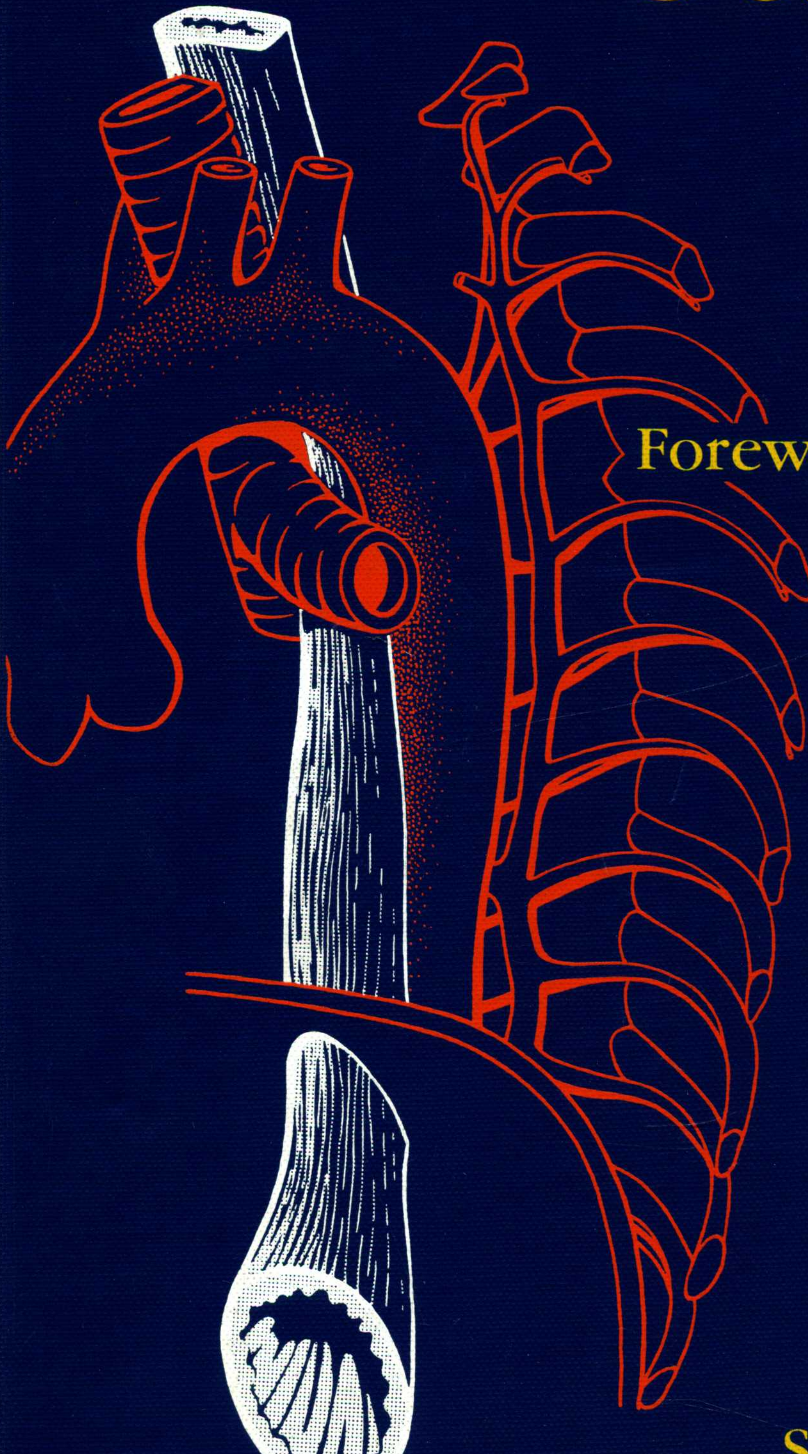
Thoracic Surgery



Edited by
H. Pichlmaier and
F. W. Schildberg

Foreword by D. B. Skinner

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Surgical Procedures on the Chest and Thoracic Cavity

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David B. Skinner

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Foreword

It is a great pleasure and honor to be asked to participate in the translation of this important and historical volume on thoracic surgery and to provide this foreword. Martin Kirschner of Mannheim/Heidelberg was an early pioneer in thoracic and esophageal surgery. His operation for bypass of the esophagus using the entire stomach remains a standard of the surgical armamentarium to this date. The original Kirschner Textbook of Surgery was a standard in its day. We are fortunate that Professors H. Pichlmaier and F.W. Schildberg and other colleagues have provided us with this important modern successor of a classic textbook.

The reader is rewarded by an extensive treatise which includes not only the most up to date techniques in pulmonary, esophageal, mediastinal, and chest wall (including breast) surgery but also provides an excellent perspective on the techniques used by pioneers in the field. Although some of these early techniques are not commonly used today, knowledge of their use and application broadens the capability of the thoracic surgeon. Changing times bring renewed problems with infectious diseases. Knowledge of the management of the pleural space and pulmonary infectious problems is a critical part of the education of the thoracic surgeon.

The illustrations in this book are detailed and helpful. They provide a broad spectrum of useful technical information for a thoracic surgeon. The text is extensive and describes procedures, indications, complications and their management in great detail. This volume is a major contribution to the world literature on thoracic surgery and marks the revitalization of an important school of non-cardiac thoracic surgery in Germany which has provided us with so many pioneers in the specialty.

New York | David B. Skinner

Preface

The last thoracic volume of the surgical text series begun by M. Kirschner and continued by R. Zenker was published in 1967. That year marked the end of a lengthy postwar period during which German surgery was again able to attain the international standard. Many questions of surgical methodology were resolved, and new procedures were developed and applied clinically. The editors of the last volume sought to detail those procedures and make them accessible to the surgical community.

In the past two decades, noncardiac thoracic surgery has been concerned less with the development of fundamentally new operative methods than with the refinement and standardization of existing procedures. This has shifted the emphasis away from spectacular innovation toward safety and the anticipated postoperative status of the patients undergoing chest surgery. Risk assessment and limitation, prognostic assessment, and an individualized approach to patient selection have become matters of increasing concern for surgeons and have led to a dramatic reduction in operative risk. Significant improvements have also been seen in late functional results.

Surgery of the esophagus has been expanded by the development of techniques for the transfer or free grafting of bowel, and it has been enriched by the rediscovery and perfection of esophagectomy without thoracotomy. Advances in long-term parenteral alimentation have been a major factor in these developments.

Operations on the lung and especially on the tracheobronchial tree have been refined and individualized by the perfection of special ventilation and intubation techniques as well as suturing techniques using absorbable materials.

Systematic mediastinal lymph node dissections have become an indispensable part of carcinoma surgery.

In operations for malignant breast disease, new insights into tumor biology and the introduction of effective adjunctive treatment modalities have shifted the emphasis away from ultraradical surgery toward less mutilating operations that conserve greater amounts of breast tissue.

This development and its results prompted the editors and publisher to create an up-to-date version of the thoracic volume. It was our intention not only to cover the points mentioned above but also to present a range of surgical treatment options and then weight those options on the basis of personal experience. True innovations relating, for example, to microsurgical techniques or advances in anesthesiology and perioperative management are described in detail. It was our special wish to advance the systematization of standard procedures while touching on organizational aspects (instrument layouts, etc.) that facilitate the conduct of surgical operations. Finally, we considered a thorough knowledge of anatomy to be an essential prerequisite for every surgeon. The publisher has made every effort to accommodate the authors' wishes in the production of this book.

We are grateful to all those who have made it possible for this book to be published in such a relatively short time. We convey special thanks to Springer Verlag and especially to Mr. Bergstedt for his always obliging and helpful support and advise. We acknowledge the great skill, insight, and patience of our illustrators, Misters Kuhn, Himmelhan and Pupp and Mrs. Schreiber. Special thanks go to the translator, Mr. Terry C. Telger, for providing a fluent and concise version of the German text.

Köln H. Pichlmaier
München F.W. Schildberg

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A. Functional Operability in Thoracic Surgical Procedures

R. THOMA

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1 Physiologic and Pathophysiologic Considerations

The bronchopulmonary system, like most other organ systems in the body, possesses a significant functional reserve. This is most apparent during exercise, when the pulmonary tidal volume and oxygen consumption can increase by a factor of 10–20 over basal values. Under normal conditions exercise tolerance is limited not by the bronchopulmonary system, but by the cardiovascular system. Respiratory limitation generally is seen only in advanced diseases involving the bronchial system, the lung parenchyma, or the pulmonary vascular system. Exercise limitation due to problems of respiratory mechanics may be presumed to exist when the absolute value of the one-second forced expiratory volume (FEV_1) is less than 800 ml [8]. This lower limit must be considered, therefore, when predicting residual postoperative function after pulmonary resection. A vital capacity of approximately 15 ml/kg body weight represents another critical value, with lower values implying, at the least, pulmonary exercise limitation [13].

Critical values for pulmonary gas exchange are more difficult to define due to the importance of adaptive mechanisms in this component of lung function. Studies in patients with pulmonary sarcoidosis have shown that if the diffusion capacity of the lung for CO falls to 40% of normal or less, exercise intolerance with pulmonary hypertension will exist in the majority of cases [12]. With regard to arterial blood gases, a PCO_2 exceeding 50 mm HG and a PO_2 less than 50 mm Hg are usually indicative of exercise intolerance. Generally these values are seen only when there is a severe impairment of respiratory mechanics which by itself is sufficient to limit exercise tolerance.

It is even more difficult to establish a critical value for pulmonary hemodynamics that would imply exercise limitation. The reserve capacity of the pulmonary vascular bed is exhausted when a mean perfusion pressure of about 30 mm Hg is reached [10]. If this value is reached under resting conditions, it is certain that exercise limitation exists. A loss of hemodynamic reserve is assumed when the exercise pulmonary artery pressure rises to 40 mm Hg at a mild level of exertion (1/2–1 W/kg body weight).

Questions of exercise tolerance are of crucial importance in potential candidates for pulmonary resection, because an inaccurate assessment of the patient's functional reserves can leave him a respiratory cripple after the surgery. Preoperative tests of pulmonary function center on the parameters that correlate most closely with performance. The foremost of these in terms of respiratory mechanics are the vital capacity and the FEV_1, whose determination requires a high level of patient cooperation. The alternative in less cooperative patients is to assess the pulmonary compliance and airway resistance. These values do not represent capacities, however, and so the prognosis is less certain.

The functional reserve for gas exchange can be assessed by determining the diffusion capacity for CO. Determination of the arterial oxygen pressure can be misleading in terms of predicting postoperative function, because shunts created by tumors can sustain a hypoxemic state.

In summary, the vital capacity, FEV_1, and exercise pulmonary artery pressure may be considered the most reliable indicators of pulmonary function in potential surgical candidates.

2 Function Studies for Assessing Operability

2.1 Thoracic Procedures without Pulmonary Resection

Even in thoracic surgical procedures that do not involve the removal of lung parenchyma, the function of the respiratory organs will be compromised at least temporarily during and after the operation. Generally this functional impairment persists for no more than 3–6 months after the thoracic surgery [7]. Pulmonary dysfunction is of minor significance in cardiac operations, for often it reflects only the extent of the hemodynamic compromise. As hemodynamics improve after the cardiac procedure, generally there will be full recovery of the patient's preoperative respiratory function.

Operability considerations for thoracic surgery without pulmonary resection follow the same general guidelines that apply to other surgical procedures, especially abdominal. The pulmonary parameters of greatest interest are also the simplest: the vital capacity and the FEV_1. The absolute value of FEV_1 is especially useful, for it represents a summation of airway obstruction, airway instability, restriction, and the level of patient cooperation. If both of these functional parameters are found to be normal, it is unnecessary to perform additional tests of respiratory mechanics. This does not apply to the parameters of gas exchange, however. One should at least obtain a blood gas analysis under resting conditions to get a baseline for predicting postoperative defects of gaseous exchange. If the vital capacity and FEV_1 deviate from normal by more than 20%, further differential pulmonary function tests should be conducted.

If evidence of airway obstruction is found, the airway resistance should be determined if possible using body plethysmography. The airway resistance measured by this technique provides a sensitive and objective basis for planning bronchospasmolytic therapy. This method is excellent for predicting functional improvement and estimating the time of optimum response. The oscillometric measurement of airway resistance is also useful in directing bronchospasmolytic therapy and enables respiratory mechanics to be quantitated even in less cooperative individuals. If there is evidence of pulmonary restriction (low vital capacity with a normal relative FEV_1) or airway obstruction, the effect of the impaired respiratory mechanics on gas exchange should be determined by analyzing the glood gases at rest and during ergometric exercise. The ergometric study yields information on the gas exchange reserves and also gives an impression of the patient's circulatory and metabolic work capacity. If the blood gas analysis during ergometry shows significant deviation from normal values ($PACO_2 > 45$, $PAO_2 < 60$ mm Hg), the hemodynamic effect should be evaluated by measuring pulmonary circulatory parameters, and appropriate treatment should be instituted.

The following guidelines may be applied when utilizing the FEV_1 as an index of operative risk:[1]

1. $FEV_1 < 0.8$ l: High anesthetic and operative risk. Indication for operation must be urgent. Resting arterial blood gas analysis is performed for further risk assessment; generally exercise cannot be tolerated.
2. $FEV_1 > 0.8$ l, < 2.0 l: Increased risk. Arterial blood gases should be measured at rest and during exercise (work rate increased by 25 W/2 min to about 50% of maximal capacity) for further risk assessment. If the $PACO_2$ rises above 45 mm Hg and the PAO_2 falls below 60 mm Hg, surgery is justified only if the indication is urgent. Supplementary measurement of pulmonary circulatory hemodynamics is advised.

In cases 1 and 2, airway obstruction should be excluded or, if present, optimally treated.

3. $FEV_1 > 2.0$ l: The operative risk is not increased, but in patients with a history of asthma or dyspnea attacks, hyperreactive airways should be excluded by provocative testing with acetylcholine, carbachol, or histamine.

[1] Based on the recommendations for preoperative pulmonary function testing of the German Society for Pneumology and Tuberculosis [6].

2.2 Thoracic Procedures Involving Pulmonary Resection

Not only must the global function impairment be known in this type of operation, but the location of the functional defect within the bronchopulmonary system must be ascertained. It must be determined whether the defect is ipsilateral, i.e. involving the lung that is to be operated, or contralateral (e.g., in patients with a complicating condition like emphysema, pleural thickening, tuberculosis, or embolism). Preoperative risk assessment, therefore, must rely on regional function testing-generally by perfusion scanning of the lungs with a quantitative comparison of both sides. Besides the pulmonary functional status, special attention must be given to the cardiac status in lung resections, as the loss of parenchyma will diminish the reserve capacity of the pulmonary capillary bed. Because of this loss of reserve capillaries, a postoperative expansion of the intrapulmonary blood volume will be more likely to precipitate an interstitial or alveolar pulmonary edema. It is imperative, then, that a cardiologic evaluation be done to exclude left heart failure. Besides special physical and radiologic studies of the cardiovascular system, including a resting and stress ECG, the pulmonary capillary pressure should be measured in patients who report dyspnea on exertion and angina pectoris. A previous myocardial infarction (within the last year) constitutes a relative contraindication to pulmonary resection. A history of myocardial infarction within six months before the contemplated surgery is considered to be an absolute contraindication.

Pulmonary resections should leave the patient with a postoperative vital capacity of 1500 ml and a FEV_1 of about 1000 ml, since lower values would imply cardiorespiratory insufficiency at mild levels of exercise. The immediate postoperative vital capacity should be no less than 15 ml/kg body weight, since lower values generally signify a need for prolonged ventilatory support [13]. The collective statistical data of several authors indicate that vital capacity is reduced by about 60% in the first weeks following pneumonectomy and by 20%–60% following lobectomy. In contrast to pneumonectomy, the functional deficit after lobectomy usually shows marked improvement (to less than half the initial deficit) within the first six months after surgery [7].

2.2.1 Assessing Candidates for Pneumonectomy

By following a prognostic scheme based on the FEV_1, the perfusion scan, and the exercise pulmonary artery pressure, it is possible to keep the postoperative mortality rate well below 10% following pneumonectomy or extended pneumonectomy [6].

A knowledge of additional pulmonary functional parameters such as residual volume, arterial oxygen tension, and airway resistance is less important for determining operability than for selecting appropriate pre- and postoperative therapeutic measures (broncholytics, O_2 therapy, respiratory training).

The significance of preoperative hypoxemia should not be overestimated in candidates for pneumonectomy, because deficient oxygen saturation can result from venous admixture through tumor-created shunts that will be eliminated by surgery. The prognostic scheme based on FEV_1, the perfusion scan, and the exercise pulmonary artery pressure satisfies the demand for a definitive postoperative FEV_1 of approximately 1 liter and for an acceptable rise in the pulmonary artery pressure during exercise. It should be noted that the absolute values cited in the prognostic scheme are only guidelines, and that individual values may deviate somewhat in either direction. This applies both to the FEV_1, which may be as low as 800 ml postoperatively without causing a prohibitive rise in mortality, and to the exercise pulmonary artery pressure, which may rise less after surgery than predicted.

A safety factor in this regard is the slight rise in the cardiac output during exercise and concomitant rise in the Hb level that are consistently observed after surgery [9].

While there is general agreement on the safe lower range for FEV_1 in pneumonectomized patients (800–1000 ml), reports vary regarding the behavior of the pulmonary artery pressure after lung resections. While Konietzko and his group claim that a rise of the pulmonary artery pressure above 45 mmHg during exercise contraindicates surgery, the follow-up data of a group of Swiss surgeons suggest that functional inoperability exists when the pressure reaches the range of 35–40 mmHg at an exercise rate of 40 W [3].

Because pneumonectomy offers the only hope of cure for most patients, the goal of preoperative evaluation should be to maximize the number of patients referred for resective surgery. The withholding of curative surgery on grounds of functional inoperability must be based on highly persuasive data. Thus, operability considerations in patients with airway obstruction should always take into account the FEV_1 after maximal broncholytic therapy, since the greater preexpansion of the remaining lung makes it likely that the airway obstruction will regress after the pneumonectomy. When assessing the hemodynamic risk, it also may be assumed that the reserve capacity of the pulmonary capillaries not open at rest will be sufficient to absorb a portion of the expected postoperative pressure rise in the pulmonary vascular system. Thus, in patients who have borderline exercise pressures in the pulmonary circuit (around 40 mmHg), it is advisable to simulate the postoperative status before surgery by occluding the main pulmonary artery branch supplying the lung that is to be removed. This makes it possible to investigate selectively the circulatory and gas-exchange reserves of the remaining lung [11]. This knowledge gives the surgeon a high degree of confidence that the success of the operation will not be jeopardized by the development of cardiopulmonary insufficiency. Daum et al. [1] advise testing the pulmonary circulation at rest and after exercise, with and without occlusion of the main pulmonary artery branch to the operative side, before every pneumonectomy, for it is common during occlusion to see a rise of pulmonary capillary pressure that correlates with an accompanying arterial hypoxemia. These authors believe that exercise testing with occlusion of the affected main pulmonary arterial branch should be routinely done before every proposed pneumonectomy to safeguard the patient against left heart failure developing postoperatively. We are unable to recommend pulmonary artery occlusion as a routine measure, because it is not without risk for the patient, and because severe postoperative exercise hypoxemia is a relatively uncommon occurrence. We believe that the test should be restricted to patients whose exercise pulmonary artery pressure reaches the upper tolerance limit of about 40 mmHg.

It has been found that pneumonectomy patients selected by the indices discribed above are well able to tolerate mild levels of exercise following their surgery. Moreover, they are not at increased risk for the accelerated development of a cor pulmonale.

2.2.2 *Assessing Candidates for Lobectomy*

In contrast to pneumonectomy, where functional recovery is slight during the months following the operation, lobectomy (or bilobectomy) may be followed by a disproportionately severe ("early") function loss occurring immediately after the surgery, or by a much less severe ("late") function loss seen after a period of about six months [7]. Thus, it is necessary to consider both an immediate and a late effect when assessing candidates for lobectomy or bilobectomy. Understandably, the postoperative function loss cannot be predicted as accurately as it can for pneumonectomy.

When patients are selected according to the prognostic scheme and given suitable postoperative management, the postoperative mortality rate is lower than 2%.

2.3 Thoracic Procedures to Improve Respiratory Function

2.3.1 *Decortication*

Pleural decortication is done to improve respiratory dysfunction caused by a residual empyema cavity, bronchopleural fistula, or scoliosis of the thoracic spine. An indication for this procedure exists when:

1) the vital capacity is 30% or more below the desired value,
2) perfusion of the affected lung half is decreased by more than 50% according to the perfusion scan, and
3) the "trapped" lung below the pleural peel is still intact and able to expand (bronchography!) [6].

2.3.2 *Bullectomy*

Patient selection for bullectomy demands careful preoperative function testing due to the very high rate of postoperative complications that is associated with generalized pulmonary emphysema, the leading cause of bulla formation. The procedure is appropriate only when:

1) there is little or no demonstrable airway obstruction during quiet respiration (as measured by body plethysmography),

2) perfusion scanning shows that the bulla occupies more than 50% of the affected hemithorax and is compressing "healthy lung", and
3) the contralateral lung shows no significant perfusion defects.

A single-stage bilateral thoracotomy for bilateral involvement should be contemplated only if it will provide a decompressive effect that will improve function [6].

2.3.3 Tracheal Stenosis, Tracheal Dyskinesia

Pulmonary function tests in tracheal stenosis are able to localize the site of the stenosis (intra/extrathoracic), establish its severity, and monitor any changes. The clinical or bronchoscopic diagnosis of tracheobronchial dyskinesia or tracheomalacia must be confirmed by careful pressure, flow, and volume measurements during quiet and forced respiration before "operative stabilization" of the major airways is justified.

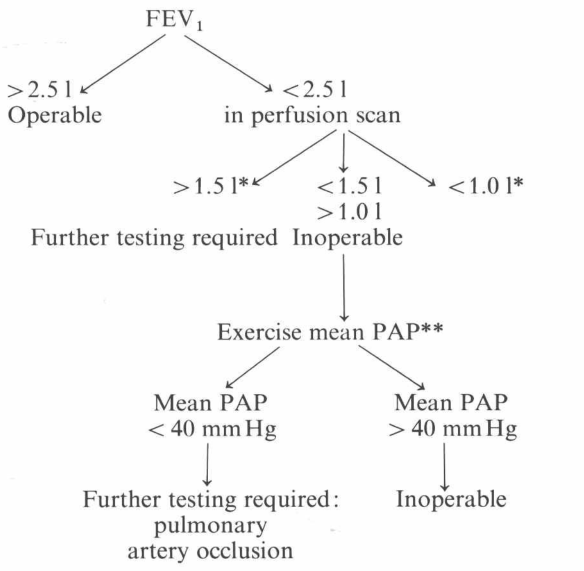
The best technique for establishing the site of a tracheal stenosis is body plethysmography. An S-shaped resistance loop in this study is characteristic of extrathoracic stenosis, a club-shaped loop signifies an intrathoracic stenosis, and an egg-shaped loop signifies stenosis of a main bronchus. Simultaneous measurement of the residual volume with body plethysmography makes it possible to differentiate stenoses of the major airways (residual volume not increased) from generalized respiratory tract diseases (residual volume increased).

Body plethysmography can also quantitate the severity of the stenosis, especially with extrathoracic lesions. Increased airway resistance is measurable when the lumen of the trachea decreases to about 8 mm or less, and a massive resistance increase is apparent when the tracheal lumen is smaller than 5 mm [2, 5]. Stenosis to less than 4 mm increases the airway resistance by more than a factor of 15 and poses an acute risk of asphyxiation. Since a rise in airway resistance is measurable when the diameter of the tracheal lumen is 8 mm, surgical correction of the stenosis generally should be contemplated only when the lumen is substantially smaller. Conversely, a normal tracheal lumen is not an essential goal of tracheal reconstructive surgery [5].

3 Appendix

3.1 Calculation of Postoperative Pulmonary Function

Flowchart for identifying patients at risk[1]



[1] Modified from Recommendations on Preoperative Pulmonary Function Testing. Prax Klin Pneumol 37:1199 (1983).

* Calculated postoperative FEV_1 (a semiquantitative assessment based on the evaluation of perfusion scans in four projections by an experienced examiner or an exact calculation of the fractional loss over areas of interest yield comparable results).
** Mean PAP = mean pulmonary artery pressure at a mild to moderate level of exercise (50–70 W).

Calculation of Postoperative Pulmonary Function [6]

$$FEV_1 \text{ postop} = FEV_1 \text{ preop} \frac{100 - A - k \times B}{100} \quad \text{(I)}$$

FEV_1 postop = forced expiratory volume calculated for the early postoperative period
FEV_1 preop = FEV_1 measured preoperatively
A = perfusion of the resected specimen as % of total lung
B = perfusion of the rest of the operative side as % of total lung
k = 0.37, a constant for the early postoperative period

The preoperative FEV_1 is determined by spirometry. A and B are calculated by scanning over areas of interest.

Example

A 56-year-old man has a malignant coin lesion in the right upper lobe. His preoperative FEV_1 is 1.4 l. Perfusion scans show an absence of perfusion in the right upper lobe that is to be resected, and the remaining perfusion of the right lung is 40% of the total lung perfusion. For an upper lobectomy, we calculate

$$FEV_1 \text{ postop} = 1.4 \frac{100-0-0.37\times 40}{100} = 1.19 \text{ l}$$

The calculation for a pneumonectomy would be:

$$FEV_1 \text{ postop} = 1.4 \frac{100-40-0.37\times 0}{100} = 0.84 \text{ l}$$

The calculations indicate that lobectomy would pose an increased but acceptable risk in this patient, while the risk of pneumonectomy would be prohibitively high.

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B. Surgical Instruments, Materials, and Approaches

H. PICHLMAIER

CONTENTS

Surgical operations on the chest and chest wall and in the thoracic cavity require knowledge of many general and specialized techniques. The relatively poor accessibility of the thoracic cavity through the bony thorax requires the use of special positions to ensure optimum exposure with minimal trauma. To aid the operating team in organizing and preparing for thoracic procedures, we present the basic surgical techniques (of the approaches, etc.) along with the necessary materials and instrumentation. Besides possessing a knowledge of general surgical techniques, the operator must be experienced in vascular surgery, bone surgery, plastic surgery, and perhaps even microsurgery as well as in the use of modern stapling instruments. The list of necessary surgical instruments makes this clear.

1 Instruments for Thoracic Surgery

A thoracic operation can be made more efficient and less costly, and the work of the OR staff simplified, by making up basic instrument sets and extra sets that are selected according to the requirements of the procedure. With modern container systems it is possible to set up an exact program that will simplify handling, cleaning, sterilization, and sterile storage of the instrument sets. When implementing a container system of this kind, careful consideration must be given to the physical layout of the OR suite and the hospital practices that are followed (e.g., centralized or decentralized sterilization, large or small stock of sterile supplies, centralized or decentralized surgery department, separation of septic and aseptic areas, demands on sterilization service, etc.).

1.1 Basic Set

The *basic set* contains the instruments needed for every operation on and in the thorax. The components of the set are listed in the Appendix at the end of this chapter.