The Place of Pulmonary Resection in the Treatment of Tuberculosis

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Introduction

Within the space of the past few years, pulmonary resection has been accepted as an essential part of any well coordinated therapeutic program in the treatment of pulmonary tuberculosis. The important problem remaining to be solved is the establishment of the proper indications for resection.

The application of any surgical procedure in the treatment of tuberculosis should be based on the safety of the operative procedure and its effectiveness in controlling the disease. Thus, the place of pulmonary resection in the plan of therapy of the tuberculous patient can be determined best by a careful evaluation of two factors: (1) the risk of the operative procedure itself, and (2) the late follow-up of patients who have been subjected to resection. The analysis of these two factors represents the main purpose of the paper.

The risk of resection should be interpreted in the light of present day statistics which have resulted from the application of modern surgical and anesthetic techniques and the use of the protective antibiotics. The administration of streptomycin alone has changed the picture so much that the statistics of even four or five years ago must be recognized as being of only historical interest. The late follow-up will help to determine the effectiveness of resection in controlling the disease and to evaluate how well these patients have withstood the test of time.

Definition of Terms

In the discussion and tables to follow, the postoperative period will indicate the first 60 days following operation; the late period will indicate any time following these 60 days. The pre-strepto-
mycin era extends from 1934, when the first case was done, to January 1, 1947 when streptomycin became available. The streptomycin era extends from January 1, 1947 to January 1, 1950.

A negative sputum in this report means that the patient is considered to be consistently negative by the physician or institution now caring for him. Because of the wide geographical distribution of these patients, it has been impossible to secure a standard bacteriological examination of the sputum.

Outline of Paper

When possible, the tables and graphs will be self-explanatory. Additional comment will accompany them only when needed to clarify or enlarge on the subject matter and will be located either beneath or on the page opposite the chart. Excessive detail will be omitted intentionally, since the purpose of this paper is to give the overall picture of the resection series without special emphasis on any one phase of the problem.

Scope of Paper

This study represents a careful analysis of 426 tuberculous patients subjected to 437 pulmonary resections between 1934 and January 1, 1950 (11 patients had a second resection). All except two of the living patients have been followed and their present condition evaluated. The following points of special interest shall be emphasized:

(1) Outline of Indications
   a. Associated suppuration
   b. Thoracoplasty failure
   c. Predicted thoracoplasty failure
   d. Preservation of function
   e. Elected as operation of choice.

(2) Comparison of Results in Pre- and Post-Streptomycin Era
   a. Lobectomy
   b. Pneumonectomy
   c. Segmental resection.

(3) Analysis of Present Day Risk of Resection
   a. Lobectomy
   b. Pneumonectomy
   c. Segmental resection.


(5) Late Follow-up of Patients
   a. Pre-streptomycin era — 3 years to 16 years
   b. Post-streptomycin era — 6 months to 3 years.
General Statistics

PULMONARY RESECTION FOR TUBERCULOSIS

1934 to January 1, 1950

Total Resections — 437
Total Patients — 426 (11 patients had 2nd resection)

Operations:

<table>
<thead>
<tr>
<th></th>
<th>Pneumonectomy</th>
<th>Lobectomy</th>
<th>Segmental Resection</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1934 - Jan. 1, '47 Pre-Strep. Era</td>
<td>152</td>
<td>72</td>
<td>5</td>
<td>229</td>
</tr>
<tr>
<td>Jan. 1, '47 - Jan. 1, '50 Streptomycin Era</td>
<td>137</td>
<td>47</td>
<td>24</td>
<td>208</td>
</tr>
<tr>
<td>TOTAL</td>
<td>289</td>
<td>119</td>
<td>29</td>
<td>437</td>
</tr>
</tbody>
</table>

Endobronchial Tuberculosis:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Submucosal</td>
<td>18 (8)</td>
<td>20 (10)</td>
<td>38 (9)</td>
</tr>
<tr>
<td>Ulcerative</td>
<td>8 (3)</td>
<td>13 (6)</td>
<td>21 (5)</td>
</tr>
<tr>
<td>Ulcero-stenosis</td>
<td>18 (8)</td>
<td>14 (6)</td>
<td>32 (7)</td>
</tr>
<tr>
<td>Fibro-stenosis</td>
<td>40 (17)</td>
<td>31 (15)</td>
<td>71 (17)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>84 (37)</td>
<td>78 (37)</td>
<td>162 (37)</td>
</tr>
</tbody>
</table>

Sex:

<table>
<thead>
<tr>
<th></th>
<th>No.</th>
<th>Sputum:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>289</td>
<td>Positive</td>
</tr>
<tr>
<td>Male</td>
<td>137</td>
<td>Negative</td>
</tr>
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</table>

Age of Patients:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3 years</td>
<td>1</td>
<td>Under 1 year</td>
</tr>
<tr>
<td>8 years</td>
<td>1</td>
<td>1 to 5 years</td>
</tr>
<tr>
<td>15 to 20 years</td>
<td>21</td>
<td>5 to 10 years</td>
</tr>
<tr>
<td>20 to 40 years</td>
<td>317</td>
<td>10 to 15 years</td>
</tr>
<tr>
<td>40 to 55 years</td>
<td>81</td>
<td>Over 15 years</td>
</tr>
<tr>
<td>Over 55 years</td>
<td>16</td>
<td>Survey Lesion</td>
</tr>
</tbody>
</table>

Ipsilateral Lung:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) No Previous Collapse Therapy</td>
<td>158 (36)</td>
<td>Pneumonothorax</td>
</tr>
<tr>
<td>(b) Previous Collapse Therapy</td>
<td>278 (64)</td>
<td>Phrenic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thoracoplasty</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Revision Thoracoplasty</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lobectomy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extrapleural Plombage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cavernostomy</td>
</tr>
</tbody>
</table>

Contralateral Lung:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Contralateral Disease</td>
<td>183 (42)</td>
<td>Pneumonothorax</td>
</tr>
<tr>
<td>(b) Previous Collapse Therapy</td>
<td>34 (8)</td>
<td>Phrenic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extrapleural Pneumothorax</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thoracoplasty</td>
</tr>
</tbody>
</table>
General Statistics

Comment

1. Operations:
   
   Note the increased use of segmental resection during the streptomycin era. This is a reflection to some extent of the increased experience with this procedure gained in treating other conditions, especially bronchiectasis, but also represents an actual widening of the indication for its use in the treatment of tuberculosis.

2. Sputum:
   
   The 61 negative sputa occurred in the following groups of patients:
   
   1) Tuberculoma.
   2) Bronchiectasis remaining after control of tuberculosis.
   3) Non-expandable lungs with bronchial stenosis and/or empyema.
   4) Mistaken pre-operative diagnosis.
   5) Survey lesions with inadequate sputum studies.

3. Duration of Disease:
   
   As would be expected, the majority (49 per cent) of patients had been ill for one to five years. However, 32 per cent had been ill for more than five years and 14 per cent for more than 10 years.

4. Ipsilateral Lung:
   
   Note that 64 per cent of the cases represent failures to one or more collapse therapy procedures.

5. Contralateral Lung:
   
   Forty-two per cent of the patients had definite contralateral disease (excluding calcified foci) and 8 per cent had had collapse therapy. Many of these had previously had extensive contralateral disease that had undergone resolution. Although most of the contralateral lesions were considered to be stable at the time of operation, a few were definitely active.

6. Endobronchial Disease:
   
   In view of the preferential effect of streptomycin on bronchial tuberculosis, it is of interest to note that the incidence of tuberculous bronchitis is exactly the same in the pre-streptomycin and the post-streptomycin eras. Even more surprising is the fact that there has been no essential change in the distribution of submucosal, ulcerative and fibrotic lesions.
RESECTION FOR PULMONARY TUBERCULOSIS

GENERAL INDICATIONS
1. Associated Suppurative Disease.
2. Thoracoplasty Failure.
3. Predicted Thoracoplasty Failure.
5. Elected as Operation of Choice.

SPECIFIC INDICATIONS
437 Resections
1934 to January 1, 1950.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Strep. Eras</th>
<th>Strep. Eras</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Associated Suppurative Disease</td>
<td>20 (9)</td>
<td>14 (7)</td>
<td>34 (8)</td>
</tr>
<tr>
<td>2. Thoracoplasty Failure</td>
<td>38 (17)</td>
<td>57 (27)</td>
<td>95 (22)</td>
</tr>
<tr>
<td>3. Extensive Unilateral Disease</td>
<td>113 (49)</td>
<td>86 (41)</td>
<td>199 (45)</td>
</tr>
<tr>
<td>4. Upper Lobe Disease</td>
<td>30 (13)</td>
<td>24 (11)</td>
<td>54 (12)</td>
</tr>
<tr>
<td>5. Basal Disease</td>
<td>19 (8)</td>
<td>18 (9)</td>
<td>37 (9)</td>
</tr>
<tr>
<td>6. Tuberculoma</td>
<td>7 (3)</td>
<td>9 (4)</td>
<td>16 (4)</td>
</tr>
<tr>
<td>7. Bilateral Giant Cavities</td>
<td>2 (1)</td>
<td>0</td>
<td>2 (0.5)</td>
</tr>
</tbody>
</table>

Comment
It is impossible to list in a categorical fashion the indications for resection since each case must be considered as an individual problem. However, the general indications listed in the table above represent the five criteria used in the Overholt Clinic in accepting patients for resection.

Associated Suppurative Disease:
This is a generally accepted indication for resection and requires no comment.

Thoracoplasty Failure:
(a) Adequate Thoracoplasty
When cavity and positive sputum persist under adequate thoracoplasty collapse, resection has become the procedure of choice unless the respiratory reserve will not permit it. In such cases, cavernostomy and extrapleural procedures are resorted to.

(b) Inadequate Thoracoplasty
When the thoracoplasty collapse is inadequate, revision thoracoplasty or resection can be used. If the residual cavity is large and the chance of failure of revision thoracoplasty is considered
great, resection is the procedure of choice in our clinic. Revision thoracoplasty is reserved for those cases with small residual cavities under a grossly inadequate thoracoplasty.

**Predicted Thoracoplasty Failure:**

This refers to a group of cases in which thoracoplasty is either contraindicated or offers less chance of control of the disease than a resection, e.g., tuberculoma, associated suppuration, high grade bronchial stenosis, cavities distributed in both upper and basal portions of lung, basal disease, and giant cavities.

**Preservation of Function:**

At times, resection can be applied with the preservation of more lung tissue and function than when thoracoplasty is used. This is especially true now since it has been demonstrated that segmental resection can be performed in well selected cases with a high degree of safety. The following types of cases fall into this category:

1) Segmental resection of certain types of disease limited largely to one segment.
2) Lobectomy in cases where an open cavity remains in a contracted lobe under pneumothorax.
3) Lobectomy and decortication in preference to extensive thoracoplasty in cases with residual cavity and non-expandable lung.
4) Lower lobectomy in preference to extensive thoracoplasty in uncontrolled lower lobe disease.

**Elected as Operation of Choice:**

As will be shown later, the mortality and morbidity statistics for lobectomy during the streptomycin era approximate those of thoracoplasty. As a result, the indications for lobectomy are gradually extending. It is frequently used now in preference to thoracoplasty in well selected cases such as those with dense, opaque residual infiltration remaining after treatment with bed rest and antibiotics, those with large to giant-sized cavities, and those with cavities in the superior segment of the lower lobe. In recent months, segmental resection has been used deliberately in many cases who could have been treated by other collapse therapy measures. Present day results justify this approach in well selected cases.

Resection is used more frequently in preference to revision thoracoplasty than it was a few years ago. Extrapleural pneumonectomy as described by Sarot is now considered the procedure of choice in the treatment of cases of empyema with active parenchymal disease.
**Lobectomy**

<table>
<thead>
<tr>
<th>Infectious Complications</th>
<th>Pre-Strep Era</th>
<th>Strep Era</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empyema</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>Fistula</td>
<td>8%</td>
<td>0%</td>
</tr>
<tr>
<td>Contralateral Spr.</td>
<td>9.7%</td>
<td>0%</td>
</tr>
<tr>
<td>Ipsilateral Spr.</td>
<td>7%</td>
<td>0%</td>
</tr>
<tr>
<td>Contralateral Exac.</td>
<td>11.1%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Fistula</td>
<td>22.3%</td>
<td>21%</td>
</tr>
<tr>
<td>Stump Ulcer</td>
<td>7%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Tbc Wound Inf.</td>
<td>9.7%</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Pneumonectomy**

<table>
<thead>
<tr>
<th>Infectious Complications</th>
<th>Pre-Strep Era, 152 Cases</th>
<th>Strep Era, 137 Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empyema</td>
<td>16%</td>
<td>7.2%</td>
</tr>
<tr>
<td>Fistula</td>
<td>9.5%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Contralateral Spr.</td>
<td>16.4%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Contralateral Exac.</td>
<td>23.5%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Stump Ulcer</td>
<td>15.7%</td>
<td>7.2%</td>
</tr>
<tr>
<td>Tbc Wound Inf.</td>
<td>12.6%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Tbc of Chest Wall</td>
<td>5.0%</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

**Segmental Res.**

<table>
<thead>
<tr>
<th>Infectious Complications</th>
<th>Pre-Strep Era, 5 Cases</th>
<th>Strep, 24 Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empyema</td>
<td>20%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Fistula</td>
<td>40%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Contralateral Spr.</td>
<td>20%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Contralateral Exac.</td>
<td>20%</td>
<td>8.2%</td>
</tr>
<tr>
<td>Ipsilateral Spr.</td>
<td>20%</td>
<td>0%</td>
</tr>
<tr>
<td>Ipsilateral Exac.</td>
<td>20%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Tbc Wound Inf.</td>
<td>0%</td>
<td>4.1%</td>
</tr>
</tbody>
</table>

**Figure 1**
Specific Indications:

The specific indications in the 437 cases are listed in the second portion of the above table. Associated suppuration, thoracoplasty failure, basal disease and tuberculoma are well accepted indications for resection in most clinics and represent 43 per cent of the 437 cases. In addition, a high percentage of those with extensive unilateral disease had either associated bronchial stenosis or basal cavities. However, some of this group and the majority of those resected for upper lobe disease could have been treated by thoracoplasty, but resection was elected as the procedure of choice.

Infectious Complications

Lobectomy

Pre-Streptomycin Era:

Eighteen per cent of this group had tuberculous complications in the postoperative period. Empyema and fistula were entirely a postoperative complication, whereas a high percentage of the spreads and exacerbations occurred late.

Streptomycin Era:

Only 2.1 per cent of this group had tuberculous complications in the post-operative period.

Note that tuberculous empyema, fistula, contralateral spreads, ipsilateral spreads and wound infections have been eliminated in the streptomycin period.

There has been no change in the incidence of contralateral exacerbation. In fact, in view of the shorter follow-up period, there may be an actual increase. This may be the result of too much faith in streptomycin and performing lobectomy in the face of an active or recently active contralateral focus.

The marked reduction in the incidence of ipsilateral exacerbation is probably real in spite of the difference in follow-up periods since most of these have become manifest in the first two years.

The incidence of stump ulcer has not undergone any significant change.

Pneumonectomy

Pre-Streptomycin Era:

Thirty-one per cent of this group had tuberculous complications in the postoperative period. Empyema, fistula, and contralateral spread occurred predominantly in the postoperative period. Contralateral exacerbation, stump ulcer and wound infection were more common as late complications. Tuberculosis of the chest

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wall refers to infection discovered at the time of post-resection thoracoplasty which had produced no signs or symptoms.

The only tuberculous infections not in the chart were three contralateral pleural effusions and two cases of miliary tuberculosis.

**Streptomycin Era:**

Only 6.5 per cent of this group had tuberculous complications in the postoperative period. The marked reduction in all complications is evident. The late complications cannot be compared directly, as the follow-up time is so different in the two groups. However, they probably are of real significance, since most of the late complications occur during the first 12 to 24 months.

(Seven non-tuberculous empyemas occurred in the pre-streptomycin era and two in the streptomycin era.)

**Segmental Resection**

**Pre-Streptomycin Era:**

This group is so small that it is not of significance statistically. All the tuberculous complications occurred in one patient. One patient had a temporary fistula associated with a non-tuberculous empyema. One other patient had a non-tuberculous empyema that responded to penicillin and did not require drainage. There have been no late complications in this group. All five of these patients are living and well and have a negative sputum.

**Streptomycin Era:**

Only one patient of the 24 had a tuberculous complication in the postoperative period (fistula and empyema). In the late period there have been one contralateral spread, two contralateral exacerbations, one ipsilateral exacerbation and one wound infection.

There have been no deaths in this group due to tuberculosis. One patient died of a pulmonary embolism. Of the remaining 23 living patients, 21 are well and have negative sputa.

Experience is already demonstrating that the complications of segmental resection depend on the type of case in which it is used. As this procedure is extended in an attempt to salvage cases with bilateral cavities and extensive disease, the complications and deaths can be expected to increase.

**Risk of Operation**

This graph portrays the risk of the operative procedure separately and also a summary of the statistics for the entire group. The statistical risk of the pre-streptomycin era is given on the left side of the chart. These are of historical interest only and are
presented primarily to serve as a comparison with the statistics of the streptomycin era on the right side of the chart. The figures for the streptomycin era are of real significance since they represent the experience with modern techniques and the use of antibiotics. They should serve as the basis for estimating the risk of operation at the present time.

Comment on Pre-Streptomycin Series:

Sixty-one per cent were carried through the 60-day postoperative period without any type of complication and 73 per cent

<table>
<thead>
<tr>
<th>Risk of Operation</th>
<th>by %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lobectomy</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Pre-Strep</strong></td>
<td>72 cases</td>
</tr>
<tr>
<td>28</td>
<td>Total P.O. Comp</td>
</tr>
<tr>
<td>18</td>
<td>Tb. P.O. Comp</td>
</tr>
<tr>
<td>4.1</td>
<td>Tb. P.O. Deaths</td>
</tr>
<tr>
<td>2.0</td>
<td>Non Tb. P.O. Deaths</td>
</tr>
<tr>
<td>6.9</td>
<td>Total P.O. Death Rate</td>
</tr>
</tbody>
</table>

| **Pneumonectomy** |      |
| **Pre-Strep**     | 152 cases | **Strep Era** | 137 cases |
| 44                 | Total P.O. Comp | 21 |
| 31                 | Tb. P.O. Comp   | 6.5 |
| 7                  | Tb. P.O. Deaths | 0.7 |
| 8                  | Non Tb. P.O. Deaths | 5.1 |
| 15                 | Total P.O. Death Rate | 5.8 |

| **Segmental Resection** |      |
| **Pre-Strep**           | 5 cases | **Strep Era** | 24 cases |
| 60                    | Total P.O. Comp | 8.3 |
| 20                    | Tb. P.O. Comp   | 4.2 |
| 0                     | Tb. P.O. Deaths | 0 |
| 0                     | Non Tb. P.O. Deaths | 4.2 |
| 0                     | Total P.O. Death Rate | 4.2 |

| **Total Resections**   |      |
| **Pre-Strep**         | 229 cases | **Strep Era** | 208 cases |
| 39                    | Total P.O. Comp | 16 |
| 27                    | Tb. P.O. Comp   | 5.3 |
| 6                     | Tb. P.O. Deaths | 0.5 |
| 6                     | Non Tb. P.O. Deaths | 4.3 |
| 12                    | Total P.O. Death Rate | 4.8 |

**FIGURE 2**
without tuberculous complications. Half of the deaths were due to tuberculosis and half to non-tuberculous causes. Both tuberculous and non-tuberculous complications and deaths were more common in the pneumonectomy group. This merely reflects the fact that a more extensive operative procedure was performed on patients with more serious and advanced types of disease.

Although the segmental series is small and percentage of complications high, it is interesting to note that there were no deaths and that all five of these patients are well with a negative sputum at the present time.

Comment on Streptomycin Series:

Eighty-four per cent were carried through the postoperative period without complications of any kind and 94.7 per cent without tuberculous complications (pneumonectomy, 93.5 per cent; lobectomy, 98 per cent; segmental, 96 per cent). The marked reduction in the incidence of tuberculous complications and deaths is very important. In contrast to this, note that there has been no significant decrease in the percentage of deaths due to non-tuberculous causes. Operative shock, cardiovascular accidents, cardiopulmonary insufficiency and pulmonary embolism are now the outstanding causes of death. The total post-operative death rate for the group of 208 cases was 4.8 per cent. Non-tuberculous deaths accounted for 4.3 per cent and tuberculous deaths for 0.5 per cent. The only tuberculous death in the entire series occurred in a 51 year old woman who died of fistula, empyema and disseminated tuberculosis following left pneumonectomy. The one death in the lobectomy group was caused by a contralateral non-tuberculous pneumonia (autopsy). The death in the segmental group was due to pulmonary embolus (autopsy).

Results

Present Status of Patient Analyzed According to Operative Procedure:

This chart analyzes the fate of patients according to the operation employed. The charts are self-explanatory. Results are expressed in percentages. The following points bear emphasis:

Pneumonectomy Group:

The majority of the pneumonectomy patients fall either into the living and negative or dead columns. Only 6 per cent of the pre-streptomycin and 10 per cent of the streptomycin era are in the intermediate classifications.
RESULTS

PULM. RESECTION FOR TBC.

PRE-STREP ERA '34-JAN.1,'47

Post-op Deaths...... 28 (12.7%)
TBC...14
Non-TBC...14

Late Deaths...... 43 (19.5%)
TBC...35
Non-TBC...8

Living...... 149 (67.7%)

Living Neg.
Pos. Sput. and/or Unstable X-ray
Prog. Dis. or Resp. Cripple
No Follow-up

133
7 (4.7%)
7 (4.7%)
2 (1.3%)

Follow-up Period
3 yrs+...100%
5 yrs+...50%
8 yrs+...8%

PULM. RESECTION FOR TBC, 208 pts.
STREP ERA JAN.1,'47 - JAN.1,'50

Post-op Deaths...... 10 (4.8%)
TBC...1
Non-TBC...9

Late Deaths...... 6 (2.9%)
TBC...3
Non-TBC...3

Living...... 192 (92%)

Living Neg.
Pos. Sput. and/or Unstable X-ray
Prog. Dis. or Resp. Cripple
No Follow-up

171
14 (6.7%)
7 (3.4%)
0

Follow-up Period
6 mos+......100%
1 yr+......66%
2 yrs+......34%

Figure 3
**Lobectomy Group:**

The percentage of living and negative patients is not significantly greater than in the pneumonectomy group. This is somewhat surprising in view of the fact that lobectomy has been used as a rule in treating less extensive and less serious disease.

As compared with the pneumonectomy group, more of the lobectomy patients fall into the intermediate classifications and distinctly less in the dead column.

**Segmental Resections:**

This is a small group and represents a more selective series of patients. However, it is extremely interesting to note that of the entire 29 patients only one has died. This was caused by a pulmonary embolus. There have been no tuberculous deaths. All five of the pre-streptomycin series and 87.5 per cent of the streptomycin series are well with negative sputum.

**RESULTS**

**PULM. RESECTION FOR TBC.**

437 RES., ~ 426 PTS.
1934 - JAN. 1, 1950

<table>
<thead>
<tr>
<th>Post-Op Deaths, ...38 (8.9%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late Deaths, ...49 (11.5%)</td>
</tr>
<tr>
<td>Living, 339 (72.6%)</td>
</tr>
</tbody>
</table>

Living, Neg.
302, (89%)

Pos. Sput.
and/or
Unstable X-ray
21, (6%)

Prog. Dis. or
Resp. Cripple
14, (4%)

No Follow-Up
2, (0.6%)

**FIGURE 4**

Results

This chart presents the results and follow-up statistics of: (a) the 220 patients operated upon prior to 1947 (Pre-Streptomycin Era) and (b) the 208 patients operated upon since 1947 (Streptomycin Era). The incidence and causes of post-operative and late deaths can be compared. The percentage and present status of living patients is also given.
Comment:

1. The post-operative death rate dropped from 12.7 per cent to 4.8 per cent. This was largely due to the marked drop in tuberculous deaths (14 of 28 or 50 per cent in the pre-streptomycin era to one of nine or 11 per cent in the streptomycin era). There has been no significant change in the percentage of post-operative deaths due to non-tuberculous causes.

2. The late deaths are not directly comparable because of the difference in the follow-up period. However, 86 per cent of the streptomycin era patients have been followed for more than one year and 34 per cent for more than two years. In view of this, the marked reduction in late deaths due to tuberculosis is undoubtedly of significance. We believe this is a reflection of the fact that during this time 94.7 per cent of all patients were carried through to post-operative period without a tuberculous complication. In the entire series 77 per cent of the tuberculous deaths, early and late, have been related to or associated with a tuberculous operative complication.

3. The status of living patients likewise cannot be compared directly because of the variation in the follow-up period. However, here again we feel from this study that the marked difference in the percentage of living patients (92 per cent as compared with 67.7 per cent) is due not so much to the effect of time as it is to the fact that 94.7 per cent of those operated upon since 1947 had no post-operative tuberculous complication as compared with 73 per cent in the pre-streptomycin era.

4. The classification of living patients is expressed in percentages of the living patients, not of the entire group. It is interesting that the percentage of living and negative patients is identical in the two groups (89 per cent) and that the distribution in the other classifications is very similar. This also suggests that the follow-up period is not the most significant factor concerned with the status of these patients.

5. The level of activity of the 149 living patients of the pre-streptomycin era, all of whom have been followed for more than three years is as follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>Pct.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Full Activity</td>
<td>130 (87.2)</td>
</tr>
<tr>
<td>2. Graded Exercise</td>
<td>8 (5.4)</td>
</tr>
<tr>
<td>3. Bed Rest</td>
<td>9 (6.0)</td>
</tr>
<tr>
<td>4. No follow-up</td>
<td>2 (1.3)</td>
</tr>
</tbody>
</table>

6. Although the chart does not reveal it, all tuberculous deaths during the streptomycin era, early and late, have occurred in the pneumonectomy group. There have been no tuberculous deaths in those treated by lobectomy or segmental resection. This is undoubtedly due to more serious types of disease treated by pneumonectomy.
RESULTS
Pre-Strep Era - 1934 - Jan. 1, 1947
Present Status of Pts.

![Graph showing the results of pneumonectomy, lobectomy, and segmental surgery during the pre-Strep era.]

Strep Era 1:1:47 - 1:1:50
Present Status of Pts.

![Graph showing the results of pneumonectomy, lobectomy, and segmental surgery during the Strep era.]

FIGURE 5
Results

Entire Series

This chart presents the summary for the entire group of 426 tuberculous patients treated by resection. All except two patients have been followed and their present condition evaluated.

There were 8.9 per cent who died during and 11.5 per cent following the 60-day post-operative period.

Of the entire group, 79.6 per cent (339 patients) are living and of this group 89 per cent are clinically well and have a negative sputum. Ten per cent fall into the intermediate classifications. Some of those with positive sputum and/or unstable x-rays are still salvable. The 14 patients classified as respiratory cripples or with progressive disease are hopeless.

For those who prefer to have all statistics based upon the total number rather than upon the living patients, the following table will be of interest.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Patients</td>
<td>426</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative Deaths</td>
<td>38</td>
<td>8.9</td>
<td>87</td>
<td>20.4</td>
</tr>
<tr>
<td>Late Deaths</td>
<td>49</td>
<td>11.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well with Negative Sputum</td>
<td>302</td>
<td>70.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive Sputum and/or Unstable X-ray</td>
<td>21</td>
<td>4.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progressive Disease or Resp. Cripple</td>
<td>14</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Follow-up</td>
<td>2</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion

During the streptomycin era since 1947 the results of pulmonary resection in the treatment of tuberculosis have improved so much that the statistics of previous years are only of historical interest. In the future, even better results may be expected because of the more intelligent use of streptomycin and the concomitant use of para-aminosalicylic acid. In a large percentage of the cases in this series, sufficient streptomycin had been used prior to surgery to create partial to complete resistance of the tubercle bacilli. However, the prolonged use of the antibiotic was justified in many of these patients because it served to actually save their lives and thus permit them to come to resection. Our experience has been similar to others in that complications were more frequent in those who had had the long courses of streptomycin. However, this is a difficult factor to evaluate because these same patients also had the most extensive and complicated types of disease. In addition, even in these patients the percentage of complications has been low. Regardless of how much drug the patient has re-
celved prior to surgery, we have given one gram daily for 30 days following resection.*

The results with resection at present permit us to conclude that it represents a relatively safe form of treatment. In fact, the mortality and morbidity rates for lobectomy and segmental resection now approximate those of thoracoplasty. However, we must not be lulled into a false sense of security by statistics. Just because we can perform an operative procedure with a high degree of technical finesse and safety does not necessarily mean that it is the operation of choice. In the majority of cases resection and thoracoplasty should not be competing forms of therapy and thoracoplasty should be used preferentially when there is a reasonable chance that it will succeed. On the other hand, when this reasonable chance of success with thoracoplasty does not exist, resection should be used without a preliminary thoracoplasty, in our opinion. Primary resection is considered the treatment of choice also in those cases in which experience has already proved that the results with resection are superior to those with thoracoplasty and in those with cavities so situated that thoracoplasty would collapse unnecessarily large segments of normally functioning lung.

The success of the major surgical procedures, both thoracoplasty and resection, behooves us to stop and take stock of our therapeutic regimens. Too frequently, treatment is planned according to a routine in which major surgical procedures are used only when other methods, particularly pneumothorax, have been tried and failed. This concept does away with case selection and implies that the simpler measures are either neutral or harmless and in no way jeopardize the patient's future or the success of the major procedures. All too often, however, the simply crushed phrenic and the easily given pneumothorax are likened to the "boy sent out to do a man's job." They fail to control the disease and inevitably rob the patient of a portion, and often too much, of his pulmonary reserve. There can be no doubt that in many instances an ill-advised minor procedure represents a more radical approach than major surgery if we use failure, prolongation of treatment, complications and deaths as our criteria rather than the magnitude of the operation itself.

This is not an incrimination of phrenic paralysis or pneumothorax when indicated, nor the recommendation for the wholesale application of thoracoplasty or pulmonary resection. This is, however, a plea for case selection with the early application of the major surgical procedures when the indication exists.

Only by such individualization of cases can we find the true

*The streptomycin for this work was generously donated by Merck and Company of Rahway, New Jersey.
place for pulmonary resection or any other type of treatment for tuberculosis. Pulmonary resection is a very useful tool, but it is only one of many in our present-day therapeutic "tool box." With the timely and proper use of each of these tools, we can accomplish the goal which physicians all desire and which, in the final analysis, is the true measure of success of any plan of treatment—namely, the return of the greatest possible number of these tuberculous patients to a comfortable, useful and happy life.

**SUMMARY**

This study represents a careful analysis of 426 tuberculous patients subjected to 437 pulmonary resections between 1934 and January 1, 1950 (11 patients had a second resection). All except two of the living patients have been followed and their present condition evaluated. The following points of special interest are emphasized:

1) Outline of indications.
2) Comparison of results in pre- and post-streptomycin eras.
3) Analysis of present day risk of resection.
4) Preliminary report of a small group of segmental resections.
5) Late follow-up of patients
   (a) Pre-streptomycin era — 3 years to 16 years.
   (b) Post-streptomycin era — 6 months to 3 years.

**RESUMEN**

Este estudio representa un análisis cuidadoso de 426 enfermos de tuberculosis que se sujetaron a 437 resecciones pulmonares entre 1934 y Enero de 1950 (11 enfermos sufrieron una segunda resección).

Con excepción de dos, todos los demás se han observado y su estado actual se ha evaluado. Es de llamarse la atención sobre los puntos siguientes:

1) Esquema de indicaciones.
2) Comparación de resultados en las pre y post-estreptomicina.
3) Análisis del riesgo de la resección al presente.
4) Informe preliminar de un pequeño grupo de resecciones segmentarias.
5) Observación de los enfermos a largo plazo:
   (a) En la era pre-estreptomicina de 3 a 16 años.
   (b) En la era post-estreptomicina de 6 meses a 3 años.

**RESUME**

Cette étude représente une analyse très précise de 426 tuberculeux qui ont été soumis à 437 exérèses pulmonaires entre l’année 1934 et le premier janvier 1950 (onze malades eurent un second
temps d'exérèse). Tous les malades encore vivants à l'exception de deux, ont été complètement suivis et leur état actuel précisé. L'auteur insiste sur les points suivants dont l'intérêt est tout particulier:

1) Limite des indications.

2) Comparaison des résultats dans la période antérieure au traitement par la streptomycine et dans la période qui a suivi son utilisation.

3) Examen du risque actuel de l'exérèse.

4) Rapport préliminaire portant sur une petite quantité de malades ayant subi une résection segmentaire.

5) Dernier examen des malades:
   (a) avant l'époque de la streptomycine, 3 à 16 ans.
   (b) après l'époque de la streptomycine, 6 mois à 3 ans.

REFERENCE