Second Edition VOLUME II

DIAGNOSIS OF DISEASES OF THE CHEST

FRASER
PARÉ

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W. B. SAUNDERS COMPANY
PHILADELPHIA • LONDON • TORONTO

W. B. Saunders Company: West Washington Square
Philadelphia, PA 19105

1 St. Anne's Road
Eastbourne, East Sussex BN21 3UN, England

1 Goldthorne Avenue
Toronto, Ontario M8Z 5T9, Canada

Listed here is the latest translated edition of this book, together with the language of the translation and the publisher.

Spanish (*1st Edition*)—Salvat Editores, S.A., Barcelona, Spain

Diagnosis of Diseases of the Chest ISBN 0-7216-3853-8

Last digit is the print number: 9 8 7 6 5 4

PREFACE TO THE SECOND EDITION

It was stated in the Preface to the First Edition that the book was written with the aim of defining an approach to the diagnosis of diseases of the chest based on the abnormal roentgenogram and of emphasizing the value of the roentgenogram as the *first* rather than the *major* step in diagnosis. Our experience during the years since publication in 1970 has not caused us to alter these principles. However, we wish to reiterate that the emphasis we place on the roentgenogram as the first step in reaching a diagnosis does not represent an attempt to relegate history and physical examination to a position of no importance, but merely to place them in proper perspective. We have never ceased to recognize that an intelligent integration of information from roentgenologic, clinical, laboratory, and pathologic sources is essential to the diagnosis of chest disease, and we trust that the approach we have taken in this second edition clearly illustrates that conviction.

Because of the vast amount of new knowledge that has accumulated since the publication of the first edition and of a number of important omissions from the first edition, simple revision has proved impossible. It has been necessary to rewrite the book almost completely. Inevitably, its length has increased and the original two volumes have expanded to four. We have regretted this because we recognize the danger of the book's becoming purely a reference work rather than a textbook. However, we have continued to hope that the organization of the book will enable readers to be highly selective in the material they wish to read. The subdivision of virtually all descriptions of chest disease into etiology, pathogenesis, pathologic characteristics, roentgenographic manifestations, and clinical manifestations should permit readers to cull the material appropriate to their disciplines. For example, a substantial part of the research in chest disease in recent years has been concerned with pathophysiology, and we felt obliged to include much of this highly pertinent information in the text. Since such material is indicated by appropriate headings, readers can choose whether they wish to delve deeply into this aspect of any disease.

The first three volumes contain the 18 major chapters of the book. Volume I includes descriptions of the normal chest, methods and techniques of investigation, clinical features and roentgenologic signs of chest diseases in general, and diseases of developmental origin. Volume II deals with the infectious diseases, immunologic disorders, neoplasms, thromboembolic disease, and pulmonary hypertension and edema. In Volume III, we have grouped together environmental and airway diseases, abnormalities caused by external physical agents, diseases of unknown origin, and abnormalities of the pleura, medi-

astinum, chest wall, and diaphragm. The final chapter deals with respiratory disease associated with a normal chest roentgenogram. The tables of differential diagnosis, formerly in Volume I, now constitute a major portion of the smaller Volume IV. This volume also contains a number of tables of normal values in roentgenologic, biochemical, and function test assessment, and other material that we thought should be available for ready reference.

A new approach to the differential diagnosis of chest disease has been developed in the form of "decision trees," also included in Volume IV in association with the tables of differential diagnosis. Since publication of the first edition, it has become apparent that use of the tables of differential diagnosis has been largely restricted to radiologists, chiefly those in training. As a means of involving the chest physician in this exercise, we have designed "decision trees," which incorporate into the equation the clinical presentation of the patient. As in the tables of differential diagnosis, the patterns of disease are subdivided into a number of diagnostic possibilities, each of which follows a different "branch" of the tree, and the most likely diagnoses are color-coded. The presenting symptoms and signs of each disease likely to produce the specific roentgenographic pattern are indicated at the base of each branch, followed up the branch by the appropriate diagnosis, and at the top by the major methods of confirming the diagnosis. We hope that this method of presentation will find favor with our more clinically oriented readers.

In addition to updating virtually all sections of the book, we have made major additions and revisions in a number of specific areas. There are detailed descriptions of the geometry, dimensions, and morphology of the conductive, transitory, and respiratory zones of the lung and the vascular system; blood gases and acid-base balance; the nonrespiratory functions of the lung; development of the lung; diagnostic applications of ultrasonography; mass chest roentgenography as a screening procedure; the techniques, indications, yield, and complications of lung biopsy; new methods of evaluation of pulmonary function, particularly of the small airways; host defense mechanisms in bronchopulmonary infections, including a thorough discussion of the compromised host, opportunistic infections, and host-etiology relationships; prognosis in neoplastic disease of the lungs; and drug-induced pulmonary disease. In addition, there is a complete reorganization of the chapter on pulmonary abnormalities of developmental origin, a complete revision of the section on pulmonary edema, a revision of the chapter on occupational diseases to conform to the UICC-ILO classification, and extensive additions to the discussion of the obstructive airway diseases, particularly with regard to their pathophysiology.

The burgeoning of knowledge in the field of chest disease since 1970 has been astonishing. The 4,300 odd references that made up the bibliography in the first edition were selected from 19 journals and several books that had been published during the previous 15 years. In the 7 years since publication of the first edition, more material on chest disease appeared in the same journals and in a number of new books than had been written in the previous 15 years. We thus faced the rather prodigious task of reviewing several thousand new articles and of selecting those whose content we felt was appropriate for inclusion in the manuscript and in the bibliography as sources for further reading. As a result, the bibliography has more than doubled since the first edition. We suspect that we could be justly criticized for not being more selective in our choice of referenced material, but we wish to emphasize that the articles cited, although numerous, represent a relatively small proportion

of the total output. Each of the first three volumes in the second edition will have its own list of references. Since new references were added to the manuscript late in the writing, such material has of necessity been cited with out of sequence numbers. However, all references are numbered consecutively if not sequentially.

At the end of the Preface to the First Edition, we invited our readers to inform us of differences of opinion they may have had with the contents of the book. Many were kind enough to write us, pointing out several errors and suggesting ways and means of improving the book generally. Several of these suggestions have been effected in this second edition. Again, we invite our readers to express their opinions and offer their advice. To reiterate a statement made in the original Preface, it is only through such interchange of information and opinion that we can hope to establish on a firm basis the knowledge necessary for a full understanding of respiratory disease.

R. G. F.

J. A. P. P.

ACKNOWLEDGMENTS

Although it might be assumed that the preparation of the second edition of a book is a relatively simple task compared with preparing the first, our experience has proved that assumption erroneous. The 4 years required for the production of the first edition expanded to at least 5 for the second, providing clear evidence that even with experience the complexities involved in the production of a book of this magnitude are difficult to appreciate. The writing of manuscript and the choice and preparation of new illustrations were the most formidable part of the undertaking, but the many steps necessary to the final product required the unselfish and enthusiastic contributions of many hands and minds, and the support and encouragement we received from many of our friends are greatly appreciated and duly acknowledged.

It is not possible to overstate our gratitude to our secretaries, who handled magnificently the tedious and necessarily exacting task of transcribing manuscript from tape, typed the several drafts up to and including the final manuscript, and cheerfully coped with all the innumerable problems encountered. Mrs. Joan Bell, Miss Bridget Byrne, and Mrs. Jean Farrel of the Royal Victoria Hospital in Montreal and Ms. Carolyn Lehman and Miss Sheila Walker of the University of Alabama Medical Center in Birmingham all exhibited exemplary patience and devotion in accomplishing this thorny chore. With some help, these assistants also carried out the tedious job of recording, filing, checking, and final validation of the more than 5,000 new references, an extremely frustrating chore that they performed with meticulous accuracy. The devotion and diligence with which they carried out their various tasks is deeply appreciated. We are also grateful to Ms. Ursula Matthews for the skill with which she subedited several chapters of the book.

Many of our medical colleagues were kind enough to review sections of the manuscript and to offer advice for their improvement. Special thanks are due to Drs. Peter Macklem, Stefan Vas, Len Moroz, John Seely, Rudy Dollfuss, James Hogg, Peter Paré, Jr., and Fred Winsberg for their valued counsel and discerning criticism.

The majority of case histories and roentgenograms reproduced here are of patients of members of the Attending Staff of the Royal Victoria Hospital. Our indebtedness to these friends and colleagues cannot be overemphasized, not only for their generosity in permitting us to publish these case reports but also for the benefit of their experience and guidance over the years.

During the period of writing, it was inevitable that the time expended by the authors on teaching and clinical responsibilities was reduced significantly. These additional responsibilities were added to the already overburdened shoulders of our colleagues in the Departments of Diagnostic Radiology and Medicine of the Royal Victoria Hospital and Queen Mary Veterans Hospital of Montreal, and the Department of Radiology, the University of Alabama Med-

ical Center in Birmingham. Their contributions to the book, although indirect, are sincerely appreciated.

The superb photographic work throughout these volumes was the accomplishment of Ms. Pat McKenna and her staff, particularly Ms. Edith Boltz, of the Department of Visual Aids of the Royal Victoria Hospital and Mr. Charles Walton of the Department of Radiology, University of Alabama Medical Center in Birmingham. Their craftsmanship and rich experience in photography are readily apparent in these pages. Most of the graphs and diagrams were charted with meticulous accuracy by Mr. Lionel Bartlett; the majority of function tests were performed with care and devotion by Mr. J. Nowaczek.

We are indebted to Mr. Douglas McDonald, Executive Director of the Royal Victoria Hospital, for arranging financial assistance toward the cost of illustrations. Throughout our labors, we have received tremendous support and cooperation from the publishers, notably Mr. Jack Hanley, Ms. Kathy Pitcoff, and Ms. Evelyn Weiman, who effectively and sympathetically minimized the many obstacles we encountered.

Finally, and with immense gratitude, we recall the patience and understanding displayed by our wives and children throughout our labors. Without their continuous encouragement, this book surely would not have been completed, and we acknowledge their many virtues with much love.

R. G. F.

J. A. P. P.

PREFACE TO THE FIRST EDITION

This book was written with the aim of defining an approach to the diagnosis of diseases of the chest based on the abnormal roentgenogram. Experience over the years has led the authors to the conclusion that the chest roentgenogram represents the focal point or sheet anchor in the diagnosis of the majority of pulmonary diseases, many patients presenting with either no symptoms and signs or entirely nonspecific ones. This emphasis on the roentgenogram as the first step in reaching a diagnosis does not represent an attempt to relegate history and physical examination to a position of no importance, but merely an effort to place them in proper perspective. In no other medical field is diagnosis so dependent upon the intelligent integration of information from roentgenologic, clinical, laboratory, and pathologic sources as in diseases of the chest. We submit that the roentgenogram is the starting point in this investigation; the knowledge of structural change thus obtained, when integrated with pertinent clinical findings and results of pulmonary function tests and other ancillary diagnostic procedures, enables one to arrive at a confident diagnosis. Some patients manifest symptoms and signs that themselves are virtually diagnostic of some chest disorders, but even in such cases the confirmation of diagnosis requires the presence of an appropriate roentgenographic pattern.

A glance through the pages will reveal an abundance of roentgenographic illustrations that might create the illusion that this book is written primarily for the roentgenologist, but this is not our intention. In fact, the clinical, morphologic, and laboratory aspects of many diseases are described at greater length than the roentgenologic, a fact pointing up the broad interest we hope the book will engender among internists, surgeons, and family practitioners interested in chest disease. The numerous illustrations reflect the aim of the book—to emphasize the value of the roentgenogram as the *first* rather than the *major* step in diagnosis.

During the writing of the book, our original plan was considerably modified as the format unfolded and we became even more aware of the complexities of design and organization. Originally, our approach to differential diagnosis suggested a division of chapters on the basis of specific roentgenographic patterns. It soon became apparent, however, that since many diseases give rise to various different roentgenographic patterns, this method of presentation would require tedious repetition of clinical and laboratory details in several chapters. To obviate this, we planned tables of differential diagnosis, listing etiologic classifications of diseases that produce specific roentgenographic patterns and describing briefly the clinical and laboratory characteristics of each disease, thus facilitating recognition of disease states.

The tables are designed to be used with the text in the following manner. When a specific pattern of disease is recognized, the appropriate table should be scanned and those conditions selected that correspond most closely with the clinical picture presented by the patient. Additional information about the likeliest diagnostic possibilities can be obtained by referring to the detailed discussions in the relevant sections of the text (page numbers are cited after each diagnosis). The tables relate to 17 basic patterns of bronchopulmonary, pleural, and mediastinal disease; they are grouped together in Chapter 5 in Volume I and may be located with ease from the black marks found on the upper corners of their pages. Each table is preceded by a detailed description and representative illustrations of the specific roentgenographic pattern. An attempt has been made to indicate the relative incidence of the diseases.

Although our original plan called for a one volume presentation, it soon became apparent that the length of the text and the number and size of illustrations necessary for full coverage of the subject required two volumes. Volume I includes descriptions of the normal chest, methods and techniques of investigation, clinical features, and roentgenologic signs of chest diseases, the tables of differential diagnosis, and chapters devoted to diseases of developmental origin and the infectious diseases; in Volume II appear detailed discussions of the morphologic, roentgenologic, and clinical aspects of all other diseases of the thorax arranged in chapters according to etiology.

The roentgenograms have been reproduced by two different techniques, the majority in Volume I by the logEtronic method and those in Volume II by direct photography. The publishers have been generous in allotting sufficient space for the reproduction of the roentgenograms in a size adequate for good detail recognition.

Much of the material in the book has been based on our personal experience gained in the past almost two decades, during which we have had a predominant interest in pulmonary disease. Obviously, this experience has been greatly enhanced by the extensive literature that has accumulated during these years, and we are mindful of the tremendous help we have received from the contributions of others. Our free use of the literature is reflected in the extensive bibliography.

Certain differences from the contents of other books on respiratory disease will be noted. First, this text contains no reference to treatment. Since drug therapies and surgical techniques are constantly changing, any attempt to include them would make the book out of date almost before it was published. Second, we have intentionally made only passing reference to pulmonary disease peculiar to children, a full description of which would require a complete separate text.

The relative incidence of respiratory diseases has changed considerably over the last quarter century. In some diseases, such as tuberculosis and bronchiectasis, a decreased frequency reflects improved public health measures and therapeutic innovations; in others, man's therapeutic triumphs have proved a mixed blessing, enabling patients with disabling chronic respiratory disease to live longer despite formerly fatal pneumonias. Perhaps even more important, man himself is responsible for varying the spectrum of respiratory disease as a result of his irresponsible insistence upon increasing the amount and variety of atmospheric pollutants. Inhaled contaminated air not only is regarded as the major etiologic factor in chronic obstructive pulmonary disease and the inorganic dust pneumoconioses, but also has been incriminated

in the etiology of several hypersensitivity diseases of the lungs. This last group comprises the "extrinsic" form of allergic alveolitis. The number of conditions involved, when added to the better known "intrinsic" counterpart —the collagen diseases—is largely responsible for the length of the chapter devoted to immunologic diseases. Other changes that have contributed to the "new face" of pulmonary disease include increasing knowledge of the hormonal effects of neoplasms; the discovery that various immunologic defects may reduce host resistance to infection; and finally the appearance in the western world of parasitic infestations and bacterial infections formerly considered so rare in those areas as to warrant little consideration in differential diagnosis, but now of some importance because of the modern day ease of intercontinental travel. Although the novelty of these recent changes may have led the authors to consider them in greater detail and length than is their due, the emphasis may serve to bring them into proper perspective.

Finally, we recognize our fallibility. It is inevitable that some observations in a text of this magnitude will prove erroneous in time or will find disagreement among our knowledgeable readers. This we expect and accept. We sincerely hope that such differences of opinion will be made known to us, so that they may be weighed and, where appropriate, introduced into subsequent editions or revisions. It is only through such interchange of information and opinion that we can hope to establish on a firm basis the knowledge necessary to a full understanding of respiratory disease.

R. G. F.

J. A. P. P.

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VOLUME II

CHAPTER 6

INFECTIOUS DISEASES OF THE LUNGS

HOST DEFENSE MECHANISMS IN BRONCHOPULMONARY INFECTIONS

A basic understanding of the mechanisms by which the lungs prevent and deal with infection is an essential feature of the diagnostic process. In addition to their response to an invading microorganism, the body tissues and cells can recognize and eliminate exogenous inert particles, neoplastic cells, and endogenous material formed as the result of destructive autoimmune or degenerative diseases.

Like the gastrointestinal tract but unlike other mammalian organs, the bronchopulmonary system is relatively accessible to the multifarious microbes of the environment. In health the pharynx is continually colonized by potentially pathogenic bacteria that fail to penetrate to the lower conducting system and pulmonary parenchyma. If contamination of the lower respiratory tract occurs, the invader is confronted by a formidable barrier in the epithelium lining the airways and air spaces. Beneath this wall, in the lamina propria and the interalveolar connective tissue, lie IgA-secreting plasma cells and tissue macrophages that neutralize, lyse, and remove the offending organisms. Within the lumen of the airways the microorganism is bathed by a viscous material that in itself is antimicrobial. The tracheobronchial secretions contain lysozyme, lactoferrin, and interferon, and organisms that survive their passage down the conducting system find the surfactant layer of the air spaces even less hospitable. Mired down in the sticky secretions, they are engulfed by scavenger cells and propelled within the gel layer of the mucous blanket by ciliary action to the external environment.

When this first line of defense fails, and the invader penetrates the tissues and establishes a foothold, there follows a highly complex, integrated sequence of events, termed the inflammatory response. Initially constriction of arterioles occurs, followed by vasodilatation and increased blood flow; slowing of flow in the capillaries is accompanied by escape of edema fluid into the area occupied by the invader and by the adherence of phagocytes to capillary walls. Various channels mount a concentrated effort to attract phagocytes (chemotaxis). Messages are sent (1) as the result of antibody reacting with the microbial antigen and activating complement, (2) by properdin, which acts on complement even in the absence of specific antibody, (3) via lymphokines (chemical mediators) derived from T lymphocytes, (4) by phagocytic early arrivals, and (5) even by some self-immolating microorganisms. Complement and specific antibodies have a further role to play: by combining with the antigenic chemical components (polysaccharides or polypeptides) of the bacillary capsule, they garnish the virulent victuals, a process known as opsonization (preparation for eating). Increasing numbers of phagocytes (initially polymorphonuclear neutrophils and later macrophages) are attracted and ingest the prepared material. The T lymphocytes continue to act, overseeing production by the B lymphocytes of specific antibody to the microbial antigen and producing other chemical mediators that hold the phagocytes at the invasion site. Of primary importance to successful defense is the performance of the phagocyte: not only must it engulf the invader, but it also must produce enzymes in sufficient quantity and variety to destroy the phagocytosed organism.

Although the essential steps in host defense are discussed individually, it must be remembered that success depends upon both phagocytic activity and the *interaction* of humoral and cell-mediated immunity. When these defense mechanisms break down, the host becomes compromised and prone to infection by ordinarily avirulent (opportunistic) microorganisms.

LOCAL DEFENSE MECHANISMS

Nonspecific Mechanisms

Like other body regions exposed to foreign agents, the bronchopulmonary tree is covered by a tightly knit epithelium that extends over connective tissue composed of cells and fibers suspended in a mucoprotein gel matrix. This connective tissue layer contains lymphocytes, plasma cells, and tissue macrophages prepared to resist any attempt at invasion. In contrast to the open or punctate junctions of capillary endothelial cells (maculae occludentes), which allow escape of fluid into the interstitial tissues (*see* page 88),[270] alveolar epithelial cells are joined by continuous or