

FURTHER STUDIES IN POSTOPERATIVE PNEUMONITIS¹

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DURING the years 1915 and 1916, the subject of postoperative pneumonitis at the Presbyterian Hospital was carefully studied by Whipple (1) and reported by him in SURGERY, GYNECOLOGY and OBSTETRICS, January, 1918. The work has been continued for another year for comparison with the statistics of the preceding two years and also to observe the effect of certain prophylactic measures which had been instituted. A special analysis sheet has been used in each case of postoperative pneumonitis to insure a uniformity in ascertaining data. A copy of this sheet is again published with this paper since it shows the line along which our investigations have run and it may be of interest in the development of comparative work by others (Fig. 1).

There has recently appeared in SURGERY, GYNECOLOGY and OBSTETRICS, a very comprehensive study of postoperative pulmonary complications by Cutler and Morton (2). A considerable part of this work deals with pneumothorax, mediastinitis, and pulmonary embolism of mechanical origin, and which of necessity does not come within the scope of this present article, dealing only with inflammatory conditions of the lungs following surgical operations. It will be in-

teresting to contrast certain of the statistics of Cutler and Morton relating to postoperative pneumonia with those of the 1915-1916, and 1917 series of the Presbyterian Hospital.

Previous to Whipple's work there had been reported no series of postoperative pulmonary inflammations in which the bacteriology had been carefully studied. Roentgenography as a routine procedure in all cases had likewise been neglected and the bedside history analysis of the complication had been very meager. With these facts lacking, any work on postoperative pneumonitis must be very incomplete.

It seems advisable to divide quite arbitrarily, postoperative pneumonitis into at least three types.

1. The true postoperative pneumonia, often called ether pneumonia: a disease coming on within the first few days after operation, accompanied by cough, rise in temperature, usually due to some exposure.

2. Embolic pneumonia, occurring at any time after operation and as far as is known, one of the accidents of the postoperative course.

3. Terminal pneumonia, occurring usually as an incident in patients *in extremis* after a short or protracted postoperative course.

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The Presbyterian Hospital
IN THE CITY OF NEW YORK

Ward..... History No.....

Name..... Age..... Division.....

Operation..... Anesthetist..... Time of Anesthesia.....

Operator, Dr.....

Untoward Symptoms Occurring During Anesthesia:
Cyanosis (1), Vomiting (2), Excessive mucus (3), Aspiration of vomitus (4).

History of Recent Concurrent Respiratory Trouble Before Entering Hospital:
Recent cold (1), Cough (2), Bronchitis (3), Tonsillitis (4).
Exposure during examination (1), following admission bath (2), from operating room to ward with length of time (3), after operation till patient is in bed (4), in ward after operation (5).

Mode of Life and Habits of Patient:
Works in-doors (1), out-doors (2), wears cotton underwear (3), woolen underwear, one suit (4), more than one suit (5), takes cold baths (6), hot baths (7).
Number of blankets patient sleeps under, 1, 2, 3, 4, etc.

Patient Has on Admission, Physical Signs of Inflamed Condition of Respiratory Tract:
Rhinitis (1), Tonsillitis (2), Pharyngitis (3), Laryngitis (4), Bronchitis (5), Pulmonary Tuberculosis (6).

Cardio Vascular and Renal Systems on Admission:
Normal (1), Valvular Disease (2), Arrhythmia (3), Tachycardia (4), Insufficiency (5), Thickened Peripheral Arteries (6), Hypertension with Blood Pressure (7), Nephritis (8).

Disease:
Symptoms of Onset in Order of Appearance, With Date (underline important one):
Cough (1), Pain in chest (2), Dyspnoea (3), Chill (4), Rapid respiration (5), Cyanosis (6), Temperature (7), Rusty sputum (8).

Marked Symptoms during Attack (underline important one):
Cough (1), Pain in chest (2), Rapid respiration (3), Cyanosis (4), Rusty sputum (5), Herpes (6).

Temperature Remained Over 102° F. (note number of days, 1, 2, 3, 4, 5, etc.):

Blood Count, Date..... W. B. C..... Differential.....

Signs of Congestion or Consolidation Made Out in:
R. U. L. (1), R. M. L. (2), R. L. L. (3), L. U. L. (4), L. L. L. (5), Entire Right (6), Entire Left (7).

Congestion.	Date
Consolidation, lobular, (1).	Date
Consolidation, lobar, (2).	Date
X-ray shadow with no signs of consolidation.	Date
Signs of consolidation with no X-ray shadow.	Date
X-ray shadow and signs of consolidation agree.	Date
X-ray showed shadow before signs of consolidation appeared.	Date
X-ray showed wedge shaped shadow.	Date
No X-ray taken.	

Cardio Vascular and Renal Systems During the Disease.

Blood Pressure:
Pulse: Strong (1), Weak (2), Regular (3), Irregular (4), Rate.....

Heart: Arrhythmia (1), Fibrillation, etc. (2), Tachycardia (3), Insufficiency (4)

Kidneys:
Albuminuria (1), Nephritis (2).

Complications:
Empyema (1), Lung abscess (2), Sero-fibrinous pleurisy (3), Otitis (4), Peritoneal abscess (5), Pneumococcus peritonitis, local (6), Diffuse (7).

Postoperative Respiratory Disease Other Than Pneumonia:
Bronchitis (1), Pleurisy (2), Embolus (3).

Bacteriology:
Pneumococcus I (1), II (2), III (3), IV (4), Non-haemolytic Streptococcus (5), Haemolytic Streptococcus (6), Bacillus Influenza (7), Friedlander Bacillus (8), No organism recovered (9).

Ante-operative sputum.	Date
Postoperative sputum.	Date
Blood culture.	Date

Agglutinations:
Blood with sputum Ante-operative (1), Postoperative (2).

Prophylactic Measures:
Pneumonia bed jacket (1), Digitals M XV 4 i. d. (2), Bath Rules (3), Counter irritation with liniments (4)

Treatment:
Open air (1), Serum (2), Croup tent (3), Digitals (4), Other stimulation.

Final Result:..... Autopsy:.....

Fig. 1.

This is more often discovered by the pathologist than by the clinician. There are often no physical signs, usually no abrupt rise in temperature and no cough. This type of pneumonia is merely mentioned in this article as a matter of interest and will be

summarily dismissed. It is outside the scope of any work attempting to consider the prevention of postoperative pneumonitis. During the year, five of these terminal pneumonias, usually bronchopneumonia, were found by the pathologist in autopsies on

surgical patients. None of them presented clinical signs.

There were noted several cases of postoperative bronchitis during the year. These were uniformly mild, clearing up within two or three days.

Postoperative pleurisy with effusion occurred once. The patient had severe pain in the chest with a temperature of 103°. Signs of fluid appeared at the right base and 200 cubic centimeters were aspirated.

In this present work only pneumonitis *per se*, exclusive of those terminal pneumonias not recognized clinically, will be dealt with, in order to compare results with those obtained by Whipple. The embolic pneumonias will be considered separately, frequently contrasting them with the postoperative pneumonias:

INCIDENCE

The postoperative pneumonitis encountered at the Presbyterian Hospital during 1917 is divided as follows:

Postoperative pneumonia	58
Postoperative embolic pneumonia	7
Total cases	65

Out of 1940 operations during the year, this gives a morbidity percentage of 3.3, which is high, but at the same time there has been a disappearance of the unexplained so-called "postoperative reaction." Every case with a temperature of 101° or over after operation, without the presence of known infection, has been carefully examined for signs of pulmonary involvement and has been radiographed. The latter procedure not infrequently gives the clue to the rise in temperature some time before physical signs appear. In a number of cases these signs never do appear. The increasing morbidity percentage of postoperative pneumonia in our series is, we are convinced, a tribute to greater diagnostic accuracy and keener observation rather than any actual increase. The physical signs in this series have in no instance been discovered without turning the patient and listening at the base of the lungs.

Referring to Table I, the relation of ap-

TABLE I

	Postoperative Pneumonias Number of Cases	Embolic Pneumonias Number of Cases
Sex		
Males.....	45	4
Females.....	13	3
	58	7
Months of the year		
January.....	5	1
February.....	7	
March.....	7	1
April.....	7	
May.....	6	1
June.....	2	
July.....	2	1
August.....	6	1
September.....	4	1
October.....	1	
November.....	5	1
December.....	6	
	58	7
In decades		
1-9.....		
10-19.....	8	
20-29.....	17	
30-39.....	13	5
40-49.....	8	
50-59.....	8	2
60-69.....	4	
70-79.....		
	58	7

pearance to (1) sex, (2) season and (3) age, may be appreciated.

1. *Sex.* While the embolic pneumonias were nearly evenly divided between men and women, the postoperative pneumonias were present in men four times as frequently as in the women. It may possibly be due to the fact that the women are less exposed to coughs and colds than men and that the oropharynx is not so chronically inflamed in women.

2. *Season.* The influence of the season on the occurrence of the postoperative pneumonias is seen when 65 per cent, practically two-thirds of the cases, occurred during the six winter and spring months. No explanation for the relatively large number of postoperative pneumonias in August can be advanced unless it was due to a general relaxation of prophylactic vigilance toward the end of the summer. The embolic pneumonias were widely distributed, no two within the same month. This is what might be expected.

3. *Age.* Fifty-two per cent of the cases of postoperative and embolic pneumonia occurred in the third and fourth decades, agreeing almost exactly with Whipple's findings. Only four of the patients were over 60 years of age. These figures differ quite materially from those of Cutler and Morton. In their series of 40 postoperative pneumonias, 67 per cent were over 40 years of age.

PREDISPOSING FACTORS

Among the predisposing factors of postoperative pneumonia are the following: (A) coughs, colds, etc., previous to or on admission to the hospital; exposure to cold while in the hospital; (B) condition of the patient; (C) type of operation; (D) anaesthesia.

A. *Coughs, colds and exposure.* The great importance of this subject warrants a detailed discussion (see Table II). Of the six-

TABLE II

Patients giving history of recent cold or cough, 2 days to a month before admission.....	16
Patients giving history of exposure following admission bath or change from heavy underwear to their ward clothing.....	4
Patients giving a history of exposure from open windows, insufficient covers, etc., after operation.	11
Patients having on admission physical signs of an acute inflammation of the respiratory tract, acute bronchitis, acute tonsillitis, acute rhinitis, etc....	5
Patients having on admission physical signs of low grade or chronic inflammation of the respiratory tract, such as hypertrophied tonsils, chronic bronchitis, red throat, etc.....	18
Total cases.....	54

teen patients who gave a history of having had a cold before admission, three had previously been sent home to recover and returned apparently cured. None of these patients showed any physical signs of inflammation of the respiratory tract. The risk of catching cold from exposure, following the admission bath, has been largely eliminated during the year. Two women patients caught cold from failure of their hair to dry properly after their bath. The electric dryer was installed directly after this. Exposure after operation from insufficient covering, draughts from windows, etc., claims its fair share of victims. Some patients, owing to restlessness when coming out of anaesthesia, are of

course very difficult to keep properly protected against exposure. The five patients entering the hospital with acute inflammation of the respiratory tract were exceedingly poor risks from the standpoint of pneumonia, but they were all emergency operations and the surgeon was left no choice in the matter. The low grade inflammations of the respiratory tract noted, range from hypertrophied tonsils to chronic bronchitis and are doubtless important predisposing factors. These chronic respiratory ailments are extremely prevalent and the only way to be sure of their importance would be to note them carefully in the physical examinations of all patients about to undergo operation and see what percentage developed postoperative respiratory disease.

B. *Condition of patient.* This series offers a relatively small number of cases of the aged and infirm, but there are several instances of those worn down by the cachexia of malignancy or constitutional disease, falling an easy prey to postoperative pneumonia. Under the heading of condition of the patient, it will be well to consider the average type which comes to operation at the Presbyterian Hospital. Of the 65 cases in this series, the occupation of 62 was ascertained. Of these, 53 worked indoors while only 9 worked in the open air. The great majority stated that they changed from heavy to light underwear according to the season and took hot or cold baths by the same token. In regard to general physical condition, 59 of the patients were examined and 78 per cent of these were recorded as having normal cardiovascular and renal functions in so far as routine physical examinations and urinalysis showed. Six patients had albuminuria, three with casts; one patient had slight cardiac insufficiency and another hypertension of 195-105. It will thus be seen that roughly speaking, these patients were in good physical condition, though as a class they are quite susceptible to changes in temperature.

C. *Type of operation* (Table III). Eighty-six per cent of the operations performed in this series were coeliotomies and a majority of these were of a relatively simple nature,

TABLE III.—SUMMARY OF OPERATIONS

	Cases
Hernia, inguinal and ventral.....	19
Appendectomy.....	16
Pelvic-gynecological.....	10
Gall-bladder.....	7
Exploratory cœliotomy.....	3
Gastrostomy.....	1
Enterocolostomy.....	1
Incision and drainage of abscesses (extraperitoneal)	3
Mastectomy for carcinoma.....	1
Sk ingraft following mastectomy.....	1
Thyroid, excision of cyst.....	1
Decompression, fracture of skull.....	1
Phlebectomy.....	1
Laminectomy.....	1
Total cases.....	65
Total cœliotomies.....	56

such as hernia repair and removal of simple appendix. These findings lend added weight to the argument that those operations which tend to limit respirations by splinting the abdominal or thoracic muscles, predispose to postoperative pneumonia. In Whipple's series 90 per cent of the operations were cœliotomies. Cutler and Morton likewise ascribe to restricted respiration the high percentage of postoperative pneumonia following cœliotomy, particularly after epigastric incisions. In this series there were eight epigastric incisions, which is certainly a relatively high percentage of the total of such incisions.

D. *Anæsthesia.* Time was when the entire blame for postoperative pneumonia was laid at the door of anæsthesia. "Ether pneumonia" was a term well known and widely circulated. The surgeon was only too willing to shift the blame to the anæsthetist or consider the pneumonia as one of those unavoidable accidents of the postoperative course. That the anæsthetic *per se* does not cause the pneumonia is no longer doubted. The irritation of the anæsthetic does, however, prepare the way for organisms already present in the upper respiratory tract by lowering the resistance of the lung tissue. The commonest organism present in the mouth is the pneumococcus group IV, which is, indeed, the one most commonly responsible for postoperative pneumonia. Patients markedly obstructed with mucus during the anæsthetic may very easily aspirate a considerable quantity loaded with organisms

from the mouth. In six cases it was noted that there was considerable mucus, causing obstruction to breathing. Cyanosis due to obstructed respirations was present in 14 cases. This condition is simply an indication of insufficient aeration or oxygenation of the blood and a congestion of the pulmonary vessels and favors a descending infection according to Whipple. The anæsthetic of choice has been gas and ether, by the closed method with the Bennett apparatus, though recently there has been a trend toward ether by the drop method. This latter certainly tends less toward cyanosis. Ether has rarely been used during the year where there was any inflammatory condition of the respiratory tract that was considered a risk from the standpoint of postoperative pneumonia. Gas and oxygen, local anæsthesia and chloroform are used in such cases. Table IV, shows the number of cases developing pneumonia after the various anæsthetics. The number following chloroform is large in proportion to the total number of chloroform anæsthesias, but these cases were almost invariably bad risks.

TABLE IV

	Cases
Gas-ether sequence, closed method.....	44
Gas-oxygen-ether.....	7
Ether, drop method.....	7
Ether-intrapharyngeal.....	3
Gas-oxygen.....	2
Chloroform.....	2
Total cases.....	65

The cases were divided among the various anæsthetists, professional and members of the house staff about in proportion to the number of anæsthetics given by each. The length of anæsthesia had very little, if any, influence. The shortest in the series was three minutes and the longest two hours and twenty minutes, with an average of sixty-two minutes.

Before further detailed consideration of the postoperative pneumonias encountered in this series, the routine followed in their study should be understood. A pre-operative sputum examination was made on all patients. As soon as a patient came under suspicion of postoperative pneumonia, whether for a sudden rise in temperature, cough or

pain in the chest, with or without the presence of physical signs, the following measures were taken: (1) postoperative sputum examination; (2) blood count, leucocytes and differential; (3) blood culture; (4) urine for pneumococcus precipitation test (this latter has been in use only since September 1917); (5) roentgenograph of lungs.

The type of postoperative pneumonia which it is our object to emphasize, has most frequently occurred in otherwise healthy young adults. In our 58 cases an attempt was made to subdivide them into lobar and lobular with the aid of the roentgenograph to check up physical findings. This is a rather crude method of stating the extent of the consolidation. Twenty-six of the cases were lobular and twenty-eight lobar; four were undetermined.

SYMPTOMATOLOGY

(SEE TABLE V)

A typical case of postoperative pneumonia has very definite characteristics of its own. The average time of onset is 48 hours after operation, though that of 55 per cent of the cases occurred within 24 hours after operation. A sudden rise in temperature to about 103° or cough, or less frequently pain in the chest, may mark the onset. There is rarely an initial chill. During the course of the disease the temperature falls by lysis within a day or two. In this series it remained over 102° for an average of only 2.5 days. The most important symptom during this period is cough, as shown in 66 per cent of the cases, followed by rapid respiration and pain in the chest, respectively. In the meantime signs of consolidation usually appear at either base and the roentgenogram shows the shadow. This disease *per se*, unaccompanied by cachexia, debility, or by any other constitutional disturbance, has not proven itself a dangerous complication in this present series.

In strong contrast to the foregoing, embolic pneumonia has likewise very definite earmarks. The average day of onset was the twelfth day after operation. The most important symptom of onset was pain in the chest in six out of the seven cases. The temperature falls by lysis after persisting for seven

TABLE V.—SYMPTOMS

Symptoms of Onset	Postoperative Pneumonias 58 Cases	Embolic 7 Cases
Cough.....	41	1
Temperature.....	39	6
Pain in chest.....	19	7
Rapid respiration.....	32	1
Cyanosis.....	10	1
Dyspnoea.....	9	1
Chill.....	3	1
Rusty sputum.....		1
Average day of onset after operation.....	2.4	7
<i>Symptoms during attack</i>		
Cough.....	44	5
Pain in chest.....	16	5
Rapid respiration.....	40	5
Cyanosis.....	6	2
Dyspnoea.....		
Rusty sputum.....		2
Herpes.....	1	1
<i>Temperature remained over 102°</i>		
Never reached 102°.....	11	
1 day.....	11	2
2 days.....	17	0
3 days.....	4	1
4 days.....	7	
5 days.....	3	1
6 days.....	2	1
8 days.....	1	0
9 days.....	1	0
10 days.....	1	
15 days.....	0	1
19 days.....	0	1

or eight days. The pain in the chest continues as the most important symptom throughout. Cough is usually present and in about one-third of the cases blood-tinged sputum was noted. The signs in the chest are those of consolidation often preceded by pleuritic friction rubs. The roentgenograms checked up the physical findings in every case in which it was employed.

PHYSICAL SIGNS

The physical signs of consolidation of postoperative pneumonia, in our experience, have invariably been found in one or the other lower lobe, usually at the extreme base. These signs may be easily missed unless the patient is turned over on his side and the bases are carefully searched with percussion and auscultation. Any patient can be turned after operation without danger if proper care and gentleness are exercised. In the postoperative pneumonias the signs usually appear with the onset or shortly after, in about 70 per cent of the cases within the first 24

hours. In the embolic pneumonias of this series the signs of consolidation were a little slower to appear, 43 per cent occurring from the third day to the fifth day after the onset of the disease. The right lower lobe was most frequently involved, being solely affected in 27 out of the 54 cases of postoperative pneumonia and in conjunction with the left lower lobe in 10 or more cases, while the left lower lobe was involved alone in but 15 cases. Among the embolic pneumonias the bases were also the chosen sites, though in one case the right upper and right middle lobe were involved. These signs frequently appeared first as a slight congestion with a few râles, followed by dullness and later, by frank bronchial signs of consolidation. They are often fleeting, clearing up within a day or so in distinction to the regular medical lobar pneumonia, due to pneumococcus groups I, II, or III.

In the meantime, as a rule, the heart shows but very slight signs of embarrassment in a typical postoperative pneumonia. The pulse is always slightly increased in rate, though of good quality and regular. There was marked irregularity of the pulse in but five cases in this series, three of which proved fatal. Tachycardia was noted twice and an auricular fibrillation once. The blood pressure, recorded in 31 cases was quite within normal limits of systolic and diastolic pressure, in all except one case of hypertension and three of slightly diminished tension.

THE ROENTGENOGRAM IN RELATION TO SIGNS OF CONSOLIDATION

Roentgenography was employed as an aid to diagnosis in 56 out of the 65 cases. It has been our purpose to subject every patient suspected of postoperative pneumonia of either variety to this procedure. Of the nine who escaped, four were private patients on whom permission was withheld. The remaining five failures represent three patients considered too sick to move and two overlooked through careless failure to carry out orders.

The importance of roentgenography cannot be overestimated as a diagnostic procedure in the study of postoperative pneu-

TABLE VI.—PHYSICAL SIGNS AND ROENTGENOGRAPHIC FINDINGS

	Postoperative Pneumonias	Embolic
Signs of consolidation elicited	54	7
Signs consolidation not elicited	4	0
Lobar	28	3
Lobular	26	4
Right lower lobe	27	3
Left lower lobe	15	2
Right and left lower lobe	10	1
Entire left side	1	
Left lower lobe and left upper lobe	1	
Right upper lobe and right middle lobe		1
Number of cases roentgenographed	51	5
Number of cases not roentgenographed	7	2
X-ray shadow with no signs of consolidation	4	
Signs of consolidation with no X-ray shadow	6	
X-ray shadow and signs of consolidation agreed	41	5
X-ray shadow present before signs appeared	6	
Roentgenographic shadow wedgeshaped	7	

monia. In four cases there could have been no diagnosis made without roentgenography, for the signs of consolidation never appeared though the shadow was perfectly frank, and the customary symptoms were present. The shadow in the lung not infrequently precedes the advent of physical signs of consolidation. With the knowledge that a shadow is present a careful search for the signs is continued until they may be found.

In a certain number of cases there are signs of consolidation present with no shadow displayed by roentgenography. In this series there were six of these cases. In three the signs were at the left base where a small shadow of consolidation might easily be obscured by the heart shadow. The remaining three were at the right base, but one of these was not roentgenographed until four days after the signs appeared, which was evidently too late to show a shadow. Just as the physical signs of consolidation are transitory, so is the shadow, and there should be no delay in roentgenographing the patient under suspicion. The shadow appearing at the right base offers better opportunity to study its contour. In seven cases it was noted to be wedgeshaped with the base of the wedge

pointing downward and outward. This peculiarity has been mentioned by Whipple and others.

In the great majority of cases the roentgenogram agrees with the physical signs, proving it a valuable and conclusive aid in the diagnosis. The details of the roentgenographic shadow in relation to physical signs may be seen in Table VI.

COMPLICATIONS

Complications directly due to the pneumonitis arose in six cases of the postoperative and two of the embolic pneumonias. The most frequent of these complications was serofibrinous pleurisy occurring in three postoperative pneumonias. In none of these was an organism recovered on culturing the fluid. Another postoperative pneumonia developed a serofibrinous pleurisy from the fluid of which a gram-positive diplococcus was recovered. This same patient also had a marked localized pneumococcus peritonitis and was jaundiced. Jaundice occurred in one other patient. These pleural effusions mentioned were uniformly small and relatively unimportant.

The most serious complication noted among the postoperative pneumonias was a lung abscess following a delayed resolution for five weeks. This patient eventually recovered without operative treatment.

The embolic pneumonias had far more spectacular complications. One patient with a hæmolytic streptococcus in the blood culture and sputum developed an empyema which was drained by rib resection and thoracotomy. The pus likewise yielded a pure culture of hæmolytic streptococcus. A second embolic pneumonia with a staphylococcus aureus present in his blood culture developed a small pleural effusion. The fluid removed was tinged with blood which very probably accounts for the presence of the staphylococcus aureus in the culture. The effusion soon cleared up.

BACTERIOLOGY

In the study of postoperative pneumonitis, the greatest importance has been placed upon this aspect of the work. We have been

fortunate in having the services of a thoroughly scientific bacteriologist, Miss Marion Olmstead, who has followed the subject of postoperative pneumonia during the entire three years covered by the present work and that of Whipple. We have been particularly anxious to learn what organism or organisms are responsible as direct causative factors in the disease. This has meant a large increase in the routine work of the bacteriologists, but has been carried out with a splendid spirit of co-operation. The pre-operative and postoperative sputum examinations and blood cultures and blood agglutination should have been done in every case as was intended. The failures represent a certain carelessness on the part of the nursing and house staff, and include a few private patients on whom permission to obtain specimens was withheld. The urine precipitation test was not adopted until September, 1917, but since then has been tried consistently.

1. *Sputum* (see Table VII). A little less than half of the pre-operative sputum examinations showed no pneumococcus present, but after operation this was reduced to one-sixth. Of the organisms present the pneumococcus group IV holds the pre-eminent place, being present in 32 per cent before operation and in 57 per cent after operation in cases developing postoperative pneumonitis. The other groups of pneumococcus were all represented except group I. Hæmolytic streptococcus and bacillus mucosus capsulatus also were occasionally found. In 17 cases the pre-operative and postoperative sputum examinations showed the same organism, 10 of these showing pneumococcus IV.

2. *Blood culture*. This test was made in fifty-one cases of postoperative pneumonia and found positive in but three. Pneumococcus group IV was present in the blood of one patient, non-hæmolytic streptococcus in that of another, both of whom recovered, and finally pneumococcus group III was found in the blood of a third who died.

In the embolic pneumonias with two positive blood cultures out of seven, the incidence was much greater in proportion, as might be expected. In one case hæmolytic streptococcus was present in the blood both before

TABLE VII.—SPUTUM EXAMINATIONS

Postoperative Pneumonias	Total Cases Examined	No. Organisms Recovered	Pneumococcus IV	Pneumococcus III	Pneumococcus II Atypical	Pneumococcus II	Pneumococcus IV, III	Hemolytic Streptococcus	Bac. Mucos. Capa.	Sacillus Mor. Capa. Pneumoc. IV.
Pre-operative sputum	46	20	15	4	4	1		1	1	
Postoperative sputum	54	7	3	4	4	1	1	2	3	1
Pre- and postoperative coincided with same organisms	17		10	2	2	1		1	1	
<i>Embolic Pneumonias</i>										
Pre-operative sputum	5	3	1	1						
Postoperative sputum	7	2	3	1				1		
Pre- and postoperative coincided with same organisms	2		1	1						

TABLE VIII.—PNEUMOCOCCUS AGGLUTINATION

Case No.	Pre-operative Sputum	Postoperative Sputum	Agglutination	Test
1	No organism	Pneumococcus IV	+	3rd
2	Not examined	Pneumococcus IV	+	3rd
3	No organism	Pneumococcus IV	+	2nd
4	Pneumococcus IV	Pneumococcus IV (different strain)	With postoperative strain	4th
5	Not examined	Pneumococcus IV	+	3rd
6	Pneumococcus II (atypical)	Pneumococcus II (atypical)	+	4th
7	Pneumococcus II (atypical)	Pneumococcus II (atypical)	+	3rd
8	Pneumococcus IV	Pneumococcus IV	+	1st
9	Not examined	Pneumococcus IV	+	3rd
10	Pneumococcus IV	Pneumococcus IV (different strain)	With pre-operative strain	4th

and after the operation which merely consisted of incision and drainage of abscesses. In the second case staphylococcus aureus was found in the blood of a paraplegia with a huge sacral decubitus. The operation had been an exploratory laminectomy. The blood culture remained positive for weeks after the pneumonia subsided.

3. *Pneumococcus agglutination.* This test depends upon the development in the serum of the individual suffering from postoperative pneumonia of specific agglutinins, which will act upon the organism recovered from the pre-operative or postoperative sputum, or both, causing agglutination. The reaction is quite specific and its presence shows that the patient has developed a reaction against the organism. The only organisms agglutinated by this test were pneumococcus group IV and pneumococcus group II (atypical). This atypical group II is said to be closely allied to the group IV. The test is seldom positive at the beginning of the disease, but if it be

repeated at three day intervals, three or four times, it will become positive, usually with the third or fourth tests, i.e., the ninth or twelfth day, if the patient develops the reaction at all. This probably indicates the length of time during which the individual is acquiring his agglutinins. When pneumococcus group IV, recovered in the postoperative sputum, is of a different strain from that in the pre-operative sputum, if the serum develops the power of agglutination, it will be specific for either one strain or the other, but not for both. The agglutination test was performed in forty-two cases of postoperative pneumonia with positive results in about 24 per cent. None of the embolic pneumonias showed a positive agglutination. Table VIII shows relation of sputum to agglutination and time required for reaction to develop.

4. *Urine precipitin test.* This is probably an equally specific test depending upon the precipitation by a protein in the urine of the organism recovered in the pre-operative or

TABLE IX

Hospital	No. of Cases	Pneumonia Morbidity	Morbidity Percentage	Mortality	Mortality Percentage	Mortality Per Cent of Morbidity
Mayo (Beckman) 1910 (3).....	3657	10	0.27	5	0.14	50.0
Mayo (Beckman) 1912 (4).....	5835	19	0.32	6	.10	31.5
Mayo (Beckman) 1913 (5).....	6825	27	0.39	0	0.0	0.0
Roosevelt Hospital, N. Y., (L. S. B.) (6).....	2612	23	0.9	7	0.26	30.4
New York Hospital, F. W. B. (7).....	1413	15	1.06	7	0.50	46.6
Mass. General, E. C. C. L. J. J. M.....	3490	40	1.14	22	0.63	55.
Montreal General, Armstrong (9).....	2500	30	1.20	22	0.88	73.3
Leipzig Laeven (8).....	9755	180	1.8	113	1.15	63.
Presbyterian, A. O. W. 1915-16.....	3719	97	2.1	25	0.66	31.7
Presbyterian, M. C.....	1940	65	3.3	7	0.36	10.7

postoperative sputum. This test has only been tried during the last four of the twelve months during which this series runs. It was positive in five out of sixteen cases which is a somewhat higher percentage than the agglutination test. In one case in which the bacillus mucosus capsulatus was recovered in both pre-operative and postoperative sputum, the test was positive for pneumococcus group I, showing that although the sputum failed to demonstrate it, there must have been a group I infection. When the pre-operative and postoperative pneumococci were of different strains of the same group, the precipitation held for one strain only.

The result of the bacteriological investigation has been to establish the specificity of the causative organism in 18 out of 58 cases of postoperative pneumonias. In eleven of these the pneumococcus group IV was the causative organism. During the disease this organism was isolated from the sputum twice as frequently as all the other organisms combined. There can be but little doubt but that the pneumococcus group IV is in most instances the cause of that definite and distinct type of pneumonia already described and called in this instance, postoperative pneumonitis. The bacteriology of the embolic pneumonias presents a different aspect. In one instance the positive blood culture may be the cause of the pneumonia by a bacterial embolus. The pneumonia may possibly in another instance be the result of a secondary infection of an embolus already present in the lungs. The pneumococcus group IV was however, found most frequently in the sputum of pneumonias of this type as well as in that of the postoperative pneumonitis.

MORTALITY

In considering the mortality in postoperative pneumonia, attention should be paid to whether or not the patient died as a result of his pneumonia. There were seven deaths in the sixty-five patients, making the mortality 10.7 per cent. No one of these occurred where the pneumonia was the only complication, in other words no otherwise healthy patient undergoing operation died as a result of his pneumonia. Malignancy claimed three patients, one with carcinoma of the colon, another with carcinoma of the oesophagus and a third with carcinoma of the cystic duct. All of these were in very poor condition. A pulmonary embolus caused one death. Another patient died in a diabetic coma following incision and drainage of an alveolar abscess. A mastectomy in a patient sixty-five years of age, not in very good condition, resulted in a fatal pneumonia. The seventh patient died of inanition following a duodenal fistula rather than from the pneumonia. It is only fair to say that two other patients in the present series died in the hospital; one, a paraplegia with a positive blood culture, died of sepsis six weeks after the embolic pneumonia had subsided, the other died over a month after his pneumonia and from no associated condition. One of the most distressing tragedies of hospital experience is to see a young, healthy individual undergo a simple surgical operation and die of postoperative pneumonia. During the past year, we have fortunately been spared this, perhaps due to greater care in prophylaxis.

For the greater part of Table IX, the writed is indebted to Cutler and Morton.

The Presbyterian Hospital statistics have simply been added. As the above mentioned investigators have pointed out the statistics from the Mayo clinic can in no way be compared to those of a general city hospital, because their patients must be fit to stand railway journeys of varying distances. The low morbidity of this clinic is quite remarkable. Although the morbidity of postoperative pneumonia at the Presbyterian Hospital has been increasing during the past three years, the mortality percentage has been falling even more markedly. The present series shows the highest morbidity percentage in Table IX, but it shows also by far the lowest mortality percentage of morbidity. This leads to the question whether at the other clinics there might not have been other post-operative pneumonias not altogether frank clinically, which roentgenography and bacteriological investigations might have revealed.

TREATMENT AND PROPHYLAXIS

The following prophylactic measures have been instituted and followed out with considerable faithfulness during the past year.

1. Great care is taken to elicit a history of recent cold, cough, sore throat, etc., and in the physical examination the respiratory tract is given special attention. Patients with history of recent cough or signs of rhinitis, tonsillitis, pharyngitis, etc., are sent home to wait a week or two if their operation be one of choice.

2. In case of operations of necessity in patients with signs of inflammation of the respiratory tract, ether is seldom used, if it can be avoided. Chloroform, gas and oxygen, and local anaesthesia have been used with such patients whenever possible.

With the experience gained from Whipple's work on the problem, the following measures for prophylaxis were put in the form of rules for the nurses to observe:

1. The temperature of the bathroom for the routine admission bath must be 70° F.
2. No patient who has had his admission bath and is to be operated on the following day shall be allowed out of bed.
3. The hair of all female patients is to be thoroughly dried with an electric blower.

4. Before leaving operating room each patient shall be given a dry, warm night shirt and be carefully covered with sufficient blankets.

5. On arriving in the ward, a cotton pneumonia jacket shall be put on each patient.

6. Sufficient blankets must be provided and all draughts avoided.

7. As soon as the patient is conscious, a heavy woolen bed jacket is to be worn. (The rules relating to blankets, bed jackets, etc., did not apply during hot weather.)

Two additional experiments in prophylaxis were tried:

1. All the patients of one male ward were given tincture of digitalis, 15 minims on admission and every four hours until they had 40 minims in an attempt to obtain a digitalis effect on the heart to combat pulmonary congestion during the operation.

2. All patients of another male ward had their chests rubbed with a turpentine camphor liniment immediately after operation.

Of these two measures the counter irritation seemed to be of some benefit and came into pretty general use throughout the hospital in cases where any respiratory trouble was anticipated after operation.

The treatment of postoperative pneumonia is almost entirely symptomatic. If it should be due to pneumococcus group I, serum is to be used. Fresh air by an open window and forced fluids were almost invariably used. Digitalis was used in 38 cases out of the 65, usually in the form of the tincture, though occasionally digipuratum or digalin was given intravenously. On rare occasions camphor or caffeine was given, but when such stimulation was indicated it was of doubtful benefit.

CONCLUSIONS

1. Coughs, colds, and other inflammatory conditions of the respiratory tract are the most important factors predisposing to postoperative pneumonia. Restriction of abdominal respiratory movements as a result of incision, postoperative distention, tight dressings, is also a definite factor.

2. Exposure of the patients to cold while in the hospital before, as well as after, operation, is responsible for a certain number of postoperative pneumonias.

3. The pneumococcus group IV is most frequently the inciting organism of postoperative pneumonia.

4. The urine of patients suffering from postoperative pneumonia frequently develops precipitins against the organism recovered in the pre- or postoperative sputum, while the blood develops agglutinins.

5. The pneumonia due to pneumococcus group IV is a definite clinical entity, differing from the pneumonia due to pneumococcus groups I, II or III.

6. The use of the roentgenogram in all cases of suspected postoperative pneumonia

and the careful and constant search for physical signs will reveal more postoperative pneumonias than have hitherto been reported.

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