POSTOPERATIVE ATELECTASIS

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THE occurrence of several cases of atelectasis following surgical operations at the Evanston Hospital during the last few months, coupled with the apparent rarity of the condition previous to this time has prompted the following study of postoperative pulmonary complications.

Wm. Pasteur[1] in 1890 was the first to describe atelectasis, calling attention to pulmonary collapse following diphtheria. In 1910 the first case of postoperative atelectasis was recognized clinically, also by Pasteur.[2] Scott,[3] in 1925, in a complete study of the literature found only 64 cases reported, these included cases which were not postoperative. Previously often mistermed postoperative or ether pneumonia, atelectasis has been recognized with increasing frequency since 1925 as a common pulmonary complication following operations, so that now it is variously estimated as comprising from 20 per cent to 70 per cent of all postoperative pulmonary complications.[4,5]

Atelectasis may be defined as the collapse of a lung or portion of a lung in such a manner that the affected portion contains little or no air and is greatly decreased in size. Most authorities, including Coryllos,[6] Mathes and Holman[7] and Bergh[8] consider inspissated secretion to be the primary cause, following the evidence presented by Jackson and Lee[9] and Elliot and Dingley.[10]

The mortality of atelectasis, per se, is low, but as Faulkner[11] points out, postoperative massive collapse is of more than academic interest because it may be complicated by either a bronchopneumonia or a labor pneumonia with fatal results. When precautionary measures are neglected or proper treatment is delayed, true pneumonia, pulmonary abscess or empyema may be the outcome.*

Eliason and McLaughlin[14] at the University of Pennsylvania Hospital have published recently the results of their observations on postoperative pulmonary complications. They found a total of 129 such complications following 8864 operations in ten years. Of these, 32 were cases of atelectasis.

At Evanston Hospital, a five year period extending from June 1930 to June 1935, was studied. Since an atelectasis card has been included in the files only during the past year, the cases were found only after searching through all other postoperative pulmonary complications, such as pneumonia, bronchitis, etc. A total of 12,494 operations under general and local anesthesia were performed during that five year period. The total number of pulmonary complications were 77. These were proportioned as shown in Table 1.

TABLE 1
POSTOPERATIVE PULMONARY COMPLICATIONS IN 12,494 OPERATIONS

	Cases	Per Cent
Bronchopneumonia	19	24.6
Pulmonary infarct and embolus	13	16.8
Lobar pneumonia	10	12.9
Bronchitis	10	12.9
Hypostatic pneumonia	9	11.7
Pleurisy and pleural effusion	8	10.3
Atelectasis	8	10.3

* Coryllos and Birnbaum even go so far as to claim that every case of pneumonia is preceded by an atelectasis. Head,[13] however, believes that there is none of the evidence presented by these authors in support of their theory which cannot be explained just as easily in simpler fashion.

To the 8 cases of postoperative atelectasis occurring during the five year period are added 2 cases which have occurred since June 1935, so that a total of 10 cases are included in the report. In one patient atelectasis occurred twice, once following appendectomy, the other following intestinal obstruction eight days later, thus the 10 cases are taken from nine patients.

The years in which these diagnoses were made are as shown in Table II.

TABLE II

	Cases
1930	1
1931	0
1932	0
1933	3
1934	1
1935	5

Three cases were in patients below ten years of age, 6 cases in patients between twenty and forty. Seven were in males, 3 in females.

TABLE III
AGE INCIDENCE

Years	Cases	Per Cent
0 to 10	3	30
10 to 20	1	10
20 to 30	2	20
30 to 40	4	40

TABLE IV
SEX

	Cases	Per Cent
Males	7	70
Females	3	30

Five cases followed appendectomies, one case followed each of the following: intestinal obstruction, cholecystectomy and appendectomy, gastrojejunostomy, defundectomy, and drainage of prostatic abscess. Worthy of note is that 80 per cent of the cases occurred following lower abdominal surgery, which is contrary to the findings of Head,[15] Eliason[16] and others, who claim that high abdominal operations are more frequently followed by atelectasis, due to the fact that these operations restrict the diaphragm more thus decreasing forceful respirations and concomitantly, vital capacity.

However, one important factor in the development of atelectasis would seem to be injury to those muscles which help force the air out in expiration. The obliques, most commonly cut in appendectomies and hernial repairs, play an important part as accessory muscles of respiration. Scott's[17] collection of all cases reported up to 1925 seems to support this, since of the 64 cases, 11 were hernias and 17 were appendectomies. These two operations led all others easily in frequency and together made up nearly half of the total number of cases.

This series of cases is hardly large enough to draw any conclusions as to the part that anesthesia plays in production of atelectasis. (Table v.) Brown[18] believes that spinal anesthesia predisposes to atelectasis, due to its marked depression of the respiratory center, not only during the operation itself but for a considerable period thereafter.

TABLE V
ANESTHESIA

	Cases	Per Cent
Ether	5	50
Ethylene	3	30
Spinal	1	10
N_2O	1	10

Premedication was morphine and atropine, or scopolamine. One case received atropine alone. (Table VI.)

TABLE VI
PREMEDICATION

	Cases	Per Cent
Morphine sulphate and atropine	6	60
Morphine sulphate and scopolamine	2	20
Atropine	1	10
Morphine sulphate	1	10

Atropine, of course, tends to thicken secretions, thus producing a condition which would seem to be favorable toward

the production of atelectasis. That it played only a minor part, if any, is indicated by the fact that 3 cases received no atropine at all.

In 60 per cent of the cases the operation consumed more than one hour; 40 per cent less than one hour; 50 per cent received intravenous therapy postoperatively, 50 per cent did not.

The onset in the majority of the cases was quite typical, 70 per cent of the cases occurring the first three postoperative days. (Table VII.)

Table VII
TIME OF ONSET

Postoperative day	Cases	Per Cent
1st	4	40
2nd	1	10
3rd	2	20
4th	1	10
Over 4 days	1	10
Date not known	1	10

The atelectasis was ushered in in most cases with a sharp rise in temperature followed within a period of hours by cyanosis, shortness of breath, pain in the chest and increase in respiratory rate and pulse. Very significant is the fact that in 8 cases a history of inability to raise mucus, expectoration or coughing, occurred before the onset of the atelectasis. The temperature, pulse and respiration curves are very typical, the sharp rise being noted in all but one case. (Figure 1.)

Table VIII
LUNG TISSUE INVOLVED

	Cases	Per Cent
Entire right side	1	10
Right lower lobe	7	70
Right middle lobe	1	10
Right upper lobe	1	10

Physical findings are difficult to analyze. Head[19] claims that if the typical signs of atelectasis are not present, we are not dealing with an atelectasis. On the contrary, Van Allen[20] claims that many cases of atelectasis are misdiagnosed because of a lack of pathognomonic signs, the physical findings being modified, or difficult to

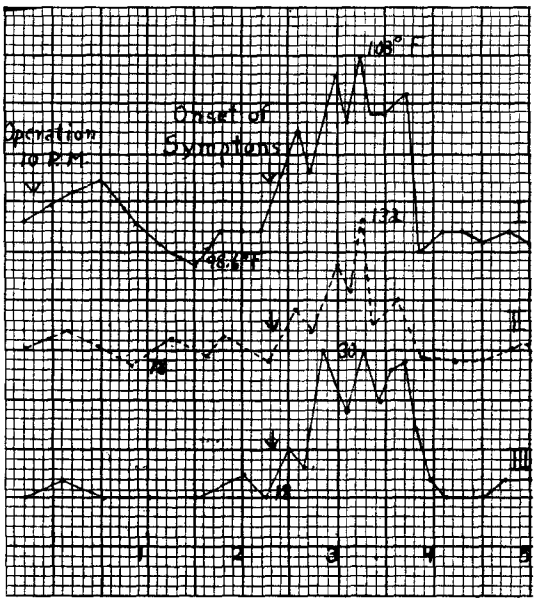

Fig. 1. Typical curves of temperature, pulse and respirations in a case of postoperative atelectasis. Vertical in graph I shows temperature in degrees Fahrenheit; in graph II, pulse rate per minute; in graph III, respirations per minute. Horizontal represents days postoperative. Case V. Typical of majority of cases.

ascertain, by the amount of surrounding normal lung tissue. The lung tissue affected is as shown in Table VIII.

Physical findings showed dulness to percussion in all cases over the affected area. Breath and voice sounds, which textbooks claim are always absent, were absent in 50 per cent of the cases, increased in 40 per cent and not charted in one case. As Scott[21] emphasizes, even when the breathing is largely suppressed there is often a bronchial quality to the sound that is heard. This factor easily gives rise to errors in physical diagnosis. Râles may or may not be present.

Restricted respiration on the affected side was noted in 3 cases on physical examination. In most of the cases no mention was made of observation of respiration or of a mediastinal shift. Sante[22] states that the mediastinum may remain undisturbed in the midline. The trachea alone may shift to the affected side. In

children, a scoliosis is a common finding, the concavity being directed toward the affected side.

The lack of uniformity in physical findings in so far as breath sounds are concerned demonstrates the importance of *x*-ray evidence. Nine of the cases were diagnosed as atelectasis by *x*-ray, one case had no *x*-ray. The importance of *x*-ray in diagnosis cannot be stressed too strongly. It is brought out clearly by Table IX, which is possibly the most instructive in the report. This table deals with the diagnosis made before *x*-ray findings.

TABLE IX

CLINICAL DIAGNOSIS MADE BEFORE *x*-RAY

	Cases
Not diagnosed	1
Atelectasis	3
(In only one case was a positive diagnosis made.)	
Bronchopneumonia	3
Postoperative pneumonia	1
Pleural effusion	1
Bronchitis	1
"Focus of infection"	1
Serofibrinous pleurisy	1

To summarize, a total of twelve diagnoses were made clinically, some cases receiving two diagnoses. A positive diagnosis of atelectasis was made in only one case. In 2 additional cases atelectasis was considered as a possibility. Thus in only one-fourth of the diagnoses was atelectasis even considered. This may well be contrasted to the statistics, quoted before, that 20 to 70 per cent of all pulmonary complications occurring postoperatively are atelectatic.

A history of upper respiratory tract infection preceding operation was found in 30 per cent of the cases, a high figure when the total number of operations is considered.

The atelectasis cleared the second day of its course in 50 per cent of the cases, while 80 per cent had cleared the third day. In almost every case relief came abruptly, with a fall in temperature and pulse rate to close to normal in a matter of several hours. Complete relief of symptoms, almost dramatic in character, was the rule. Coughing and expectoration of mucus usually continued for several days.

In one case, the atelectasis persisted until the day of discharge, the thirty-eighth postoperative day. Since it was discovered the day of discharge, no treatment had been instituted.

The frequency with which an incorrect diagnosis was made in these cases is perhaps paralleled by the diversity of treatment prescribed. Careful study of the records, including nurses' bedside notes, revealed that in only 3 cases was the type of treatment administered designed to correct the underlying cause. These 3 cases were relieved almost immediately and dramatically. Even after *x*-ray diagnosis was made, most treatment seemed to be directed toward controlling the cough.

From these statistical data presented, four important deductions may be made:

1. The clinical diagnosis is difficult.
2. Early *x*-ray examination in postoperative pulmonary complications is of first importance in making a diagnosis.
3. Proper prophylaxis definitely decreases the incidence of atelectasis.
4. The proper method of treatment is not commonly understood. When it is employed, the recovery is much more rapid.

1. *The clinical diagnosis is difficult.*

Nine additional cases were studied. These cases were chosen among the pulmonary complications as being most likely cases of atelectasis, but were not included in the report since neither a positive clinical nor *x*-ray diagnosis was made on them. In only one of them was atelectasis even considered in the differential diagnosis. They were diagnosed as shown by Table X.

TABLE X

	Cases
Bronchopneumonia	5
Lobar pneumonia	1
Hypostatic pneumonia	1
Pulmonary infarct	2
Bronchitis	1

Despite the diagnosis made on them clinically, atelectasis must be considered as a possibility in every case because of typical temperature, pulse and respiration curves and physical signs. In 6 of the 9 cases the

duration of the complication was less than forty-eight hours, with an abrupt rise and abrupt fall in temperature and pulse

Fig. 2. Atelectasis occurring in right lower lobe one day following operation for appendicitis. Case III. No marked shift of mediastinal structures.

curves. Absent breath sounds were noted in 45 per cent of the cases. Mucus, postoperatively but previous to the onset of the complication was noted in 6 of the 9 cases. *X*-rays were taken in 6 cases, 2 of which were negative but were taken eighteen to twenty-six days postoperatively. In 2 cases, films were unsatisfactory, and the last 2 cases are possible atelectasis. (Crowder.[23])

The purpose of including these doubtful cases is not to prove necessarily that they are all errors in diagnosis, but to further demonstrate the important fact that atelectasis is not being considered often enough in the differential diagnosis of postoperative pulmonary complications. It is in diagnosing and treating early complications as cases of pneumonia, rather than as atelectasis, that the danger lies. (Faulkner.[24])

The onset and symptoms, according to Faulkner[25] may vary somewhat according to the suddenness in onset of bronchial plugging, size of plugged bronchus, alterations in intrapleural pressure and disturbance in position of mediastinal structures. Sante[26] claims that at times it is impossible to make a differential diagnosis between bronchopneumonia and atelectasis. This is true when a case of atelectasis has been allowed to continue for several days without proper treatment. The lung starts to expand, but atelectatic areas are still present, thus giving a condition simulating

Fig. 3. Atelectasis occurring on entire right side two days following operation for intestinal obstruction. Case IV. Mediastinal structures far to right.

bronchopneumonia closely both by physical findings and by *x*-ray.

II. *Early x-ray examination in postoperative pulmonary complications is of first importance in making a diagnosis.*

The *x-ray* findings are summarized by Sante[27] and Van Allen.[28] The half of the diaphragm on the affected side is elevated, the rib interspaces are narrowed, the mediastinal structures deviated to the affected side, and the lung tissue affected gives a homogenous shadow. (Figures II and III.) Sante[29] adds however, that when a single lobe alone is affected, such as the lower lobe, the heart and trachea may remain undisturbed in the midline, the space lost by atelectasis of a single lobe being taken up by a compensatory emphysema of the uninvolved portion of the lung. In children scoliosis is found often.

The fluoroscope frequently plays an important part in the diagnosis of an atelectasis, being of value chiefly in children due to the mobility of their mediastinum and their inability to cooperate. In one of our cases, the child could not be induced to hold his breath in

full inspiration, the resultant roentgenogram showed the heart and mediastinal structures exactly in the midline. Fluoroscopic examination however, showed these structures definitely move toward the affected side in inspiration.

In stressing the importance of *x*-ray findings, there is no intent to create the impression that physical findings are valueless or that a diagnosis cannot be made on the basis of physical findings alone. Such is not the case, although physical findings are definitely subordinate to the roentgen ray in a not inconsiderable proportion of cases.

III. *Proper prophylaxis definitely decreases the incidence of atelectasis.*

Prophylaxis is simple and should be standard in all hospitals. Deep breathing exercises for every postoperative case is desirable. Slow inspiration and expiration ten times per hour every waking hour. If the patient is not breathing deeply, carbon-dioxide oxygen inhalations two or three times every one-half hour should be added. No operation should be performed, except emergencies, when any condition predisposing to excessive secretion is present, e.g., sinusitis, laryngitis, bronchitis, etc. Faulkner[30] points out that atropine thickens secretions and should be used sparingly or not at all postoperatively. This view is shared by Alexander.[31] Brown[32] claims that the viscosity of the mucus determines whether a lobar or lobular atelectasis occurs, the more viscus mucus blocking off larger portions of the lung.

Stormy anesthesia predisposes to atelectasis. A patient on the table often becomes restless, vomits a little and the anesthetist may clamp a mask over his face. Crowder[33] believes foreign body from vomitus to be one of the common causes of atelectasis. The pharynx, during anesthesia, must be kept clear of excess mucus by aspiration.

Postoperative medication should be given carefully. Morphine depresses the cough reflex. However it also diminishes the pain on respiration thus allowing the lungs to get better ventilation and increase the vital capacity. Thus a happy medium, where the cough reflex is maintained, should be desired. The patient must be urged to cough. KI and NH_4Cl by reducing tenacious sputum, are useful drugs postoperatively. Dehydration plays a part in the production of atelectasis postoperatively by making secretions thicken, thus tending to form mucus plugs.

Posture is extremely important. The Trendelenburg position is indicated in every patient who has had an upper respiratory tract infection previous to operation, who has had a stormy anesthesia, or who is raising large quantities of mucus postoperatively, unless it is contraindicated by the surgical condition, as in peritonitis. All patients should have their positions changed frequently the first few postoperative days. Distention of the bowel or stomach, because it tends to elevate the diaphragm, should be relieved.

Binders put on abdominal wounds so tightly as to affect respiration reduce the vital capacity of the lungs and tend to hypoventilation, one of the predisposing causes of atelectasis.

IV. *The proper method of treatment is not commonly understood. When it is employed, the recovery is much more rapid.*

After the condition has been established, actual treatment is simple and gives dramatic results. Head[34] tells of a case occurring in a week old infant, wherein the treatment consisted only of turning the baby in an effort to examine the back. This change in position caused the infant to cough up a large quantity of mucus. A few whiffs of CO_4-O_2 were then given in addition. The child was better almost immediately.

The patient should lie on the uninvolved side, rolled back and forth and urged to cough. Sometimes slapping the affected side, which is uppermost, is of value. Sedatives which diminish the cough reflex should be reduced to a minimum and breathing exercises should be instituted, plus CO_2 inhalations. If these simple but effective methods of treatment do not give

relief, resort must be made to bronchoscopy. An oxygen tent is sometimes of value.

The question of lobular, or focal atelectasis has not been discussed fully in this report. Eliason and McLaughlin[35] in their report of 30 cases had 18 lobar and 12 lobular. There is a very strong possibility that some of the 9 cases discussed in this report as doubtful were lobular atelectasis. Van Allen[36] claims that the majority of cases of postoperative atelectasis are of the focal or lobular form, and Brown[37] seems to have demonstrated quite definitely, both by iodized sputum injection in animals and bronchoscopic examination of clinical cases, the existence and mechanism of production of scattered lobular atelectasis. The similarity between lobular atelectasis and bronchopneumonia, both by physical and roentgenological findings, may lead to treatment for bronchopneumonia if careful diagnosis is not made. To treat atelectasis as true pneumonia may rob the patient of his chance for recovery.

If there is any doubt about the consolidation being due to lobar pneumonia, bronchopneumonia, pulmonary infarct, pleurisy with effusion, etc., a safe procedure which often establishes the diagnosis is to roll the patient upon his uninvolved side and urge him to cough.

SUMMARY

1. The clinical diagnosis is difficult and is seldomly made; the *x*-ray diagnosis is generally easy. The importance of early *x*-ray examination of all postoperative pulmonary complications is indicated.

2. Atelectasis probably occurs far more frequently postoperatively than is suspected.

3. Proper prophylactic treatment decreases the incidence of atelectasis.

4. The proper methods of treatment will greatly accelerate recovery.

5. A report of 10 cases of atelectasis occurring postoperatively is presented.

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