

**War wounds of the lung : notes on their surgical treatment at the front / by Pierre Duval ; authorized English translation.**

**Contributors**

Duval, Pierre, 1874-1941.

**Publication/Creation**

Bristol : J. Wright, 1918.

**Persistent URL**

<https://wellcomecollection.org/works/dtqm7zev>

**License and attribution**

Conditions of use: it is possible this item is protected by copyright and/or related rights. You are free to use this item in any way that is permitted by the copyright and related rights legislation that applies to your use. For other uses you need to obtain permission from the rights-holder(s).



Wellcome Collection  
183 Euston Road  
London NW1 2BE UK  
T +44 (0)20 7611 8722  
E [library@wellcomecollection.org](mailto:library@wellcomecollection.org)  
<https://wellcomecollection.org>

# WAR WOUNDS OF THE LUNG

Pierre Duval

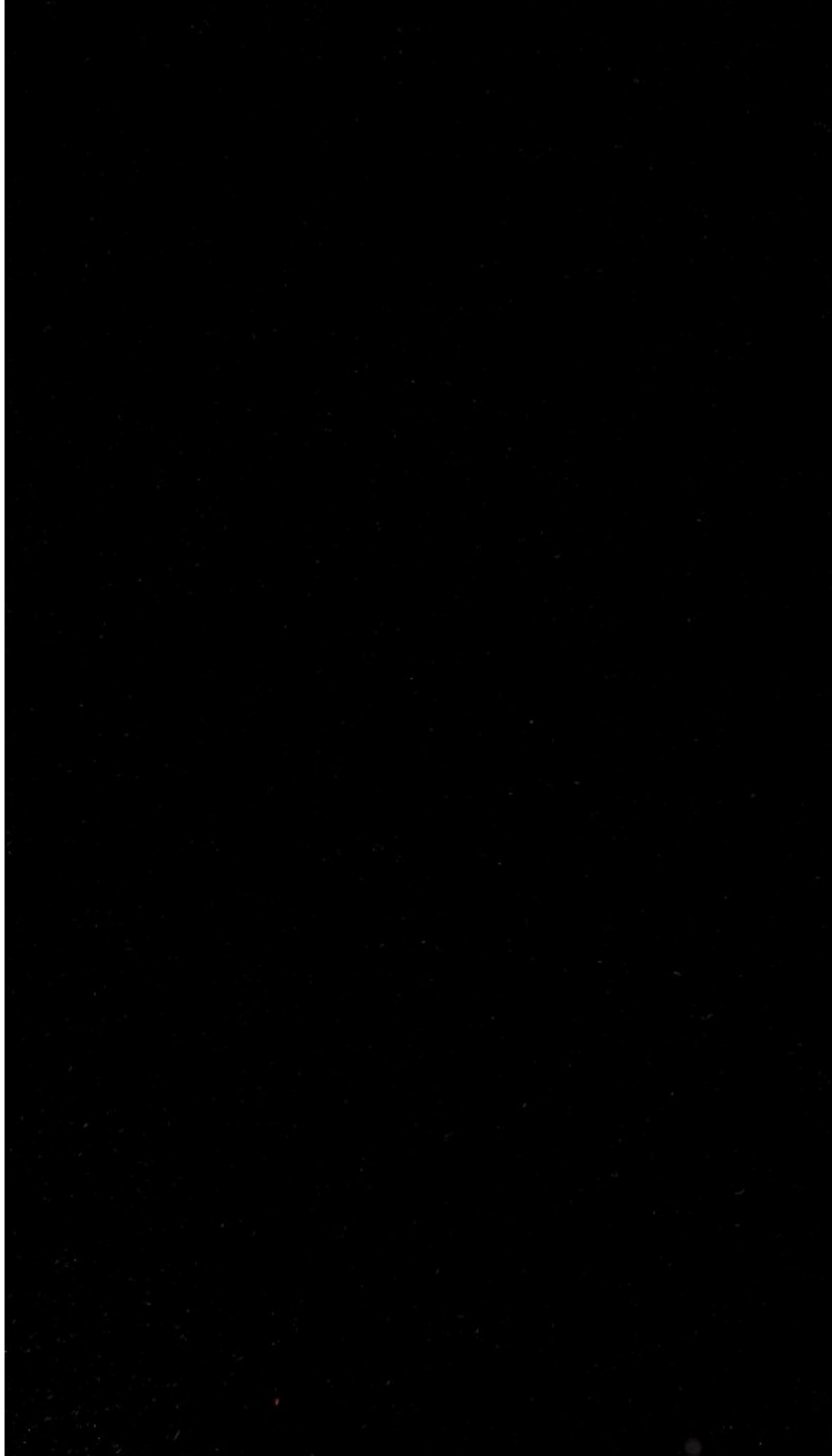


TRO  
RAMC  
Coll.  
/DUV

2



22101944090





15. d. 28. - C

Cal. -

# WAR WOUNDS OF THE LUNG:

NOTES ON THEIR SURGICAL  
TREATMENT AT THE FRONT

BY  
PIERRE DUVAL.



2B 2

WITH 27 PLATES AND ILLUSTRATIONS.

*Authorized English Translation.*

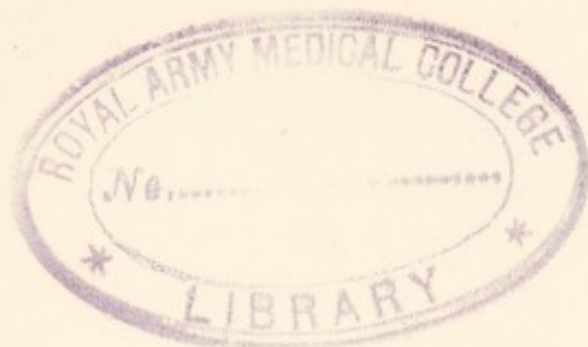
8182

BRISTOL: JOHN WRIGHT & SONS LTD.  
LONDON: SIMPKIN, MARSHALL, HAMILTON, KENT & Co. LIMITED.

1918

COPYRIGHT ENGLISH TRANSLATION  
PRINTED BY  
JOHN WRIGHT AND SONS LTD., BRISTOL, ENGLAND

TRO  
RAMC  
Gill.  
/DJV



## DÉDICACE DES TRADUCTEURS.

---

À


PIERRE DUVAL,

AUTO-CHIR. No. 21, ARMÉE FRANCAISE,  
cette traduction avec les affectueux hommages de  
36 CASUALTY CLEARING STATION, B.E.F.

Votre livre est une telle révélation que nous avons respecté,  
le plus possible, vos propres expressions.

Nous avons eu l'honneur de travailler côte à côte, et nous  
vous retrouvons dans votre œuvre tellement personnelle . . .  
en lisant ces pages on vous voit, on vous entend parler . . .





Digitized by the Internet Archive  
in 2018 with funding from  
Wellcome Library

<https://archive.org/details/b29932464>

## AUTHOR'S PREFACE.

I DEDICATE this book to my comrades of the Auto-Chir. No. 21, which I have the honour of commanding.

We lived together during a long period of surgical stress on the Somme, and this book is the result of our combined experience, of our despair at the terrible fatality of lung wounds and of our helplessness in treating them.

Surgeons, Assistants, Physicians, Bacteriologists, Radiologists, all have been moved by the one idea of giving better aid to our soldiers, and have made common cause in this study of chest wounds. These notes are the result of our collaboration, the new ideas brought forward are ours in common, the personality of each individual is merged in the common work.

My comrades have honoured me by leaving to me the publication of our work, and I cannot sufficiently thank them.

These notes are not to be regarded as a complete treatise on gunshot wounds of the lung, they deal only with those points which have thrust themselves into the range of our experience.

Surgery of the lung has been revolutionized during the war and has taken its place in the routine of general surgery.

We are convinced that, with this new operative technique, the general rules of war surgery must be applied to wounds of the lungs, and that better results are thus obtained than with a non-operative policy. What will be the outcome of these ideas which, to-day, seem almost revolutionary?

The future may acclaim them as right or reject them as wrong; our object has been simply to improve the lamentable lot of men suffering from lung wounds, and for this, at least, I trust our critics will give us credit.

IN THE FIELD, 25th April, 1917.



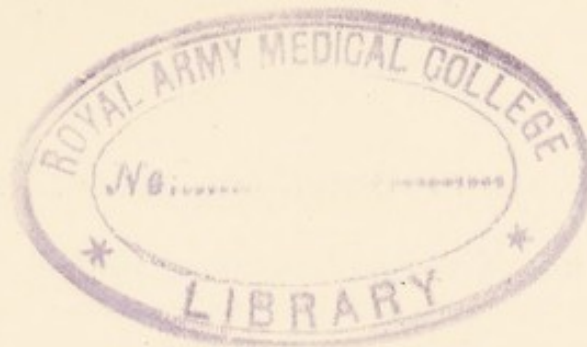
## CONTENTS.

CHAP.	PAGE
I.—MORTALITY OF LUNG WOUNDS IN THE ZONE OF THE ARMIES - - - - -	1
II.—PATHOLOGICAL ANATOMY OF LUNG WOUNDS - - -	7
III.—FATAL HÆMORRHAGE IN WOUNDS OF THE LUNG : PRE- VENTION POSSIBLE BY IMMEDIATE SURGICAL TREAT- MENT - - - - -	19
IV.—INFECTION IN LUNG WOUNDS - - - - -	33
Bacterial Findings in Cases of Shell Wounds— Septic Bronchopneumonia and Pneumonia—Abscess and Gangrene of the Lung—Pleuro-pulmonary Lesions of the opposite side—Infection of the Hæmothorax— Source of the Infection and characters of the Infected Fluid—Acute and Subacute Pleuro-pulmonary Sep- ticæmia in a Hæmothorax.	
V.—OPERATIVE TREATMENT OF WOUNDS OF THE LUNG -	44
VI.—THE URGENT SURGERY OF 'OPEN THORAX' - - -	58
VII.—OPERATIVE TECHNIQUE - - - - -	61
The Blood-pressure during Operation on the Lung— Anæsthesia—The Thoracotomy—Delivery of the Lung —Direct Arrest of Hæmorrhage from the Lung—Early Extraction of Foreign Bodies in the Lung—Treatment of the Wound in the Lung : Suture of the Lung— Treatment of the Pleura—Closure of the Thorax— Treatment of the Parietal Wound—Subsequent Course and Post-operative Treatment.	
VIII.—LATER RESULTS - - - - -	79



## APPENDIX :

	PAGE
NOTES OF 17 CASES OF SEVERE HÆMORRHAGE OF THE LUNG TREATED BY THORACOTOMY AND DIRECT ARREST OF THE BLEEDING - - - -	81
NOTES ON THE SURGICAL TREATMENT OF LUNG WOUNDS	88
Simple Immediate Extraction of Missile where Direct Arrest of Hæmorrhage was required—Extraction of Missiles as part of the Direct Treatment of Lung Wounds without Urgent Symptoms—Extraction of Fragments of Bone—Treatment of Severe Hæmorrhage by Direct Hæmostasis—Direct Treatment of the Wound without Urgent Pulmonary Symptoms.	
OTHER CASES OF INTEREST - - - -	94
BACTERIOLOGICAL FINDINGS IN 25 CASES OF HÆMO- THORAX INFECTED WITH ANAEROBES - -	98



# WAR WOUNDS OF THE LUNG, AND THEIR SURGICAL TREATMENT.

## CHAPTER I.

### MORTALITY OF LUNG WOUNDS IN THE ZONE OF THE ARMIES.

A CONSIDERABLE number of statistics have been published, a detailed study of which gives a general idea of the fatality, during this present war, of wounds of the lung.

The attached table shows that among 3453 cases there were 688 deaths, a mortality of 20 per cent.

	NUMBER OF CASES	DEATHS		NUMBER OF CASES	DEATHS
Dupont et Ken-			Weitzel ..	91	11
dirdjy ..	38	1	Schneider ..	14	1
Michaux ..	7	3	Simon ..	13	2
Hartmann ..	30	2	Froelich ..	59	4
Picqué ..	10	0	Gross ..	171	23
Morestin ..	5	0	Gross et Gré-		
Michon ..	20	0	goire ..	404	45
Walther ..	36	3	Jeanbrau ..	200	37
Mauclore ..	29	1	Sauvageot et		
Lenormant ..	29	6	Popp ..	85	25
Seneert ..	130	31	X. ..	59	8
Schmid ..	64	10	Auto-Chir. 21		
Phocas ..	7	2	(Pierre Duval)	194	42
Chavannaz ..	60	12	Maisonnet ..	104	20
Picqué ..	46	8	Maillet ..	115	28
Rouvillois ..	110	30	Gatellier-Bar-		
Thévenot ..	102	27	bary ..	154	20
Duponchel ..	269	94	Augé ..	121	24
Debeyre ..	138	18	Fuster ..	15	0
Latarjet ..	90	39	Lemaître ..	56	10
Cotte ..	18	2			
Depage ..	360	99	Total ..	3453	688



The incidence of deaths from lung wounds in the different medical formations should be established—those occurring in the aid posts, in the divisional ambulances, the evacuation hospitals, and the field stationary hospital units. Unfortunately we have not been able to obtain accurate figures from the regimental medical officers, but a considerable mortality occurs at the aid posts: the many difficulties and dangers of the work there make it impossible for the officers to render exact statistics. But their estimates agree that there is terrible mortality among chest wounds at the aid posts, 25 to 30 per cent being the figures given as an average. An officer of ripe judgement, quoted by Baudet, said that he did not remember one case of severe bullet wound of the chest in which death did not rapidly occur (at the aid post). According to Picqué, the seriously wounded die at the aid post. Hartmann writes that cases of severe hæmorrhage often do not reach the divisional ambulances.

Hæmorrhage and mechanical asphyxia (open thorax with traumatopnœa) are the two chief causes of death. Regimental medical officers are also of opinion that a number of men die on the field from wounds of thoracic vessels; these cases cannot appear in any statistics.

The divisional ambulances and the evacuation hospitals being at much the same distance from the front line, and as, during the fighting, cases of chest wounds are usually taken direct to the evacuation hospitals, the mortality of chest wounds occurring at these units may be considered together.

The automobile-chirurgicale units (Sencert, Gross, Grégoire, Thévenot, Jeanbrau, Rouvillois, Pierre Duval) have had an average death-rate of 18 to 20 per cent. The best figures are those of Grégoire and Gross—14·4 per cent in 400 cases. During the Somme battles the mortality was high: Rouvillois, 26·1 per cent; Thévenot, 27 per cent; Pierre Duval, 20·1 per cent. The wounds were due chiefly to shell fire, and the flora of the soil has a most important bearing on chest and lung—as on all other—war wounds. In stationary hospitals the mortality is lower—10 to 12 per cent.

It can be laid down, then, that the mortality of lung wounds is proportionately lower the further they are seen from the fighting line. In the French Army the rule is that a chest



wound shall be detained in the nearest medical unit which can receive and deal with it; thus the only patients who reach the hospitals situated farther back are those in very good condition, who have survived the complications of the first few days.

With an aid-post mortality of 25 per cent, ambulance and evacuation-hospital death-rate of 20 per cent, and a stationary hospital figure of 10 per cent, one sees that half the fatal cases die early; and these statistics do not include patients who succumb to chronic and delayed sequelæ of chest wounds, empyema, abscess of lung wounds, and all the late complications of chest wounds.

This mortality is staggering, especially as it was unsuspected before this war. How did the idea arise that wounds of the chest were comparatively trivial? The first statistics of this war, those of Dupont and Kendirdjy at the end of 1914, showed a mortality of 2.6 per cent in 38 cases. Even then, the Société de Chirurgie noted that this was only a lucky series of cases; but it was later, in the meetings of the army surgeons, when surgeons employed with the armies compared their statistics, that it was fully realized how seriously wounds of the lung should be regarded.

The explanation of the supposed benign character of chest wounds is simple. The experience of civil and military practice was based on bullet wounds (rifle and revolver). In this war, however, we have found ourselves faced with an enormous preponderance of wounds due to shell fire. Bullet wounds of the lung are infinitely less serious than those caused by shell fragments, and they alone deserve to retain their old reputation of being trivial, with the exception of cases which die on the field, the number of which is unknown.

Several surgeons have recorded in their statistical tables the relative number of bullet and shell wounds —

Depage :

52 per cent bullet wounds, with mortality 17.6 per cent

48 per cent shell wounds, with mortality 26.8 per cent.

Pierre Duval :

24.2 per cent bullet wounds, with mortality 2 per cent

75.8 per cent shell wounds, with mortality 28.2 per cent.

Debeyre :

Bullet wound mortality, 12 per cent

Shell wound mortality, 16 per cent.



Maillet :

41·7 per cent bullet wounds, with mortality 16 per cent

57·4 per cent shell wounds, with mortality 20·5 per cent.

Schmid :

Bullet wound mortality, 4 to 5 per cent

Shell wound mortality, 40 per cent.

Bullet wounds of the lung are either fatal at once by reason of injury to a large vessel, or comparatively benign. With this class of wound there are few complications; the wound is either aseptic or seldom followed by grave infection. To this single factor their slighter severity is due.

Shell wounds of the lung may also be immediately fatal: less frequently perhaps than bullet wounds, but the septic sequelæ make for great danger.

On the Somme we were able to establish the relative mortality of through-and-through shell wounds, and of those in which the missile penetrated and was retained in the lung.

Through-and-through shell wounds, mortality 21·2 per cent

Shell wounds, with missile retained, mortality 30·3 per cent.

This simple table proves that in the lung, as in any other tissue, the retention of a shell fragment, with any other foreign body carried in with it, is a factor of undoubted and grave peril.

The figures are supported by those of Rouvillois :—

42 through-and-through wounds, 10 deaths = 23 per cent

60 missile-retained wounds, 27 deaths = 45 per cent.

Of the 10 deaths caused by traversing wounds, 9 were from shell wounds, 1 from bullet. Of the 27 deaths caused by wounds with missile retained, 26 were from shell wounds, 1 from bullet. No figures could show better the serious nature of wounds by shell fragments.

It is interesting to ascertain the date on which death occurred after the wound, and we quote the figures given by Gatellier and Barbary, Depage and Janssen, Maisonnnet.

Of Gatellier and Barbary's 20 fatal cases :

7 (one-third) died on the first day

8 (one-third) died on the second day

2 died between the third and eighth days

3 died after eight days.



Of Maisonneuve's 21 fatal cases :

- 11 (one-half) died during the first two days
- 0 died between the third and seventh days
- 4 died between the seventh and tenth days
- 6 died after the tenth day.

Depage and Janssen had 59 fatal cases ; of these :

- 30 (one-half) died on the first day
- 5 died on the second day
- 4 died on the third day

The remainder between the fourth and twentieth days.

It is perfectly clear that the mortality is highest during the first forty-eight hours. During the first twenty-four hours Depage lost 50 per cent of his cases. Gatellier and Barbary lost 34 per cent. Of 101 of our fatal cases, we lost 61 (60·3 per cent) during the first forty-eight hours. The death-rate again rises between the seventh and tenth days.

On one point in the statistical study of wounds of the lung stress must be laid (to which we believe Hartmann first drew attention), namely, the greater gravity of open wounds of the chest as opposed to closed.

This is a most important point ; wounds with an open thorax are at least twice as dangerous as those with a closed thorax. Regimental medical officers all agree that wounds of the chest with a gaping opening in the thorax, stove-in ribs, and traumatopnoea, are extremely serious cases.

Depage has compiled the following figures : Open thorax, 55 cases, 16 deaths, 29 per cent ; closed thorax, 205 cases, 43 deaths, 16 per cent.

Gatellier shows : Open thorax, mortality 25·8 per cent ; closed thorax, mortality 11·11 per cent.

On these broad lines it is possible to resume our study of the statistics ; we have compiled them with every care, but they do not represent the real facts. The impossibility of comparing the number of chest wounds with those of other regions, the absolute impossibility of gauging the mortality on the battle-field, the inevitable difficulty of finding out the chest mortality rate in the trenches, render these figures, like all other medical statistics, relatively inexact. Nevertheless these figures give a fairly correct idea of the mortality from chest wounds in the cases which reach the field surgical units.

Chest wounds are among the most fatal of battle injuries,

and demand the most vigorous efforts to improve their treatment.

MORTALITY FROM LUNG WOUNDS IN THE ARMY AREAS.  
(Based on 3453 admissions to hospital).

Death-rate of all admissions for wounds  
of the lung to field surgical units 20 per cent\*

Death-rate at the Various stages	{	Aid posts .. ..	25 per cent
		Divisional ambulances and evacuation	
		hospitals .. ..	20 per cent
		Field stationary hospi- tals .. ..	10 per cent

Average mortality from the aid posts  
to the field stationary hospitals .. 45 per cent

Death-rate according to the nature of the projectile :—

Rifle-bullet wounds from	5 to 15 per cent
Shell wounds .. ..	25 per cent†
Through-and-through wounds	21 per cent
Missile retained in the lung..	30 per cent
Wounds with 'closed thorax'	15 per cent
Wounds with 'open thorax'	27 per cent

Mortality in the first twenty-four hours, from 32 to 50 per  
cent of all fatal cases.

Mortality in the first forty-eight hours, 60 per cent of all fatal  
cases.

---

\* This figure is based on the impressions of battalion medical officers,  
not on any statistics. It is not reckoned in the figures of cases  
admitted to field surgical units.

† Battle of the Somme.



## CHAPTER II.

## PATHOLOGICAL ANATOMY OF LUNG WOUNDS.

WAR wounds of the lung may present such different aspects that a didactic description of them is exceedingly difficult. Yet they have a general resemblance; with varying characteristics, they always exhibit lesions of the same nature. These lesions must be dwelt upon, not only to explain the nature of lung wounds, but also to try and formulate from them various methods of surgical treatment which may be resorted to.

A wound of the lung may be either perforating (through-and-through), or penetrating (with lodgement of the missile), or entirely on the surface of the lung. From a surgical point of view bullet wounds are of little interest, as they do not demand operative interference. Shell wounds are the typical examples to be considered.

The through-and-through track is sometimes clean cut with entrance and exit wounds of the same size. *Fig. 1* shows a track of even dimensions throughout, with comparatively clean-cut walls. When the shell fragment is large, the track is irregular and tortuous. More often than not the exit is larger than the entrance wound. The two photographs (*Fig. 2*) show an entrance wound of moderate size, and a large wound of exit with destruction of tissue. In this case splinters of bone driven into the lung contributed to the destruction of the parenchyma.

One must remember, to appreciate during operation the real extent of lung wounds, that the organ is collapsed and little more than half its normal size. The edges of the wounds are frequently ragged, with more or less pedunculated tags of tissue (*Fig. 4* shows a magnificent example). Only once have we seen a moderate-sized entrance wound accompanied by a tear of the lung some centimetres long.

A large wound is usually found on the thoracic surface of



the lung, and is caused either by a tangential blow, or by a direct blow with fracture of the ribs. It is sometimes an actual burst of the parenchyma, which is split in every direction; such a wound always involves the complete or partial detaching of a portion of lung tissue of greater or smaller extent.

When the wound is not too large, we have found it possible to deal with it successfully by excising the edges, cleaning up the surface with curved scissors, and suturing the wound with deep stitches. These wounds are often accompanied by grave hæmorrhage; but suture, and very exceptionally ligation of an actual vessel, will ensure arrest of the hæmorrhage.

The most important damage is due to the destruction of lung tissue, and blood infiltration. Every wound of the lung includes a zone, more or less extensive, of cellular necrosis, absolute destruction of tissue such as occurs in every wound, particularly in those involving muscle. On the wall of the track, and even extending for a certain depth into the substance of the lung, the tissues are bruised and dead. Infiltrated with blood, they appear compact and lifeless. When one takes hold of them to suture the edges of the wound they feel thickened and infiltrated, in contrast with the normal lung tissues, which yield and crepitate on pressure. The photographs (*Fig. 2*) show this destruction of the lung tissue.

When a through-and-through track is laid open, it is found to be ragged, covered with tags of tissue, some pedunculated, others lying free. With a swab one can gently rub off a varying amount of mashed-up tissue. In a large wound one finds a considerable amount of this pulped tissue. The blood infiltration spreads to a varying extent, forming an actual traumatic infarct, sometimes limited merely to the edges of the wound, at other times a red mass invading a more or less extensive area in the lobe, or even, occasionally, an entire lobe.

The extreme vascularity of the lung explains this hæmorrhagic infiltration, which is always present. One even wonders why severe hæmorrhage is not more frequent, why the fragile pulmonary vessels at some distance from the wound do not give way under the great pressure which must be exerted by



the missile smashing into the comparatively incompressible, liquid mass of which the lung consists.

*Figs. 1, 2, and 10* are good examples of varying degrees of hæmorrhagic infiltration. The first shows moderate infiltration round a clear-cut track, the second an infiltration of small extent round a large wound of exit, the third displays a massive infiltration of the whole lobe from a penetrating wound in it. This is also illustrated in colour (*Fig. 8*).

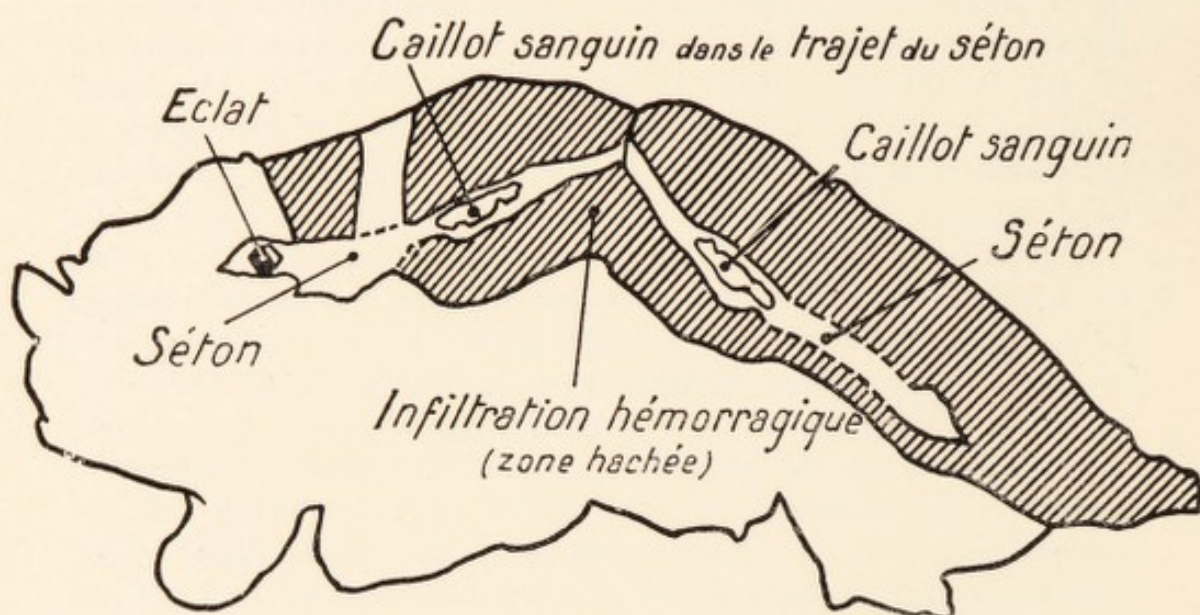
The zone of blood infiltration shows very well with *x* rays, as a patch of relative opacity in the lobe. The radiograph (*Fig. 5*) shows distinctly the difference between the healthy lobe and the lobe—with a through-and-through wound—which is almost entirely infiltrated with blood.

Whether or no the lung has a missile retained, it cannot be too strongly emphasized that there may be other foreign bodies lodged in it. Fragments of clothing are often driven into the lung. During three of our operations of urgency we have removed fragments of the great coat which surrounded the missile. Even though the missile—bullet, or shell fragment—may have passed right through the chest, fragments of clothing may remain in the lung.

Paschoud has reported two instances. In one a rifle bullet had passed through the chest and left lung, from back to front. Four months later the patient developed an empyema, and in the pus were found fragments of clothing which the bullet had carried into, and left in, the lung. In the other case a shell fragment traversed the left lung and lodged in the wall of the heart, whence it was extracted by Paschoud. The fluid in the pericardium was sterile, and the wound in the heart muscle showed no signs of infection. After the operation the patient developed grave pleuro-pulmonary suppuration, and died. At the autopsy the wall of the heart was found to be uninfected, the pericardial fluid was sterile, but there was suppuration of the lung wound which contained fragments of clothing. The pus from the lung contained streptococci.

Another variety of foreign body in the lung deserves particular notice, namely, splinters of bone from the ribs, the scapula, and the transverse processes.

## PLATE I.



*Fig. 1.*—Wound by small shell fragment—the missile retained in the wound track. Death in 24 hours.

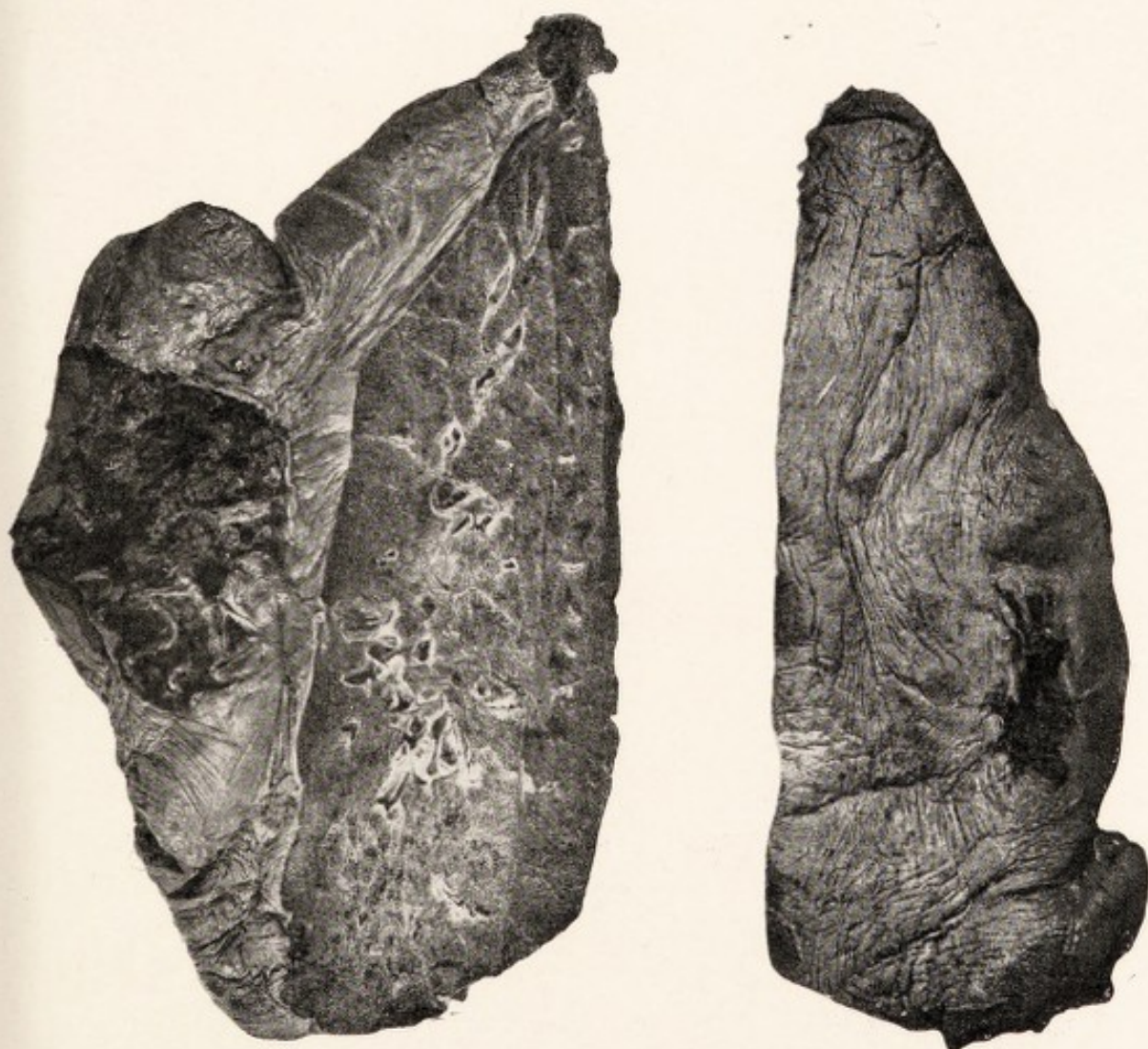
*Fig. 2.*—Lung wound, showing small entrance wound and large wound of exit. Splinters of indriven bone. No hæmorrhagic infiltration.



*PLATE 1.*



*Fig. 1.*



*Fig. 2.*





Fracture of the bony wall of the thorax occurs frequently, and splinters of bone are almost always driven in. In the course of twenty-one operations we have five times extracted bone splinters from the lung or pleura.

These splinters are a source of great danger, either primarily or secondarily. They are violently driven into the lung and cause extra injury by crushing, bruising, and necrosis of the

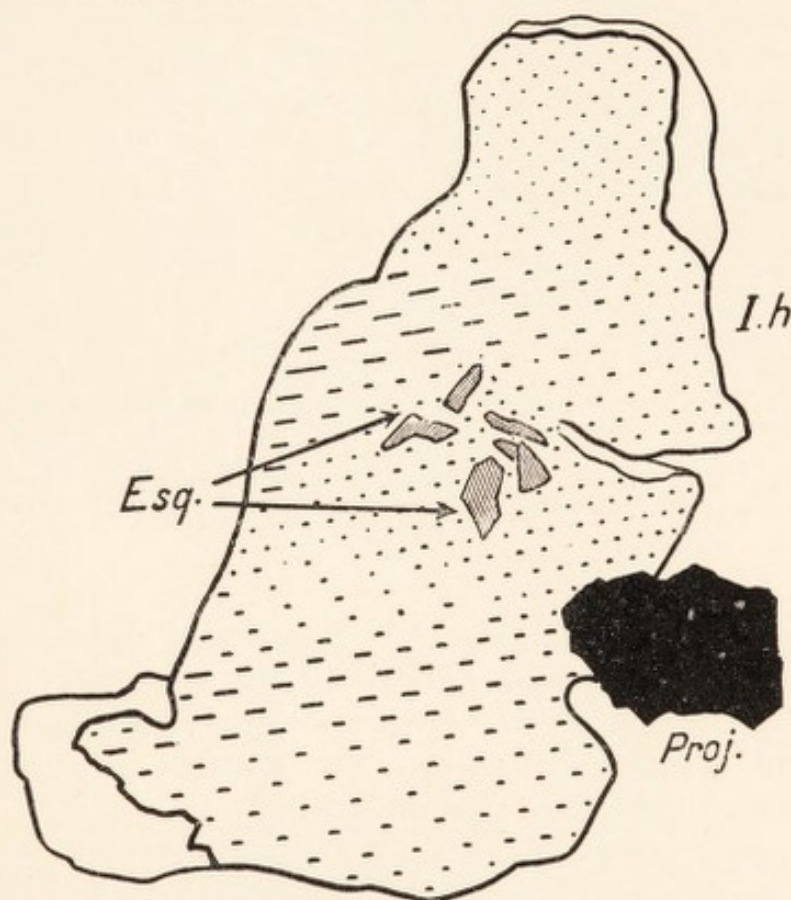


Fig. 3.—Diagram of radiograph. (*Proj.*) Shell fragment fracturing rib. (*Esq.*) Indriven splinters of bone. (*I.h.*) Extensive hæmorrhagic infiltration.

lung, in addition to the damage done by the projectile. They penetrate a considerable distance, and we have found them up to a depth of 5 cm. in the lung substance. They cause a torn and jagged wound, and the zone of dead tissue is very extensive. Injury to vessels often gives rise to grave pulmonary hæmorrhage. Later, the bone splinters nearly always cause suppuration; the deeper the splinters penetrate, the more serious the pleuro-pulmonary infection.



*Fig. 2* shows the large lung wound caused by splinters of rib, and the extensive zone of tissue laceration. *Fig. 3* shows a collection of splinters in a large wound on the external aspect of the lung. These splinters are not demonstrable by radioscopy, nor even in a radiograph of the whole thorax. A systematic search for them is imperative in every case with fracture of the bony skeleton of the chest wall.

Lenormant was among the first to urge the great danger of tangential wounds of the lung with fracture of the ribs. Splinters of bone driven into the substance of the lung are undoubtedly responsible for the extreme gravity of this type of wound, for its immediate dangers, the hæmorrhage, and the later complications, especially the endless suppuration.

#### PLATE II.

*Fig. 4.*—Wound of lung—the pulmonary border is torn. Immediate death due to other injuries.

*Fig. 5.*—Radiograph of *Fig. 4*. Probe in the wound track. The dark shade indicates the hæmorrhagic infiltration. Lower lobe normal.

The sum of these facts proves a new and most important point, that chest wounds possess all the characters of every other shell wound,—tissue destruction and hæmorrhagic infiltration of varying degrees, the presence of all sorts of foreign bodies, projectiles, and débris.

The morbid anatomy of a lung wound is thus the same as that of any other gunshot wound. As in any ordinary muscle wound, it is there and then contaminated by the mere entrance of the foreign body, whether retained or not. Like any other wound, there is an area of necrotic tissue destined to autolysis and forming a culture medium for traumatic infection. As with any other shell wound, after a certain number of hours it will become infected, and the infection will follow the same course as in any war wound. The anatomical injuries; the infecting foreign bodies; the bacteriological findings; and the biological changes, are all the same.

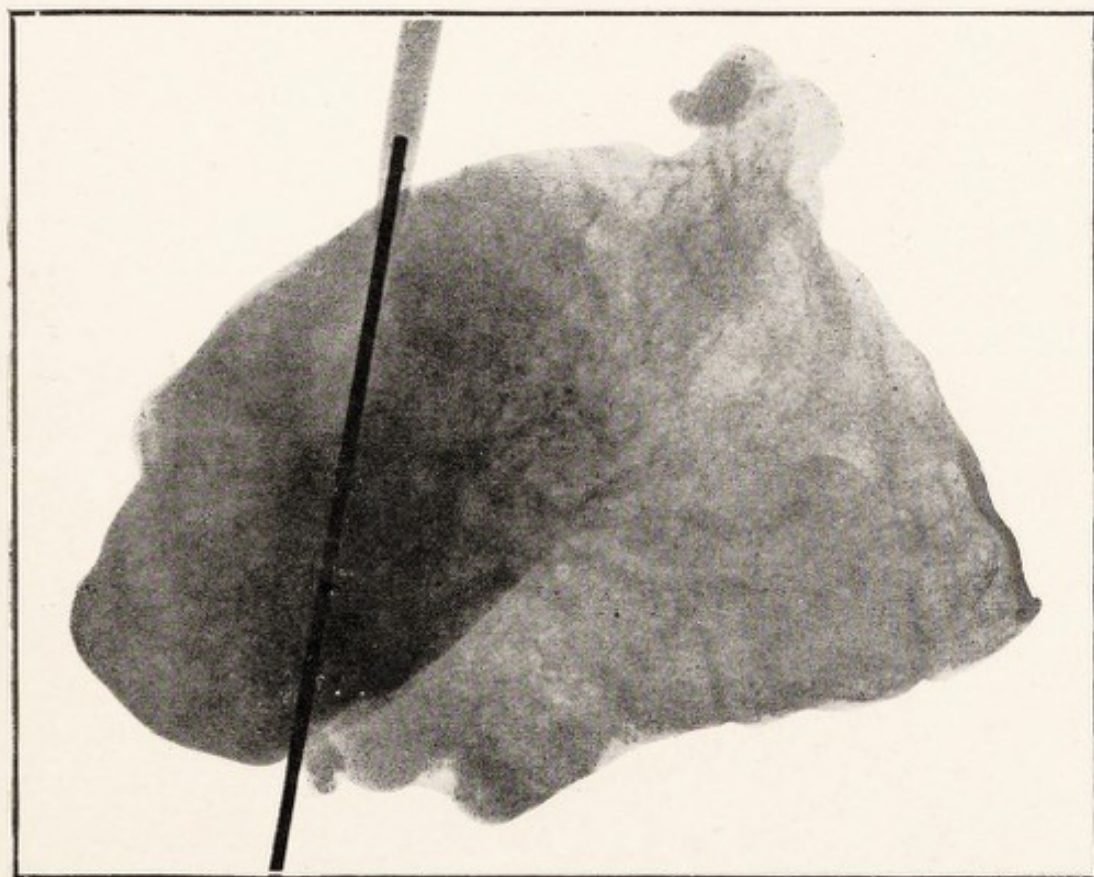
This complete and absolute resemblance between gunshot wounds of the lung and of muscle must be the starting-point



PLATE II.



*Fig. 4.*



*Fig. 5.*





of any discussion as to the best surgical treatment to be adopted in dealing with war wounds of the lung.

Remote injuries in the lung are also important. The lower, sometimes the middle, lobe, whether injured or not, may be in a state of complete collapse owing to pressure from the hæmothorax. Above the level of compression a zone of emphysema testifies to the increased effort of the unaffected lung tissue. The remote lesions are very often most curious, both in the injured lung itself and on the opposite side.

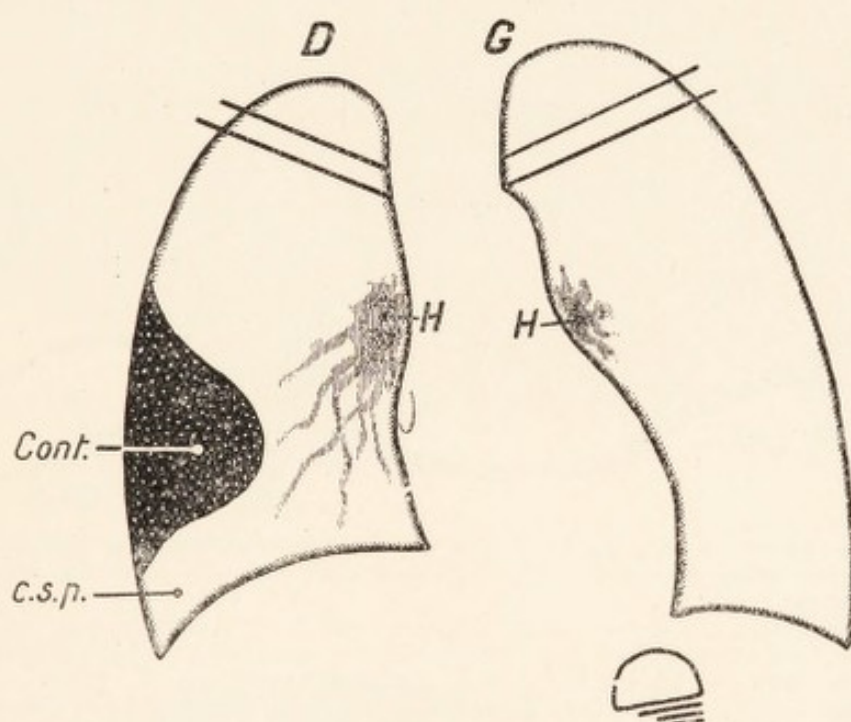


Fig. 6.—From diagram showing contusion of right lung. (Cont.) Area of contusion clearly defined. (D) Right. (G) Left. (c.s.p.) The pleural cul-de-sac is quite free. (H) Shadows in hilus.

It is not uncommon to find, either at the base or apex of the injured lung, an area of contusion—with blood infiltration of varying extent—simple contusion by *contre-coup*. We have once seen a small tear of the visceral pleura on the opposite side. Martin has demonstrated in our clinic similar contused areas by *contre-coup*, on the thoracic aspect of the lung, at the base, and at the apex. These contused areas are shown by radioscopy as limited opacities in the lung (Fig. 6). He has demonstrated also that fine pleural adhesions are formed in the area of the contusion—these have been proved histo-

## PLATE III.

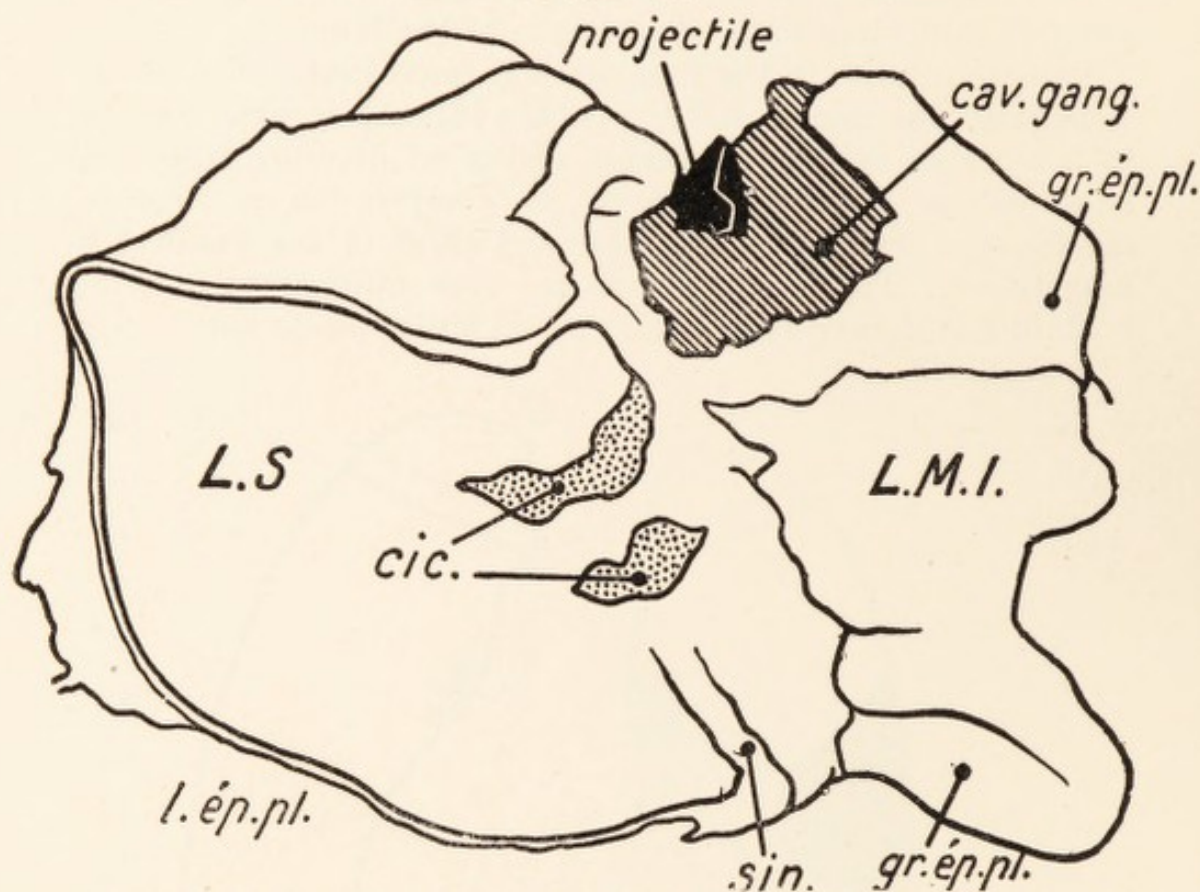


Fig. 7.—Lefèvre's case of a man who died of violent hæmorrhage and hæmoptysis 25 days after being wounded. A missile had been removed from the inferior lobe on the second day.

(*c.i.c.*) Band of cicatricial tissue, 10 cm.  $\times$  5 m.  $\times$  2 mm., the only trace of the pulmonary wound whence the missile had been extracted. (*L.S.*) Superior lobe practically normal, except for a slight pleural thickening (*l. ép. pl.*). (*L.M.I.*) Middle and inferior lobes where an unsuspected projectile had been left, recovered with much pleural thickening (*gr. ép. pl.*). In the centre is an abscess with necrotic walls (*cav. gang.*) containing the projectile and a blood-clot.

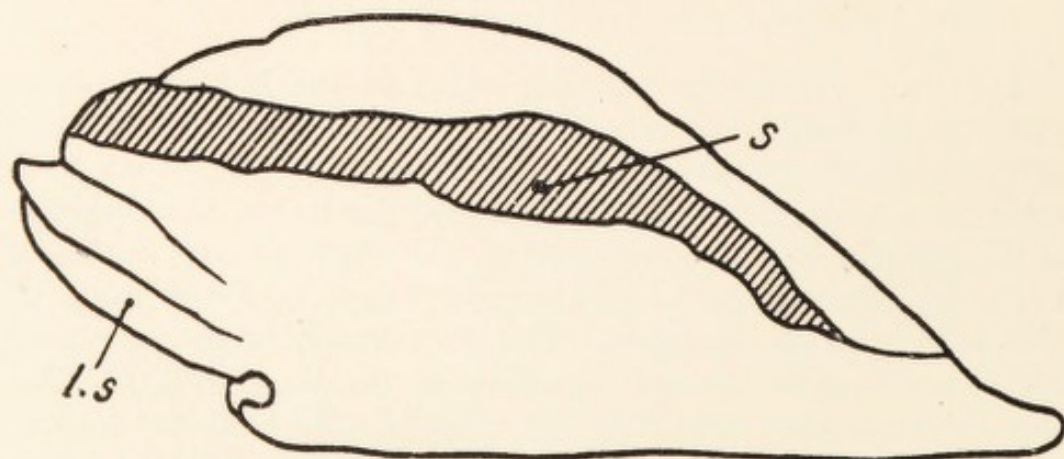
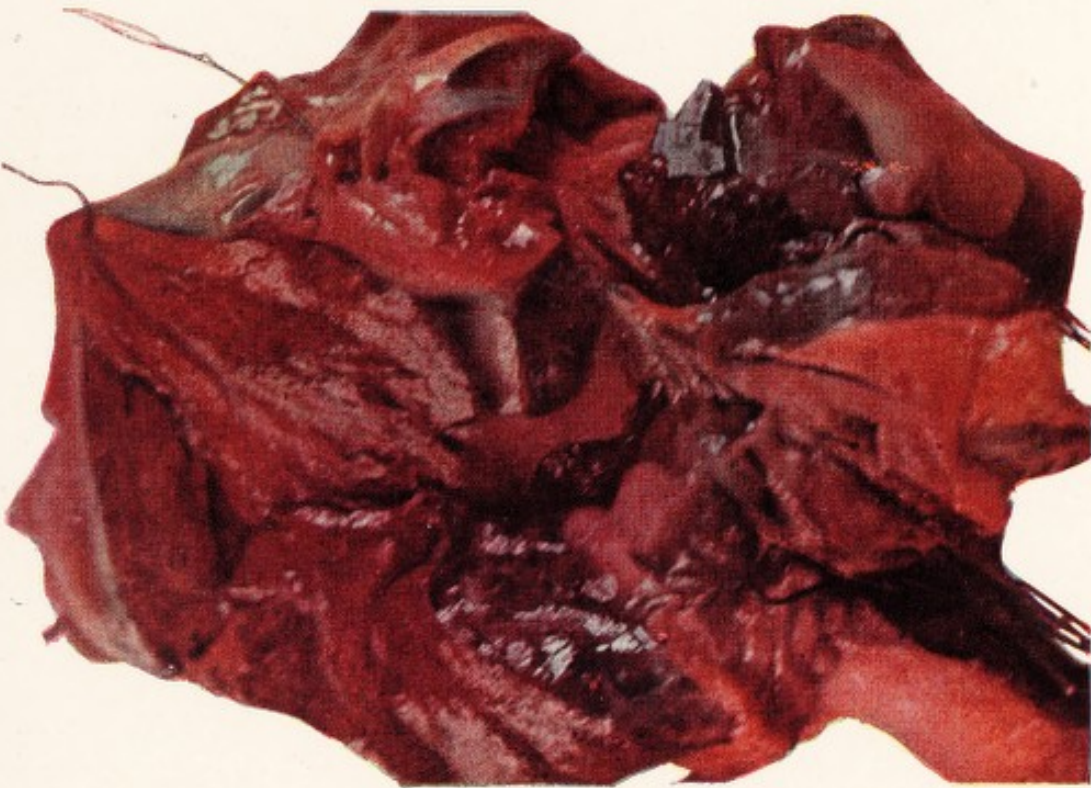


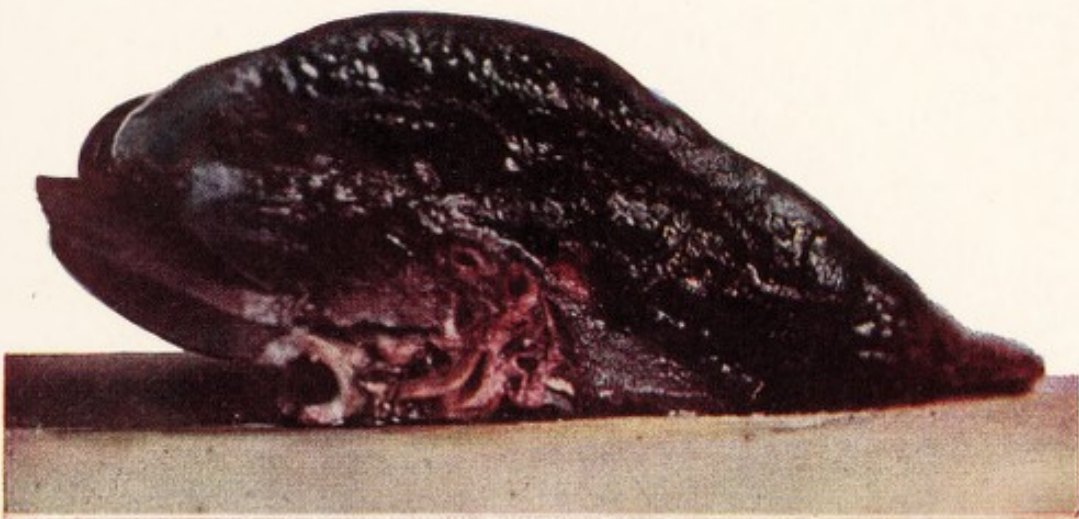
Fig. 8.—(*s.*) Track of wound with dense hæmorrhagic infiltration. (*l.s.*) Normal lobe.



*PLATE III.*



*Fig. 7*



*Fig. 8.*





logically to be new adhesions, and their formation is very rapid, as Martin has found them nine hours after the infliction of the wound.

Cases of chest wound often develop, either on the injured or uninjured side, multiple irregular foci of pulmonary congestion which may develop simultaneously or one after another. Possibly they are occasionally due to areas of contusion and hæmorrhage.

Among early septic complications, empyema on the opposite side is not uncommon; perhaps the pleural reaction around these subserous contusions may be a predisposing cause.

It is of the utmost importance to grasp the fact that not only does the actual wound affect the lobe traversed, but the other lobes of the same lung may sustain partial injury, and the opposite lung may, by *contre-coup*, be more or less seriously injured.

*Plates IV and V* show cases in point: *Fig. 9*—Non-penetrating contused wound of thorax. Death occurred the same day. Area of hæmorrhagic infiltration of the lung. Filamentous adhesions on the parietal pleura and between the lobes. *Fig. 10*—Wound of the lung. Death within twenty-four hours. Adhesions between the injured lobe (left) and the thoracic wall. On the right side, diffuse filamentous adhesions to the parietal pleura. *Fig. 12*—Wound penetrating abdomen, injury to right kidney and liver. Death occurred in three days. Recent broad adhesions between the lower edge of the right lung and the thoracic wall.

Latarjet observed a most interesting diffuse lesion: a man was killed on the spot by a bullet fired at close quarters; the whole lung was found in a state of massive congestion—a sort of hæmorrhagic infiltration of the entire organ (*Fig. 13*).

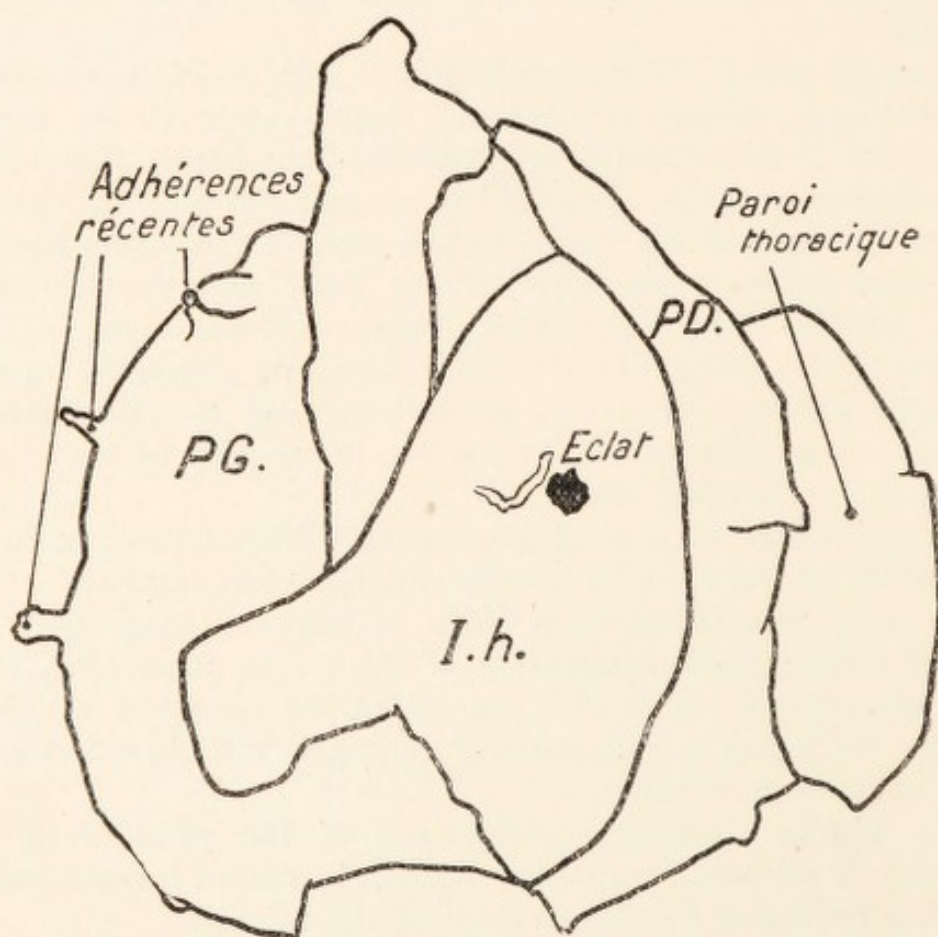
In one of our cases also, on which we operated without success, we found a lung entirely engorged with blood, which sank at once in water.

This diffuse traumatic congestion of the whole lung is probably a phenomenon of the sudden increased intrathoracic pressure produced by the passage of the missile.

A case reported by Lefevre shows how completely a lung wound may heal after operation. In this case death occurred three weeks after the infliction of the wound. At the autopsy

## PLATE IV.

*Fig. 9.*—Contused non-penetrating shell wound of thorax.—Death the same day. Hæmorrhagic infiltration of lung. Rapidly forming filamentous adhesions over the whole of the pleura.



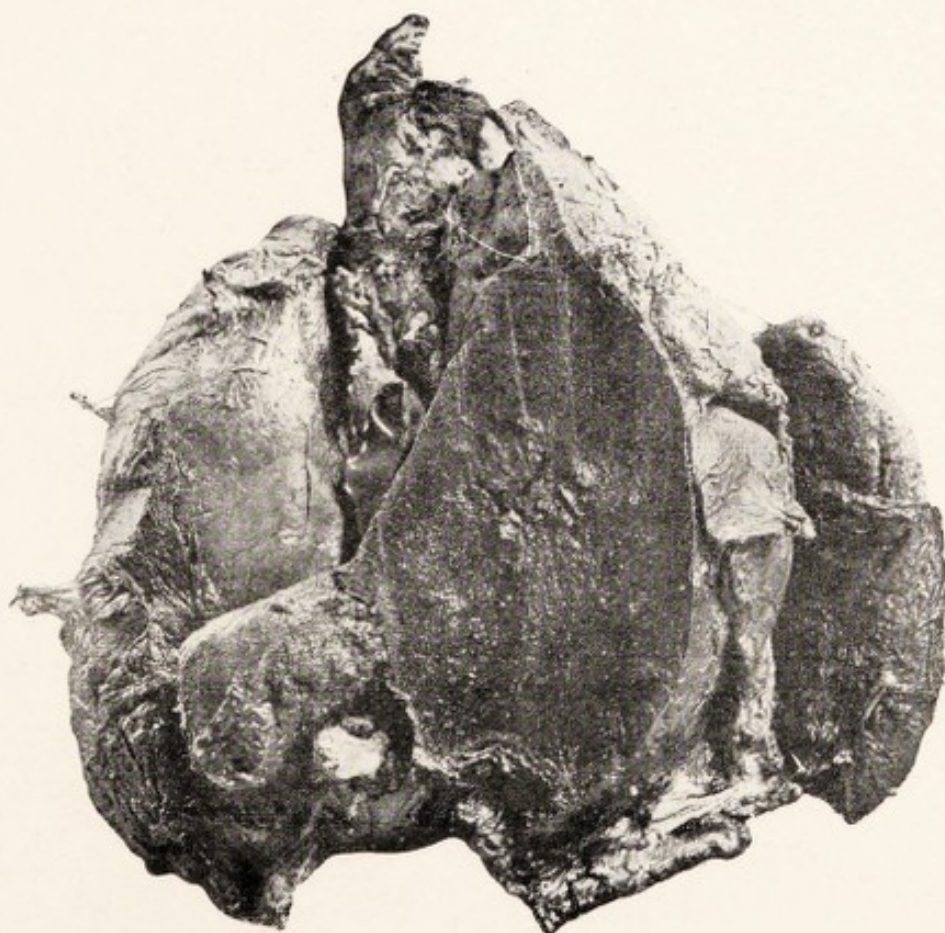
*Fig. 10.*—Wound of lung with retained shell splinter.—Death in 24 hours.  
 (I.h.) Diffuse hæmorrhagic infiltration. (P.D.) Right lung bound to the thoracic wall by recent adhesions.



PLATE IV.



*Fig. 9.*



*Fig. 10.*





a band of fibrous tissue, 5 or 6 mm. long and 2 mm. broad, was at first taken to be the scar of the wound in the upper lobe. On further investigation it proved to be organized exudate in the interlobar fissure, while no trace of the wound scar could be found.

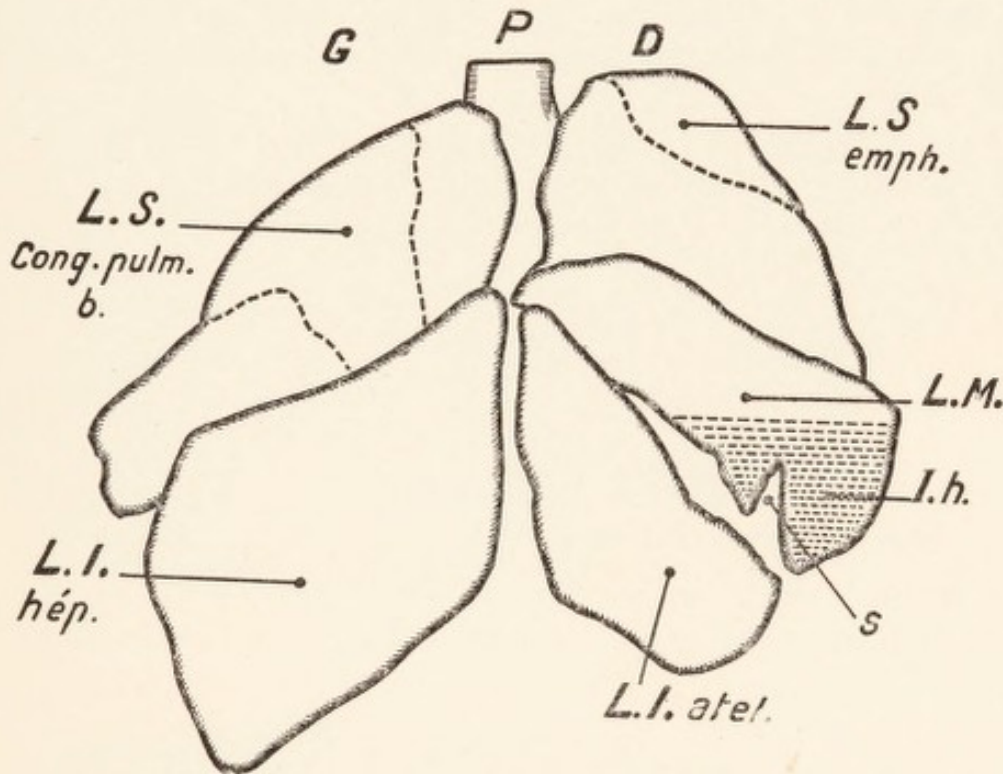


Fig. 11.—D. *Right Lung*: (L.S. *emph.*) Emphysema of upper lobe. (L.M.) Perforating track of middle lobe. (I.h.) Hæmorrhagic infiltration. (L.I.) Lower lobe compressed by hæmothorax.

G. *Left Lung*: (L.S.) Pulmonary congestion of upper lobe. (L.I.) Massive hepatization of lower lobe.

Shell wounds of the lung, then, can heal as readily and completely as—as classic work has taught us—do bullet wounds.

We publish in the Appendix, *Case 27*, the autopsy report on a case which we examined with Coudelaire, which was most interesting because it presented every possible lesion in the two lungs (*Fig. 11*). *On the right*, the wounded side, a perforating track of the middle lobe, with zone of hæmorrhagic infiltration; lower lobe collapsed by pressure of hæmothorax; upper lobe, compensatory emphysema. *On the left*

*side*, upper lobe, ordinary pulmonary congestion; lower lobe. massive hepatization. Death occurred in thirty-seven hours.

This study of the pathological anatomy of gunshot wounds of the lung shows us that these have exactly the same characteristics as any other battle wounds. All are there: the area of dead, traumatized tissue, the zone of hæmorrhagic infiltration extending outward from the wound, the retained foreign bodies—fragments of metals, of clothing, or of bone.

The surgical treatment of all other wounds is governed by their pathological anatomy. Why should not the same principles be applied to wounds of the lung?

#### PLATE V.

*Fig. 12.*—Penetrating abdominal wound (survived for 3 days). Contusion of lung by contrecoup. Rapidly forming adhesions between inferior border of lung and thoracic wall.

*Fig. 13.*—Wound of lung (immediately fatal).—Massive hæmorrhagic infiltration.



*PLATE V.*



*Fig. 12.*



*Fig. 13.*





## CHAPTER III.

FATAL HÆMORRHAGE IN WOUNDS OF THE LUNG,  
AND IMMEDIATE SURGICAL TREATMENT.

THERE is no denying that wounds of the lung give rise to fatal hæmorrhage. Without being able to tell what proportion of cases die of hæmorrhage on the battle-field, no one disputes them. With a wound of a large pulmonary vessel a man cannot long survive. These appalling cases of hæmorrhage are beyond human aid.

At the Société de Chirurgie (1916-17) there were lively discussions as to whether cases which reach the field surgical units die there of hæmorrhage; if so, in what proportion, and whether it is possible to help them by operation.

Diametrically opposed views were held by M. Hartmann and by myself. M. Hartmann summed up his opinion, based on inquiries in the Army to which he is 'Inspecteur,' as follows: "Cases of severe hæmorrhage usually die before reaching the front-line medical units and the surgical ambulances"; while I brought forward a number of operations, performed in my surgical unit, to arrest pulmonary hæmorrhage which would otherwise certainly have been fatal. This discussion would have had no interest if it had not been for one point of the utmost practical importance.

Do fatal hæmorrhages occur in the surgical units, and can they be arrested by direct operation on the lung?

The fact that fatal hæmorrhage from the lung does occur at the aid posts is established; there the terrible death-rate of 25 per cent of wounds of the lung is attributed to *hæmorrhage and asphyxia*. There are no records to decide how many of these cases have pure pulmonary hæmorrhage, how many have hæmorrhage from the hilus, and how many have sustained wounds in the great vessels of the mediastinum; but the important point is, that men frequently do die of pulmonary hæmorrhage at the aid posts, and, unfortunately,



we have to regard these cases as being beyond surgical aid. The next question is, whether cases of fatal pulmonary hæmorrhage occur at the surgical units.

Marcel Maillet wrote in March, 1916, that at the ambulances the prognosis of chest wounds was always serious on account of hæmorrhage. Rouvillois, in an excellent article on profuse hæmorrhage, expressly says, "At each expiration, blood and air are forced out of the gaping wounds in the thorax; almost the whole of the pleural cavity is filled by a hæmopneumothorax. The patient survives, at the outside, two days." Pierre Delbet has several times insisted that there are cases of pulmonary hæmorrhage in which "an operation might save a dying man, and doing nothing leaves to his death a man who might have been saved."

When one considers, in conjunction with these general opinions, the great early mortality of lung wounds in the ambulances—32 to 50 per cent on the first day, 60 per cent during the first two days—surely one must attribute a considerable number of deaths to hæmorrhage. This is the logical conclusion, and it is fully borne out by clinical as well as operative experience.

It is very seldom an acute infection carries off a wounded man in twenty-four or forty-eight hours. Hæmorrhage and mechanical interference with respiration account for the large majority of these early deaths in the ambulances.

Merely running over reports affords evidence of quite a number of cases. Lenormant\* quotes a very obvious case: "Hæmoptysis, traumatopnœa, and profuse external hæmorrhage, death on fourth day." Sencert† quotes 2 such cases on which he had to perform operations of urgency. Baudet‡ reports 4 cases observed by himself, Quénu, Hartmann, and Michaux. At the Automobile-Chirurgicale Unit, No. 21, we had to operate on 17 cases for hæmorrhage which actively imperilled the patient's life. Combier and Murard saw 10 men die of hæmorrhage and asphyxia, then operated on 3 cases and sutured the lung. Grégoire saw 5 cases die soon after admission, for whom surgical interference might have been considered. Gatellier and Barbary operated on one case

\* *Bull. Soc. de Chir.* 1916, p. 250. † *Ibid.* p. 272. ‡ *Ibid.* 1915, p. 152.



for pulmonary hæmorrhage. Chalier and Glénard felt forced to attempt arrest of a hæmorrhage which threatened the life of a patient who had, in addition, a severed spinal cord.

The foregoing are definite and indisputable observations; let us now turn to statistics: Latarjet, out of 90 cases of early death, attributes 26 to hæmorrhage or asphyxia. Marcel Maillet, out of 20 deaths, attributed 16 to hæmorrhage. Rouvillois, in his table of 106 cases, includes 22 of profuse hæmorrhage, described thus: "Hæmorrhage abundant or considerable, hæmoptysis, traumatopnœa—*x* rays showing total hæmothorax." Debeyre, at a stationary hospital, quotes 4 per cent as the death-rate from hæmorrhage. At the Automobile-Chirurgicale Unit, No. 21, we have had hæmorrhage calling for operation in 9 per cent of cases.

These records make it clear that patients do reach the surgical units "in immediate danger" (Pierre Duval) from pulmonary hæmorrhage, and in these cases an operation of urgency is justifiable.

We must now consider the signs, symptoms, and determining causes of fatal pulmonary hæmorrhage in cases as they arrive at the ambulances.

Fatal hæmorrhage may be primary or delayed. Primary hæmorrhage is merely the continuation of the initial hæmorrhage, and this may begin some little time after the actual infliction of the wound from some accidental cause.

Hæmorrhage may be external or entirely intrapleural. External hæmorrhage occurs in two forms, either through a large opening in the thorax, or when there is a closed thorax the blood may well through the entrance or exit wound in the chest. In the case of an open thorax, when there are old adhesions between the lung and the thoracic wall, the blood flows directly out of the chest.

Lungs which are adherent and sustain large wounds are liable to most severe hæmorrhage; we have successfully operated on two such cases. Two factors are lacking in these cases for the spontaneous arrest of hæmorrhage, namely, the retraction of the lung, and its compression by the hæmothorax itself. When the lung is free in the pleural cavity, it retracts more or less, and air passes into the pleura; then blood and air gush out at each respiratory movement.



In these 'open-thorax' cases the retraction of the lung is not so complete as in a closed thorax—there is no hæmothorax to exert pressure—and for this reason a pulmonary hæmorrhage severe from the first has little chance of becoming spontaneously arrested.

In cases of closed thorax, external hæmorrhage occurs through an opening in the chest wall which, though large enough to allow blood to escape, does not permit the entry of air into the pleural cavity. The blood from the lung collected in the pleural cavity wells out little by little. The wounds may penetrate the chest, but may be situated outside and at some distance from the thorax; we have seen continuous oozing from a wound on the outer side of the deltoid muscle, and from a wound in the neck, and M. Depage reports it from a wound of the arm. Finally, blood may leak from a lung wound into the peritoneal cavity through a wound in the diaphragm.

In all these cases of external, or extrapleural, hæmorrhage, the hæmothorax is relatively small, and this is an important point to which M. Depage has drawn attention, and which we have verified at operation.

But the small hæmothorax found at autopsies on these cases has been advanced as an argument that death has not been due to hæmorrhage. The fact is that very little blood is found in the pleura because it has been voided externally. This type of case dies actually of a purely extrapleural hæmorrhage.

Fatal intrapleural hæmorrhage is undoubtedly very much less common than fatal external hæmorrhage. Hæmorrhage within the pleura causes death either by its very bulk compressing the thoracic organs, or by its recurrence immediately after aspiration.

The following are typical instances :

Baudet saw a wounded man who was evacuated in good condition but collapsed *en route*. An exploring needle proved that the left chest (closed thorax) was full of blood. The patient died before any operation could be performed.

M. Quénu reported a case in which a hæmothorax recurred after two aspirations. The patient's condition became so alarming that an operation had to be performed. The man recovered.



Vielle had under his care a patient with a large and increasing hæmothorax. He operated, and found a bleeding wound in the lung. This was sutured, and the patient recovered.

These are rare cases, as with a closed thorax and no external hæmorrhage the complete retraction of the lung and the pressure exerted by the hæmothorax are usually sufficient to cause arrest of hæmorrhage.

One might think that the greater the pressure of the hæmothorax the more certainly would it arrest hæmorrhage; but one must not forget that one boundary of the hæmothorax is yielding, and that too great pressure on this partition may fatally interfere with the heart, or the opposite lung.

A hæmothorax may, by rapid recurrence after several aspirations, cause death by anæmia. Fatal hæmothorax is more common in wounds of the upper lobe, as the whole pleural cavity has to fill before the blood collected in the thorax can exert sufficient pressure to arrest the hæmorrhage from the lung.

Let us now consider what may be the accidental causes of death from pulmonary hæmorrhage in cases which are able to reach the surgical units.

There are certainly cases in which the initial bleeding is slight, and the patient's condition is good enough to allow of his removal to a more distant medical unit, but the hæmorrhage does not stop or diminish, and by the time the patient reaches the ambulance he may be in a condition of grave danger. The initial hæmorrhage may have been quite trivial, but it often becomes aggravated and a real danger to the patient's life during the transport to the ambulance. The shaking during the journey has transformed into severe—often fatal—hæmorrhage, a case where spontaneous arrest would have occurred had the patient been immobilized completely as soon as possible after the infliction of the wound. We believe this to be the explanation of the relatively large number of cases of hæmorrhage upon which we operated on the Somme. The journey to our hospital was a long and rough one, so that wounded who left the advanced units in good condition reached us bleeding dangerously.

Hartmann, speaking of men bleeding from a lung wound, has said in the most concise fashion: "They die of it at the



aid post, they die of it during transport." We most emphatically say, that they die of it *because* of the transport. Two typical cases are worth citing :—

In one, reported by Baudet, a man, wounded in the chest, was evacuated from the front by train, in good condition. On arriving at the Gare du Nord, he became suddenly suffocated ; he was taken to hospital, where an exploratory puncture revealed the fact that the left pleural cavity was full of blood. The patient died before an operation could be performed. A case of fatal intrapleural hæmorrhage, made fatal by the transport of the patient.

The second case was one of our own : A soldier with a chest wound was kept three days in an ambulance, then evacuated owing to bombardment. The patient left the ambulance in excellent condition, and was evacuated to our unit. He arrived acutely anæmic and bathed in blood. A jet of bright blood gushed from the thoracic wound at each expiration. We performed an operation of urgency, without anæsthesia, and sutured the lung. The patient recovered. A case of dangerous external hæmorrhage from the thorax, made so by the transport of the patient.

Delayed pulmonary hæmorrhage is seen in two forms : hæmoptysis and hæmorrhage, alone or together. Pure hæmoptysis is relatively uncommon ; it is more often associated with internal hæmorrhage. Two cases can be quoted.

Picqué reported the case of a man wounded in the lung who expired during a profuse late hæmoptysis. Lenormant cites the case of a man wounded on September 22. Traumatopnœa, early abundant hæmoptysis, and much external bleeding. The patient improved, but on October 5 hæmoptysis and external hæmorrhage reappeared, and the patient died.

Dufourmentel saw two cases of delayed hæmorrhage. One occurred on the twenty-ninth day, and proved fatal ; no operation performed. Delayed hæmorrhage in the second case commenced on the thirteenth day ; operation was performed, and hæmorrhage arrested by forcipressure on the lung. This patient recovered.

A case of Baudet's, already quoted, was one of delayed hæmorrhage. We have had two cases : one on the third day, external hæmorrhage due to the transport of the wounded



man (*Case 4*). External hæmorrhage and hæmoptysis commenced in the other case on the seventh day (*Case 2*). We operated on these two cases, and both recovered.

Lefèvre has described to us a case where death occurred three weeks after the wound, from external hæmorrhage and sudden profuse hæmoptysis. In this case a shell fragment was retained in the lung. Mauclaire also quotes a case, with shell fragment in the lung, which died of sudden, rapidly fatal hæmorrhage from the lung on the tenth day.

These last two cases particularly emphasize the fact that one of the many dangers of leaving a shell fragment in the lung may be delayed fatal pulmonary hæmorrhage. Such hæmorrhages may be mechanically produced by jolting during transport. More often they are the result of an infected focus in the lung, and as such are instances of true secondary hæmorrhage. They need not have been preceded by any great initial hæmorrhage from the wound; at the same time they may be merely a repetition of an initial hæmorrhage.

From this long array of cases the certain conclusion is drawn that fatal pulmonary hæmorrhage is fairly frequent as far back as the field surgical units. It is not only on the battlefield and at the aid posts that men die of pulmonary hæmorrhage; patients also die of bleeding from the lung who have had time to reach the surgical units farther back.

This conclusion leads us to a most important question in therapeutics. Can one, and ought one, to operate upon cases of dangerous hæmorrhage in the field surgical units, and can operation snatch these patients from certain death?

This question has been regarded by various authors since the war began, just as it had been in civil practice before the war. One can to-day consider the whole question in the light of experience gained during the last two years and the vast number of chest wounds seen during the war.

At the beginning of the war, surgical treatment of dangerous pulmonary hæmorrhage was a mere hypothesis which had been raised, if one may say so, on general principles, but which had been rejected as impracticable.

Sencert (Feb. 3, 1915) wrote: "There is no chance of operating, of making an exploratory thoracotomy with direct arrest of hæmorrhage from the lung, in the ambulances." "Surgical



interference," he said again, "may be indicated by the large quantity of external hæmorrhage." He operated upon two of his cases, and one recovered.

Maillet, in March, 1916, said: "We have not thought it possible, considering the patients' condition, to operate." Rouvillois agreed with operation in theory, "so as not to fold one's hands and regard the patient as moribund"; but he added: "An immediate operation would be fatal." Picqué recognized that in some few cases a direct attempt may be made to arrest hæmorrhage. Chavannaz (1915) summed up thus: "Operation must be the exception rather than the rule; the persistence and quantity of the bleeding will be the chief indication."

At the Automobile Chirurgicale Unit, No. 21, we were the first, during the war, to lay down that immediate operation could save some of the cases with severe pulmonary hæmorrhage, and our first statistical table\* showed 9 recoveries out of 14 cases.

Our report stimulated M. Hartmann to communicate three operations performed by Combier and Murard, earlier than our series (May-June, 1915), but these operations were not published till later than ours (Nov. 29, 1916). After this date the subject was energetically discussed at the Société de Chirurgie. Every one agreed that the theory of operation was perfectly sound (Hartmann, Pierre Delbet, Tuffier, Baudet, Souligoux, Delorme, Grégoire and Gross, Potherat, Depage, Rouvillois); but the step from theory to practice divided the surgeons into two groups.

One party (Pierre Duval, Pierre Delbet, Souligoux, Delorme, Baudet, Depage, Tuffier) strongly advised and upheld operation, and this opinion may be summed up in a phrase of Pierre Delbet: "Certain cases of men wounded in the chest die when they might be saved by early and skilful operation. There are, then, cases in which thoracotomy must be done."

The other party (Hartmann, Potherat, Grégoire, and Gross) held the opinion (we quote the words of M. Hartmann) that "there are scarcely any indications for thoracotomy as a

---

\* *Bull. Soc. de Chir.* Nov. 15, 1916.



preliminary step to arrest hæmorrhage from the lung." M. Hartmann expressed himself as being "astounded at the number of times Duval had come across indications for the performance of thoracotomy."

It would appear from the vigorous discussion which took place that certain surgeons had changed their views. M. Hartmann, in a previous paper (Dec. 29, 1915) was of this opinion: "Surgical interference with the lung is legitimate in cases for whom operation is the only plank of safety"; but in a communication (Feb. 13, 1917) entitled, "Is thoracotomy indicated for the arrest of hæmorrhage in the treatment of chest wounds?" he concludes that "thoracotomy, as an operation for the arrest of bleeding from the lung, though theoretically sound, is—in practice—scarcely ever indicated." On Feb. 14, 1917, in his report on Maisonnnet's observations, M. Hartmann writes: "Perhaps cases of hæmorrhage would be benefited by having operation performed in suitably-equipped aid posts and advanced surgical centres." A little later (Feb. 21, 1917), commenting on the work of Gatellier and Barbary, and discussing five deaths which had occurred from hæmothorax, he adopts the conclusion of these two surgeons: "Surgical interference must be attempted in cases where the hæmothorax rapidly increases . . . granted that the patient is fit to stand the operation." Finally, on March 14, 1917, M. Hartmann, realizing that he had already decided in favour of operation for 'open thorax' (with hæmorrhage), replied to me "that he had merely wished to put surgeons on their guard against too precipitately operating upon the closed thorax."

Tuffier, who at first rejected the idea of immediate operation on patients with lung wounds, said (Feb. 21, 1917), that in a case of total pneumothorax, with lowered blood-pressure and compression of the heart and lung, thoracotomy with suture of the lung, as described by Duval, was the operation of choice, and also that this was the operation indicated when hæmorrhage was a cause of immediate danger.

Rouvillois (March 21, 1917) admitted that, in cases of 'open thorax,' one must try to tie the bleeding vessel, and later he said that "in cases of closed thorax in which hæmorrhage may recommence to such an extent that the patient's life is



imperilled afresh, one must open the thorax and try to ligature the bleeding vessel."

It seems, then, that there is now, fundamentally, complete agreement on this question. Every one admits the necessity for operation both for 'open thorax' and hæmorrhage, and for hæmothorax with danger to life, and since we have shown the advantages of operation and the practicability of operating in the automobile-chirurgicale units, thoracotomy, with arrest of hæmorrhage from the lung, has been considered feasible in selected aid posts and advanced surgical units (Hartmann, Tuffier).

The discussion at bottom was really an argument on the indications for operation, and they are difficult enough to formulate. Grégoire and Gross admirably sum up the situation: "There are some wounded who are bleeding when they reach the ambulance, there are some who no longer bleed." The problem is not to allow the former to die for want of an operation, nor to prejudice the chances of the latter by operating unnecessarily.

By what signs, then, does one recognize that a pulmonary hæmorrhage so menaces life that an immediate operation is justified and necessary? This is a most difficult decision to make. In one case we were completely misled. The patient was suffering from shock, and under the *x* rays was seen a shadow occupying all one side of the chest. This was taken to be a large effusion, but found to be due to old adhesions.\*

All cases of severe chest wounds are in a condition of grave shock, and one must quickly judge whether their dangerous condition is due solely to shock, or to hæmorrhage. And it is a heavy responsibility, as a man's life depends upon the decision.

Operation, as we shall see, saves the patient in most cases; but if performed unnecessarily and with fatal result, it must be regarded as the cause of death. Non-operative treatment, on the other hand, saves numbers of wounded who, at the first glance, seem to be almost moribund—those in whom shock outweighs hæmorrhage.

It is a harassing problem: Should one risk allowing the

---

\* *Bull. Soc. de Chir.* 1917, p. 427, obs. 12.



patient to die without attempting surgical interference, or should one try to save him by performing an immediate operation fraught with very grave danger? It is so impossible exactly to weigh the chances of life and death, and the benefit of active interference seems so uncertain in each individual case, that some surgeons always will prefer to hold their hands. Others will struggle to the bitter end, in undertaking an operation which involves great, direct responsibility. It is the eternal, distressing question, which our professional consciences must answer.

Let us consider two cases: A wounded man arrives at the ambulance with a grave external hæmorrhage, primary or delayed. An immediate operation is indicated. "Somewhere in the lung there is a vessel which is bleeding: it should be tied" (Terrier).

If the thorax is open, the operation is necessary, if only to close the gaping hole in the thorax; but it should be made a complete operation by, in addition, dealing with the bleeding wound of the lung.

When the thorax is 'closed,' but external hæmorrhage threatens the patient's life, operation must be resorted to. There is "a vessel which is bleeding: it should be tied."

The thoracotomy to arrest hæmorrhage from the lung is exactly analogous to the laparotomy which is performed to ligature the tubo-ovarian vessels in a ruptured tubal gestation. These are hæmorrhages which do not spontaneously cease.

Let us now consider the second case. A wounded man arrives at the ambulance with a hæmorrhage entirely intrapleural. Life is threatened less by the actual hæmorrhage than by the compression on the heart and lung exerted by the effusion. What are the signs indicating the necessity for operation?

With an external hæmorrhage the indication is for immediate operation, without waiting even one hour in numbers of cases; but with an intrapleural hæmorrhage the patient can be kept under observation for a while. Several examinations must be made without moving the patient more than is absolutely necessary, as sudden death may occur from a change of position. Percussion and auscultation must be done with the patient scarcely raised up at all. Radioscopy



will give only moderate results with the patient lying down ; and it is impossible to sit the wounded man up.

*Exploratory Puncture of the Pleural Cavity.*—Grégoire, Courcoux, and Gross allege that the puncture gives certain evidence as to whether or no the intrapleural hæmorrhage has stopped. If the fluid withdrawn from the pleura coagulates, they say that blood is still being effused into the pleural cavity ; if the fluid does not coagulate, it is defibrinated blood, and this incoagulability proves that the wound in the lung is no longer bleeding.

This would be an invaluable method if it were accurate, but it is based on an error of interpretation. The blood becomes defibrinated as soon as it is effused into the pleural cavity. It is the rule with all serous membranes, the synovial membranes for example. We have on several occasions made exploratory punctures in cases of chest wounds, with lung involvement, which showed signs of severe hæmorrhage ; and the resulting fluid was always defibrinated blood and incoagulable.

The coagulation *en masse* of the withdrawn fluid would seem, most frequently, to be due to the needle having penetrated the lung. In our opinion, one cannot rely on the coagulability or incoagulability of intrapleural blood for proof as to whether hæmorrhage continues or has stopped.

A most important examination to make is that of the blood-pressure. It allows one to diagnose between shock and hæmorrhage, and the value of ascertaining the blood-pressure was shown by the remarkable work of Porter and Depage on shock. The patient must be kept warm, and every half-hour the blood-pressure be gauged by the sphygmomanometer. In cases of pulmonary hæmorrhage great care must be taken not to lower the head, and not to administer subcutaneous or intravenous injections. If the blood-pressure progressively falls, operation is indicated, as hæmorrhage is outweighing shock. This line of procedure we have adopted, with M. Depage, recently. It seems to be the best.

In these cases of severe pulmonary hæmorrhage, thoracotomy, with direct arrest of the bleeding from the lung, is a truly life-saving operation. We have operated, under general or local anæsthesia, on cases where the condition appeared



absolutely hopeless. It is on such cases that we started this work.

No case illustrates better than one of Lefèvre's how a wounded man's life was undoubtedly saved by operation. He performed thoracotomy eleven hours after the infliction of the wound on a case with complete hæmothorax. The patient was pulseless, with a maximum blood-pressure of 90 mm., minimum 50 mm. During the operation blood-pressure remained unchanged, but three days later the patient had a pulse of 96, with a maximum blood-pressure of 140 mm., minimum 90 mm. (Blechman).

One can say that as long as these cases of severe hæmorrhage remain alive, one can hope to save them by directly arresting the hæmorrhage from the lung. Thoracotomy has practically no effect on the arterial blood-pressure. (*See 'Operative Technique,' chap. vii.*)

The operation can be performed even with a minimal blood-pressure of 50, when laparotomy would not be tolerated. The patient's general condition never offers a contra-indication to thoracotomy.

Having thus laid down the indications for operation, it only remains to consider the results of operation for direct arrest of hæmorrhage from the lung.\*

The following is a list of some operations performed :—

	Cases.	Deaths.
Sencert .. .. .	2	1*
Combiér and Murard .. .. .	3	0
Gatellier and Barbary .. .. .	1	0
Challier and Glénard .. .. .	1	1
Rouvillois .. .. .	3	3
Déjardins (delayed hæmorrhage) .. .. .	1	0
Dufourmentel (delayed hæmorrhage) .. .. .	1	0
Vielle .. .. .	5	1
Amb. Auto.-Chir., No. 21 .. .. .	17	5
Totals .. .. .	34	11

= 67·7 per cent recoveries.

\* Sencert has published a third case. This had a fatal termination; but the plugging of the apex of the lung was not the whole operation. Sencert had, in addition, to ligature the axillary artery and to suture the brachial plexus.

Without wishing to draw an impossible comparison between these results and those which purely medical treatment would have given, it is interesting to note that some surgeons were literally driven to operating on cases of severe hæmorrhage, by seeing all their patients die. Combier and Murard saw 10 cases with 10 deaths without operating; they then decided to operate, and saved 3 cases in succession. We ourselves only decided to operate on account of the terrible immediate gravity of chest wounds, and our 17 operations have resulted in 70·6 per cent of recoveries. On the face of this we believe it to be established that two-thirds of the cases, with hæmorrhage directly endangering the patient's life, can be saved by direct arrest of the hæmorrhage from the lung, and this—following thoracotomy—is the operation of choice.



## CHAPTER IV.

## INFECTION IN LUNG WOUNDS.

(IN COLLABORATION WITH E. VAUCHER.)

THE infections found in shell wounds of the lung are the same as those met with in any other battle wounds. Our researches have been carried out on six cases, and the results are instructive.

**Bacteriological Findings in Six Cases of Wounds by Shell Fragment.**—In two cases we found pure *B. perfringens* on the surface of the lung wound. In the third case, direct smear showed large Gram-positive racket-shaped bacilli with sub-terminal spores. This organism could not be completely identified. In the fourth case, a smear from the wound gave numerous Gram-positive bacilli, and culture from a fragment of the lung yielded *B. perfringens* and pneumococcus. In the fifth case, no organisms were found in a smear from the surface of the wound, but a culture from the damaged tissue gave streptococcus. In the sixth case, cultures from the lung tissue were sterile: the only instance of this in the series. The case was one of through-and-through wound of the lower lobe by a very minute fragment.

In two cases, cultures made from the missile—directly after early removal—gave in the first *B. perfringens*, in the second streptococcus.

Although their number is small, these cases prove that gunshot wounds of the lung are subject to the same infections as any other battle wounds. During the first few hours, organisms are frequently absent from a smear, but grow on culture.

The appearance and growth of particular organisms in the lung tissue, or in the pleural cavity, depend on many factors—the size and nature of the missile, the presence of a fractured bone, and the existence and size of the hæmothorax.

Bullet wounds of the lung are often sterile; they are often



followed by simple pulmonary, or pleuro-pulmonary, congestion adjacent to, or at some distance from, the wound. Less frequently, suppuration in the hæmothorax occurs as well, but this is usually mild.

The same is often true of minute shell fragments. Many of these do not carry pieces of clothing into the wound, and are sterile. We have proved this by culture on several occasions. The wound is quickly obliterated by collapse of the lung, and by the formation of a layer of fibrin on the surface of the wound which protects the pleural cavity against infection.

Pleuro-pulmonary congestion often occurs in the lung without infection of the hæmothorax.\*

This form of congestion does not imply an infection of the lung by the usual pathogenic organisms of wounds; it is simply the reaction of the parenchyma of the lung round, and at a distance from, the injury. The sputum of these cases reveals only the usual flora of the respiratory passages: great numbers of pneumococci, *B. catarrhalis*, *M. tetragenes*, staphylococci, streptococci, diphtheroids, etc.

Large shell fragments, on the contrary, are always infected. The lung wound is almost always the seat of a severe anaerobic infection, particularly if fragments of bone have been blown into the lung or pleural cavity. The infection may develop in one of three places: (a) the hæmothorax (the commonest site), (b) the wounded lung, (c) the lung and pleura of the opposite side.

*Post mortem*, the following lesions are practically constant in deaths from acute infection of the wound:—

*On the injured side* the lung is completely collapsed, covered by a varying thickness of fibrin more or less adherent, sometimes forming bands. Macroscopically, the infection of the lung is not evident, but it is obvious in the hæmothorax, which emits a foul odour of gas under pressure, filling the whole pleural cavity and displacing the lung completely from the thoracic wall.

*On the opposite side* there is often massive congestion of the lung, sometimes even hepatization of the lower lobe, and

---

\* The clinical study of these cortico-pleural congestions of the lung has been very thoroughly carried out by Piéry, Maillet, Reverchon and de Jong, Rouvillois, Guillaume Louis, Pédeprade and Basset.



pleural changes—dry, serous, or purulent pleurisy. Bashford has sent us an excellent account of a case which showed all these lesions most unequivocally (see APPENDIX, *Case 29*). A patient with a penetrating shell wound of the right chest died on the thirteenth day with symptoms of acute pleuro-pulmonary septicæmia. The fluid obtained with the exploring needle was foul, full of anaerobic organisms, and showed advanced hæmolysis. At the autopsy the missile was found to have traversed the right lung from top to bottom, and to be lying at the base of the lung in the cul de sac of the diaphragm. The right lung was completely collapsed, covered with fibrin and false membranes. The left lung was much congested with a small pleural effusion.

These histological changes in the right lung were typical of pulmonary collapse—persistence of the endothelial lining of the alveoli, the alveolar capillaries flattened, as were the small bronchioles, which were only recognizable by their elastic tissue.

The complete absence of any inflammatory reaction of the lung was the most striking feature; around the missile the lung tissue showed signs of old intra-alveolar and intra-bronchial hæmorrhage. In contrast with this, the left lung showed acute inflammatory changes—the alveoli filled with polynuclear cells, red cells, and fibrin. The bronchi were inflamed, the alveolar capillaries dilated, and here and there thrombosed. There were numerous chains of Gram-positive streptococci in the lumen of the bronchi.

In drawing up a plan of surgical treatment for the prevention of pleuro-pulmonary infection, two outstanding facts must be reckoned with: (1) The infrequency of lung infection when there is a large hæmothorax; (2) The almost inevitable infection of the pleura by anaerobes when, as is usually the case in lung wounds caused by large shell fragments, there is a considerable hæmothorax; this nearly always becomes infected, while the collapsed lung does not.

When the hæmothorax is small, collapse of the lung is only partial. If, further, old adhesions hold the lung to the chest wall and prevent the occurrence of intrapleural hæmorrhage, infection reaches the lung itself, giving rise to septic broncho-pneumonia and pneumonia, abscess, or gangrene of the lung.



**Septic Bronchopneumonia and Pneumonia—Abscess and Gangrene of the Lung.**—Septic bronchopneumonia and pneumonia are uncommon.

*Post Mortem.*—A massive pneumonia verging on grey hepatization has been found, and a diffuse bronchopneumonia. These are due to acute pleuro-pulmonary septicæmia, often streptococcal, and generally fatal.

An abscess of the lung may develop round a foreign body. This has not occurred in our experience, but several cases have been reported.

Gangrene of the lung has been often described. Maillet has reported two cases following shell wounds. The first appeared as a pneumonia on the sixth day in a man who had a pneumothorax. Extensive operation gave rapid relief, but pericarditis with signs of general septicæmia appeared on the twenty-first day, and proved fatal. The second developed patches of gangrene, supervening on a moderately large hæmopneumothorax, on the eighteenth day. No operation was performed, but the patient, after a very long convalescence, made a complete recovery.

In a case reported by Rouvillois, the patient coughed up sputum of a characteristic odour, a gangrenous sphacelus developed in the track of the missile, and death occurred on the fourteenth day. Gatellier and Barbary have reported two fatal cases. One died on the tenth day with commencing gangrene; the second, with gangrene of the lung complicated by a fatal hæmoptysis. In Lefèvre's case death resulted from an immense external hæmorrhage, combined with hæmoptysis, on the twenty-fifth day. There was a cavity with gangrenous walls in the lower lobe. Traumatic pulmonary gangrene bears no resemblance whatever to the classical gangrene of the lung.

None of the published accounts of autopsies, which are admittedly very incomplete, give any description of the size and shape of the focus, or its relation to the bronchi and pleura.

Many authors base their diagnosis of pulmonary gangrene on the fœtor of the breath and sputum. Arnal, who for more than two months was in special medical charge of our chest wounds, had his attention drawn several times to the fœtor of the breath and sputum coming on some days after the



wound. Dufourmentel also noticed this in patients who died about the fourth or fifth day.

We have never found the anaerobes of gas gangrene in the sputum of such cases. We have never found true gangrene of the lung post mortem, nor any lesions which could be described as gas gangrene.\* The foetor of the breath and sputum, then, is not a pathognomonic sign of gangrene of the lung. It merely betokens the elimination by the bronchi of a little necrotic tissue from the track in the lung. It is usually transitory, and is often unaccompanied by any signs of grave infection. Most of the cases described as traumatic gangrene of the lung are cases of abscess or septic pneumonia. No authentic case of gas gangrene has been described.

Whatever the nature of these processes, and under whatever name they may be described, the erosion of the lung tissue, especially of the arteries, produces fatal secondary hæmorrhage.

**Pleuro-pulmonary Lesions of the Opposite Side.**—Congestion of the opposite lung is principally seen where a large hæmothorax or total pneumothorax interferes with the action of the lungs. Our autopsies made this very clear. It occurs in scattered patches, and either takes the form of a massive congestion extending through a whole lobe—especially the lower—or else the entire lung is found of a violet-red colour, heavier than normal, and often resembling in consistence a piece of spleen or liver. There are frequently sub-pleural hæmorrhages, particularly on the posterior and diaphragmatic surfaces of the lung.

This pulmonary congestion is not unusually accompanied by a dry pleurisy, or even by a small effusion which may be serous or purulent. Pure culture of streptococci has been recovered from two such purulent effusions.

The gravity of the prognosis of lung wounds is increased considerably by the frequency with which pleuro-pulmonary lesions of the opposite side occur, and this is a further argu-

---

\* NOTE.—*January, 1918.*—Since writing the above we have twice found the anaerobes of gas gangrene in the sputum. In one case an abscess developed round bits of clothing imbedded in the lung; the sputum contained *B. perfringens*. In the second case, true gas gangrene of the lung was observed, and the sputum contained streptococci and *B. sporogenes*.



ment in favour of the early extraction of foreign bodies from the lung ; but it is a complication to be feared even when such operation has been performed.

### INFECTION OF THE HÆMOTHORAX.

The hæmothorax which accompanies battle wounds of the lung frequently becomes infected. Elliott and Henry's analysis of 500 cases is the fullest that has yet been published. Out of their 500 cases, 195 were infected, 87 by anaerobic gas-producers. Our own statistics during the battle of the Somme gave us on a total of 193 chest wounds the following figures :—

Bullet wounds 49 ; with infected hæmothorax 0.

Through-and-through shell wounds 33 ; with infected hæmothorax 6 = 18 per cent.

Wounds with missile retained 111 ; with infected hæmothorax 28 = 24 per cent.

From these statistics it is evident that infection of the hæmothorax in bullet wounds is exceptional.

In the early days of the war, one of us saw two cases of through-and-through bullet wound with infection of the hæmothorax. In one case the scapula was fractured ; in the other there was a fractured rib. Apparently the source of infection was the fracture in the chest wall. In wounds by minute shell fragments, infection of the hæmothorax is equally rare. On the other hand, large fragments always carry in with them portions of clothing, they often fracture one or more ribs, and they almost always infect the pulmonary wound and the pleural cavity.

The variety of organisms met with in infected hæmothorax is very great. Of aerobes : *Pneumococcus*, *staphylococcus*, *tetragenes*, *streptococcus*, *B. Pfeiffer*, *B. coli*. Of anaerobes : *B. perfringens* and *B. sporogenes*.

Empyema following a shell wound is generally due to a mixture of aerobes and anaerobes. Amongst the most frequent combinations observed in a series of 25 cases were : *B. perfringens* and *streptococcus* ; *B. perfringens*, *staphylococcus*, *pneumococcus*, *streptococcus*. The combination of *B. perfringens* and *B. sporogenes* gives rise to an empyema of peculiarly nauseating odour similar to that observed in some forms of



gas gangrene. (See APPENDIX, "Bacteriology of Twenty-five Cases with Anaerobe Infection of Hæmothorax.")

**Source of the Infection.**—We have seen that the infection of the hæmothorax is due to various anaerobes carried in by the missile, which contaminate the pleural cavity and the wound of the lung.

When there is a large opening in the thoracic wall, an aerobic infection from without is added to the anaerobic infection arising in the pleuro-pulmonary wound. This mixed infection is one of the reasons why 'open thorax' is so dangerous. But there are many cases in which the parietal wound is closed, yet the hæmothorax becomes infected, and at autopsy one finds a wound in the lung packed with blood-clot surrounding the missile, and that is the starting-point of the infection of the hæmothorax.

The pathological and bacteriological researches of Elliott and Henry have demonstrated that the infection originates in the clots of fibrin and blood which form on the surface of the wound and collect in the pleural cul-de-sac.

In the first two days anaerobes grow in this collection of blood and fibrin, and gas bubbles form. As the infection progresses the gas bubbles increase, they finally burst on the surface of the clot, and the unclotted fluid of the hæmothorax becomes infected in its turn. This gives rise to a hæmopyopneumothorax, which may be free or loculated.

In order to determine the infection of a hæmothorax, exploratory puncture of the diaphragmatic cul-de-sac must be resorted to. The fluid obtained at this level in contact with the fibrinous clot is often infected by anaerobes, whereas the upper layers of fluid may be sterile. A few days later the whole mass will be infected. This has often been our own experience.

The anaerobic infection of the fluid may declare itself on the second or third day in some cases, but usually it is only about the sixth or seventh day, or even later, that infection of the pleura can be demonstrated by puncture.

**Characters of the Infected Fluid.**—The fluid infected by anaerobes may present various appearances. The commonest is that of a layer of non-coagulable liquid lying above a layer of pus.



The supernatant fluid is chocolate-coloured, and almost always markedly hæmolyzed. We are convinced that early and marked hæmolysis is one of the most reliable macroscopic signs of infection of the hæmothorax. Less frequently, the macroscopic appearances of an infected hæmothorax are indistinguishable from those of a sterile one; still more rarely, it clots spontaneously.

A foetid, or even putrid, odour is a very characteristic sign, but it may be absent even in a most virulent infection, if there is not present one of the organisms of putrefaction, such as *B. sporogenes*. Effusions containing only *B. perfringens* are not putrid.

The cytological findings are very interesting, as Picqué and Dupérié, Policard and Desplas have shown, but cytology does not in every case give exact information.

Bacteriology alone enables one to say quickly whether a hæmothorax is infected. A smear stained by Gram's method may show abundant organisms (*Fig. 14*)—bacilli with or without spores, and various cocci—proving that the effusion is infected.\* This is true of the majority of cases. More rarely no organisms are seen in the smear. In this case cultures are indispensable. They often reveal an infection at its very commencement and render early intervention possible.

The absolute identification of the different organisms is a long and delicate undertaking. As a practical measure a rapid result can be obtained by inoculating 2 or 3 c.c. of the fluid into a tube of milk, which is boiled for a few seconds to expel the air, and then sealed over a Bunsen burner. This gives a sufficiently anaerobic medium. If the hæmothorax fluid contains *B. perfringens* alone, or in conjunction with *B. sporogenes*, the milk is clotted in twelve to twenty-four hours, and may be digested later. On opening the tube, gas under pressure escapes, and the characteristic odour of butyric fermentation can be detected. By this method we have been able to prove the infection of the fluid by anaerobes in several cases where other culture media only showed it a good deal later.

---

\* Plated-out anaerobes frequently take Gram's stain very badly. They may be granular and misshapen, as in old cultures.





Fig. 14.—The upper figure shows a smear from a recent wound. Three Gram-positive bacilli can be seen, one with a sub-terminal spore; also three pneumococci.

The lower figure is a smear from a hemothorax infected with *B. perfringens*. Polymorphonuclear leucocytes showing much alteration are present, together with many Gram-positive bacilli, which were granular and stained badly. On culture, a pure growth of *B. perfringens* was obtained.



Anaerobic infection of a hæmothorax produces a hæmopyopneumothorax, either free or loculated, which is always severe and often fatal. At autopsy, the lung, often no larger than a fist, is found retracted against the vertebral column, covered by a layer of fibrin and surrounded by dense false membranes. Between it and the chest wall the cavity is full of blood, pus, and false membranes, and loculated by newly formed adhesions. On section, the lung is collapsed and carnified, and, provided the process has not been too rapid, shows fibrous bands of varying thickness running through it.

**Acute and Sub-acute Pleuro-pulmonary Septicæmia.** — Suppuration in a hæmothorax usually starts gradually, the clinical course being that of all pleural suppurations which have to be discovered by repeated exploratory puncture. But there are very many cases, only too often overlooked, of acute infection, or of fulminating pleuro-pulmonary septicæmia, which kill the patient in the first two or three days. (APPENDIX, Case 27.) The number of cases which die in the first two, three, or four days is considerable. The raised temperature, the small quick pulse, the slight jaundice, the albuminuria, bear witness to an acute infection.

Many early deaths are due to hæmorrhage, but many wrongly attributed to hæmorrhage are, in reality, due to the same acute infection as occurs after all other shell wounds. Infection of the other thoracic organs, especially suppurative or adhesive pericarditis (usually streptococcal), and suppurative mediastinitis, have frequently been reported. At a glance one realizes that lung wounds are first contaminated, then infected, by the same organisms as all other battle wounds.

Anaerobes seem to grow badly in lung tissue; the lung is peculiarly resistant to them. It is interesting to have established the fact that in the majority of cases the lung infection is due to various aerobes, either constant inhabitants of the respiratory passages or accidentally introduced by the missile, and that *B. perfringens*, found by us on the surface of a lung wound, has never been demonstrated in the sputum of a case with an area of traumatic pulmonary congestion.

Does this special resistance of the lung depend on the oxygenation of the pulmonary tissue, or its extraordinary vascu-



larity, or on traumatic collapse? *No matter. It exists; you can count on it.*

The injured pleura and the hæmothorax, on the contrary, provide an eminently favourable medium for the growth of anaerobes. It may be said without exaggeration that the gravity of chest wounds, from about the fifth day onwards, is due to pleural suppuration much more than to infection of the lung itself.

Does this teach us anything as regards treatment? So far as the operative treatment of a lung wound is concerned, we learn that it is not illogical to simply close the openings of a through-and-through wound, without mechanically disinfecting the track. Closure of the track at both ends means leaving it to form a localized focus which will probably be only mildly infected with aerobes, very seldom with anaerobes. Closure of the track at its two ends certainly protects the pleura against infection by anaerobes coming from within the lung wound, a grave infection which constitutes the principal danger in chest wounds.

These few bacteriological notes are valuable in helping us to discuss the better surgical treatment of lung wounds.

## CHAPTER V.

**OPERATIVE TREATMENT OF WOUNDS OF  
THE LUNG.**

THE surgical treatment of wounds of the lung is an innovation of this war. The novelty is the idea that perhaps it is the right thing to treat such wounds, from the outset, like any other gunshot wound. We believe that we were the first to realize this possibility (December, 1916), and to operate upon wounds of the lung. The mortality due to lung wounds caused by shell fire is about 25 per cent in the field medical units—20 per cent in through-and-through wounds, 30 per cent in penetrating wounds with the missile retained. This terrible mortality is chiefly due to pleuro-pulmonary infection, and calls for every effort to find a more satisfactory line of treatment. Infection of the wound is the great factor in the lung, as in any other part. There is no reason to regard a lung wound as being different in any way from other wounds; the lesions are the same, the bacteriology, too, is the same. The anatomical lesions are characterized by just the same destruction, the same necrosis of tissue, the same hæmorrhagic infiltration. The lung, like wounded muscle, presents a mass of dead tissue, destined to undergo proteolysis (autolysis and bacteriolysis), which is a perfect culture medium for infective bacteria. And the consequences are the same. As Wright says: "Severe gunshot wounds are characterized by the sowing of infection in devitalized tissue." The same foreign bodies, missiles, bits of clothing, bone splinters, are found in lung, as in other wounds. The bacteriology is the same. Every gunshot wound is there and then contaminated. Every lung wound becomes sooner or later infected, and the infection runs the same course as in all other wounds, ranging from simple congestion of the lung to gangrene of the track.

Yet one would not put the parenchyma of the lung on the same footing as other tissues. Policard is of opinion that



lung tissue, particularly by reason of the elastic fibres, is less liable to proteolysis than is, for example, muscle fibre. The great vascularity and constant oxygenation of the lung perhaps confer special protection against infection. Observations show that in the lung there is no such thing as gas gangrene.\* Gas gangrene of the wound is comparatively rare. The lung offers a better defence than any other tissue against wound infection. Tuffier and Thévenot say that "the foreign body is more often than not tolerated by the lung, and the perforating wound spontaneously cicatrizes." Hartmann writes: "One knows the relative tolerance of lung tissue for even septic foreign bodies." But this peculiar resistance of the lung to infection should not be over-estimated. The death-rate of gunshot wounds of the lung must not be overlooked:—Through-and-through wounds 23 per cent (Rouvillois), and 21·2 per cent (Pierre Duval); penetrating wounds with missile retained, 45 per cent (Rouvillois), and 30·3 per cent (Pierre Duval). The fact is, that round the wound the lung is always infected; the danger from infected pleura is probably even greater than from infected lung; in any case, between the two the death-rate is high.

Wounds of the lung cause death sometimes through the lung, but more often through the pleura. One meets with all degrees of congestion, unilateral or bilateral, and of septic pneumonia, in the lung. The pleura is nearly always infected from the lung wound, and the infecting organisms which come from the wound in the lung have a different virulence from those which may enter from the outer air. While the lung may be particularly resistant to infection from gunshot wounds, the pleura resists particularly badly.

Pleural, or pleuro-pulmonary, infection is the most terrible complication of a wound in the lung; this is proved by the high initial mortality, as well as by the grave complications of convalescence. It is not too much to say of gunshot wounds of the lung, that the infection of the pleura is, if not on a par with infection of the peritoneum due to injuries of the abdominal viscera, at least comparable to infection of the joints in infected fractures of the epiphyses.

---

\* See footnote on page 37.



It is the first principle in war surgery to prevent infection of wounds, and the only method of preventing sepsis in gunshot wounds is to operate upon them, to remove all foreign bodies, and to excise as far as possible all necrotic tissue. It is only logical to think that the really effective treatment of infection in the lung, and of its usual complication, infection of the pleura, is preventive treatment by removal of foreign bodies and direct treatment of the lung wound.

The lung is, at the present moment, the only organ in which war surgery does not obey the general rules of surgery. Why this exception? Missiles are systematically removed from every other part—from the limbs, from the joints, from the liver, from the spleen, even from the brain when they are accessible: they are systematically left in the lung. Hæmorrhage elsewhere is arrested when it immediately endangers life; but the fact that hæmorrhage occurs from the lung is even being denied, as an excuse for not arresting it! The only preventive treatment for infection of wounds consists in the removal of foreign bodies and the surgical treatment of damaged tissue; yet foreign bodies in the lung are systematically left there, and the pulmonary wound is not treated; it is left to luck, which may be good or extremely bad!

Joint surgery is, at the present time, the only branch of war surgery which combats infection by the routine removal of foreign bodies and active treatment of bone lesions from which the joint might be infected. The surgery of the pleura is that of an established infection; there is no surgery of the pleura until it has been duly infected from the wound in the lung. Imagine what would be said to a surgeon who taught that, in a wounded joint, suppurative arthritis should be allowed to develop before any surgical treatment was undertaken.

Why this opposition? Why this complete upset of all principles of surgery? Why indeed, unless it is that the day of lung surgery is only just dawning, and that we simply do not realize our power. Put in this light, the appeal for surgical interference is perfectly logical, and the immediate treatment of the wound in the lung seems to be the only rational treatment.

This assertion is supported particularly by a case reported



by Lefèvre. A patient was wounded in the right lung by several shell fragments (*Fig. 7*). One fragment was lodged in the upper lobe, another, unrevealed by *x*-ray examination, lay in the lower lobe. Severe hæmorrhage called for immediate operation on the second day, and Lefèvre took the opportunity of removing the missile from the upper lobe. Not aware of its existence, he left the fragment in the lower lobe. Pleuro-pulmonary sepsis developed, and the patient died suddenly, after profuse hæmorrhage and hæmoptysis, on the twenty-fifth day. At the autopsy, the upper lobe—from which the missile had been removed—was soft and full of air, with no trace of the wound. In the lower lobe was a large cavity, with necrotic walls, containing a shell fragment and a large recent blood-clot.

This case well exemplifies in the upper lobe the benefit of removing a missile, and in the lower lobe the fatal mistake of leaving a foreign body. The conclusion is irresistible—that immediate removal of foreign bodies from the lung is the only sane procedure. And yet the mind that is determined not to be convinced by this logic raises all sorts of objections, having for their basis the benign reputation of lung wounds, and the severity of the operation involved.

The alleged benign reputation of such wounds is shattered by statistics (see Chapter I). Bullet wounds may be regarded as relatively benign; but injuries from shell fire are amongst the most fatal of war wounds, and the consoling sight of wounded men carrying shell fragments in their lungs without inconvenience must not be allowed to obscure the fact that very many men die of similar injuries.

Empyema must not be overlooked, nor the unsatisfactory recoveries from empyema, the sequelæ, such as adhesions, retraction of the thorax, impaired or suppressed function of the lung, and the destructive operations sometimes necessary to drain completely a traumatic empyema.

Gunshot wounds of the lung must be regarded as among the most serious of injuries; though some patients make a perfect recovery, this is the exception, and the future of men wounded in the lung is fraught with grave dangers.

The gravity of the operation itself is a much more serious argument; but here again the objection is ill-founded. The



surgery of the lung is a revolution. Dread of pneumothorax had hitherto entirely limited the field of lung surgery, but the surgery of the war has triumphantly proved the value of the old, and essentially French, method of inducing pneumothorax.

Delayed extraction of missiles from within the lung proved to us definitely that a lobe of the lung could be safely drawn up through a large thoracotomy opening and delivered on the surface like a coil of intestine from the abdomen. All necessary manipulations were found possible—incision, partial resection, suture, replacement of the lobe, and hermetical closure of the thorax.

As we said in March, 1916 (*Revue de Chirurgie*), the lung is no longer the dreaded organ it was before the war. Under these circumstances, operation upon the lung must no longer be considered as anything exceptional, a procedure only practicable by a few bold surgeons. "Surgery of the lung takes its place amongst the recognized procedures of general surgery," and the surgery of gunshot wounds of the lung must be governed by the principles of surgery as applied to any other gunshot wound.

In the application of these principles, some questions of the utmost importance have to be first considered. How should the missile be extracted from the lung? Should the wound of the lung itself be dealt with, and if so, how? When is the right moment to operate?

Clinical experience has proved that the mere extraction of the metal fragment is not sufficient to protect the wound in the lung against septic complications. The shell fragment may have carried into the track fragments of clothing or bone splinters which—after the removal of the missile—may set up grave infection.

A missile may have penetrated one surface of a lobe and been brought to rest just under the pleura at the other side of the lobe, where it is easily palpable. Should an incision into the lung be made to extract the foreign body, and afterwards closed by suture?

This method has given us excellent results in delayed extraction of foreign bodies from the lung; but in cases of immediate or early extraction its utility is doubtful. This is shown by the following case. Delmas, operating for immediate



extraction of a missile lodged in the upper lobe of the lung, removed it through a small incision on the posterior surface. He did not deal with the penetrating wound on the anterior surface. An empyema developed. Delmas re-opened the incision, and from the wound in the lung withdrew fragments of clothing which had been left in the track.

Paschoud has published notes on two cases (one of which was fatal) of late suppuration in the lung caused by pieces of clothing left in the track by the missile, which completely traversed the lung. The mere extraction of the metal fragment cannot, therefore, be regarded as sufficient.

The methods of removing the missile through an incision made directly over it, or of removing the fragment with forceps under the *x*-ray screen, are excellent for delayed extraction of missiles from the lung, but they are not suitable for early extraction, where the sole object is the prevention of pulmonary infection. No septic debris must be left in the track.

This leads to a discussion on the actual treatment of the wound in the lung. The ideal procedure is to open up the wound, excise all necrotic tissue, and pick out all foreign bodies. There are few cases in which this is feasible; experiments on animals have shown that perforating wounds of the lung can be laid open and sutured, but in the human subject this cannot be contemplated as a routine treatment; two or three lobes may be involved, or a lobe may be perforated through the centre.

The treatment of three varieties of lung wound must be considered: The penetrating wound with a missile retained; an entirely superficial wound; and the perforating, through-and-through wound.

For dealing with the penetrating wound with missile retained, the best procedure is to extract the missile by its entrance track, either under the control of the *x*-ray screen, or aided by manual palpation. Then the track is cleaned out with a mounted gauze wick, a gentle mopping to remove all fragments of clothing and the pulp which lines the bed of necrotic tissue. Suture of the opening in the lung must always be performed to guard the pleura against infection from the lung.

In dealing with perforating through-and-through wounds



is simple closure of the openings in the lung sufficient? Is it illogical to merely suture the openings of the wound, and to leave the lung tissue to its own powers of dealing with anaerobic infection in the track—only risking a focus of limited congestion of the lung? This method has always the great advantage of shutting off the pleural cavity from infection by the lung, even if it does not allow of the track in the lung being disinfected. It is somewhat analogous to the simple closing of the parietal wound in cases of 'open thorax' to prevent infection of the pleura from without.

This was our only treatment of the wound in the lung in the majority of our operations undertaken for severe hæmorrhage. It has given us some very good results; but we have also had mishaps, such as discharge of fragments of clothing which had been left in the pulmonary wound (APPENDIX, *Case 6*). In three other cases (APPENDIX, *Cases 8, 13, and 21*) we had to open the chest for empyema; these three made straightforward recoveries. We are under the impression that these cases of empyema were far less serious than those which usually follow non-operated gunshot wounds of the lung. In one case the suppuration in the pleura was due entirely to staphylococcic infection; *B. perfringens* was not present. Simple closure of the openings in the lung, therefore, must not be regarded as a complete operation. In the majority of cases it suffices; in many cases it is the only procedure practicable. It undoubtedly prevents the pleura becoming infected from the wound in the lung.

The treatment of a through-and-through wound by mopping out the whole length of the track to remove foreign bodies and necrotic tissue has never been employed by us, but it might be worth a trial.

With a large surface wound of the lung, excision may be practised; the large, shallow, jagged wound must be treated by excision of its edges, trimming up the surface, and complete suture for arresting hæmorrhage. The torn, ragged wound, which is frequently seen on the edges of the lobes, should be treated by suture, following excision or resection.

This ideal method of treatment by resection and primary suture, it will be seen, applies to the lung as to any other part. The wound on the surface of the lung can, in certain cases,



be treated by an ordinary flat dressing and the progressive sterilization method.

At a discussion, M. Quénu asked if it would be possible to suture the edges of the lung wound to the edges of the pleural incision, so that dressings could be directly applied. Cotte has reported a case so dealt with, which made a good recovery. This estimable method is only applicable to wounds on the outer aspect of the lung.

These general principles have been applied by us a number of times in performing immediate operations on wounds of the lung. In 10 cases we have performed immediate extraction alone, without treatment of the wound other than suturing the opening. In 7 of these cases we operated for direct arrest of severe hæmorrhage from the lung; 2 of the patients died of their hæmorrhages. Of the remaining 5, 3 (APPENDIX, Cases 1, 2, and 7) made perfect recoveries; the other 2 recovered after complications.

Delmas (APPENDIX, Case 6) operated on a British soldier for severe hæmorrhage. The missile had penetrated the anterior surface of the upper lobe, and was removed by direct incision over the posterior surface. The wound of entry was simply sutured, the track of the missile was not dealt with. On the thirteenth day there was suppuration and discharge of fragments of clothing which had been left in the track.

Méline (APPENDIX, Case 13) performed direct arrest of hæmorrhage from the lung, but did not sufficiently deal with the fractured rib. Subsequently the pleura became infected from the seat of fracture. In three cases operation was performed for removal of missiles, although there was no severe hæmorrhage calling for operation.

Delmas (APPENDIX, Case 19) removed a missile through an incision in the lower lobe near the interlobar fissure. He excised the entrance wound in the lung with curved scissors, and sutured it; the patient made a perfect recovery.

Léo (APPENDIX, Case 21) sutured three wounds in a lung. From the upper one he removed by a special incision a shell fragment lying superficially. The tracks in the lung were not dealt with. The patient developed an encysted empyema, but recovered.

Fiolle (APPENDIX, Case 23) extracted a missile engulfed in



the lung. The lung was sutured, and the patient made a perfect recovery. Direct treatment of the lung wound with excision and suture was performed in 5 cases, 2 of them being immediate operations for the arrest of hæmorrhage; of these 2, 1 died (APPENDIX, *Case 11*), the other made a complete recovery (APPENDIX, *Case 12*). The 3 other cases were operated upon without grave urgency; 2 made uninterrupted recoveries (APPENDIX, *Cases 19 and 20*); the third (*Case 24*) developed empyema by infection from the thoracic wound, which suppurated.

Of 7 simple extractions of missiles without excision of the wound in the lung, but with simple suture of the openings, 3 patients (*Cases 1, 2, and 7*) made straightforward recoveries, and 4 (*Cases 6, 8, 13, and 21*) developed mild suppuration. Of 4 cases in which the wound of the lung was excised and sutured, 3 (*Cases 12, 19, and 20*) made perfect recoveries, and 1 (*Case 25*) developed empyema. This is not a large number of cases to judge by, but they seem to show that the direct treatment of the lung wound gives better results, and less post-operative trouble, than extraction of the missile only, just as one might have supposed.

The primary extraction, immediate or early, of all kinds of foreign bodies from the lung must be looked upon as the rational treatment for preventing infection of gunshot wounds of the lung. By this procedure alone pleuro-pulmonary infection, the gravest of all wound complications, early or late, can be avoided. The operation is comparatively free from danger, and the results are good.

Should one extend the operation to include the treatment of the lung wound in accordance with the established principles of war surgery? It certainly would be desirable to do so, but it must be realized that the very nature of the lung lesion makes this treatment, more often than not, impossible. Surface wounds of the lung, and ragged wounds of the edges of the lobes, allow of excision and suture, but anything more than gentle swabbing is not justifiable in penetrating or perforating wounds.

The last point to be settled is the right moment for operating, but there is not yet sufficient evidence to give a definite ruling. Immediate operation seems best and most rational,



but the condition of the patient must be seriously taken into account. The wounded man generally arrives in a condition of shock, and, though the necessity of immediate operation to arrest hæmorrhage may outweigh his general condition, one would not care to operate so soon merely to treat the wound of the lung. The patient must be put absolutely at rest, must be warmed, treated for his general condition, and should be allowed to recover from the shock which always complicates penetrating wounds of the chest. Operation may be possible sooner than at first sight seems likely, as thoracotomy has practically no influence on the blood-pressure, in any case infinitely less than laparotomy. Too great haste may be dangerous, but it may be equally dangerous to delay. Sepsis in the lung occurs early, much earlier than suppuration in the pleura.

From the thirty-sixth hour onwards the focus of pulmonary congestion is formed round the missile, or the wound in the lung. Operation at this period would be undertaken on already infected tissue. The results would be uncertain, if not frankly bad. It must be supposed that, like every other battle wound, a wound of the lung passes through a phase of practical asepsis, during which, although contaminated, it is not yet infected. During this period, it is possible to treat it by excision of necrosed and contaminated tissue, followed by suture of the wound. In this connection a case of Delmas' is most instructive. A wound of the lung was excised and sutured after extraction of a missile. Vaucher made cultures from the shell fragment, and from a portion of the excised lung wound. That from the shell fragment gave a large, rapidly-growing Gram-positive diplococcus (unidentified). The culture from the piece of tissue gave streptococcus and pneumococcus only, after sixty hours. An officer, wounded at 10 a.m., was operated on at 3.30 p.m. on the same day, five and a half hours after the wound, during the period of practical asepsis, when the contamination was merely superficial and had not extended deeply into the wound. The wound in the lung was excised; the patient made an ideal recovery, with a minimum of pulmonary reaction and no pleural reaction at all. He left us in perfect condition, which was maintained when we last heard from him three months later.



We have performed this early operation seven times, not for urgent hæmorrhage or asphyxia, but simply to treat the wound of the lung on the rational lines of war surgery, and to avoid infection. Gatellier has related to us an eighth case which he has not published. (APPENDIX, *Cases 18-25.*)

Cases 18 and 21 were abdomino-thoracic wounds, in which the injuries to abdominal viscera were treated as well as the lung wound.

Simple suture of the lung was performed six times (in one case three openings were closed), missiles were removed in five cases, and in two the wound of the lung was excised before it was sutured.

The eight cases all recovered, two of them after the development of a localized empyema. Cultures taken from the lung wound of one of the eight patients gave streptococci and pneumococci. The wound was excised, and perfect recovery followed. On auscultation, a small patch of pulmonary congestion was noticed. On *x-ray* examination the lung appeared normal and was seen to be working normally.

Case 19 (Delmas), a patient with a wound of the lung with missile retained, was dealt with in accordance with the general rules of war surgery—operation seven and a half hours after the infliction of the wound, removal of foreign bodies, excision and cleaning-up of the wound, complete closure by suture. The wound of the lung healed by first intention, treated as it was during the period of contamination only, before the development of infection. This was an ideal case of recovery; the patient was up in a fortnight, and we had very good news of him three months later.

Gatellier operated upon his patient under most favourable conditions, two and a half hours after the wound. The missile was removed and the lung sutured.

The four other cases also made perfect recoveries.

Recently our lead has been followed. Three surgeons, belonging to the same army as ourselves, have sent me notes on most satisfactory cases of immediate operation for lung wounds.\*

Ravary operated eight hours after the infliction of the

---

\* PIERRE DUVAL, *Soc. de Chir.*, 1917, June 13.



wound. He found that the lung had been torn by a splinter of rib which was embedded in the parenchyma. The fragment of bone was removed and the lung sutured. The patient made an excellent recovery, which was maintained one month later.

Ravary operated on another case four and a half hours after the wound, and removed a shell fragment which was lying 5 cm. deep in the lung; he then sutured the lung. Uninterrupted recovery followed.

Perriol operated six hours after infliction of the wound; he found and dealt with a tear of the lung caused by a fractured rib. His patient recovered.

Lefèvre operated four hours after the wound; removed a missile and a bone splinter from the parenchyma, and sutured the lung. The patient recovered, and was evacuated in excellent condition three weeks after the operation.

The general rules of war surgery, as applied to wounds of the lung, have given, in these twelve cases, twelve recoveries; ten of them quite perfect, two following slight complication by empyema.

During the period of reaction and pulmonary congestion, operation can yet be attempted if the curative treatment of the focus depends on the removal of the retained foreign body. We were once led to operate under these unfavourable conditions (APPENDIX, *Case 14*).

Méline operated upon a case to arrest hæmorrhage from the lung which threatened the patient's life. A shell fragment was left in the lower lobe. The presence of this septic fragment provoked a succession of patches of pulmonary congestion which did not yield to medical treatment. We operated on the twenty-seventh day, and removed the missile; but the lung was adherent, and we had to plug the incision in the lung. The patient recovered, but only after a very long convalescence.

The course of a case operated upon late is by no means so straightforward as that of a case operated on early. The best moment for operation, then, is directly the patient has rallied and has a fair blood-pressure, before the contaminated lung has become infected and developed pulmonary congestion. Quénu's formula for dealing with wounds of joints



applies to pleuro-pulmonary wounds, "Operation must be performed before symptoms of infection appear."

The gravest complications of lung wounds occur at two periods: about the second or third day, due to infection of the lung, or direct infection of the pleura; from the fifth day onwards, due to infection of the pleura from the lung. The opportune moment, then, for operating on a wound of the lung, is within twenty-four hours after the infliction of the wound, and time—as in all war surgery—is all-important. In the twelve cases (with eleven recoveries) of immediate treatment of the lung wound, operation was performed at periods of from two and a half to twelve hours after the wound, so that the time for operating on lung wounds, as well as the technique, obeys the ordinary rules.

Nearly all our operations have been performed under general anæsthesia; but local anæsthesia would be very much better. The extent of the lesions in the wounded lung, the latent infection, and the frequent injury of the opposite lung are definite contra-indications to the use of general anæsthesia by inhalation. Local anæsthesia might be of immense value in the surgery of these wounds.

Should this new treatment of lung wounds be systematically practised in all cases, or are there exceptions, and numerous ones?

Far be it from us to suggest that every wound of the lung should be operated upon. To begin with, bullet wounds should be left alone; unless they give rise to dangerous hæmorrhage they very seldom call for operative interference. Bullet wounds are generally benign, and heal without complication. They are usually uninfected, and the bullet very rarely carries fragments of clothing into the lung. In the chest, as in other regions, bullet wounds cannot be classed with shell wounds.

In wounds inflicted by shell fragments, operation is, in theory, always indicated; but clinical observation proves that many perforating wounds of the lung heal uneventfully, and that fragments are often retained without complications. Minute fragments can be left without particular danger. They do not carry portions of clothing in with them, and they are often sterile. In these cases the wound in the lung closes spontaneously, the immediate danger is nil, as a rule,



and early or delayed complications are very unusual. The large fragment, on the contrary, must always be removed. In this class of case, severe pleuro-pulmonary infection is the rule. Between these two extremes the indications for operation are, as yet, undetermined. Our experience is too small. In difficult situations, where even the best established dogmatic rules cannot indicate the right procedure, the last word must rest with the surgeon's clinical instinct and conscience.

The progress already made in the surgical treatment of gunshot wounds of the lung is most encouraging. The policy of 'doing nothing,' which, even to-day, helplessly looks on while the grave complications of these wounds run their course, ought to make way—in some cases, at any rate—for active and effective surgery. As technique improves, the general surgery of gunshot wounds is being applied little by little to wounds of the lung, and some wonderful recoveries have already resulted. Let us dare to hope that those who follow in our steps may soon have many more numerous, and many more brilliant successes.

## CHAPTER VI.

**THE URGENT SURGERY OF 'OPEN THORAX.'**

'OPEN THORAX' is a term that has been coined during the war to describe a class of chest wound in which the thorax is widely opened, and air passes directly into the pleural cavity with each respiratory movement. Urgent surgical intervention is called for to close the thorax.

Two reasons make this necessary. Closure of the thorax lessens the danger of asphyxia which is threatened by an open thorax, and protects the pleura against infection from without. This operation was adopted by Thévenot, then by Thévenot and Tuffier, Combier, and Murard, who have proved anew its great and undoubted value. It had already been practised by Larrey, who held that it had been performed by the ancients.

The operation is simple, within the scope of everybody, and it can be performed at any field medical unit. It is an operation of imperative necessity, but its results must not be exaggerated.

Thévenot has operated 109 times, with 27 deaths, a mortality of 24·7 per cent, and in 8 cases empyema followed. What causes this relatively high mortality and these septic complications? This obviously necessary operation deals with only one complication of the gaping wound in the thorax, the pneumothorax, and leaves the lung wound exposed to infection from within. Closure of the thorax guards the pleura against infection from without, but it has no influence on infection arising from the wound itself, or from foreign bodies retained in the wound.

Quite recently we met a clear example of the inadequacy of parietal suture. The case was one of open thorax with fracture of the ribs, a through-and-through wound caused by a shell fragment. The thorax was sutured, and relieved the asphyxia. The patient's temperature rose, and a large pleural



effusion formed, showing streptococcus and *B. perfringens* in a direct smear. The patient died on the eighth day. The closure of the thorax averted the urgent danger of asphyxia, but the pulmonary wound, which was not treated, infected the pleura, with the fatal result. Would it not have been undoubtedly better, seeing that operation was performed some hours after the wound, to have examined the lung wound and treated it directly, to have made the toilette of the pleura, and not to have left an effusion of blood, an excellent culture medium, in the pleural cavity?

The death-rate of 24 per cent after suture for open thorax is that of wounds of the lung in a closed thorax. The operation has merely converted an open into a closed thorax; it has had no effect on the course of an infected wound of the lung.

It is admitted by all who have discussed or advocated the operation, that it is illogical to close a wound in which a missile is retained; but they have taken cover behind the tolerance of the lung for missiles embedded in it. Tuffier and Thévenot state: "Experience shows that in a case without traumatopnœa the foreign body is usually tolerated and the track spontaneously cicatrizes." Hartmann remarks: "One knows the relative tolerance of lung tissue for even septic foreign bodies." Statistics are a sufficient reply to this argument. Through-and-through shell wounds have given us a death-rate of 20 per cent; retained fragments, one of 30 per cent. If there is in the lung a relative tolerance for foreign bodies, even septic foreign bodies, these figures prove that the tolerance must be very relative!

Closure of the thorax must be regarded as an operation of urgency which is practicable in all field medical units, but it must also be regarded as an unfinished operation, which should be completed by dealing directly with the wound of the lung.

Open thorax is nearly always accompanied by fracture of the ribs. Is it logical to clear out all fragments of bone from the site of the fracture and to leave those in the lung? And since an operation is performed, why should only one complication (pneumothorax) be dealt with, and the wound in the lung, a nidus of every infection, be left alone? Why should the operation not be made complete?



The complete operation is too complex to be performed in all field units, but simple closure of the thorax, as Tuffier and Thévenot remark, could be carried out anywhere, and the wound in the lung treated as a secondary operation at a proper surgical unit. Or the patient could be evacuated, as a specially urgent case, direct to the surgical unit, with a dressing firmly plugging the opening in the thorax, and the whole thing done there at one operation. The latter procedure is, perhaps, the better of the two; a thick dressing well applied, with firm pressure, combats the traumatopnœa as readily and as well as parietal suture.

Direct evacuation to a surgical unit is a simple matter of organization, which must adapt itself to the exigencies of surgery if the complete operation in one stage is proved to be best.

To epitomize: Simple closure of the thorax, without treatment of the wound in the lung, can only be regarded as a palliative measure, which gives good immediate results; it cannot be considered a curative operation.

The death-rate of 24 per cent shows conclusively that though asphyxia, the immediate danger, can be effectually relieved by closure of the thorax, yet this operation has no influence on the ultimate course of the wound in the lung, which, owing to the danger of pleuro-pulmonary infection, is rendered no whit less grave.

Simple closure of the thorax merely transfers the death-rate of these cases from the account of open thorax to that of closed thorax. Therefore the whole operative technique of closed thorax should be associated with the simple operation which, planned to avert the immediate danger of pneumothorax, transforms open into closed thorax. Surely it is logical to think that all the efforts made to diminish the danger of lung wounds with closed thorax, should be associated with the operation which successfully combats the immediate peril of open thorax.

Our observations and those of Vielle prove the overwhelming advantages of the complete operation at one sitting.



## CHAPTER VII.

**OPERATIVE TECHNIQUE.**

**A**MONG operations rendered necessary by war injuries, the surgery of the lung forms a veritable revolution.

It must be realized that hitherto the surgery of the lung has been limited solely by the dread of pneumothorax. The physiological conditions under which the organ acts have seemed to necessitate special conditions without which operations could not be performed. Hence arose the German method of operating either in low-pressure chambers or with high-pressure respiratory apparatus. Physiologically, these methods are quite rational, but they are of small practical value. Their inconvenience has limited their use, and has prevented the field of pulmonary surgery from being enlarged. The necessary apparatus is too costly and cumbersome for our war equipment.

These methods have, so far as the actual surgery of the lung is concerned, a much more serious disadvantage. With a negative perithoracic pressure, or a positive intrapulmonary pressure, the lung distended with air is kept in tight contact with the chest wall. This artificial adhesion limits the field of operation to the actual size of the thoracotomy opening, the idea being, as with the pleuro-pulmonary suture, to avoid pneumothorax. The delivery of the lung on to the surface, its inspection and manipulation, are made quite impossible. War surgery of the lung is not feasible by these methods.

Before the war, the essentially French method of producing total pneumothorax by a large opening had been proved to be possible. Work done during the war has shown that this procedure, which was formerly regarded as something quite exceptional and bold, is entirely practicable, and constitutes the method of choice in intrathoracic surgery.

Furthermore, the procedure which we described in March, 1916, for the late extraction of missiles from within the lung,



demonstrated that the organ could be pulled out, lobe by lobe, for examination or surgical interference; that it could be delivered on to the chest wall, like small intestine on to the abdominal wall, for surgical manipulation; that one could, if there were adhesions between the lung and the ribs or the mediastinum or diaphragm, cut across such adhesions and set free the lung; that incision and suture of the lung were both easy and safe. In a word, that the rules of general surgical technique were perfectly applicable to the lung.

Granted that a slow and progressive pneumothorax is not dangerous, its presence is a great advantage in manipulating the lung. The delivery, inspection, incision, and suture of the organ are only possible when it is collapsed.

Nothing is easier, with a lung reduced in volume and freely movable on its pedicle, than to tilt the upper lobe downwards and forwards through the wound, inspect it, and palpate it. The lobes can be lifted up to examine their interlobar and diaphragmatic surfaces. The collapsed lung can be pushed forwards or backwards, and the mediastinum inspected.

#### [ THE BLOOD-PRESSURE DURING OPERATION ON THE LUNG.

All these manipulations—grasping the lung with forceps, its delivery, freeing it from adhesions, traction on the pedicle—if very gently performed—have no influence on the heart or respiration. Respiration maintains its normal rhythm, depth, and frequency, and we have not noticed any reflex disorder of the heart's action. Thoracotomy, with total pneumothorax, allows of any necessary manipulation of the lung.

During two operations, which Barnsby paid me the compliment of asking me to perform at his ambulance, Blechmann took a continuous record of the arterial pressure during thoracotomy, showing the effect of pneumothorax production, and of handling the lung. The charts are shown in *Figs. 15 and 16.*

*Case A.—Extraction of a bullet from the lung on the eleventh day—Postero-lateral thoracotomy—Localized hæmothorax—Pneumolysis—Extraction.*

The blood-pressure, which rose under the anæsthetic (ether), fell during the rapid formation of the pneumothorax and during the



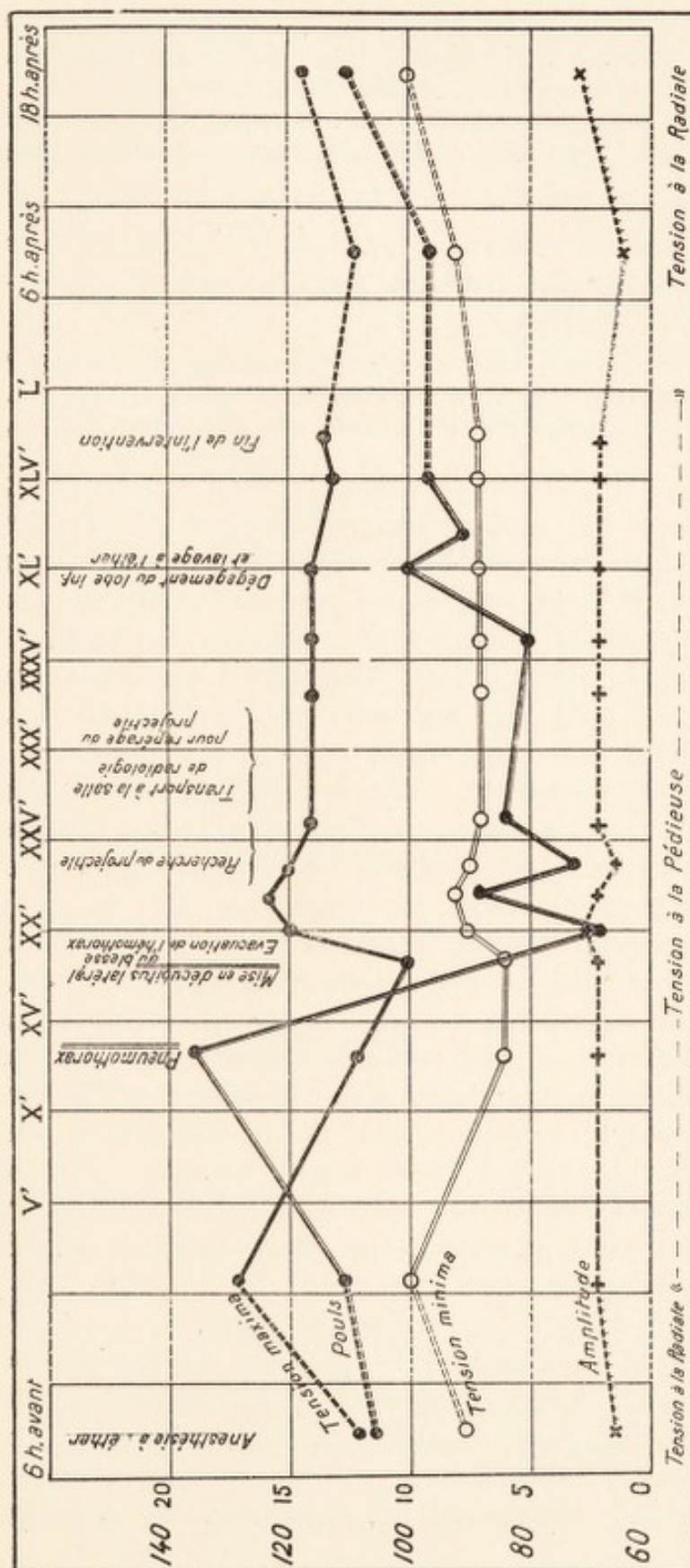


Fig. 15.—Chart of the blood-pressure taken during thoracotomy in Case A. The estimation was carried out on the dorsalis pedis artery: in this vessel the maximum pressure is on the average 3°, the minimum pressure 1°, greater than in the radial artery. (Dr. J. Blechmann)

placing of the patient on his side, then rose again and kept steady. The lung was grasped with forceps, the lower lobe was then freed from adhesions between it and the diaphragm and thorax, and was partially delivered. The denuded area of the diaphragm was 'peritonized' by suture. The pleura was swabbed quite dry. (Fig. 15.)

*Case B.—Total hæemothorax, infected—Thoracotomy—Removal of a very large shell fragment from the pleural cavity—Local anæsthesia, cocaine.*

The local anæsthesia was insufficient, and a temporary fall of pressure followed the skin incision and resection of the rib. The establishment of a total pneumothorax did not affect the pressure. (Fig. 16.)

For purposes of comparison, Blechmann shows a curve obtained by him during a laparotomy for a battle wound of the abdomen on a patient whose general condition was good and who suffered from neither anæmia nor shock (Fig. 17).

The reading of these curves shows that the blood-pressure is far less affected by thoracotomy, pneumothorax, and manipulation of the lung, than by the manipulation in an intra-abdominal operation. Thoracotomy with manipulation of the lung is not a shock-producing operation; Crile had already proved this. It is a point of the utmost importance in determining operation on the lung.

In an abdominal wound, shock is the first thing that has to be considered before doing a laparotomy, and the immediate success of the operation depends on the blood-pressure and the way it behaves during and after operation. In the case of men wounded in the lung, who are always suffering more or less from shock on their arrival at the ambulance, the first indication may be to get them warm, to raise their arterial pressure. But thoracotomy has so small an effect on the blood-pressure that one need not wait for it to regain the normal; it is much more important to forestall the rapid reaction in the lung by an early operation.

A recent note on a case of Lefèvre's is worthy of record in this connection. A man wounded by a fragment of shell on June 7, 1917, had grave intrapleural hæmorrhage. The pulse was uncountable. Blechmann took the blood-pressure, which was as follows: maximum 90, minimum 50,  $A = \frac{3}{4}$  weak.



A thoracotomy of urgency was performed eleven and a half hours after the infliction of the wound, and the lung was sutured. During the operation there was no alteration in blood-pressure. On the third day the patient had a pulse-rate of 96. The blood-pressure was : maximum 140, minimum 90,  $A = 2$ .

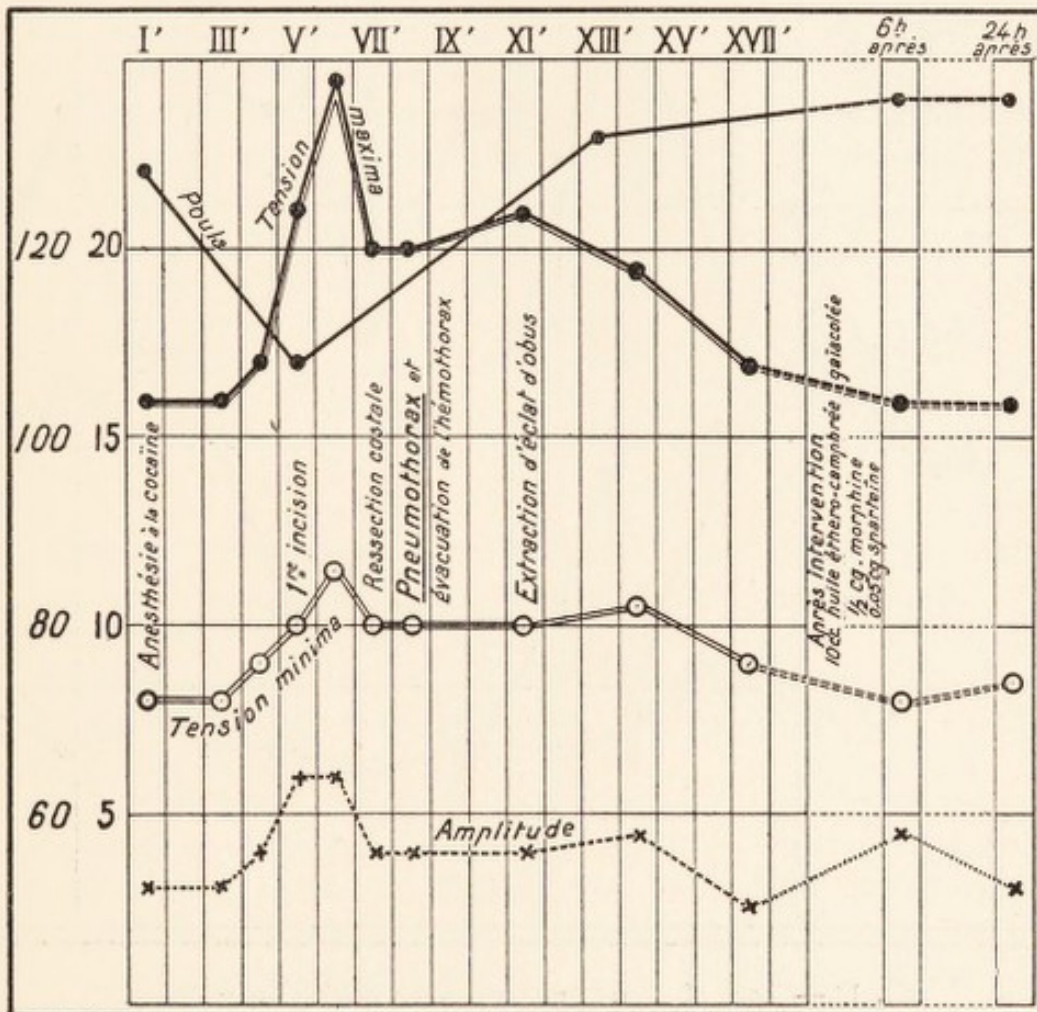


Fig. 16.—Chart of blood-pressure taken during thoracotomy in Case B.

Thoracotomy with arrest of hæmorrhage from the lung can, it is thus proved, be performed on a subject with so low a blood-pressure that laparotomy could not be performed. And the operation of thoracotomy does not lower the blood-pressure.

Thoracotomy on patients with wounds of the lung is an

operation involving much less shock than is laparotomy on patients with wounds of the abdomen and viscera.

Surgery of the lung no longer demands the normal physical conditions under which the organ usually works. A total pneumothorax, so far from being a source of danger, actually

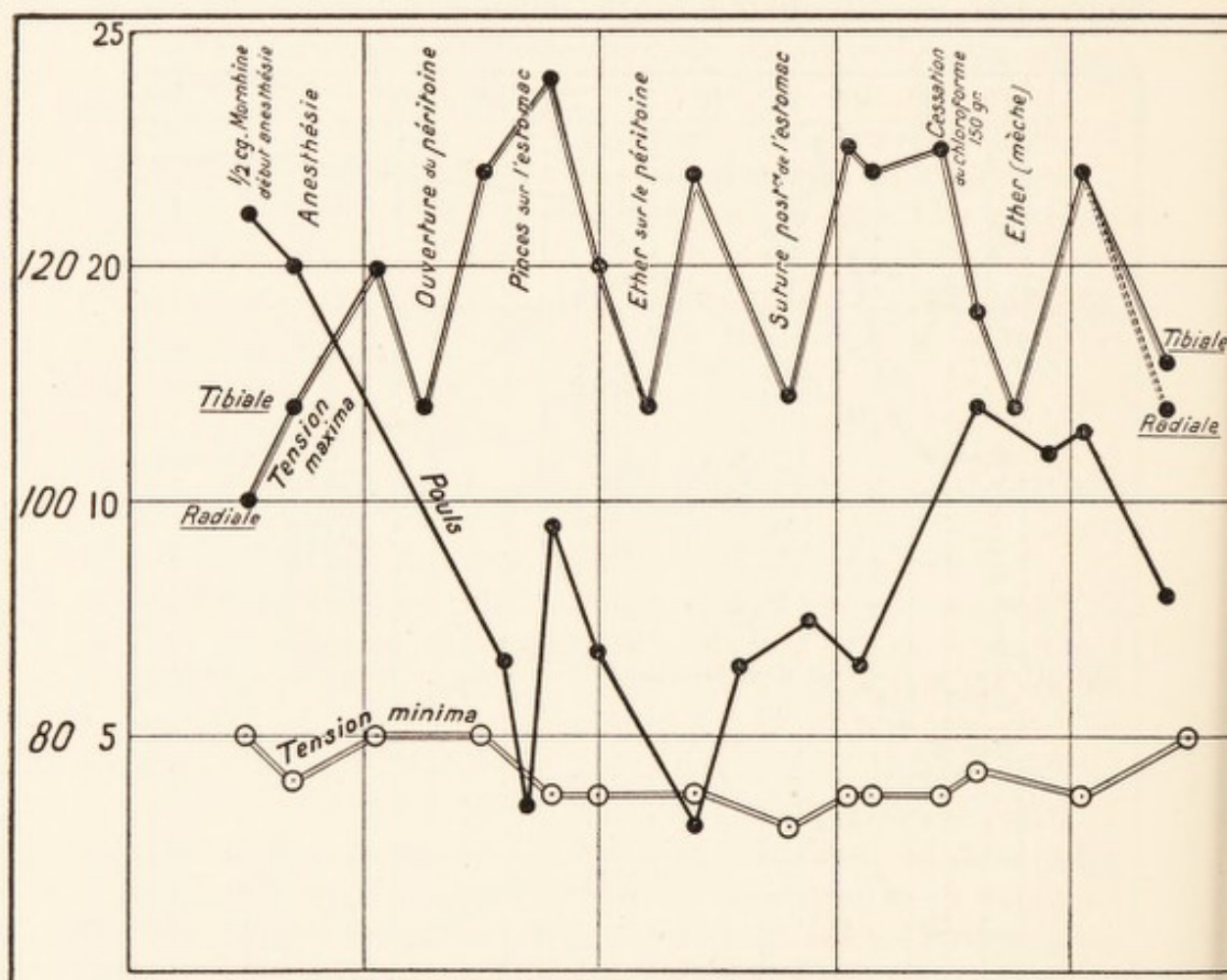


Fig. 17.—Chart of blood-pressure taken during laparotomy.

places the lung under the best possible conditions for surgical manipulation.

The lung is no longer an organ regarded with dread by the surgeon, as it was before the war, and the surgery of the lung takes its place among the simple procedures of surgery.



## ANÆSTHESIA.

As we have already said, it is best not to administer a general anæsthetic by inhalation. For many reasons local or regional anæsthesia is preferable; the patches of pulmonary congestion which so frequently occur after operation, may be in some measure attributed to the effects of inhalation anæsthesia, as well as to the after-effects of the wound of the lung. We have attempted spinal anæsthesia, but our results have not been sufficiently uniform.

When performing operations of urgency, we have been able at times to dispense with anæsthesia entirely—at other times we have used cocaine locally. Bellot (of Cherbourg) has used this latter method with consistent success for delayed extraction of missiles from within the lung. This method, too, appeals to us for early operations on lung wounds.

Anæsthesia by inhalation must be regarded in war surgery of the lung as a factor of considerable risk.

## THE THORACOTOMY.

There are two methods of making the opening in the thorax: the temporary flap; and the extensive resection of a rib (Willy Meyer). A discussion was recently raised as to which method was best for extracting missiles from the mediastinum. Le Fort (of Lille), then Delorme, advocated the 'flap' method, as giving most room.

Le Fort has recently modified his technique. He makes a long antero-external intercostal incision, then cuts through one, or two, costal cartilages. He claims to secure by this method a very workable flap, which can be widely retracted to give considerable room for work inside the chest. The flap can be replaced without permanently damaging the bony wall of the thorax.

Pierre Delbert, Jacob, Hallopeau, and we ourselves, advocate the simple resection of 10 cm. of a rib, retracting the rib above and below with a powerful mechanical retractor (Willy Meyer or Tuffier model—*Fig. 18*).

In our operations we have adopted the technique of Willy Meyer; this has always enabled us to effect the necessary manipulation of the lung, either outside or inside the thorax.

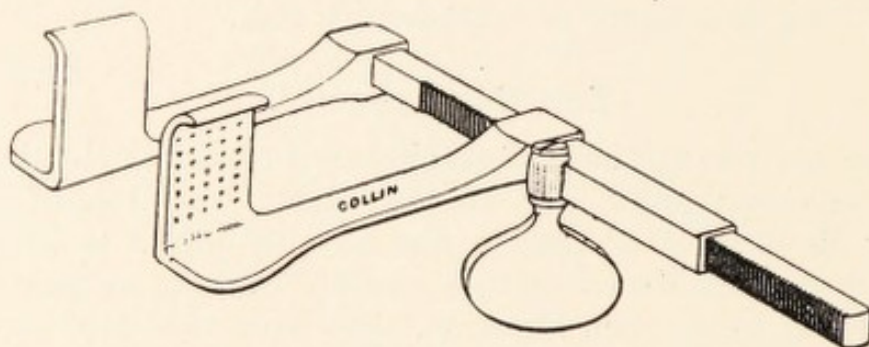


Seeing that we have rejected the 'flap' method in delayed extraction of missiles from the lung, as producing too much shock and mutilation, there is the more reason for adopting the method of least disturbance in early operation.

The wounded men with whom one deals are usually young, and in young subjects the resection of a rib causes very little inconvenience. Bone repair occurs very quickly, and neither the strength nor the suppleness of the thorax is impaired.

Ombrédanne prefers to save the whole rib. He cuts through a rib in one place, then fractures it at another; he bends it back against the edge of the wound, and replaces it after the operation. In our opinion this method is not suitable for a thoracotomy of urgency.

The choice of the site for thoracotomy is a subject for discussion. For the delayed extraction of a missile, thoracotomy should be performed at the spot nearest the missile—and this



*Fig. 18.*—Tuffier's retractor for use in thoracotomy.

spot varies with each case. But early operation for wounds of the lung involves a much freer handling of the organ. One or more lobes may have to be examined and brought completely out of the wound. The incision required is the one which most easily allows of all these manipulations. Drainage of the pleura need not be considered, as it is not practised.

There is no doubt that an antero-external incision, from the mid-axillary to the parasternal line, about the level of the fifth rib, gives easiest access to the whole extent of the lung. It goes without saying that the incision may at times be governed by the lesion in the parietes (fracture of ribs, open thorax). Sometimes two incisions may be necessary, one for thoracotomy, another for dealing with the parietal wound.

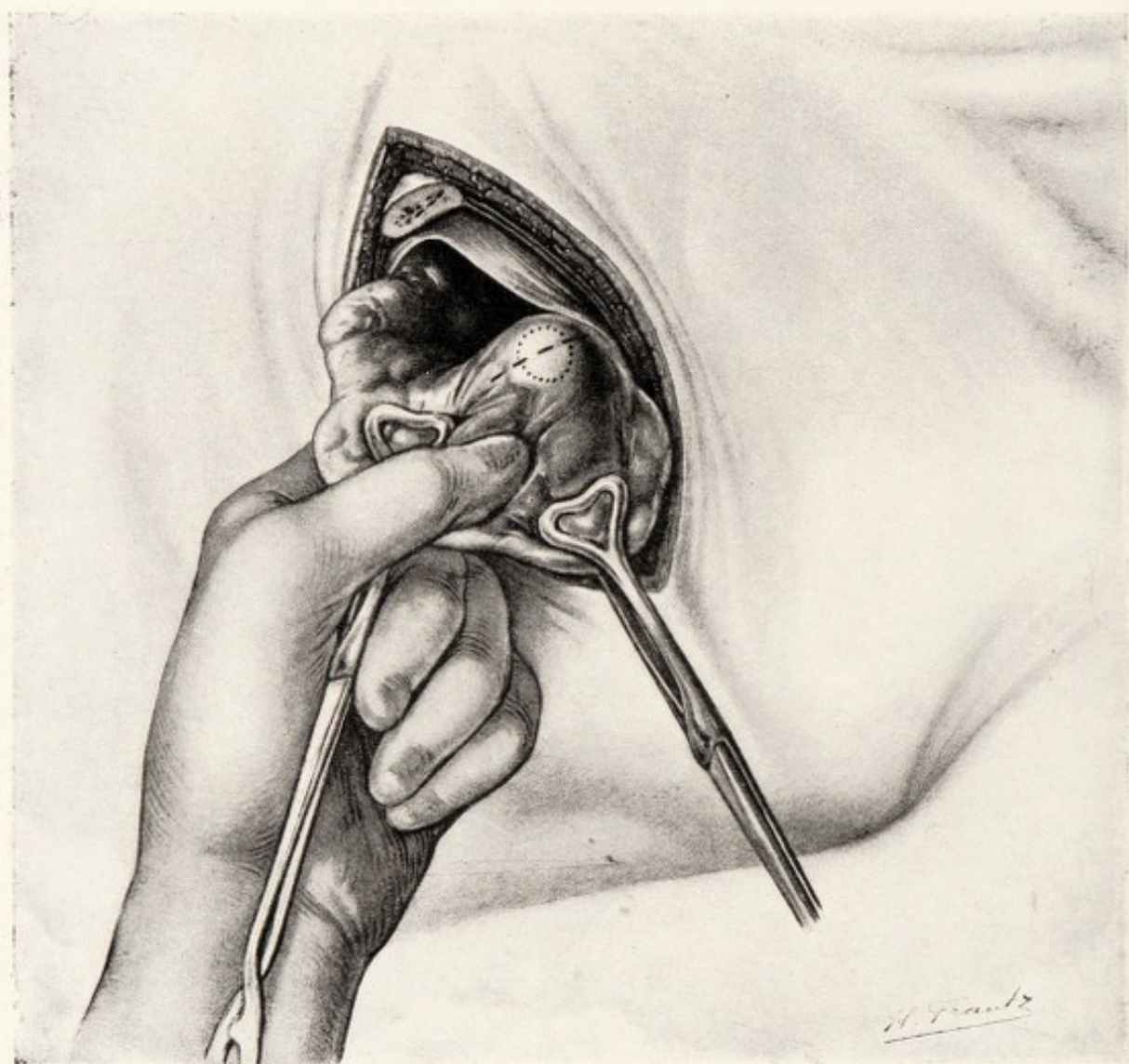


PLATE VI.



*Fig. 20.*—Delivery of the lung. The pleura has been opened, with resulting total pneumothorax, and the collapsed lung drawn out of the thorax with forceps.

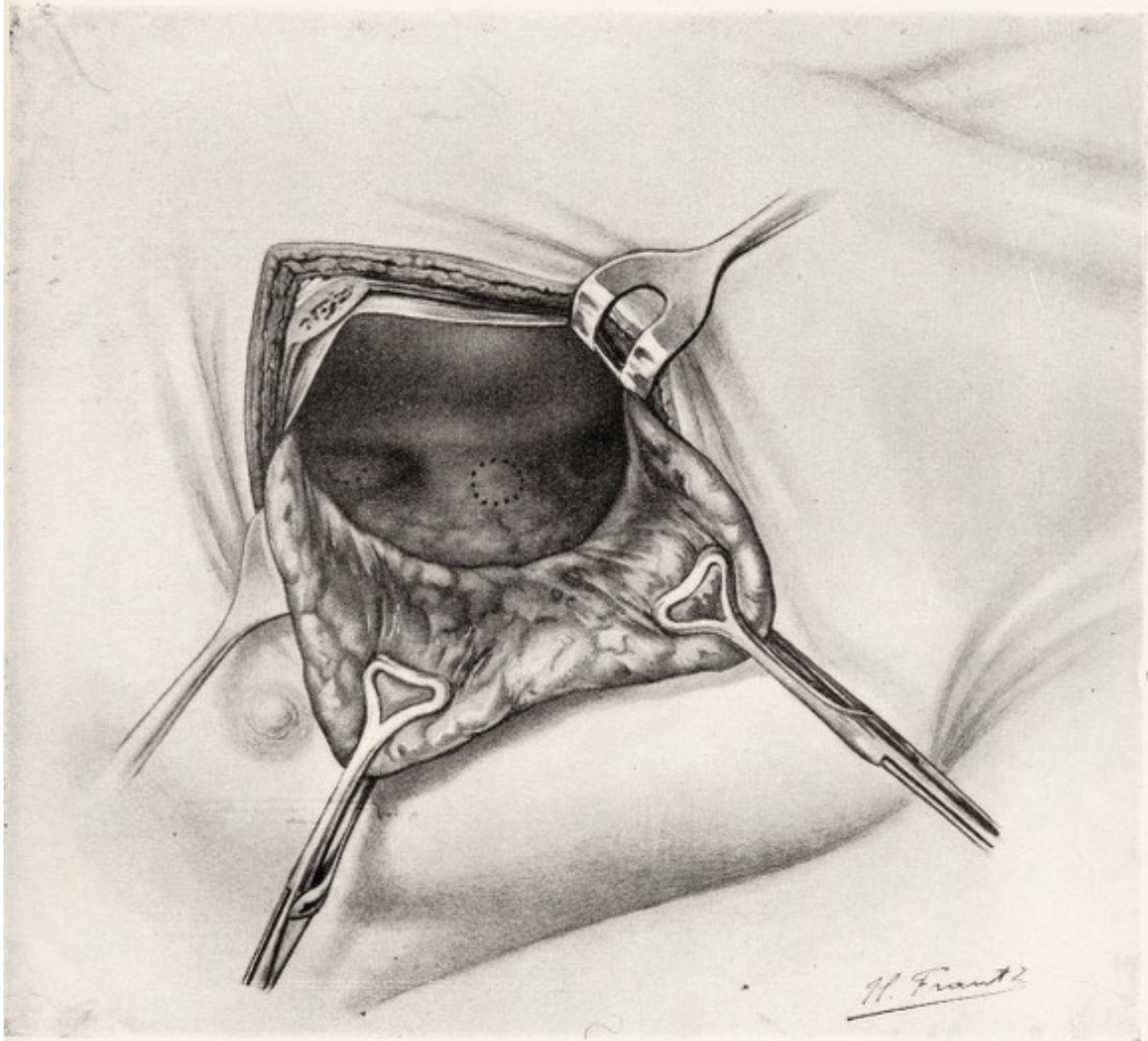
PLATE VII.



*Fig. 21.*—A missile having been felt in the lung, and palpation indicating that it is near the mediastinal surface, the lobe is turned over, a finger of the left hand makes the missile stand out and fixes it, and the lung is incised.

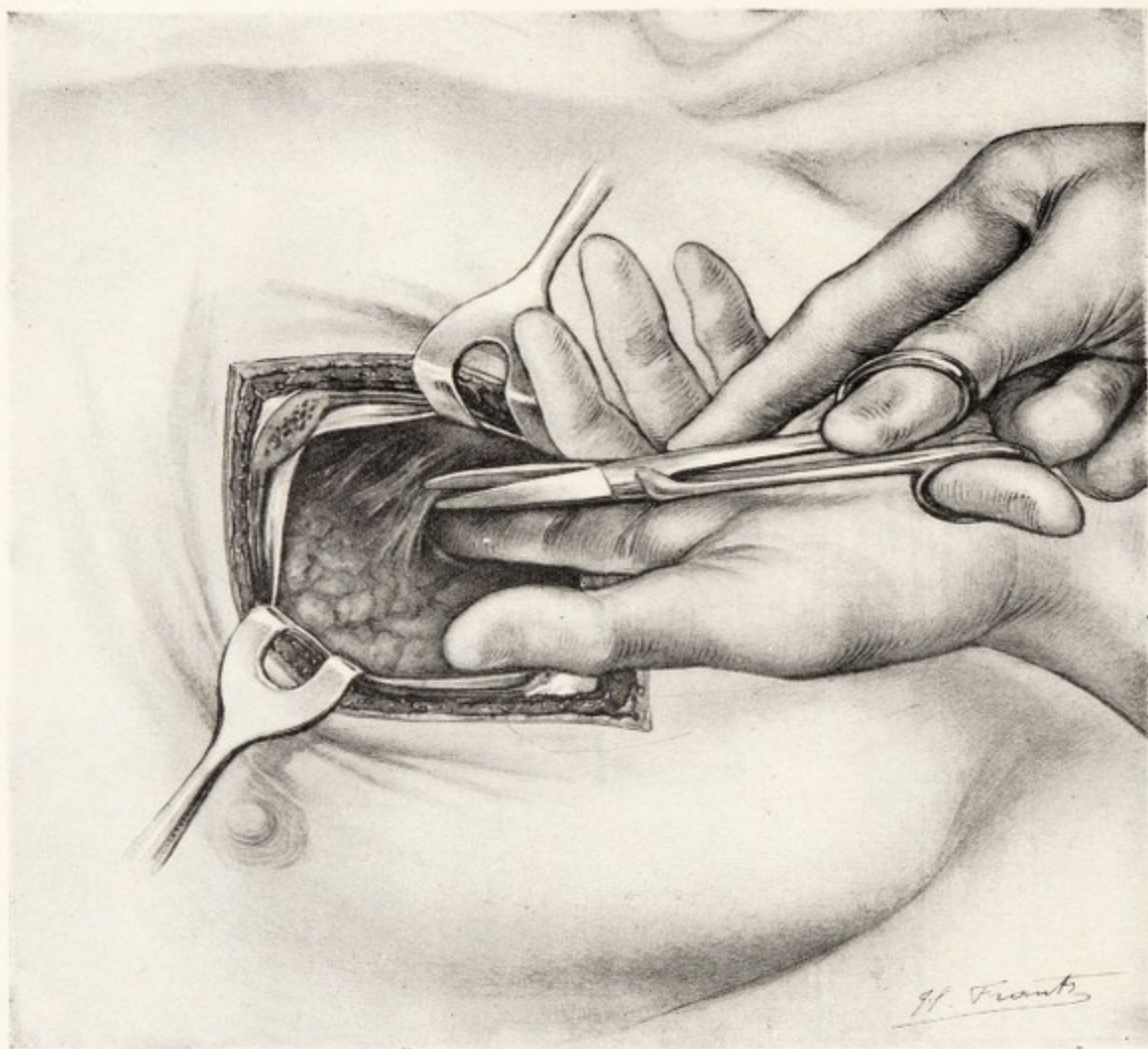


PLATE VIII.



*Fig. 22.*—The upper lobe, grasped by its anterior border, is partly withdrawn from the thorax, and the hilum of the lung exposed. A missile is seen on the mediastinal surface, above the hilum.

PLATE IX.



*Fig. 23.*—The anterior border of the upper lobe is adherent to the pericardium. The adhesions are being freed by the finger and scissors, in order to extract a missile which has lodged in the surface of the lobe adjacent to the heart.



## DELIVERY OF THE LUNG.

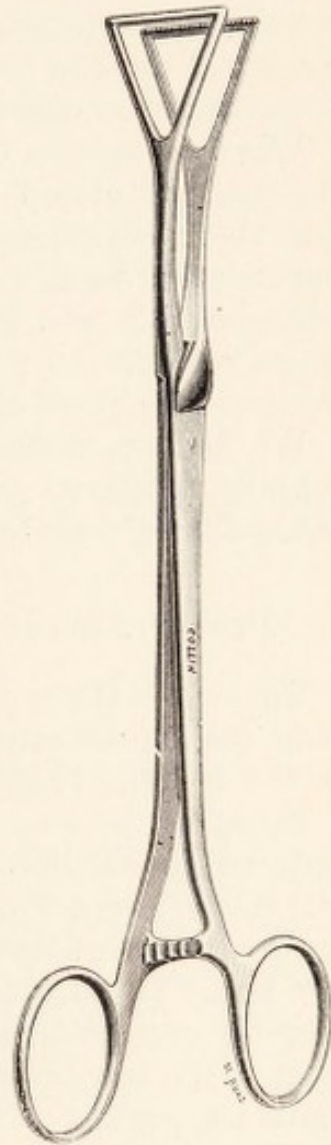
With the thorax widely opened, the hæmothorax is expelled in gushes with each respiratory movement. It is best not to evacuate the hæmothorax at once, but to deal first with the lung; the careful toilette of the pleura is best done as the last step in the operation before closing the thorax.

Simple inspection of the collapsed lung will reveal which is the injured lobe. It is carefully grasped, either on the external surface or by an edge, with special forceps; those (made by Collin) shown in *Fig. 19* are handy, have a strong grip, and do not contuse or damage the lung.

By gentle rocking movements in different directions, the injured lobe is pulled up and delivered on to the surface, where it is immediately wrapped in gauze wrung out of saline solution. By means of this gradual delivery of a lobe, turning it in different directions, each of its surfaces can be examined in succession. (*Figs. 20, 21, 22, 23.*)

As soon as the wound in the lobe is located, manual pressure by an assistant on the gauze-covered lobe of the lung immobilizes it; the opening into the thorax is shut off by thick pads to prevent air passing in and out. When the wound affects two or three lobes, these are successively delivered on to the surface in the same way.

While the lung is outside the thorax, the operator must keep a careful watch on the patient's condition, pulse, and respiration. The grasping of and traction on the lung have seldom any effect on the patient's heart or respiratory rhythm, but these may, at times, be slightly disturbed.



*Fig. 19.*—Collin's forceps for grasping the lung.



One must operate quickly, but not roughly, and the opening in the thoracic wall must be shut off as soon as possible, to prevent mechanical troubles produced by the traumatopnœa. If any trouble should occur, it is better to bring the lung out rapidly and to close off the rest of the wound, rather than to abandon delivery of the lung for the moment in the hope of starting again presently. The plugging of the aperture in the thorax at once re-establishes quiet breathing, and after a very short time the operation can continue.

When adhesions, old or recent, bind the lung to any part of the parietal pleura or fill up the fissure between the lobes, and these adhesions interfere with the delivery of the lung, pneumolysis must be performed. It is quite easy to free the adhesions; it can usually be done with the finger, though at times one has to use a pair of scissors or a bistoury. This pneumolysis gives rise to no hæmorrhage or oozing.

We have performed pneumolysis, a new extension of lung surgery, ten times during operations for the early or delayed extraction of missiles from within the lung.

#### DIRECT ARREST OF HÆMORRHAGE FROM THE LUNG.

There are three methods by which hæmorrhage from the lung can be directly arrested: plugging, suture, and ligature of the bleeding vessel.

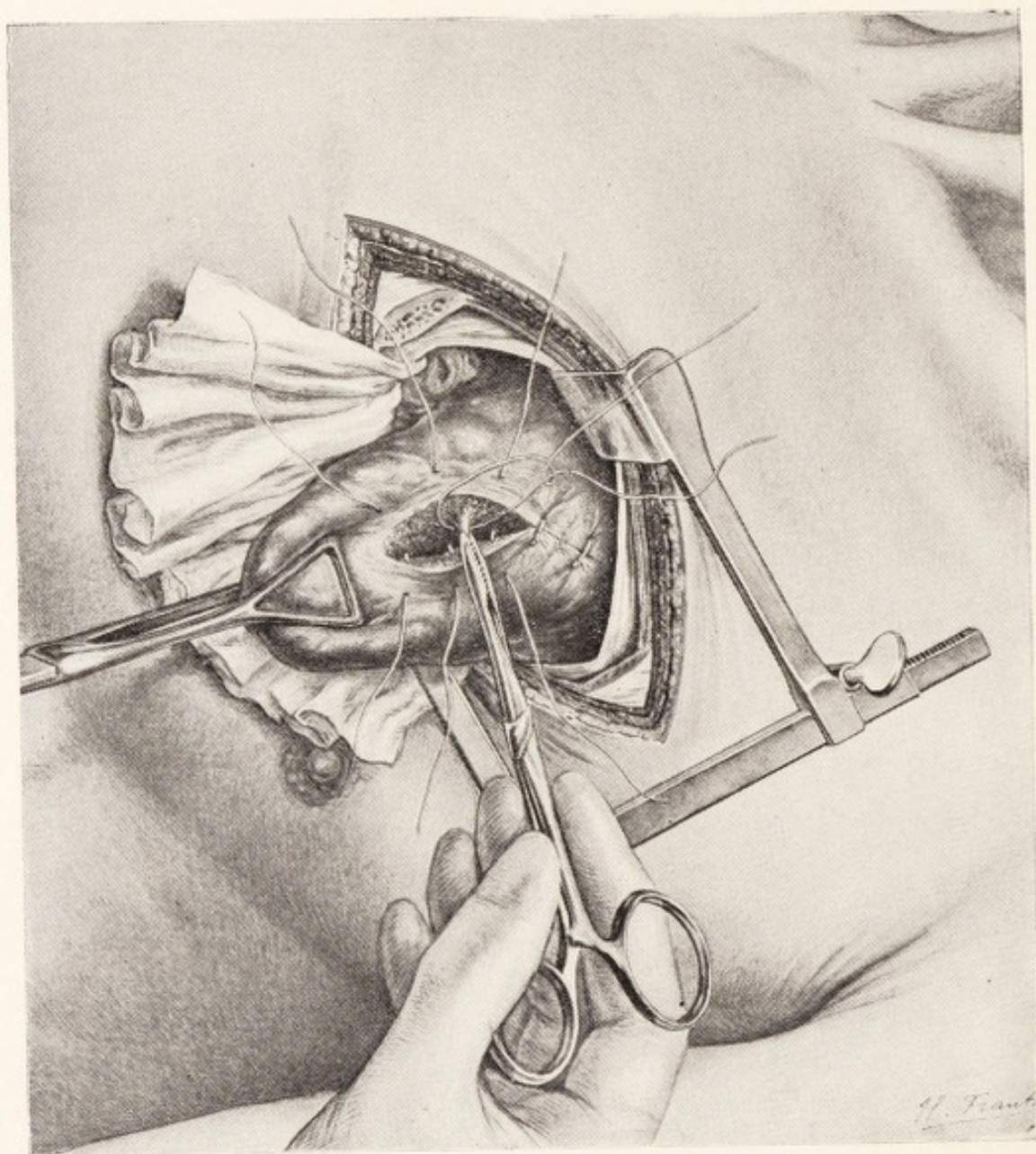
Plugging is only a makeshift. There are, in our opinion, only two conditions which call for it: old, firm adhesions of the lobe; and a wound so large that it cannot be adequately sutured, or with such great infiltration round the wound that the tissue is too friable to hold sutures. We have twice had to plug wounds for grave hæmorrhage from the lung; in each case plugging was made necessary by old adhesions. Both cases did well.

When the lung is free in the pleura, suture of the lung and ligature of the bleeding vessel are the two alternatives. Simple suture of the openings of the wound of the lung seems, *a priori*, an illogical proceeding, since closure of the entrance and exit of a perforating track which is bleeding is an indirect method of arresting hæmorrhage, and may seem risky. But in practice it has given us very good results, and is the only method





PLATE X.



*Fig. 24.*—Closure of a wound of the lung showing deep U sutures and superficial 'peritonization' sutures; also forcipressure and ligature of a pulmonary vessel.



we employ in dealing with a through-and-through wound. In one case only, after having sutured the two openings of a perforating wound, we saw a hæmatoma forming along the track of the wound. This hæmatoma was forming so rapidly that we applied a series of ligatures above the track in the lung. Our patient died, and we had no opportunity of seeing what would have been the fate of the ligatured segment of lung. Actual practice teaches us that we can, and must, count upon the resistance of the lung tissue itself to arrest hæmorrhage in a track both ends of which are closed.

The ideal course is to apply a ligature direct to the bleeding vessel. In large wounds this is simple, and in one case we were able to clip and tie a spurting artery (*Fig. 24*). Desjardin tied a vessel in the hilus which had caused secondary hæmorrhage, and the patient recovered.

Theoretically, it should be possible to lay open the track of a perforating wound, search for and ligature the bleeding vessel. Souligoux has done this experimentally on the dog. But in a very large majority of cases it is quite unnecessary to do more than close the openings of the wound in the lung. Moreover, in cases of severe hæmorrhage, suffering from considerable shock, the simplest procedure is the one to be employed.

#### EARLY EXTRACTION OF FOREIGN BODIES IN THE LUNG.

The early extraction of the foreign bodies involves the removal, not only of metallic fragments, but also of fragments of clothing and splinters of bone which may have been carried in. The *x* rays give information as to metallic fragments, but do not help in detecting portions of clothing or small splinters of bone. When manipulating the lung, it is more difficult to palpate and detect foreign bodies in a recent wound than in a wound inflicted some time previously. Hæmorrhagic infiltration thickens the lung tissue, and gives a solid elastic feel to the mass, in the midst of which it may be difficult to feel a small shell fragment or splinter of bone. One cannot detect fragments of clothing by palpation. It is well to recognize that palpation of recent lung wounds does not give clear information, as does palpation of the normal



lung tissue or of a lung in which a foreign body has been retained for some time without causing great reaction of the surrounding tissue.

Even after accurate localization, extraction should only be undertaken provided radioscopy can be resorted to during the actual operation.

When the missile has not penetrated deeply, and is lying near the opening of the wound, it can be grasped with forceps, controlled by palpation, and easily withdrawn. If the missile has penetrated deeply—has entered the upper lobe, for instance, low down on the anterior surface, and is felt to be lodged high up on the posterior surface—an incision can be made over the missile and the foreign body removed. The incision is easily closed by suture. But it is best not to make a new incision unless one is forced to do so—one should make every effort to extract the missile by the same opening which it made.

This latter procedure has a very distinct advantage, in that the track of the missile is explored along its whole length, and unsuspected fragments of clothing and splinters of bone may be discovered. Also there may be several missiles lodged in the lung, and the withdrawal of these along the tracks made by them is obviously better than making further incisions.

The absolute necessity of avoiding infection, by withdrawing from wounds in the lung every foreign body lodged in them, leads one to consider the question of gently cleansing the track of the wound. In through-and-through wounds, forceps are passed into one opening of the track and out at the other, a fine gauze wick is then grasped by the forceps, and pulled backwards and forwards along the track. In penetrating wounds having only the one opening, the track, after extraction of the missile, is swabbed out with a gauze wick held in forceps.

This procedure, which we have not ourselves practised, would seem to be, *a priori*, a good one for removing all foreign bodies from perforating or penetrating tracks which cannot be laid open or exposed. It would also remove the dead tissue pulp which lines the walls of the track and forms a nidus for infection.



## TREATMENT OF THE WOUND IN THE LUNG—

## SUTURE OF THE LUNG.

The treatment of a large wound in the lung consists in excision and suture. Bouvier on one occasion freely resected a ragged wound on the margin of the lung with a bistoury. Excision has been performed by Delmas, Léo, Vielle, and ourselves, using curved scissors—a regular trimming-up of the surface of the lung.

Suture must ensure arrest of hæmorrhage, and the edges of the sutured surfaces must be accurately approximated. The sutures must be deep, and, in our opinion, deep U sutures which encircle the whole depth of the wound are the best. The needle must enter and emerge as near as possible to the edges of the wound, so as not to sacrifice too much lung tissue and not to risk tearing the parenchyma when the lung re-expands after the chest is closed.

Superficial sutures may be put in with a fine needle between the deep sutures, to bring the edges of the pleura accurately together. The accurate adjustment of the pleura is designed to limit adhesions or to prevent them entirely. This peritonization of the pleura is a procedure which we have frequently employed.

This method of treating the wound in the lung is nearly always feasible. The deep U sutures, of medium catgut, tied just tight enough to grip the whole extent of the wound, do not, as a rule, cut out, even if they are passed through the zone of hæmorrhagic infiltration.

## TREATMENT OF THE PLEURA.

After the lung has been sutured and replaced in the thorax, the pleural cavity requires special treatment; it must be emptied of blood and clot, and also, perhaps of the air inside it. Every trace of blood must be cleaned out, and this is done with swabs mounted on long forceps. Liquid blood is removed, clots are hunted for in all the pleural culs-de-sac, and the whole extent of the pleural surface is wiped dry.



The toilette of the pleura should be undertaken systematically—the swabs first passed round the apex of the lung, then over the wall of the mediastinum, then the costo-diaphragmatic cul-de-sac wiped dry all over from sternum to vertebræ. In this dependent portion the last clots may be hidden. We have several times, on the analogy of the treatment of synovial membranes, concluded by passing an ether swab over the whole surface of the pleura; a procedure which has caused no disturbance. Recovery was normal; but it may be that the ether swab has no beneficial effect.

The question arises as to whether the air should be removed from within the pleural cavity. Some surgeons never attempt removal, as spontaneous absorption proceeds very rapidly. Personally we nearly always do so. As is proved by daily *x*-ray examination, spontaneous absorption of the pneumothorax is not completely effected for several days, and during this period the function of the lung is diminished. Now it must not be forgotten that one of the causes of congestion in the sound lung is the extra work thrown upon it.

Hallopeau prefers to leave the air, so that the hæmostatic action of the pneumothorax may not be lost; but a well-sutured lung has no need of this assistance. The patient undoubtedly breathes more quietly, and suffers less, when the pneumothorax has been done away with. In two cases we have had to withdraw the air from the pleural cavity, on the day after the operation, to allay the patient's suffering and dyspnœa. In both cases relief and quiet respiration were at once obtained. We believe that, from every point of view, the aspiration of the intra-pleural air is an excellent procedure.

There are two methods by which immediate evacuation of air from the pleural cavity can be accomplished: by respiration under pressure; or by simple aspiration after closure of the thorax. M. Depage, during some operations which he very kindly asked us to perform at his excellent Ambulance de l'Océan (La Panne, Belgium), advised us to bring the lung back at once to the chest wall—before the closure of the thorax—by a few respirations under positive pressure. This



sudden, and perhaps rather rough, dilatation of the lung, seems to us to risk a tearing through of the sutures on the sudden increase in size of the organ. We have all along followed Quénu's very simple technique. Through the closed incision, or any point in the thoracic wall, aspiration is made with an ordinary syringe. On auscultation, the normal low-pitched vesicular murmur is heard immediately, while dilatation of the lung can be seen by the *x* rays. This procedure has no harmful effect on the lung.

#### CLOSURE OF THE THORAX.

The thorax must be hermetically closed by suture of the muscles in one or two layers and by suture of the skin. In the antero-external incision the deep layer includes the intercostal muscles and the pleura, the middle layer the pectoralis major. It is most important to cover the resected ends of the rib with a staunch muscle suture, for here the pleura cannot be brought together, and a leakage of air might occur. The skin incision is completely closed.

In an operation of urgency for closure of an open thorax, suture in layers is preferable to suture *en masse*.

Whether or no the pleural cavity should be drained is a most important question. Drainage may be disastrous in two ways: the pleural cavity is exposed to secondary infection; and air passing into the pleura may give rise to mechanical respiratory troubles as well as sepsis. Drainage of the wound, either by tube or gauze wick, must be completely abandoned; the treatment of the pleural membrane must be the same as that of a synovial membrane.

Some surgeons in operating on gunshot wounds of the pleura and lung, fear infection of the effusion, and complete their operation by what they call 'preventive drainage.' To us it seems beyond argument that, in immediate or early operations for gunshot wounds of the lung, drainage of the pleura is not merely contra-indicated, but positively harmful. The toilet of the pleura, performed as we have described it, allows of the thorax being closed tight. If a septic effusion does supervene, better by far treat it by puncture or incision than by 'preventive drainage' of the pleura.



## TREATMENT OF THE PARIETAL WOUND.

During an operation of urgency for the arrest of pulmonary hæmorrhage, even if thoracotomy has not been performed at the point of entry or exit of the missile, on no account should treatment of the opening in the thorax be neglected. Above all, should there be a fracture of the ribs, the parietal wound must be dealt with thoroughly.

Méline operated upon a case for direct arrest of pulmonary hæmorrhage; the patient's general condition seemed to him so bad that he did not prolong the operation to deal with the parietal wound, which involved a fracture of the ribs. The patient recovered, but the parietal wound at the site of fracture suppurated, and the pleura became secondarily infected.

Either in an early or in an urgent operation, if the site of the thoracotomy does not correspond with the wounds in the thoracic wall, these openings into the thorax must be specially and completely dealt with, no matter if such secondary manipulations seem to unduly prolong the operation. Suppuration of the parietal wounds may, by secondary infection of the pleura, gravely compromise the result of the operation. Excision of the wound and soft parts, and removal of bone splinters from the seat of fracture, must be followed by complete closure of the thorax without any drainage of the pleura.

## SUBSEQUENT COURSE AND POST-OPERATIVE TREATMENT.

Post-operative progress may be uneventful, but this is the exception rather than the rule; more often it is a period of distress for the patient, and of anxiety for the surgeon. The complete pneumothorax which develops at the operation entails impairment of the function of the lung for several days. Congestion of the injured lung, or, worse still, of the opposite one, is so dangerous, that the patient must be kept under the best possible conditions to lessen the gravity of this complication.

After the operation, the patient groans and is restless, and he suffers constant pain from the pneumothorax and from



respiratory movement of the resected thorax. Respiration is short and jerky, the pulse small and quick; hæmoptysis, or at least blood-stained sputum, is the rule, but this rarely persists for longer than twenty-four hours. Morphine, and camphor and oil, must be freely given, the patient placed in a semi-sitting position, and kept in this posture for several days.

On the day after the operation and following days, the high temperature, the rapid pulse, the dyspnœa, the blood-stained mucous expectoration, are signs of pulmonary congestion. It is useless and dangerous to fatigue the patient by auscultation before the third or fourth day. Dyspnœa is relieved by large doses of camphor and oil, and morphine. If the pulse-rate rises and the dyspnœa increases, wet cupping over the sound side may be performed. In most cases the temperature drops and becomes normal about the third or fourth day after operation.

On auscultation, one or more patches of râles are found in the opposite lung, with or without tubular breathing. Breath sounds are often entirely absent on the side of the operation, but occasionally a very faint vesicular murmur can be detected.

As a rule absorption of the pneumothorax is complete by the fifth or sixth day, if it has not been removed by aspiration at the close of the operation.

Sometimes a succession of transient patches of pulmonary congestion may account for a persistent pyrexia lasting ten days or so.

A slight pleural reaction often occurs, accompanied by extensive or limited pleural friction, with small collections of sero-fibrinous or hæmorrhagic fluid which disappear spontaneously. These minor complications are particularly common after immediate operation for severe pulmonary hæmorrhage.

The subsequent course of non-urgent operations is more straightforward. Nursing is of the utmost importance, especially in forward units where all the comforts of a hospital in peace time cannot be expected.

A special ward must be set aside for these patients which can be kept constantly and evenly warmed, and free from

draughts. It ought to be close to the operating theatre, or at any rate connected by covered and heated passages. In our advanced hospitals there is too often a fairly long carry in the open between the theatre and the wards. After the operation the patient must be taken back to his bed swathed, head and all, in hot blankets, so that he cannot directly inhale damp or cold air.

Subcutaneous injections of saline should be given in small quantities (250 c.c.) repeated at intervals. Depage's heater-bed is of great value in the after-treatment of operations of urgency.



## CHAPTER VIII.\*

**LATER RESULTS.**

SINCE this work was first published, I have seen, during two offensives, 161 cases of lung wounds. The new surgical arrangements in our armies have enabled me, as 'Inspecteur,' to observe all the wounded in my sector, from the advanced ambulances to the general hospitals of the interior. The 161 cases include all the lung wounds occurring in this sector. Excluding deaths which occurred at the regimental aid posts, these statistics are complete. They include all deaths which occurred shortly after admission, whether death was due to the lung wound or to associated wounds of other parts.

Of the 161 cases, 13 (8 per cent) died before any treatment could be carried out. Of the remaining 148 cases, 29 had urgent operations performed, either for dangerous hæmorrhage or for open thorax. Of these 29, 13 (44·8 per cent) died. Indications for urgent operation were found, therefore, in 18 per cent of the cases.

Of the remaining 119 cases, 17 were operated upon without indications of urgency, for removal of intrapulmonary missiles and for direct treatment of the lung wound, i.e., prophylactic operation against pleuro-pulmonary infection. All these 17 cases recovered, and, added to those previously quoted, they give a total of 33 cases of early operation, with 33 recoveries.

Our technique has been materially improved. In one case I laid open a through-and-through wound of the lung, excised, and sutured it; the patient recovered. In another case I mopped out the track with gauze; this patient also recovered. In superficial wounds, excision with curved scissors before suture was always carried out. In one case the wound was excised, curetted, and cleaned with ether; recovery was uneventful except for a small sterile pleural effusion. In

---

\* Addendum, January, 1918.



this case the wound contained a missile and splinters of bone, which gave cultures of *B. perfringens* and staphylococcus. In two cases I resected a third of the injured lobe and afterwards sutured the lung; both cases recovered. In one of them the missile was in the pericardium, whence it was removed, the pericardium being incised and sutured.

Thus, in the majority of cases lung wounds can be treated according to the general principles of war surgery: that is to say, removal of all foreign bodies (metal fragments, splinters of bone, pieces of clothing), excision of the wound, and complete suture.

The prophylactic value of such operations is clearly brought out in our statistics. Empyema has occurred several times after operation, but the infections were mild, and due, in the majority of cases, to staphylococcus. Of the 148 cases, 102 were treated medically (early operation not performed), and empyema developed in 11 of these, with 1 death; this was due to a late empyema set up by an undiscovered fracture of the scapula.

*Summary :—*

Total cases	..	..	..	..	..	161
Died on, or shortly after, admission (no operation)	..					13
Immediate operations (death-rate 44·8 per cent)	..					29
Early operations (no deaths)	..	..				17
Treated 'medically' (early or immediate operation not performed) (1 death)	..	..	..	..	..	102

We can regard 119 of these as cases upon which the majority of surgeons would not have operated. We operated upon 17 of them, with 17 recoveries. We treated 102 of them 'medically,' with 1 death, due, it must be admitted, to an error.

The end we had in view when we started this work has in our opinion been absolutely justified by the results. With careful technique there is no special danger in the operations. Apart from urgent cases, the mortality of lung wounds treated 'medically' is about 15 per cent. Our final figures, when we operated on 17 out of 119 such cases, show only 1 death. Lung wounds are analogous in every respect to any other battle wound, and must be treated according to the same surgical principles.



## APPENDIX.

### NOTES OF 17 CASES OF SEVERE HÆMORRHAGE OF THE LUNG TREATED BY THORACOTOMY AND DIRECT ARREST OF THE BLEEDING.

(12 RECOVERIES AND 5 DEATHS.)

CASE 1.—*Wound of lung by shrapnel ball (retained)—Severe hæmorrhage—Immediate operation (Pierre Duval)—Suture of three perforations of lung—Extraction of missile—Recovery.*

E. D. Wounded Oct. 7, 1916. Shrapnel ball, entering on front of left chest at 4th rib, lodged in mediastinum. Condition very grave. Profuse hæmorrhage.

Anterior thoracotomy. Suture of three perforations of the lung, two in the upper lobe, one in the lower. Shrapnel ball extracted from mediastinal surface of the lower lobe.

CASE 2.—*Shell wound of lung (missile retained)—Severe hæmorrhage—Immediate operation (Pierre Duval)—Extraction of missile from region of hilus—Plugging of adherent lung—Recovery.*

S. Wounded on the night of Oct. 20. Penetrating wound of left lung by shell fragment. On the seventh day considerable hæmorrhage both from wound and bronchi.

Thoracotomy. Old adherent lung. A very large fragment extracted from the lung near the hilus. The lung was plugged, as it was impossible to bring it out of the wound. Evacuated on Nov. 14.

CASE 3.—*Shell wound of lung (missile retained)—Severe hæmorrhage—Immediate operation (Pierre Duval)—Plugging of adherent lung—Recovery.*

C. J. Wounded Oct. 11 at 6 p.m. Admitted to Auto-Chirurgicale 21 at 10 p.m. Wound of chest, entering at left acromion. Severe hæmorrhage from the wound.

Anterior thoracotomy (4th rib). Upper lobe torn vertically in two. Outer portion completely adherent to the chest wall up to the apex. Dangerous hæmorrhage. Rapid plugging, as the lung could not be brought out of the wound.

Radioscopic examination on Oct. 22: increased opacity of the



whole left lung; large shell fragment localized in the precordial space, probably removable by secondary operation. The patient was seen again and shown at the Société de Chirurgie in March, 1917, in perfect health. The intrapulmonary fragment is still *in situ*, but it will be removed.

CASE 4.—*Shell wound of lung—Serious hæmorrhage as a result of travelling—Immediate operation (Pierre Duval)—Suture of lung—Recovery.*

F. L. Wounded Nov. 3, and admitted to a divisional ambulance. As the result of a heavy bombardment on Nov. 6, patient was evacuated to H.O.E. Condition good on departure, but very grave on arrival at 7 p.m. Hæmorrhage occurred during the journey; dressings soaked through, patient pulseless. On taking off the dressings blood spurted out of the anterior wound of the chest with each expiration.

Resection of 4th rib (left). Large wound in the upper lobe below the apex, two finger-breadths wide. No fragment felt. A large fragment of rib found in the left pleura. Suture of lung wound. Evacuation of a total hæmothorax. Pleura swabbed dry with ether. Chest completely closed. The wound of the lung must have been caused by the fracture of the rib. Gradual improvement. Patient evacuated at the end of a month in very good condition.

CASE 5.—*Shell wound of lung—Severe hæmorrhage—Immediate operation (Pierre Duval)—Suture of lung—Death.*

G. N. Wounded Oct. 24, 1916. Penetrating wound of chest by shell fragment. Condition grave. Large hæmothorax, extreme anæmia.

Thoracotomy. Suture of perforation in lung. Died immediately after operation.

CASE 6.—*Shell wound of lung (missile retained)—Signs of severe hæmorrhage—Immediate operation (Delmas)—Removal of missile—Suture of lung—Large spontaneous discharge of portions of clothing from the lung—Recovery.*

C. J. Wounded Dec. 23, 1916, at 3 p.m. Evacuated to Auto-Chirurgicale 21 on Dec. 24 at 2 p.m. Shell wound of chest. Signs of severe hæmorrhage. Radioscopic examination: fragment 7.5 cm. deep from anterior wall, not moving with respiration; separated from the mediastinal shadow by a very narrow clear band.

Operation, Dec. 24, 4 p.m.—Resection of 3rd rib (left) close to sternum. Large hæmothorax. Missile size of hazel nut felt in posterior surface of the upper lobe. Apex of lung drawn forward and delivered. Posterior surface of upper lobe incised, and the missile, lying 1 cm. deep, extracted. Suture of both pulmonary



perforations. Pleural cavity swabbed dry with ether. Complete closure of chest.

*Progress.*—Dec. 26: No breath sounds on left side. Signs of localized congestion at right apex. Dec. 27: Same signs. Progressive improvement. Jan. 4: At 1 p.m. temperature fell suddenly. Pus oozing between sutures (temperature  $40.2^{\circ}$ ).\* Wound opened up and large quantity of pus evacuated, with portions of clothing. Above the apex of lung, which had been pulled down, a small localized empyema was found, not communicating with the general cavity. For ten days afterwards bits of clothing were discharged. Temperature fell, and patient was evacuated in good condition on Jan. 18 (25th day). Auscultation: lungs normal, except for left apex.

*CASE 7.—Bomb wound of lung (missile retained)—Asphyxia—Immediate operation (Delmas)—Extraction—Suture of lung—Recovery.*

L. D. Wounded Oct. 11, 1916, by bomb fragment. Penetrating wound of lung. Entry in the vertebral furrow at level of 10th dorsal vertebra. Grave signs of asphyxia.

Resection of 9th rib. Hæmopneumothorax. Extraction of missile embedded in surface of lung. Suture of lung wound. Chest completely closed. Evacuated Nov. 7.

*CASE 8.—Shell wound of lung—External hæmorrhage—Immediate operation (Fiole)—Suture of lung—Recovery after empyema.*

J. S. Wounded Oct. 15 at 5 p.m. by shell fragment posteriorly in the left chest. Operation Oct. 16, 2 p.m. From the time of being wounded there was continuous bleeding from the wound. Traumatopnœa.

Incision parallel to 7th rib, which was comminuted for a distance of 3 cm. After removal of the fragments considerable oozing was immediately seen. A pair of lung forceps was introduced into the wound, and an edge of the lung caught and drawn out. A large laceration was found in the lower lobe of the left lung. The edges, which bled freely, were approximated and sutured by two very deep U sutures of catgut. The bleeding at once stopped. On the following days no signs of effusion could be discovered, neither diminution of vocal vibrations, dullness, nor decreased breath sounds. On the seventh day symptoms of pulmonary congestion round the sutured area appeared—fine râles, pain in the side, temperature  $38^{\circ}$ ; no dullness, no diminished breath sounds. These signs disappeared, and the temperature fell to  $36^{\circ}$ . But on Nov. 9 signs of empyema developed, without any marked pyrexia, and a low pleurotomy with resection of the rib was immediately performed.

---

\* The temperatures in this and other cases in the Appendix are expressed in degrees Centigrade.



CASE 9.—*Shell wounds of lung, with fractured ribs—Pulmonary hæmorrhage—Temporary plugging of the lung (Léo)—Suture of chest wall—Recovery.*

L. G. Wounded Oct. 18 at 7 p.m. by shell fragments. Admitted to Auto-Chirurgicale 21 on Oct. 19 at 1 a.m. Operation at 10.30 a.m., fifteen and a half hours after the wound.

*Condition.*—Punctiform wound of the left arm. Shell wound of left scapula, with fracture of ribs and hæmopneumothorax.

*Operation.*—Thoracotomy at the level of the fractured ribs behind, under the scapula. Site of fracture cleaned up. Lung seized with forceps. Considerable hæmorrhage. Lung found to be adherent to the chest wall. Temporary plugging of the thoracic cavity with large thick abdominal pads. Resection of one rib above and one below the site of the fracture. Total closure of the chest wall, with gradual removal of the intrathoracic pads. The suturing of the parietes completed and maintained the arrest of bleeding from the injured area of the lung. The shell fragments were not looked for. Excision of the wound of the arm, and of a small superficial wound of the thorax.

*Progress.*—Evacuated Nov. 7; temperature  $37.1^{\circ}$ .

CASE 10.—*Shell wound of lung—External hæmorrhage—Immediate operation (Léo)—Suture of lung—Death.*

L. R. Wounded Oct. 7, 1916, at 5 a.m. by shell fragment. Admitted to Auto-Chirurgicale 21 on Oct. 17, 1916. Operation at 8.30 a.m. General condition bad; pulse very rapid and small. Through-and-through wound of chest from front to back, from the left nipple to the 8th rib behind. Smashing of ribs at exit wound. Hæmopneumothorax. External hæmorrhage from posterior wound.

Rapid excision of posterior wound. Removal of fragments of rib adherent to the intercostal muscles. Lung seized with forceps. Lower lobe had been split by the injury almost to the bottom of the interlobar fissure, and was bleeding freely. Small splinters of rib had been driven into the wound of the lung and were embedded there; these were extracted. Pulmonary wound sutured for a length of about 12 cm. by interrupted catgut sutures. Blood swabbed out of pleural cavity. After excising the dirty, crushed edges of the parietal wound, a muscle-skin flap was rapidly made and slid upwards to close the huge hole in the chest wall and to enable it to be brought together by sutures.

There still remained an open pneumothorax in front at the level of the left nipple. This wound was excised, the rib fragments were removed, and the chest wall was hermetically closed with sutures. The whole operation lasted forty-five minutes.

*Progress.*—Temperature  $37.2^{\circ}$  on the evening after operation. It remained between  $37^{\circ}$  and  $37.5^{\circ}$  till death occurred, on Oct. 19, forty-eight hours after operation.



CASE 11.—*Wound of lung—External hæmorrhage—Excision of marginal wound in lung—Suture (Léo)—Death.*

V. Wounded Oct. 17, 1916, by shell fragment and bullet at 5 a.m. Admitted at 2 p.m. Operation at 5 p.m., twelve hours after wounding.

*Condition on Admission.*—Through-and-through wound of chest (antero-posterior). Fracture of two ribs. Pneumothorax. External hæmorrhage.

*Operation.*—Wounds laid open and damaged tissues excised. Fractured ribs trimmed. On examination of the lung, a portion of the lower border of the lower lobe was found torn, but still attached by a pedicle the thickness of a thumb. A small splinter the size of an oat embedded in the wound of the lung. The edges of the lung wound were freshened. The pedunculated fragment was cut off. Interrupted catgut sutures inserted in the wound of the lung. Chest wall closed without drainage.

*Progress.*—Temperature up to 39° and 40° till death, on Oct. 21, five days after operation.

CASE 12.—*Shell wound of lung—Severe hæmorrhage—Immediate operation (Bouvier)—Excision and suture of pulmonary wound—Recovery.*

H. B. Wounded Oct. 24, 7 a.m. A through-and-through wound at the right base of the chest by a large fragment which entered behind. Dyspnœa. Hæmorrhage. Condition serious. X-ray examination negative.

*Operation*, Oct. 25, 3.30 p.m.—Chloroform. Excision of wound in chest wall. Fracture of 9th, 10th and 11th ribs (right) found. Hæmothorax. Laceration of lower border of lung for an extent of 7 cm. Excision of pulmonary wound, and suture by U-shaped sutures. Splinters of rib extracted from lung. Diaphragm uninjured. Pleural toilet. Lavage with ether. Suture of thoracic wound in one layer. Drainage.

*Progress.*—Drain removed on seventh day. By the twelfth day the temperature was normal. Pulse 90. Respirations 24. Serous oozing from the site of drainage.

CASE 13.—*Shell wound of lung (missile retained)—Signs of severe hæmorrhage—Immediate operation (Méline)—Removal of fragment from pleura—Suture of pulmonary wound—Recovery with suppuration.*

T. H. Wounded Dec. 26, 6 p.m. Shell wound of chest. Admitted to Auto-Chirurgicale 21 at 1 a.m. Condition grave. Almost pulseless. Appearances of severe hæmorrhage. External bleeding. Radiography (Béclère): missile, moving with respiration, 12 cm. deep from anterior chest wall; dense thoracic shadow.

*Operation*, Dec. 27, 1 a.m.—Posterior incision. Resection of 7th rib, the interlobar fissure presenting. Below, the lung was adherent



to chest wall. Separation of adhesion of lower lobe. Localized hæmothorax between the base of the lung and the diaphragm, in which the missile was found loose. Wound of posterior surface of lung. Suture. Thorax closed in three layers. Entry wound at level of 9th rib excised, and comminuted fragments of the rib removed. Suture.

*Progress.*—Dec. 28: Absence of breath sounds over the whole of right lung. Patch of bronchopneumonia at left base. Jan. 2: Condition not changed since last note. Jan. 3: Suppuration of entry wound and at site of fractured ribs. Jan. 6: Suppuration of thoracotomy wound. Both wounds widely open into pleural cavity (traumatopneæa). A succession of patches of bronchopneumonia in left lung. The patient's condition gradually improved, and he was evacuated on Jan. 22.

In this case the septic sequelæ were due to insufficient treatment of the fractured ribs.

*CASE 14.—Wound of lung with shell fragment retained—Severe external hæmorrhage—Urgent operation (Méline)—Suture of lung—Missile removed later on account of a patch of relapsing pulmonary congestion—Recovery.*

J. B. Wounded Dec. 2, 1916, at 8 p.m. by shell fragment. Admitted to Auto-Chirurgicale 21 on Dec. 3, at 1 a.m. Penetrating wound of right chest. Considerable dyspnœa; pulse small and rapid. Blood welled with each expiration from the wound, which was situated in the right mid-axillary line. X rays showed a large missile, moving freely, at a depth of 9 cm.

*Operation*, Dec. 3, at 1.30 a.m.—Fracture of rib. Fragments of bone removed. Wound of lung 6 cm. long. Complete suture of the wound. The missile was not felt, and as the patient's condition was very grave it was not searched for. Total hæmothorax evacuated. Chest wall sutured. For 11 days after operation the temperature remained in the neighbourhood of 38°. A series of patches of bronchopneumonia in the right lung.

*Second operation*, Dec. 29 (Pierre Duval).—The missile found, situated 11 cm. from anterior, and 12 cm. from posterior wall, above the diaphragm. This operation was performed because of the persistent pyrexia and the daily appearance of small patches of bronchopneumonia resulting from the retained missile. The 8th rib was resected anteriorly. The lung was adherent to the diaphragm. The slight adhesions were separated. The lung and diaphragm were bound together into a dense mass in the right cul-de-sac as high as the level of the dome of the diaphragm. The missile was demonstrated by the Hirtz compass (Béclère) to be lying in the centre of this mass at a depth of 1 cm. The mass was incised and the fragment removed. Temporary light plugging. Chest wall sutured.



*Progress.*—On Jan. 14 the temperature rose suddenly. A small patch of bronchopneumonic congestion was present, with slight pleural effusion. The patient was evacuated in good condition to the base on Jan. 20, as the hospital was being closed.

CASE 15.—*Abdomino-thoracic injury, with missile retained in the lung—Hæmorrhage—Urgent operation (Tuffier)—Laparotomy—Thoracotomy—Extraction of missile—Suture—Death.*

P. D. Admitted to Auto-Chirurgicale 21 on Nov. 12, at 9 a.m., suffering from a penetrating wound in the lumbar region opposite the posterior aspect of the liver, and involving both the abdomen and thorax.

*Operation.*—Anterior exploratory laparotomy. No abdominal lesion found. Anterior thoracotomy (resection of the 6th rib). Delivery of the lung. Extraction of the missile from mediastinal surface of the lower lobe below the hilus. Suture of the two pulmonary wounds. Suture of the chest wall. Excision of the lumbar wound, and plugging of a superficial wound on the upper aspect of the liver. Death on Nov. 13 at 6 p.m.

CASE 16.—*Wound of lung, with missile retained—Urgent operation (Alexandre)—Extraction of missile—Suture of lung—Death.*

J. F. Admitted Dec. 1, 1916. Chest wound, with dangerous hæmorrhage from thoracic wall.

*Immediate Operation.*—Huge laceration of right lung by fractured rib. The fragments of bone were removed from the lung substance. The missile was lying superficially and was also removed. Suture of the lung. Suture of a small wound of the diaphragm. The patient, who was pulseless, and required no anæsthetic for the operation, died on Dec. 2 at 4.30 p.m.

CASE 17.—*Wound of lung by shell fragment—External hæmorrhage—Urgent operation (Alexandre)—Suture of lung—Second operation for extraction of the missile from the pleural cavity—Recovery.*

J. G. Admitted Dec. 5. Wound of the right lung. The missile had entered the outer surface of the right arm and traversed the apex of the axilla. Active external hæmorrhage.

*Immediate Operation, 11.15 p.m.*—Anterior thoracotomy (4th rib). Suture of an extensive laceration of the upper lobe of the right lung on its antero-external surface. Missile not found. Suture of the chest wall.

*Second Operation, Dec. 20, 3.30 p.m. (Pierre Duval).*—For empyema. Missile extracted from the cul-de-sac of the diaphragm. Drainage. The patient was evacuated in a satisfactory condition.

## NOTES ON THE SURGICAL TREATMENT OF LUNG WOUNDS.

### I.

SIMPLE IMMEDIATE EXTRACTION OF MISSILES IN THE LUNG  
WHERE DIRECT ARREST OF PULMONARY HÆMORRHAGE  
WAS REQUIRED.

*(Cases 1, 2, 6, 7, 13, 15, and 16 above.)*

CASE 1.—Suture of three perforations of the lung. Removal of a shrapnel ball from the mediastinal surface of the lower lobe. Recovery. (Pierre Duval.)

CASE 2.—Old adhesions of the lung. Extraction of a very large shell fragment near the hilum. Plugging. Recovery. (Pierre Duval.)

CASE 6.—Removal of a missile which penetrated the upper lobe from the front and lodged near its posterior surface. Incision of the lung over the fragment. Suture. Discharge of bits of clothing from the lung on the fifteenth day. Recovery. (Delmas.)

CASE 7.—Removal of a missile embedded in the surface of the lung wound. Suture. Recovery. (Delmas.)

CASE 13.—Removal of a missile from a basal hæmothorax. Suture. Recovery after empyema due to incomplete treatment of the fractured rib. (Méline.)

CASE 15.—Removal of a missile from the mediastinal surface of the lower lobe. Death. (Tuffier.)

CASE 16.—Removal of a missile lying superficially in the lung. Death. (Alexandre.)

### II.

EXTRACTION OF MISSILES FROM THE LUNG AS PART OF THE  
DIRECT TREATMENT OF LUNG WOUNDS WITHOUT  
URGENT SYMPTOMS.

CASE 19.—Removal of a missile from the inferior lobe, close to the interlobar fissure, by incision of the lung. Excision of the lung wound. Recovery. (Delmas.)

CASE 21.—Removal of a missile from the lung by the track of its entry. Suture of three wounds. Recovery with encysted empyema. (Léo.)



CASE 23.—Removal of a missile embedded in the surface of the lung. Suture of the lung. Recovery. (Fiole).

CASE 24.—Removal of a missile lodged deep in the lung (10 cm.). Suture of the lung after excision. Recovery after mild empyema originating in the chest wall. (Fiole.)

### III.

#### EXTRACTION OF FRAGMENTS OF BONE FROM THE LUNG WOUND.

(Cases 4, 10, 11, 12, and 16 above.)

### IV.

#### TREATMENT OF SEVERE HÆMORRHAGE FROM THE LUNG WOUND BY DIRECT HÆMOSTASIS.

CASE 11.—Refreshing of the lung wound. Suture. Death on fifth day. (Léo.)

CASE 12.—Laceration of lower margin of lung. Excision of the lung wound and closure by U sutures. Recovery. (Bouvier.)

### V.

#### DIRECT TREATMENT OF THE LUNG WOUND WITHOUT URGENT PULMONARY SYMPTOMS.

CASE 18.—*Abdomino-thoracic wound—Operation (Pierre Duval)—Splenectomy, suture of the duodeno-jejunal angle, and removal of intra-abdominal missile—Suture of a double wound of the lung—Recovery.*

H. B. K. Wounded on Nov. 2, 1916, by shell fragment. Abdomino-thoracic wound, with fracture of the 12th rib (left).

*Operation, 2 p.m.*—Laparotomy by an incision parallel to the cartilages of the false ribs (left), with resection of the costal cartilage. The injuries consisted of a perforation of the pleural cul-de-sac, a through-and-through wound of the lower margin of the lung, a perforation of the spleen wounding the splenic vein, and a single perforation of the duodeno-jejunal angle. Suture of the entry and exit wounds in lung. Suture of the diaphragm and closure of the thorax. Splenectomy. Suture of the duodeno-jejunal angle. Removal of the missile lying in contact with the wound of the intestine. The patient is still under treatment at the ambulance, but is in excellent condition. Recovery.

CASE 19.—*Wound of the lung, with missile retained—Operation (Delmas)—Removal of the missile—Suture of the lung after excision of the wound—Uneventful recovery.*

M. L. Wounded Dec. 24, 1916, at 10 a.m. by a shell fragment.



Admitted to Auto-Chirurgicale 21 on Dec. 24 at 5 p.m., with a penetrating wound of the right chest. General condition good. Moderate-sized effusion (right).

*X-ray examination.*—Large piece of shell (the size of a very large hazel nut) moving freely at a depth of 5.5 cm. from the front at the level of the 7th rib. The missile appeared to be immediately above the dome of the diaphragm.

*Operation, Dec. 24, 6 p.m.*—Resection of the 7th rib external to the spinal muscles. Evacuation of medium-sized hæmothorax. Delivery of the lung. Incision of the lung, and removal of the missile from the lower lobe near the interlobar fissure. Suture of the incision. The wound of entry into the lung was contused and required excision with curved scissors and suture. Toilet of the pleura with a swab wrung out of ether. Complete suture. Excision and suture of the parietal entry wound.

*Progress.*—On Dec. 27 a few crepitations were heard at the right base without bronchial breathing. These cleared up in a few days. Temperature by the twelfth day settled to 37°. The two sides were absolutely normal when the patient was evacuated on the fifteenth day. X-ray examination just before discharge showed the side operated on perfectly clear all over. Excellent reports have been received from him since.

*Bacteriological Report (Vaucher).*—Anaerobic cultures from the missile yielded a large diplococcus, Gram-positive, not identified. Cultures from the lung tissue round the missile were positive at the end of sixty hours, and gave streptococci and pneumococci.

*CASE 20.—Shell wound of lung—Operation (Léo)—Excision and suture of lung wound—Recovery.*

V. Wounded at midnight on Oct. 8, 1916, by a shell fragment. Operation Oct. 9, at 11.30 a.m., 11½ hours after being wounded.

*Condition on Admission.*—Multiple superficial shell wounds in the dorsal region. A wound of the back in the 8th intercostal space, with surgical emphysema round about.

*Operation.*—Trimming of the wound, in which a minute penetration of the pleura was discovered. Resection of the rib at the level of the wound. Delivery of the lung, which was wounded on its lower border. This wound was excised and sutured with catgut. Complete closure of the chest wall. Excision and suture of the multiple wounds of the back.

*Progress.*—Temperature between 38° and 39° for five days; 37.5° to 38.5° for four days. Approximately 39° for four days, rising to 40° for three days. Gradual fall to 38° in the next ten days. Returned to 37° on the thirtieth day.

*Radioscopic Examination* (patient lying down), Oct. 24, 1916.—Apex of left lung opaque, base clear. Outline of diaphragm ill defined, no movement. Abnormal shadow of collapsed lung up to the level of the lower lobe; this shadow showed the cardiac



impulse. Nothing in particular in right lung. Diaphragm rising very high and abnormally mobile. Heart obviously displaced to the right. Small missile in the lower third of the right lung—very probably in the chest wall—showing no movement and no sign of surrounding induration. If there was any fluid at the left base, it was certainly only a small amount.

*CASE 21.—Abdomino-thoracic wound of liver, diaphragm, right lung—Missile retained in the upper lobe—Laparotomy (Léo)—Plugging of liver—Thoracotomy—Suture of three wounds in the lung—Extraction of missile—Suture of the incision in the lung—Recovery, after formation of a small empyema.*

G. R. Shell wound of right side, affecting the lung and penetrating the diaphragm, with superficial wound of the liver. Radioscopy showed a shell fragment in the lung at the level of the 3rd rib.

*Operation, Dec. 22, 1916, 10 a.m.—(a) Excision of the entrance wound and resection of the fractured 10th rib (right). (b) Suture of a tear, about 2 cm. long, in the diaphragm. (c) Anterior thoracotomy, with resection of the 3rd rib 10 cm. outwards from the cartilage. The lung was delivered, and a shell fragment palpated on the mediastinal surface about 1 cm. deep; this was easily removed. The track was examined, and three openings made by the missile in the lung were sutured with catgut. These sutures arrested all hæmorrhage. All blood (about 400 c.c.) was carefully swabbed away, and a gauze swab wrung out of ether passed over the whole surface of the pleura. The thoracotomy wound was then tightly closed. (d) Laparotomy, by a horizontal incision 6 cm. below the original entrance wound. A superficial wound was found on the upper surface of the liver. No intestinal injury. The laparotomy was closed. (e) The entry wound of the missile was also closed, after it had been excised, except for a strip of gauze passing to the liver.*

*Progress.*—At the close of the operation the patient had a good pulse of 100. Temperature rose to 39°, and swung between 38° and 39° for four days. A succession of patches of bronchopneumonia appeared at the apex and base. The gauze drain was removed on the fourth day.

On the fourteenth day, as the temperature remained up, the patient was again radioscopically examined. A shadow was seen about the middle of the right side of the chest, and this exactly corresponded to a spot where auscultation had revealed signs of pleurisy.

*Secondary Operation, Jan. 5, 1916.*—Local cocaine anæsthesia. Resection of 5 cm. of the 5th rib, and evacuation of about 5 c.c. of sero-purulent, foul-smelling fluid. Following this operation, the temperature dropped to 37°, and the patient was evacuated in good condition on Jan. 10.



## CASE 22 (Pierre Duval).—

A. D. Wounded at 6 p.m. on May 21, 1917, admitted to Auto-Chirurgicale 21 at 4 a.m. on May 22, and operated upon twelve hours after the infliction of the wound. Penetrating wound by shell fragment at the level of the 11th rib (left), near vertebral column. Missile lodged in the posterior axillary line (shown by *x* rays to be lying in the latissimus dorsi). Hæmoptysis. Limited surgical emphysema round the wound.

*Operation.*—Left thoracotomy from wound of entry to point of lodgement of the missile. Resection of 11th rib, which was fractured. Opening in pleura enlarged and small hæmothorax found. A superficial wound, 2 cm. long, was found in the lower lobe. Marked hæmorrhagic infiltration of the lower half of the lobe. The wound in the lung was sutured, toilet of the pleura performed, and the thorax tightly closed.

*Progress.*—May 23: Patient suffered from dyspnœa. The pneumothorax, which had not been evacuated after the operation, was aspirated, and this gave the patient immediate relief. May 28: Patch of pulmonary congestion at the left base, which completely cleared. The incision healed by first intention, and on June 18 the patient's condition was perfect.

## CASE 23 (Fiole).—

C. I. Wounded at 4 p.m. on Dec. 13, 1916, and admitted to the Auto-Chirurgicale the same day at 9.30 p.m. The wound was above the right costal arch, in line with the outer border of the right rectus, and had penetrated the thorax. There was also a wound of the right temporal region. Radioscopy showed a large shell fragment, sub-costal, and about 5 cm. above the wound.

*Operation.*, Dec. 14, 1 a.m.—Chloroform. A vertical incision was made, dividing the costal cartilages. The pleura had been opened by the missile, which was stuck in the unretracted lung. It was removed without difficulty. There was no hæmorrhage. The lung was sutured, and the thorax completely closed, after excision of the entrance wound. The wound in the temporal region was cleaned up and dressed.

*Progress.*—Uneventful recovery. Pulse and temperature normal. The patient was evacuated in excellent condition on the 8th day.

## CASE 24 (Fiole).—

B. H. Wounded at 4 p.m. on May 20. Admitted at 10 p.m. the same day. A shell fragment, the size of half a hazel nut, had passed through the left shoulder, and was shown, by radioscopy, to be lying in the lower lobe of the left lung. The patient's general condition was good, and there were no signs of hæmorrhage.

*Operation.*, half an hour after admission.—Ten cm. of the 5th rib were resected in the axillary line. The lung was delivered and the wound located in the lower lobe. The missile was not deeply



embedded, and was easily withdrawn from the lung. The lung wound was cleaned up, its edges were excised, and it was sutured. The pleura was mopped dry by swabs moistened with ether. The thorax was completely closed by suture. The extra-thoracic track of the missile was then dealt with; it had already become infected, and was widely drained.

*Progress.*—The patient's pulse remained good after the operation. Respiration was quick for some days, but dyspnœa was relieved, 48 hours after operation, by aspiration of the air from the pleural cavity. The shoulder wound became gangrenous on the third day, and suppuration spread to the thoracotomy wound. The sutures were removed and the infected superficial wound was laid open. On the tenth day the temperature rose, and a small encysted collection of fluid was evacuated from the pleura; this fluid had accumulated at the point of contact with the superficial wound. The temperature did not drop as the result of draining this small cavity, and an effusion formed in the general pleural cavity. It was immediately aspirated; but, as it became purulent, resection and drainage at the left base were performed. (The general cavity and the earlier encysted collection did not communicate.) The temperature at once began to fall. The patient, in excellent condition, is still in our ambulance.

*CASE 25.—Wound of the lung by shell fragment—Operation two and a half hours after the wound—Extraction of the missile—Suture of the lung—Recovery after suppuration in the parietal wound (Gatellier).*

H. G. Wounded at 2 p.m. on May 2, 1917; was admitted at 4.30 p.m. Penetrating wound at level of 8th intercostal space in front. Acute pain in the side. Respiratory distress. Radioscopy revealed a missile the size of a large marrowfat pea  $4\frac{1}{2}$  cm. deep and moving with respiration. The missile was judged to be within the lung, and operation was at once performed.

*Operation.*—Local cocaine anæsthesia. Incision made in front over the 8th rib, the cartilage of which had been divided by the missile. With two retractors it was possible widely to dilate the intercostal space; the lobe was grasped with forceps and delivered. The missile was felt to be lying 2 cm. deep in the lung; it was removed and the lung sutured. The pleural cavity contained very little blood and was sutured. The opening in the thoracic wall was closed.

*Progress.*—May 10: Condition excellent. Auscultation negative. X rays showed the lung to be normal. The patient made a good recovery.



## OTHER CASES OF INTEREST.

CASE 26.—*Multiple wounds of the lung by retained shell fragments—Severe hæmorrhage—Urgent operation (Lefèvre)—Fragment extracted from upper lobe—Necrotic abscess in lower lobe—Death from very severe hæmorrhage on the 25th day—Healing of the lobe from which the shell fragment had been removed—Abscess caused by retention in the lower lobe of an unsuspected shell fragment.*

B. Wounded 5.45 p.m. on March 11, 1917: (1) Penetrating wound of thorax by shell fragments; one lodged in the apex of the right lung; another, which had traversed the lung, lay under the right clavicle; (2) Wound in the left popliteal space. X-ray examination showed the fragments lying in the apex of the lung and under the clavicle, also a shell fragment against the posterior surface of the lower end of the femur. 9 p.m.; Patient suffering from profound shock. Pulse uncountable. Respirations 40. The wound was punched out and about 3 cm. in diameter at the level of the 6th and 7th ribs. Practically no external hæmorrhage, only a few splashes of blood with air escaping from the pleura. No hæmoptysis. Subcutaneous emphysema round the fragment which had traversed the lung and was lying under the right clavicle. The wounded man was put to bed and thoroughly warmed. Camphor and oil, saline per rectum, and morphine administered. March 12, 9 a.m.: Pulse 140; respirations 36; temperature 38.5°. 10 a.m.: Pulse rate became quicker, and there was considerable external hæmorrhage.

*Operation.*—This was now performed without delay. The thoracic wound was excised, and the fractured ends of the 6th and 7th ribs (right) were resected. There was a wound of the lung in the lower lobe; a missile had passed across the interlobar fissure into the upper lobe, and emerged from the lung on the anterior surface of the apex at the level of the 2nd rib, which was fractured. The upper lobe was partly luxated, so that the interlobar surface was visible. A little blood welled from the track of the missile. Under the radiosopic screen, forceps were passed into the track and a large missile was withdrawn from the upper and outer segment of apex. Some splinters of rib were removed also. As hæmorrhage then ceased, the lung was not sutured. The thoracic wound was partially closed, a drain being kept in the pleural cavity. The fragment lying under the right clavicle was now removed, and a piece of the fractured 2nd rib resected. Finally, the missile was removed from the popliteal space.

*Progress.*—Uneventful till the 6th day, except for slight congestion at the left base. 7th day: Rise of temperature, fætor of breath, and dark-coloured sputum. 8th day: Suppuration round



the thoracic wound. The stitches were removed. Three Carrel's tubes were introduced (two in the pleura, one in the superficial wound), and the wound was irrigated with Dakin's solution every two hours. 13th day: Débris of necrosed lung discharged through the wound. 15th day: Fœtid odour progressively less; less expectoration, which is becoming yellower in colour. Temperature lower and general condition improved. 23rd day: Blackish viscid fluid passed through the wound. The wounds in the clavicular region and popliteal space are firmly cicatrized. 24th day: Rapid rise of temperature. At 11.30 a.m., hæmoptysis and external hæmorrhage, followed by death in five minutes.

*Autopsy (Plate III).*—Antero-lateral and posterior adhesions, except in the vicinity of the wound. Several blood-clots in the pleura. An unsuspected shell fragment found lying in the base of the lung in a necrotic cavity which also contained blood-clot. The apex of the lung was full of air. The left lung showed only slight congestion at the base, and a small quantity of sero-fibrinous fluid in the pleura. What was at first taken to be the cicatrix of the healed wound in the upper lobe was afterwards histologically found to be organised exudate in the interlobar fissure. The lung wound had healed completely without a trace of its position.

CASE 27 (Couvelaire).—

C. Wounded by shell fire at 2 p.m. on April 25, 1917. Admitted to hospital at 5 p.m. the same day. The wound was in front of the right side of the chest at the level of the 3rd rib. The patient had marked dyspnœa on admission, and complained of pain in the region of the liver at each inspiration. Pulse 110, full. Facies pale and anxious. At 8 p.m., temperature 40°, pulse 120; great dyspnœa, not allayed by morphine. April 26, 7 a.m.: Temperature 39.4°. Pulse 120, and rather weaker. Dyspnœa unchanged. 11 a.m.: Pulse weaker. Right hæmopneumothorax. Patch of pulmonary congestion on left side. 8 p.m.; Pulse imperceptible. April 27, 3 a.m.: Death.

*Autopsy (Fig. 25).*—

1. Wound of entry in 3rd right intercostal space, just inside the mammary line; no fracture of rib.

2. Right lung.—Middle lobe: through-and-through track, 3 to 4 cm. long, in postero-inferior edge; no great tissue destruction. Small fragments of clothing in the track. Area of hæmorrhagic infiltration affecting the lower third only of the lobe. Lower lobe: collapsed. Upper lobe: compensatory emphysema.

Left lung.—Lower lobe: massive hepatization. Upper lobe: ordinary pulmonary congestion.

Right hæmothorax, 1500 grammes, with pneumothorax; false membranes.



3. The missile and fragments of clothing had passed through the diaphragm and come to rest on the bruised convex surface of the liver. Some false membranes at this level.

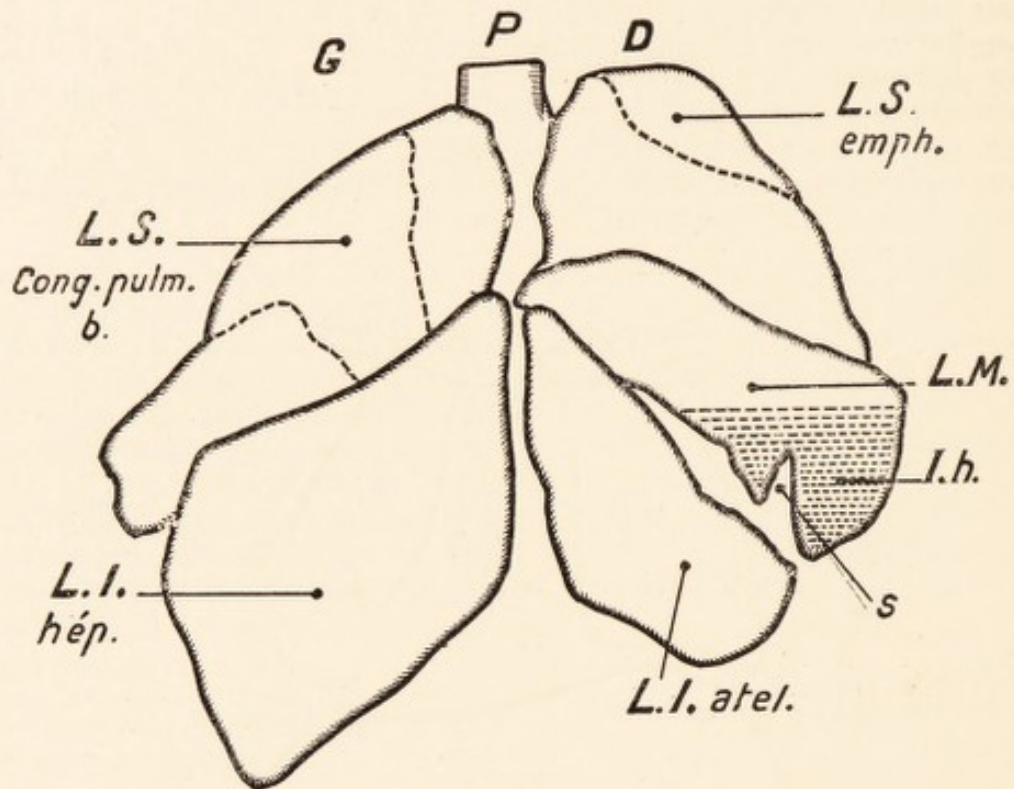


Fig. 25.

4. No intra-peritoneal effusion, and nothing abnormal in the abdomen.

CASE 28.—*Septic pneumonia with empyema on the opposite side* (Vaucher).

L. Penetrating wound of the lung by a shell fragment of moderate size. Admitted on the 3rd day. Large hæmothorax (left). Temperature raised. Hæmothorax, sterile on plating, but yielding *B. perfringens* on culture. Empyema on sixth day. Death on eighth day.

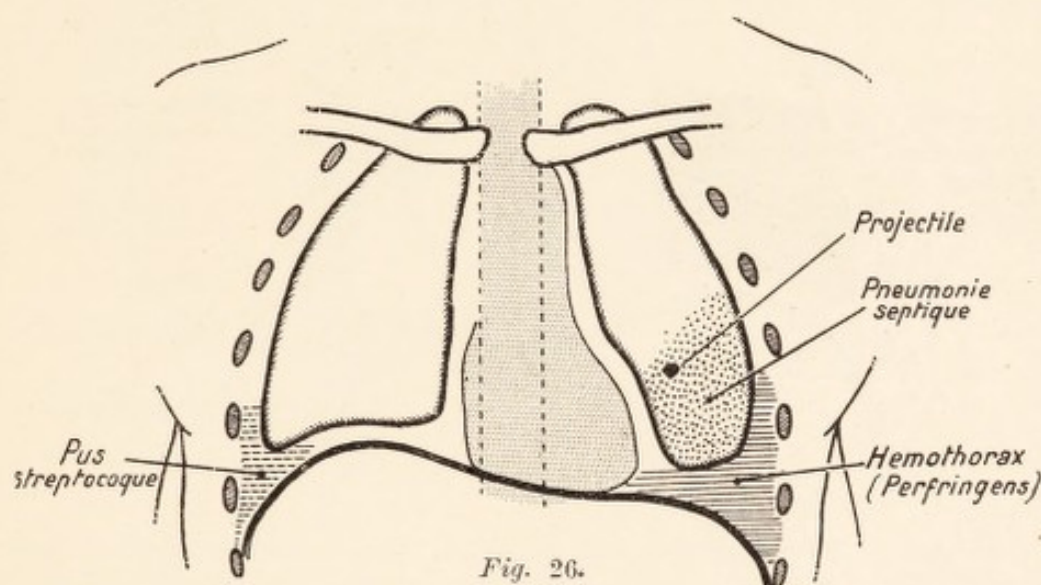
*Autopsy* (Fig. 26).—Septic pneumonia of the entire left lung. A missile lodged in the lower lobe; no fracture of ribs. Empyema (300 c.c.) in the right pleural cavity. Smears and culture demonstrated pure streptococcal infection.

CASE 29.—*Histological examination of the lungs in a case which died on the 13th day of infection following a wound of the lung by a shell fragment* (Captain Bashford, R.A.M.C.).

Pieces of the two lungs were preserved in Zenker's solution and formalin.



The right lung, in which the missile was lodged, was entirely collapsed, and covered with a layer of fibrin 3 mm. thick. This layer was separated from the lung tissue by the elastic fibres of the pleura. Endothelium of the alveoli normal; the alveolar capillaries, empty of blood, were not demonstrable. The larger capillaries were full of red cells, but contained no leucocytes. Small bronchioles only recognizable by their elastic tissue. The bronchi showed intact epithelium, and contained no inflammatory exudate. The complete absence of inflammatory tissue was most striking. The portion of the lung round the missile was



necrosed; the surrounding tissue showed traces of old hæmorrhage into the alveoli and bronchioles. A large vessel was found in the necrotic area, which was surrounded by a well-defined area of reaction.

The left lung, on the contrary, had the alveoli filled with fibrin and endothelial cells. Staining by Gram's method demonstrated no bacilli or cocci within the alveoli, many of which were filled with blood. The bronchi were filled with inflammatory exudate and leucocytes. The epithelium of the bronchi was not altered; the ciliary epithelium remained intact. In the lumen of the large bronchi were found many chains of streptococci. The alveolar capillaries were greatly distended. The vessels all through the left lung contained great numbers of polynuclear leucocytes, in contrast with the absence of these cells in the vessels of the right lung.

CASE 30 (notes from a post-mortem report).—Wound of lung by shell fragment—Splinters of bone in the lung—Massive congestion of opposite lung.

P. Missile entered from behind; fracture of the 3rd rib. The

shell fragment passed into the lower lobe of the left lung, almost completely traversing it. The lobe was reduced to pulp. Several blood-clots in the track, which contained bone splinters, three of these being of considerable size. Pulmonary congestion round the track. No pleural adhesions. Moderately large hæmothorax, with

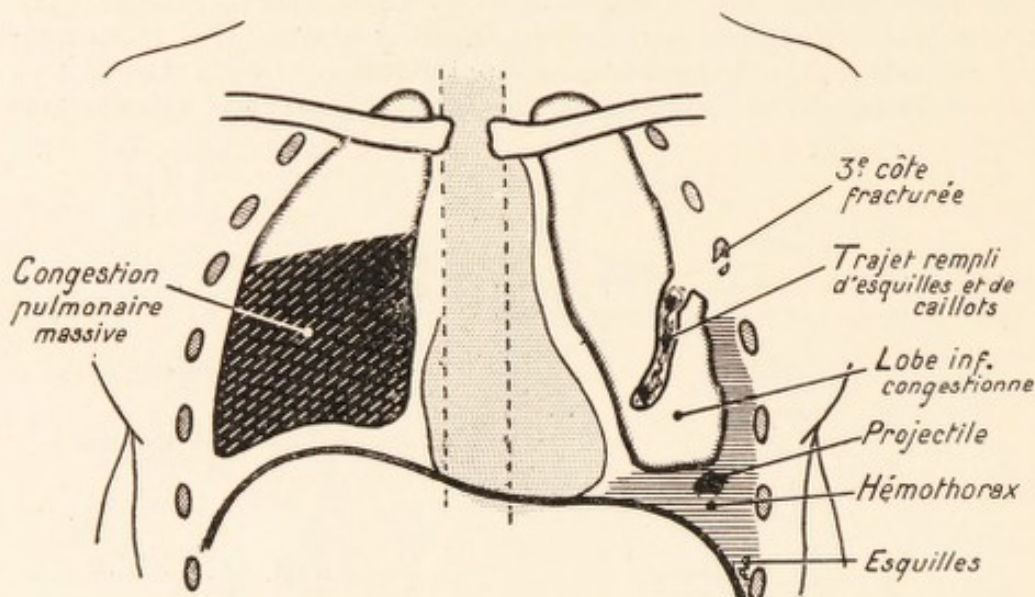


Fig. 27.

foetid odour. The missile lay loose in the hæmothorax on the diaphragm. Several bone splinters in the cul-de-sac of the diaphragm. Massive congestion of the whole lower lobe of the right lung. Radiograph of the wound is shown (Fig. 27).

#### BACTERIOLOGICAL FINDINGS IN 25 CASES OF HÆMOTHORAX INFECTED WITH ANAEROBES. (E. VAUCHER.)

We have made complete bacteriological examinations of 25 cases of hæmothorax infected with anaerobes. In all these cases we found *B. perfringens*, and in 6 cases *B. perfringens* associated with *B. sporogenes*.

The *B. perfringens* isolated from these cases presented no unusual characteristics. Effusions were not putrid in which *B. perfringens* occurred alone. It requires the association of some putrefactive organism, such as *B. sporogenes*, to cause putridity.

**B. Sporogenes.**—The features of this bacillus are as follows :—

A bacillus smaller than *B. perfringens*, very motile, Gram-positive in fresh cultures, but prone to lose its staining affinities very rapidly ; it has a subterminal, more rarely a central, spore.



*Cultures.*—In Veillon's gelose it forms gas; the opaque flocculent colonies sometimes attain considerable dimensions. In glucose broth (2-1000) uniform turbidity appears in 24 hours; the culture then settles and forms an abundant deposit in the bottom of the tube. This bacillus will digest a cube of white of egg, which in a few days is reduced to a blackish clot. It digests meat and coagulates serum; it liquefies gelatine. It turns milk acid more or less rapidly; the casein is precipitated, but coagulation *en masse* does not occur, the casein is progressively digested.

This bacillus is readily agglutinated, in 1-50 dilution, by an agglutinating serum (prepared from rabbits) which was given to us by MM. Weinberg and Seguin.

The smell of the cultures is exceptionally putrid.

The spores resist a temperature of boiling water for 10 or 15 minutes, sometimes longer.

Inoculation into the thigh muscles of animals sets up considerable painful œdema; this is spontaneously absorbed in 3 to 4 days.

THIS book has been written in the field, and the only publications to which we have had access have been: *Bulletins et Mémoires de la Société de Chirurgie de Paris*; *Presse Médicale*, with its reports of the meetings of the Medical Societies of the various armies; *Revue de Chirurgie*; *Lyon Chirurgical*. Our bibliography has been, of course, incomplete, and we apologize to the authors whose works have been unknown to us. Moreover, these notes only describe our own personal experience.



JOHN WRIGHT & SONS LTD., PUBLISHERS, BRISTOL.

---

A QUARTERLY JOURNAL DEVOTED TO SURGERY.

Published in JULY, OCTOBER, JANUARY, and APRIL.

*Subscription 31/6 per annum. Single Numbers 8/6 net, post free.  
Beautifully Illustrated throughout.*

**THE BRITISH JOURNAL OF SURGERY.** Under the Direction of a large and representative Editorial Committee of British Surgeons. *Chairman:* Sir Berkeley G. A. Moynihan. *Ed. Secy.:* E. W. Hey Groves.

Established in 1913, each part contains 160 to 200 pages, and is made up of Original Papers, Critical Reviews, Descriptive Accounts of Contemporary Surgery in other Countries, Short Notes of Rare and Obscure Cases, Reviews of Surgical Books, etc. The general dress and appearance is of the highest character, and the illustrations are a prominent feature.

The Journal is written by Surgeons, and it is the earnest endeavour of the Editorial Committee and the Publishers to present to English readers the world over, all that is best in the Surgery of the Empire in the brightest and most attractive form.

---

*Demy 8vo. With 136 Illustrations. 7/6 net. Postage 5d.*

**ON MODERN METHODS OF TREATING FRACTURES.** By ERNEST W. HEY GROVES, M.S., M.D., B.Sc. (Lond.), F.R.C.S. (Eng.); Surgeon Bristol General Hospital; Consulting Surgeon to Cossham Hospital; Lecturer on Surgery, Bristol University.

This book embodies the experimental and clinical work of the author, including that which formed the subject of his Hunterian Lecture in 1914. An endeavour is made to examine critically the various methods of Fracture Treatment which have arisen since the discovery of the X Rays. These are—the Methods of Massage and Mobilization; Treatment by Extension, both by adhesive plaster and by transfixion; Operative Fixation; and Bone Grafting.

---

*In Two Volumes. Third English Impression. With more than 1000 Illustrations and Plates. Super royal 8vo. Cloth Gilt, bevelled boards.  
50/- net; or 25/- net each Volume. Postage 10d.*

**LEJARS' URGENT SURGERY.** Translated by W. S. DICKIE, F.R.C.S. (Eng.), Surgeon North Riding Infirmary, Middlesbrough; Consulting Surgeon Eston Hospital; and ERNEST WARD, M.A., M.D., F.R.C.S.

VOL. I.—SECTION I.—Introductory. II.—The Head. III.—The Neck. IV.—The Chest. V.—The Spine. VI.—The Abdomen. Index.

VOL. II.—SECTION VII.—The Genito-Urinary Organs. VIII.—The Rectum and Anus. IX.—Strangulated Herniæ. X.—The Extremities. Index.

This unique work is not intended solely or even perhaps chiefly for the Surgeon; but will be found invaluable to the conscientious General Practitioner, who is at any time liable to be confronted by emergencies demanding surgical interference. It also enables Operating Surgeons who are unacquainted with the details of Continental practice to compare those methods with their own.



JOHN WRIGHT & SONS LTD., PUBLISHERS, BRISTOL.

*Fourth Edition. Revised and Enlarged. Illustrated. 9/6 net.  
Postage 5d.*

**SYNOPSIS OF SURGERY.** For Students and Practitioners. By ERNEST W. HEY GROVES, M.S., M.D.

"Gaining knowledge is one thing: retaining it for ready use is another, and equally important." This book has proved a wonderful help in both.

*Seventh Edition. Fully Revised. 15/- net. With over 300 Illustrations and Plates. Postage 6d.*

**PYE'S SURGICAL HANDICRAFT.** A MANUAL OF SURGICAL MANIPULATIONS, MINOR SURGERY, AND OTHER MATTERS CONNECTED WITH THE WORK OF HOUSE SURGEONS, SURGICAL DRESSERS, ETC. Edited and largely re-written by W. H. CLAYTON-GREENE, B.A., M.B., C.M. Camb., F.R.C.S.; Surg. St. Mary's Hosp.; Lecturer on Surgery in the Medical School, etc.

*Demy 8vo. Profusely illustrated with striking diagrammatic Drawings. 8/6 net. Postage 5d.*

**BROCA'S LIGATIONS AND AMPUTATIONS.** For Students and Practitioners. By A. BROCA, Professor of Operative Surgery, Faculty of Medicine, Paris. Authorized Translation by ERNEST WARD, M.A. (Camb.), M.D., F.R.C.S. With 510 Illustrations in the Text.

*Crown 8vo. 3/6 net. Postage 4d.*

**APPENDICITIS: A PLEA FOR IMMEDIATE OPERATION.** By EDMUND OWEN, F.R.C.S., D.Sc. (Hon.), Late Consulting Surgeon to St. Mary's Hospital.

The object of this volume is to help in making early operation the routine treatment of Appendicitis. The author insists that safety in the treatment of Appendicitis can be obtained only by early recognition of the disease and by prompt operation.

*Demy 8vo, Cloth. Fully Illustrated with Working Diagrams 4/- net.  
Postage 4d.*

**SHIP'S HYGIENE: SOME NEW AND INTERESTING POINTS IN.** By W. MELVILLE-DAVIDSON, M.B., B.S., late Medical Superintendent of the Booth Steamship Company, Limited.

*Demy 8vo. Paper Covers. 1/- net. Postage 2d.*

**THE IMPORTANCE OF MARITIME HOSPITALS IN THE TREATMENT OF SURGICAL TUBERCULOSIS.** By Doctor JACQUES CALVÉ, Assistant Surgeon at the Maritime Hospital, Berck-sur-Mer; Ex-interne of the Hospitals of Paris. Authorized Translation by CHARLOTTE E. RYAN.

The necessity for the seaside treatment of surgical tuberculosis has been largely accepted by the Medical Profession on the Continent, and especially in France. This pamphlet gives a survey of the French institutions, with the results attained, which will be of interest to English readers.



JOHN WRIGHT & SONS LTD., PUBLISHERS, BRISTOL.

*Crown 8vo. 5/- net.*

**WHEN TO ADVISE OPERATION IN GENERAL PRACTICE.** By A. RENDLE SHORT, M.D., B.S., B.Sc. (Lond.), F.R.C.S. (Eng.), ex-Hunterian Professor; Examiner for First F.R.C.S.; Senior Asst. Surgeon Bristol Royal Infirmary; Lecturer on Surgery, University of Bristol; Surgeon to Clifton College; Captain R.A.M.C.(T.).

The principal difference between a safe and a dangerous doctor is that the first knows when to advise an operation, and the second does not.

In purely medical cases it is seldom that life and death hang on the prescribing of a particular remedy. But it is too common for lives to be sacrificed because a case of appendicitis, cancer, intestinal obstruction, or empyema is temporized with until too late. On the other hand, to operate needlessly is highly immoral and dangerous.

An attempt is made in this book to give the best guidance available at the present time towards the formation of a sound judgement in difficult cases.

*Large 8vo. Profusely Illustrated and with 5 Coloured Plates.  
8/6 net; or Interleaved for Notes, 9/6 net.*

**AN INTRODUCTION TO SURGERY.** By RUTHERFORD MORISON, M.A., M.B., F.R.C.S. (Edin. and Eng.); Consulting Surgeon Royal Victoria Infirmary, Newcastle-on-Tyne; Prof. of Surgery, University of Durham; Examiner in Surgery in the University of Liverpool.

The object of this volume is to elucidate those fundamental general principles of Diagnosis and Treatment upon which all true Surgery must be based. When these are clearly grasped—for they hold the key to many a difficult problem—the student and practitioner cease to be overwhelmed by the otherwise seemingly endless complications which are often met with in the wards, and in daily practice.

*Crown 8vo. 5/- net.*

**SYNOPSIS OF MIDWIFERY.** By ALECK W. BOURNE, B.A., M.B., B.C. (Camb.), F.R.C.S. (Eng.), late Obstet. Surg. to Out-patients, Brit. Lying-in Hosp.; Obstet. Registrar and Tutor, St. Mary's Hosp., London; Registrar, Samaritan Hosp. for Women, London; former Res. Obstet. Officer St. Mary's Hosp.; and Out-patient Res. Med. Officer Queen Charlotte's Hosp.

*In Two Volumes, with many Illustrations and Plates. Large 8vo.  
Cloth Gilt, Bevelled Boards. 42/- net.*

**SURGICAL CONTRIBUTIONS. FROM 1881—1916.** By RUTHERFORD MORISON, M.B., F.R.C.S. (Edin. & Eng.) Consulting Surgeon, Royal Victoria Infirmary, Newcastle-on-Tyne; Professor of Surgery, Durham University; Examiner in Surgery, Liverpool University. With a Preface and Full Subject-Index contributed by W. D'OYLY GRANGE, M.D., C.M.

*Vol. I.—GENERAL SURGERY. 15/- net.  
Vol. II.—ABDOMINAL SURGERY. 30/- net.*



JOHN WRIGHT & SONS LTD., PUBLISHERS, BRISTOL.

THREE COMPANION VOLUMES.

*Third Edition, fully revised, with many New and Original Coloured Plates, and other Illustrations. 42/- net.*

*The First Edition was exhausted in six months, and has been Twice Reprinted.*

**A**N INDEX OF DIFFERENTIAL DIAGNOSIS OF MAIN SYMPTOMS. By HERBERT FRENCH, M.A., M.D. (Oxon.), F.R.C.P. (Lond.), Physician, Pathologist, and Lecturer, Guy's Hospital, Together with 22 SPECIAL CONTRIBUTORS.

This work aims at being of practical utility whenever difficulty arises in deciding the precise cause of any particular symptom. It covers the whole ground of Medicine and Surgery. The volume deals with Diagnosis from a standpoint which is unique. It is an Index in that its articles are arranged in alphabetical order; it is a work upon Differential Diagnosis in that it discusses the methods of distinguishing between the various diseases in which each individual symptom may be observed. Whilst the body of the book thus deals with *Symptoms*, the General Index, containing some 50,000 references, gathers these together under the various *Diseases* in which they occur.

*7th Edition, 22nd Thousand, over 1,100 pp. Fully revised, and with additional Articles and Illustrations. 30/- net.*

**A**N INDEX OF TREATMENT. Edited by ROBERT HUTCHISON, M.D., F.R.C.P., Physician to the London Hospital; and JAMES SHERREN, F.R.C.S., Surgeon to the London Hospital. Together with 87 SPECIAL CONTRIBUTORS.

A complete Guide to Treatment in a form convenient for reference.

*Demy 8vo. Cloth. 30/- net.*

**A**N INDEX OF PROGNOSIS AND END-RESULTS OF TREATMENT. Edited by A. RENDLE SHORT, M.D., B.S., B.Sc. (Lond.), F.R.C.S. (Eng.), Senior Assist. Surgeon Bristol Royal Infirm.; Lecturer on Surgery, University of Bristol. In conjunction with 23 SPECIAL CONTRIBUTORS.

*Crown 8vo. Illustrated. 2 Coloured Plates. 3/6 net.*

**C**LINICAL EXAMINATION OF THE BLOOD AND ITS TECHNIQUE. A Manual for Students and Practitioners. By Professor A. PAPPENHEIM, Berlin. Translated and adapted from the German by R. DONALDSON, M.A., M.B., Ch.B., F.R.C.S. Ed., D.P.H., Pathologist Royal Berks Hosp., Reading, Etc.; late Assist. Pathologist Royal Infirmary, Bristol, and Demonstrator of Pathology, Universities of Bristol and Sheffield.

*Large 8vo, Fully Illustrated in Black and White, and Colours. 21/- net.*

**T**HE BIOLOGY OF THE BLOOD-CELLS, WITH A GLOSSARY OF HÆMATOLOGICAL TERMS. For the use of Practitioners of Medicine. By O. C. GRUNER, M.D. (Lond.), author of "Studies in Puncture-fluids"; "A Code-system for the Hospital Pathologist." Late Pathologist to the Roy. Vict. Hosp. and to the Maternity Hosp., Montreal; Assist. Prof. of Pathology, McGill Univ., Montreal, etc.; late Clinical Pathologist, Gen. Infirmary, Leeds.



617-99

