, including as it does those empyemata in which infection was the primary event, and in which clotting was obviously a consequence of this. It is true that Langston and Tuttle (1947) suggested that minimal bacterial contamination was perhaps the cause of clotted haemothorax. In fact, one case in the present series lends possible support to this idea. This was a case of "sterile" clotted haemothorax in which on one occasion a few colonies of streptococci were cultured from the sample obtained at aspiration. This was thought to be due to contamination of the sample, but may not have been so. The theory is, however, unsubstantiated so far, and is perhaps best regarded for the present as not proven.

There were 23 examples of clotted haemothorax in the present series of 230 cases. This is a percentage of 10, as against the figure of 9% reported by Nicholson (1946) in 1,027 cases, and 8% reported by Kay and Meade (1946). Of the 23, 9 were right-sided and 14 left-sided. These numbers are not significant, and in fact Nicholson noted that 61 of 93 cases reported by him were right-sided. There was no instance of hepatic injury among the 23 cases. Nicholson (1946) thought that clotted haemothorax might be due to an associated wound of the liver, but this is not confirmed.

TABLE XIII

CLOTTED HAEMOTHORAX IN RELATION TO THE CAUSE OF THE WOUND

Agent	Clotted Haemothoraces	Total Number of Haemothoraces	Percentage Clotted
Splinter	9	132	7
Bullet	13	69	19
Others and unknown	1	29	3
Total	23	230	10

TABLE XIV

CLOTTED HAEMOTHORAX IN RELATION TO THE TYPE OF WOUND

Type of Wound	Clotted Haemothoraces	Total Number of Haemothoraces	Percentage Clotted
A. Penetrating	18	185	10
Perforating	5	39	13
Non-penetrating	0	6	—
Total	23	230	10
B. Sucking	6	63	9
Non-sucking	17	161	11
Non-penetrating	0	6	—
Total	23	230	10

TABLE XV

CLOTTED HAEMOTHORAX IN RELATION TO TREATMENT

Treatment	Clotted Haemothoraces	Total Number of Haemothoraces	Percentage Clotted
Adequate	8	123	6
Inadequate	15	87	15
Records insufficient	0	20	—
Total	23	230	10

Clotting occurred twice as frequently in haemothoraces due to bullet-wounds as in those due to other causes (Table XIII). The nature of the wound, whether penetrating or perforating, sucking or not sucking, or not penetrating, did not affect the incidence of clotting in the haemothorax (Table XIV). Adequate early treatment was associated with a much lower incidence of clotted haemothorax (Table XV).

Three out of the 23 clotted haemothoraces were cured by aspiration alone. The treatment was tedious, as clots repeatedly blocked the needle, but the lung expanded steadily, and final recovery took place within six weeks of wounding in all three cases. Two patients were treated by the simple removal of clots at thoracotomy. In one of these, operated on eight days after wounding, a staphylococcal empyema followed within a few days, but the other was cured, although expansion of the lung was slow. This case was of interest in that, although the operation was not performed until 26 days after wounding, the pleura was quite normal in appearance, and no trace of any fibrinous covering was to be seen. For the remaining 18, decortication was necessary.

ORGANIZING HAEMOTHORAX

There were 30 cases of organizing haemothorax in the 230 cases, including of course certain of the clotted haemothoraces which have just been discussed. Some details of these cases are shown in Tables XVI and XVII. The prolonged illness

TABLE XVI

INFECTION AND CLOTTING IN HAEMOTHORAX IN RELATION TO ORGANIZATION

Antecedent Condition	Number of Cases of Organizing Haemothorax
Clotted haemothorax (sterile)	12 } 18
Clotted haemothorax (infected)	6 }
Chronic empyema	12
Total	30

TABLE XVII

DURATION OF ILLNESS IN ORGANIZING HAEMOTHORAX

	Number of Cases	Average Duration of Illness (Days)
Sterile	12	80
Infected	18	140
Total	30	120

of the infected organizing haemothorax is clearly shown, though it is only slightly longer than the average for the 49 surviving empyemata (126 days). The sterile organizing haemothorax takes nearly three times as long to recover as does the uncomplicated sterile haemothorax. The final results in the 30 cases are given in Table XVIII.

The process of organization has been described by Samson and Burford (1947), and their account is based on material obtained at operation at various intervals after wounding. The pleura remains perfectly normal as a rule, but in cases of long standing, scar tissue extends through the pleura into the interstitial tissue of the lung. They state that in cases of traumatic empyema progress towards this stage is much more rapid, and may be reached in 10 days or so. The present series, however, provided examples of dense fibrous adhesions found at operation in the second week, even in cases of sterile organizing haemothorax. It is evident that wide variations occur, and the examination of biopsy material has failed to yield

TABLE XVIII

RESULTS IN ORGANIZING HAEMOTHORAX

Result	Number of Organizing Haemothoraces		Total
	Sterile	Infected	
Cured	6	6	12
Satisfactory	6	10	16
Fair	0	2	2
Total	12	18	30

more than a very general relationship of the histology to the duration of the illness. Perhaps infection is invariably present, though often minimal (Nicholson, 1946) and is localized at certain points, where the process of organization is hastened.

If this is so, a stripping operation, performed at an early stage of organization, might release organisms which were localized in this way, and thus promote a more general pleural infection in an apparently sterile case. This suggestion is given some support by the fact that, of six cases of sterile clotted haemothorax operated on before the sixteenth day, three developed an empyema ; whereas, of 12 operated on later, only three became recognizably infected. The figures, however, are small, and insufficient for a final conclusion.

Great importance is attached by Langston and Tuttle (1947) and by Samson and Burford (1947) to the correct timing of the operation of decortication in organizing haemothorax. Samson and Burford say that the optimal time is from three to five weeks after wounding. They argue that an early operation is difficult and tedious because the pleural jacket is thin and friable, and that at a late operation organization has advanced so far that stripping may be impossible. They do not mention pleural infection as a complication of the early operation. Though the present series with 30 cases is small compared with their series of 100, it offers examples which do not fit well with this statement. In two patients, with sterile clotted haemothorax, operated on in the third and fourth weeks respectively, dense adhesions greatly increased the difficulty of decortication, whereas of four patients operated on after the seventh week, only one gave rise to any difficulty. In none, however, was operation delayed beyond the ninth week. The date of operation varied very widely, and was usually in fact determined by the date of admission, as the need for decortication was obvious from the first. In only three cases had a stripping operation been carried out before admission. The appearances at varying dates after wounding could therefore be compared. The only conclusion which emerged was that there was so much individual variation that no satisfactory rule could be laid down. Undue delay seemed a waste of time for the patient, but the three empyemata which followed the six early operations may perhaps be an argument against intervention before the fourth week.

In four cases a second operation was necessary. In three of these, owing to technical difficulties, the lung could not be completely freed at the first operation. In the fourth, an uninfected case, an easy stripping operation was followed by full expansion, but later the lung collapsed once more, and a large effusion occurred. Aspiration failed, and at the second operation a week afterwards massive coagulation of the effusion was found. The lung was once more encased in a fibrinous " strait jacket." Decortication was this time followed by permanent cure.

Summary and Conclusions

1. In a series of 400 thoracic injuries admitted to the Chest Surgery Centre, Shotley Bridge, haemothorax was noted in 230 (58%). The low incidence is partly due to strict criteria of diagnosis, and partly to selection. More than half the cases were referred after treatment at other hospitals, and a number were sent merely for the removal of a foreign body from the lung, after recovery from the main illness.

2. Final results in the 230 cases were as follows: Cured 148 (64%); satisfactory 76 (33%); fair to poor 5 (2.2%); died 1 (0.4%).

3. The average duration of the illness in the 229 survivors was 68 days from the time of wounding.

4. The incidence of infection was 22%, a reduction of 40% compared with that recorded in 1917 (Bradford and Elliott). Neither the nature of the wound, its situation, nor the type of missile was related significantly to the incidence of infection. The incidence of infection in bullet wounds was practically the same as in 1917, and almost all the reduction in the infection rate occurred in wounds due to splintered fragments.

The large haemothorax was found to be twice as likely to become infected as was the small haemothorax. The incidence of infection was more than seven times as high among those patients whose treatment was late and inadequate, as among those correctly treated. The duration of the illness averaged 126 days, two and a half times that of the uninfected cases. There were 12 examples of bronchopleural fistula.

5. The average duration of illness in 117 adequately treated cases of sterile haemothorax was 37.5 days, but 29 of these were complicated in various ways. If these complicated cases are excluded, the average duration of illness in uncomplicated sterile traumatic haemothorax, adequately treated, is seen to be 27.8 days. The duration of the illness was more than twice as long in the patients with sterile haemothorax who were inadequately treated (less than a third of the 180 cases).

6. Traumatic haemo-pneumothorax occurred in 44 of the 230 cases. It was rather more frequent in injuries of the upper lobes, though the figures were not highly significant; and was more commonly noted in patients with sucking wounds. The rate of infection in these cases was significantly higher than that in the rest of the series, and it appeared that it was because of this that pneumothorax affected the patient's recovery.

7. Clotted haemothorax occurred in 23 cases, i.e., 10% of the series, an incidence similar to that in other reported series. Bullet wounds were found to be twice as likely to lead to clotting as were wounds due to splintered fragments, but the nature of the wound was of no importance. The inadequately treated patient was seen to be two and a half times as liable to clotting as the correctly treated patient. Decortication was usually necessary for cure (18 cases), but some patients were cured by aspiration alone.

8. There were 30 cases of organizing haemothorax, composed of organized clotted haemothorax and chronic empyemata. The total average duration was about as long as the average for the 49 surviving empyemata, but the chronic empyemata took 40 days more, and the sterile cases 40 days less, than the total average, for recovery. The sterile "organizing" case took nearly three times as long to recover as the average uncomplicated sterile haemothorax. No clear indication of the optimal time for operation was obtained, but there was suggestive evidence that "uninfected" patients operated on before the end of the second week were more liable to develop empyema. Late operation seemed merely to cause a waste of time, and it is suggested that the fourth week is probably the best time to operate. Twelve

cases were cured, and in 16 the result was regarded as satisfactory. The remaining two cases yielded only a fair result.

9. Prolonged illness after a battle wound has a deleterious moral effect upon the patient. "Cure" was assessed in terms of physical recovery, but psychological recovery by no means always kept pace with this. It is largely for this reason that so much attention was paid to the total duration of the illness.

10. Physiotherapy is an invaluable adjuvant, and should be started as soon as possible, for its moral as well as its physical effect.

11. Operation was necessary in 63 out of 230 cases (27%). The analysis of cases suggests that this figure could be reduced appreciably.

I am indebted to Mr. George A. Mason, F.R.C.S., surgeon in charge of the Chest Surgery Centre, for permission to publish these cases which were under his care.

I also wish to thank Mr. H. Campbell, M.A., F.S.S., of the Department of Industrial Health, Durham University, for most valuable statistical assistance, and Dr. T. Black for his help in the examination of several of the histological sections. My secretary, Miss D. Hall, and my former secretary, Miss M. Stansfield, helped to prepare the article for the press, and I gratefully acknowledge their services.

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