A Study of the Pathogenesis and Management of Spontaneous Pneumothorax*

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SPONTANEOUS PNEUMOTHORAX OCCURS subsequent to a disruption in the continuity of the visceral pleura with escape of free air into the pleural space. In many instances the term "idiopathic" is associated with this disease process, because it is frequently impossible to detect evidence of pulmonary pathology by clinical or roentgenographic means. The pathogenesis of pneumothorax in these patients presumably involves rupture of a minute bleb or bulla. In a few cases there is dissection of air in a central direction along pulmonary vessels toward the hilum.* In other patients, x-ray detection of larger blebs, bullae, or subpleural deposits of caseous and necrotic material does permit the establishment of a definite pathogenesis.

The importance of determining the exact etiology of the pneumothorax in each patient has not been emphasized sufficiently. Except in a few studies15,19 interest has focused primarily upon the mechanics of lung expansion rather than the condition of the underlying pulmonary parenchyma. However, selection of the most appropriate method of management for any patient is often profoundly influenced by the presence of associated lung pathology.

The purpose of this investigation is to evaluate the etiologic factors and therapeutic methods employed in the management of patients with spontaneous pneumothorax applying particular emphasis on the underlying pathology. This series consists of unselected patients from two sources: (1) a service devoted entirely to chest diseases; and (2) from the wards of a metropolitan general hospital. The study is based upon an analysis of 247 cases encountered during a nine-year period (1950-1958) on the Chest Service of Bellevue Hospital, and at the Presbyterian Hospital, New York City. Arbitrarily, patients under the age of eight years have been excluded from the series.

THE ETIOLOGY OF SPONTANEOUS PNEUMOTHORAX

The 247 patients who comprised this study were separated into five groups, depending upon the condition of the underlying lung parenchyma on the side of the pneumothorax (Table 1). Of these, Group

<table>
<thead>
<tr>
<th>Groups</th>
<th>Type of Pulmonary Disease</th>
<th>Number of Patients</th>
<th>Per cent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>No disease evident</td>
<td>110</td>
<td>44.5</td>
</tr>
<tr>
<td>II</td>
<td>Bleb formation present</td>
<td>37</td>
<td>15.0</td>
</tr>
<tr>
<td>III</td>
<td>Emphysema</td>
<td>45</td>
<td>18.2</td>
</tr>
<tr>
<td>IV</td>
<td>Inflammation or neoplasm</td>
<td>7</td>
<td>2.8</td>
</tr>
<tr>
<td>V</td>
<td>Active pulmonary tuberculosis</td>
<td>48</td>
<td>19.5</td>
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The 267 patients in this study were separated into the above five groups for purposes of analysis. I was the largest, consisting of 110 patients (44.5 per cent of the series) without any clinical or roentgenographic evidence of pulmonary disease. The second Group II was composed of 37 patients (15 per cent) who had one or more subpleural blebs detected by x-ray examination initially or following expansion of the collapsed lung. Eleven of them presented a past history of

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pulmonary tuberculosis, and were observed
to have blebs contiguous to areas of dense
scarring in the apical regions. Each pa-
tient had multiple sputum examinations for
Mycobacterium tuberculosis which failed
to disclose the presence of acid-fast organ-
isms. Group III consisted of 45 patients
(18.2 per cent) with either generalized,
obstructive emphysema and/or large areas
of bullous emphysema. In many cases, the
collapsed lung further compromised an al-
ready diminished ventilatory capacity, and
produced a critical degree of pulmonary
insufficiency. Group IV was comprised of
seven patients (2.8 per cent) with miscel-
lanous types of pulmonary or bronchial
disease complicated by pneumothorax. The
pathology encountered here included pneu-
monia (two cases), bronchogenic carcino-
ma (two cases), pulmonary granulomatosis
(one case), paragonimiasis (one case), and
severe bronchial asthma (one case). Group
V consisted of 48 patients (19.5 per cent)
with active pulmonary tuberculosis com-
licated by the development of broncho-
pleural fistula. The detailed management
of these latter patients with easily positive
sputum was covered in a previous com-
munication and will not be included in
this report.13

Prior to 1932, it was generally believed
that spontaneous pneumothorax was caused
only by tuberculosis.7 Today, although
other etiologic factors have assumed greater
importance, active pulmonary tuberculosis
must still be considered seriously in the ini-
tial differential diagnosis. Myerson11 in
1948 reported 38 per cent of 100 consecu-
tive pneumothorax patients with active tu-
berculosis, and Lindskog and Halasz7
(1957) found 71 per cent of his cases to
be Mantoux positive.

Only a few communications have spe-
cifically mentioned the role of emphysema
(either bullous or generalized) as predis-
posing to pneumothorax development.
Perry10 (1939) by a variety of criteria, in-
cluded a diagnosis of “emphysema” in 18
of 85 pneumothoraces; and Myerson11
made a similar diagnosis in five of 64 pa-
tients.

It is apparent from the study carried out
by Dubose, Price, and Guilfoil7 that isolated
blebs may be responsible for a larger per-
centage of spontaneous pneumothorax cases
than our data would indicate. On the basis
of meticulous roentgen examinations, they
discovered blebs or bullae in 78 per cent of
their patients. In another report, Baron-
ofsky and his colleagues1 noted blebs in 25
of 26 young adult males who had exploratory
thoracotomy performed with pneu-
mothorax as the primary diagnosis.

SPONTANEOUS PNEUMOTHORAX WITHOUT
ACTIVE PULMONARY TUBERCULOSIS
(199 CASES). GROUPS I, II, III, AND IV

One hundred and thirty-eight patients
(60 per cent of the series) were treated for
initial spontaneous pneumothorax, and 61
others (31 per cent) comprised a segment
who experienced recurrent episodes of pneu-
mothorax requiring multiple hospital ad-
missions (Table 2). Interrogation of these

| Table 2 |

| INITIAL PNEUMOTHORAX | 138 patients |
| TOTAL ADMISSIONS | 138 |
| Group I | 88 |
| Group II | 13 |
| Group III | 30 |
| Group IV | 7 |

| RECURRENT PNEUMOTHORAX | 61 patients |
| TOTAL ADMISSIONS | 86 |
| Group I | 33 |
| Group II | 33 |
| Group III | 20 |
| Group IV | 0 |

Table 2 indicates a division of the series into
patients who experienced an initial pneumothorax,
and those with recurrent episodes of collapse. Pa-
tients admitted originally with an initial pneu-
mothorax and who were subsequently readmitted with
a recurrence, are listed only in the “recurrent
pneumothorax” column.

latter 61 patients disclosed a previous “history” of 150 admissions to local community
hospitals for treatment of pneumothorax,
and 86 additional admissions to the chest
service of Bellevue Hospital or to the Pres-
byterIan Hospital. Clinical records were
reviewed only at Bellevue and Presbyterian
Hospitals, and comprised a total of 224 separate admissions for the 199 patients. Statistics other than those for race, age, and sex were tabulated on the basis of total admissions (224) rather than the total number of patients (199).

RACE, SEX, AND AGE DISTRIBUTION

There were 150 white Caucasians, 44 Negroes, and five Chinese in this series

<table>
<thead>
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<th>Table 3—Sex and Race Distribution (199 patients)</th>
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<tr>
<td>Groups</td>
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<tr>
<td>--------</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
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<tr>
<td>White</td>
</tr>
<tr>
<td>Negro</td>
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<tr>
<td>Chinese</td>
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(Table 3). One hundred and sixty-five of them were men (83 per cent) and 34 were women (17 per cent). In groups I and II, there was a preponderance of younger patients, 70 per cent (102 of 147 patients) being in the 20-39 age range. In contrast, group III contained a preponderance of older patients, 80 per cent (36 of 45 patients) being over 50 years of age. There was no predominant age distribution in Group IV (Table 4). These data coincide with the reports of others.10,11,14

<table>
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<th>Table 4—Age Distribution (199 patients)</th>
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<td>Groups</td>
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<td>II</td>
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<td>III</td>
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<td>IV</td>
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THE CHIEF COMPLAINT AND PROBABLE PRECIPITATING FACTORS IN PNEUMOTHORAX DEVELOPMENT

Chest pain was the chief complaint in 96 patients of Group I (81 per cent) and also in 29 patients (63 per cent) in Group II. Thirty-one patients in Group III (62 per cent) complained of severe dyspnea at the time of hospitalization, and cyanosis was noted in one-third of them during the admission physical examination (Table 5).

<table>
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<th>Table 5</th>
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<tr>
<td>Groups</td>
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<tr>
<td>---------</td>
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<tr>
<td>I</td>
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<td>II</td>
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<td>III</td>
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<td>IV</td>
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</table>

In 90 admissions (40 per cent of the entire group of 224 admissions) the patient experienced a paroxysm of coughing or was engaged in moderately active to strenuous exertion at the instant symptoms of pneumothorax became evident. Of the remaining cases, 24 were at complete rest (11 per cent) and 110 (49 per cent) did not associate a specific event with the onset of symptoms. Many of the latter patients reported to the hospital long after the lung collapse occurred, and can be assumed to have had insidious onset or to have forgotten the specific precipitating activity.

DURATION OF PNEUMOTHORAX PRIOR TO TREATMENT

Seventy-five patients of Group I (62 per cent) and 24 of Group II (52 per cent) were admitted to the hospital during the first 24 hours subsequent to the onset of symptoms. In the emphysema group III, however, a significant delay in hospitalization occurred. Twenty-nine of the 50 patients (58 per cent) were admitted between the second and 22nd day after symptoms developed, and one-half of them exhibited signs of tension pneumothorax. In a number of instances, these emphysematous patients had been observed periodically in the clinic because of a minimal degree of collapse (10-30 per cent). However, a sudden progression of the pneumothorax resulted in acute respiratory distress because of marked diminution in pulmonary reserve.
UNILATERAL OR BILATERAL PNEUMOTHORAX

Unilateral pneumothorax occurred in 220 instances (98 per cent), and bilateral collapse was detected in four others (2 per cent). In the unilateral cases, the right lung was involved 128 times, and the left lung 92 times. The estimated degree of collapse exceeded 50 per cent in 128 patients and was less than 50 per cent in 69. The degree of pneumothorax in the four patients with bilateral collapse ranged from 10 to 40 per cent on the right side, and 15 to 60 per cent on the left side. Pleural adhesions noted on the admission chest x-ray of 69 patients (31 per cent) probably prevented further deflation of the involved lung.

TENSION PNEUMOTHORAX AND HEMOPNEUMOTHORAX

Clinical or roentgenographic evidence of mediastinal shift was present in 68 patients of the series (30 per cent), and 35 of them (15 per cent) proved to have a significant degree of tension pneumothorax. Intrapleural pressures were recorded in 20 cases, and the values ranged from plus 10 to plus 25 cm. of water.

Four patients had massive hemopneumothorax upon admission to the ward (1.7 per cent), and in addition, one of them was found to have high intrapleural pressure. Pleural fluid in a quantity sufficient to opacify the costophrenic sulcus on x-ray examination was also encountered in 100 patients (45 per cent).

I. INITIAL PNEUMOTHORAX: METHODS OF MANAGEMENT EMPLOYED IN 138 PATIENTS

A. Observation. Eighty-two patients (60 per cent) representing all groups in the series were managed by bed rest and observation in the hospital. The period of observation ranged from three to 53 days, with a mean of 21 days. In most cases, expansion of the collapsed lung took place during this period. Thoracenteses were performed in 29 of these patients to ascertain the intrapleural pressure or to remove free air and hasten expansion.

Forty-one patients were young, otherwise healthy adults (Group I) who could have been followed in the outpatient clinic during the expansion phase, provided they were closely followed.

B. Closed Thoracotomy. Institution of closed drainage of the pleural space by means of an intercostal catheter was carried out in 50 patients (36 per cent). Of this number, 25 were included in Group I, six in Group II, 16 in Group III, and four in Group IV. This procedure resulted in expansion of the collapsed lung during an average of eight days and was not followed by complications referable to the intrapleural catheter. A single tube was sufficient in 27 patients, but from two to six separate catheter installations were necessary to obtain complete expansion in the other 23 cases.

C. Intrapleural Instillation of Aqueous Silver Nitrate. Instillation of 0.5 cc. of 10

<table>
<thead>
<tr>
<th>Group</th>
<th>Hours</th>
<th>Days</th>
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<tbody>
<tr>
<td>I</td>
<td>0-12</td>
<td>0-14</td>
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<tr>
<td>II</td>
<td>13-24</td>
<td>15-21</td>
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<tr>
<td>III</td>
<td>2</td>
<td>22+</td>
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<td>IV</td>
<td>4</td>
<td>3</td>
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<td>(21)</td>
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<td>(46)</td>
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<td>(50)</td>
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<td>(7)</td>
<td>1</td>
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### Table 6
Duration of pneumothorax prior to treatment (based on a total of 224 hospital admissions).
per cent silver nitrate solution diluted in 10-20 cc. of water through an intercostal catheter was carried out in two patients. This was done in an effort to obtain pleural symphysis. One of the patients expired four days later secondary to severe pulmonary emphysema and cor pulmonale. At the time of death, the involved lung was not fully expanded. The other patient developed an empyema one week after the instillation of silver nitrate. This complication was successfully managed by rib resection and open drainage, and the patient was discharged 30 days later with complete lung expansion.

D. Open Thoracotomy and Decortication. In a single patient of Group IV, a pre-existing staphylococcal pneumonia was complicated by the development of pneumothorax. Following a period of closed pleural drainage, open thoracotomy and decortication were performed because of incomplete pulmonary expansion. Postoperatively, the patient developed a bronchopleural fistula which was managed by closed tube drainage. She was discharged to the clinic after 75 days of hospitalization with the lung fully expanded.

E. The Management of Hemopneumothorax. Three of the four patients with hemopneumothorax were included in the group of cases presenting with an initial pneumothorax. All were young men (25 to 28 years of age) previously in good health, who sought admission to the hospital because of severe, pleuritic chest pain. Two, who were included in Group I, demonstrated air-fluid levels on admission chest roentgenograms. Immediate institution of closed pleural drainage and administration of whole blood resulted in prompt clinical improvement in each case. Bleeding ceased within 12 hours and was coincident with complete lung expansion. The intercostal catheters were removed after five days, and both patients were discharged from the hospital two days later.

The third patient (Group II) had a tension hemopneumothorax. Intrapleural hemorrhage continued during 12 hours of closed pleural drainage and required 7.0 liters of blood replacement. Exploratory thoracotomy was performed at this time, and a bleeding vessel was discovered in the remnant of a torn apical adhesion. A small, ruptured apical bleb was also noted, necessitating a wedge resection of the apical segment. The postoperative course of the patient was uneventful, and he was discharged 11 days following hospital admission with the lung fully expanded.

F. Mortality. There were eight deaths (6 per cent) in the group of 138 patients admitted to the hospital with an initial episode of spontaneous pneumothorax. All of the fatalities occurred in patients with pulmonary emphysema (Group III), and in six cases, death was a direct result of pulmonary insufficiency and cor pulmonale. The terminal event took place from four to 29 days after admission, and a bronchopleural fistula was demonstrated in each patient at postmortem examination. In the two remaining cases, the terminal event was precipitated by extrapulmonary factors. Massive hemorrhage from a duodenal ulcer occurred in one patient, and the second succumbed to chronic lymphatic leukemia.

G. Follow-Up Data. One hundred and thirty patients (94 per cent) survived an initial episode of spontaneous pneumothorax, and were discharged from the hospital in satisfactory condition. Because of the indigent economic status and migratory habits of many of these individuals, the results of follow-up examinations were available in only 59 cases (45 per cent). This extended over a period of six months to three years. There was no instance of recurrent pneumothorax among these patients; however, the duration of time is too short and percentage of follow-up too low to be of statistical value relative to the method of therapy employed.

In other series of pneumothorax cases, similar difficulties were encountered in obtaining adequate follow-up information. However, if we assume that the average interval between the initial pneumothorax and subsequent episodes is 23-36 months,
(as noted by two groups of investigators), suitable follow-up data would reveal a significant number of recurrences.144

II. Recurrent Pneumothorax: Methods of Management Employed in 61 Patients During 86 Hospital Admissions

A. Observation. Expectant therapy in the hospital was the principal method of management in 35 patients (41 per cent). The duration of hospitalization ranged from six to 26 days with a mean of 18 days. Twenty-three patients were included in Group I. In nine of the 35 cases, subpleural blebs were detected on the admission chest roentgenograms. The final three patients had generalized obstructive emphysema (Group II).

B. Closed Thoracotomy. Closed drainage of the pleural space was established in a total of 27 cases (31 per cent), and included patients classified in Groups I, II, and III. Complete lung expansion was accomplished in an average overall of 12 days.

Ten emphysematous patients (Group III) required a change of catheter position on more than two occasions to permit evacuation of loculated pockets of air. Considered separately, the mean duration of hospitalization in these ten cases was 20 days.

Subpleural blebs were noted on the x-ray films in 11 of the 27 cases (Group II), while the final six patients had otherwise normal roentgenograms (Group I). Complete expansion of the involved lung was attained in these 17 cases (Groups I and II) during an average period of eight days and there was no complication attributable to the intercostal catheter.

C. Intrapleural Instillation of 10 per cent Silver Nitrate Solution. Instillation of silver nitrate through an intercostal catheter attached to a closed drainage system was performed in 11 patients (13 per cent). Total lung expansion was accomplished in nine of them during an average of 13 days, and was incomplete in two others. In these latter two patients, inadequate evacuation of the accumulated (induced) pleural effusion prevented pleural symphysis. Of these 11 cases, four were classified in Group III (emphysema), three in Group II (blebs), and four in Group I (idiopathic).

D. Resection or Decortication. Twelve patients (14 per cent) who presented history of two to six recurrent episodes of ipsilateral pneumothorax were subjected to exploratory thoracotomy. In all instances, more conservative methods of management had been tried in the past. Seven of the 12 patients (Group II) were explored after unsuccessful periods of closed pleural drainage, and ruptured apical blebs were discovered and resected. The postoperative course was uneventful in each instance, and all were discharged from the hospital within 14 days.

Four patients with emphysema of the bullous type (Group III) also required surgical resection. Preliminary closed pleural drainage was instituted in all of them prior to exploratory thoracotomy, but failed to produce lung expansion. Identification of an open bronchial fistula was possible in three patients, and wedge resection of the apical bulla was followed by rapid lung expansion. Decortication of an underlying emphysematous lung was attempted unsuccessfully in the fourth patient, who had a trapped lung of two years' duration. Pneumonectomy was necessary in this case.

The final patient (Group I) was admitted with pneumothorax of four months duration. A successful decortication and apical thoracoplasty were performed after 48 hours of closed drainage, and the patient was discharged on the 14th postoperative day.

Follow-up data were available in all 12 cases for periods ranging from one to three and one-half years postoperatively. All had remained in good health.

E. Hemopneumothorax. One 35-year-old man (Group I), who had experienced two previous episodes of spontaneous pneu-
mothorax, was admitted to the hospital with tension hemopneumothorax. Closed thoracotomy was performed immediately after admission with evacuation of 2500 cc. of blood. Rapid expansion of the lung took place and was associated with cessation of intrapleural hemorrhage. The intercostal catheter was removed on the fifth hospital day and he was discharged on the ninth day after admission. He was well two years later.

F. Death Following Recurrent Pneumothorax. There were three deaths (3.5 per cent) in the recurrent series of cases and, once again, all occurred in patients with pulmonary emphysema (Group III). Two of these patients were admitted to the hospital with clinical evidence of tension pneumothorax, and although immediate pleural decompression was instituted, they expired six days later. The deaths were secondary to extensive pulmonary fibrosis and cor pulmonale. The third emphysematous patient committed suicide one week after pleural symphysis had been achieved utilizing intrapleural silver nitrate.

G. Follow-Up Data. Forty-one of 61 patients (70 per cent) returned to the clinic for examination subsequent to hospital discharge. All were in good health for periods ranging from six months to three and one-half years. This interval was considered inadequate to permit a valid analysis of the methods of management employed.

DISCUSSION

From analysis of this group of patients, one may readily see that the figures for age, sex, race, proportion of cases with tension pneumothorax, etc., do not differ markedly from those of other major series. We have been in a position to evaluate a variety of therapeutic methods, and, based on the type and presence of underlying pulmonary disease, have been able to evolve a definite and logical plan of treatment for the given case.

INITIAL PNEUMOTHORAX

GROUPS I AND II ("IDIOPATHIC" OR VISIBLE BLESSES):

These two groups, which some authors\textsuperscript{1,2,6} would consider identical in etiology, contain the majority of cases (the young, otherwise healthy adult). They have a uniformly good prognosis, with any form of treatment, unless tension pneumothorax is present. In the past, many such patients were tested in the hospital expectantly with considerable loss of time. The average length of time for complete lung expansion by this method in our series was 21 days. Leach\textsuperscript{4} found those with under 50 per cent collapse required 19 days, while those over 50 per cent needed 48 days to complete re-expansion. The mean time for lung re-expansion without treatment reported by Briggs\textsuperscript{7} and by Hyde\textsuperscript{8} was 34 days. Kircher and Swartzel\textsuperscript{9} obtained daily x-ray films in 16 patients and noted a rate of re-expansion of 1.25 per cent per day. We have not found it possible to correlate time required for re-expansion with the degree of pneumothorax present.

The principal argument for a program of treatment that is more aggressive than simple rest and observation is the duration of treatment and its consequent economic ramifications. In our experience, intubation of a pneumothorax of over 20 per cent in Groups I and II can be expected to produce complete re-expansion in approximately eight days. In actual fact, the lung has come out in much less time, but during the period covered it was the practice to leave the thoracostomy tube in situ for three to four days after re-expansion to promote local pleuritis and consequent adhesion formation. Thus, by intubation, we can reduce the time to complete lung re-expansion by two-thirds. In the young working population represented by Groups I and II, this has obvious economic advantage for the patient. Other authors\textsuperscript{14} have had similar satisfaction in observing re-expansion times of 3.0 and 3.4 days following intubation. More than one tube may be required in slightly less than half the cases,
but the risk of complication from the intubation itself is negligible.

A small percentage of patients within these two groups will have continued air leaks or otherwise demonstrate failure of complete expansion on intercostal drainage beyond three to four days. These cases among the young and vigorous should undergo exploratory thoracotomy. This is especially true of Group II patients (visible blebs), which, as we have shown (Table 2), is a prominent group among the recurrent pneumothoraces. In them, if full lung expansion with cessation of air leak is not achieved in 24-48 hours, thoracotomy should be recommended.

Minor collapse (under 20 per cent) may, if one is dealing with an intelligent, cooperative patient, be followed on an outpatient basis. This method should only be used, however, after a period of hospital observation for two or three days, during which time the pneumothorax has been shown to be stable radiologically.

GROUP III (BULLOUS AND/OR OBSTRUCTIVE EMPHYSEMA)

All the deaths in our series occurred in this group of 30 patients with initial pneumothorax. Some were hospitalized as acute emergencies after insidious onset of symptoms. Others were followed in clinic because of minor degrees of collapse, only to require sudden emergency admission when more significant degrees of collapse or tension developed.

The high mortality rate here may be due to the patients' small margin of reserve and, therefore, poor tolerance of even a small pneumothorax. On the other hand, the occurrence of a pneumothorax in a patient with major emphysematous disease may just represent an ominous sign of progression of the underlying pathology. Further investigation of this aspect of the problem is needed.

Because of the poor tolerance to pneumothorax, we recommend an early use of intercostal catheter drainage for rapid re-expansion of functioning lung tissue. The time for re-expansion in this group of cases is prolonged (even with catheter drainage) because of the poor healing qualities of leaking emphysematous lung. For this reason, patients with emphysema, especially those with giant bullae, should be considered for thoracotomy if their problem is not resolved by intubation within a few days. Treatment of the emphysematous patient should also include the use of bronchodilators, intermittent positive pressure respiration, and antibiotics.

GROUP IV. (INFLAMMATORY AND NEOPLASTIC DISEASE)

This group of patients is too small and diverse to draw any specific conclusion. However, it includes one case that deserves some explanation. The patient was a ten-year-old girl whose pneumothorax developed during the pneumatocele stage of staphylococcal pneumonia. Since her hospital course was not unlike that of an adult suffering from pneumothorax secondary to rupture of a giant bulla, she was incorporated in the study.

TENSION PNEUMOTHORAX AND HEMOPNEUMOTHORAX

It is our feeling that tension pneumothorax should be treated by immediate intercostal intubation. The presence of intrapleural tension can be assumed when the following are found: excessive dyspnea, cyanosis, tracheal deviation, air-hunger, apprehension, supraclavicular or intercostal retraction, mediastinal deviation by x-ray examination, or positive intrapleural pressure readings. In most instances, the diagnosis can be assessed on a clinical basis without the use of a manometer.

We, as well as others, have noted that treatment by simple thoracentesis does not hasten re-expansion beyond that obtained by observation alone. Although prompt relief may be obtained by needle aspiration of the pleural space, there is considerable hazard of recurrence in a matter of hours. Therefore, an intercostal catheter should be used from the onset.
Hemopneumothorax, which in addition to systemic hypotension may produce tension symptoms, should certainly be treated by immediate catheter drainage along with blood volume replacement. Hemorrhage usually ceases spontaneously after intubation, and prompt evacuation of blood will avert future fibrothorax. In addition, the physician is provided with a means of following blood loss and estimating the degree of air leak. Clotting of the hemothorax, continued bleeding, or prolonged leakage of air should be treated by thoracotomy, evacuation of clot, and appropriate suturing.

**Recurrent Pneumothorax**

It has been reported that the probability of recurrence of pneumothorax is in the range of 10 to 30 per cent, and that the average interval between episodes is 23 to 36 months. In this series, 30 per cent were recurrent cases. Unfortunately, the quantity of follow-up information was inadequate to determine the effectiveness of treatment in the initial episodes, or to evaluate the relapse rate in the untreated cases. Nevertheless, it has been demonstrated that a more aggressive approach to treatment is indicated in all groups of patients.

**Groups I and II**

Twenty-seven patients with recurrent pneumothorax were treated by "observation," and 32 others were effectively managed by the institution of intercostal drainage. Eight patients required surgical exploration because of a failure of lung re-expansion after closed thoracostomy. All did well. In seven additional cases, silver nitrate pleurodesis was utilized with complete success.

The 47 patients treated aggressively were re-expanded and discharged within 14 days; those treated by observation alone languished in the hospital for three weeks or more.

It is our feeling that the young and otherwise healthy patient with a recurrent pneumothorax should be managed as follows:

1. An exploratory thoracotomy should be carried out if pulmonary re-expansion does not occur within three to four days after institution of therapy.

2. In patients with blebs visible by x-ray, surgical exploration should be advised on the occasion of the first recurrence.

3. An exploratory thoracotomy should be advised in "idiopathic" cases after a second significant recurrence; however, silver nitrate pleurodesis may be of value in patients who experience three or more minor (less than 20 per cent) pneumothoraces.

4. Patients with roentgenologic evidence of a peel on the lung surface should be treated by exploratory thoracotomy and decortication.

**Group III**

The management of emphysematous patients consists of intercostal tube drainage even for a minimal degree of pneumothorax. If at all possible, surgical exploration with resection of the offending bullae or blebs should be carried out after an appropriate interval of stabilization and an estimation of pulmonary function. Those patients who are too ill for thoracotomy and cannot be re-expanded with an intercostal tube present a problem in therapy for which we have no definite answer. Some cases may occasionally respond to silver nitrate pleurodesis. We do not advocate routine use of silver nitrate (or gentian violet, hypertonic glucose, talc, etc.) in emphysema cases, but as a "last ditch" resort it has occasionally been successful.

**Tension and Hemopneumothorax**

Following tube decompression of the tension pneumothorax, definitive treatment may follow the patterns outlined above. Recurrent hemopneumothorax is very rare, since the blood itself produces an adhesive pleurisy. Our single patient with hemopneumothorax in the recurrent group had two previous ipsilateral collapses without bleeding. He was treated effectively by
Summary

1. An analysis of 247 cases of spontaneous pneumothorax was undertaken in an effort to evaluate etiology, pathogenesis, and methods of management.

2. Forty-eight patients (19.5 per cent) were found to have active pulmonary tuberculosis and were excluded from further study.

3. The etiology of the pneumothorax in 199 patients was considered to be as follows:
   - No lung disease evident, 110, bleb formation present, 37, bullous or obstructive emphysema, 45, and pulmonary inflammation or neoplasma, 7 patients.

4. Particular emphasis is placed on the role of the underlying pathology in determining the treatment of choice.

5. Cardiopulmonary disease (emphysema, pulmonary fibrosis, and cor pulmonale) complicating pneumothorax were the major factors contributing to the 11 deaths (5.5 per cent) in this series.

Resumen

1. Se emprendió un análisis de 247 casos de neumotórax espontáneo en un esfuerzo de valuar su etiología, patogenia y los métodos de tratamiento.

2. En 48 enfermos (19.5 por ciento) se encontró que había tuberculosis pulmonar activa y fueron excluidos para otro estudio.

3. La etiología del neumotórax, en 199 pacientes, fue considerada como sigue: sin ninguna enfermedad pulmonar (110); presencia de formación de ampolla (37); enfisema buloso u obstructivo (45); inflamación pulmonar o neoplasia (7).

4. Se hace especial énfasis en el papel de la patología subyacente para determinar el tratamiento de elección.

5. Las enfermedades cardiopulmonares (enfisema, fibrosis pulmonar y cor pulmonale) que complican el neumotórax fueron los mayores factores que contribuyeron a las 11 muertes (5.5 por ciento) en estas series.