THE HAND IN RADIOLOGIC DIAGNOSIS

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Professor of Radiology, The University of Michigan; Co-Director of Pediatric Radiology, C. S. Mott Children's Hospital, The University of Michigan; Research Scientist, Center for Human Growth and Development, The University of Michigan, Ann Arbor, Michigan

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E. JAMES POTCHEN, M.D., *Consulting Editor*

Professor of Radiology
The Johns Hopkins University School of Medicine
Baltimore, Maryland; formerly Professor of Radiology
The Edward Mallinckrodt Institute of Radiology
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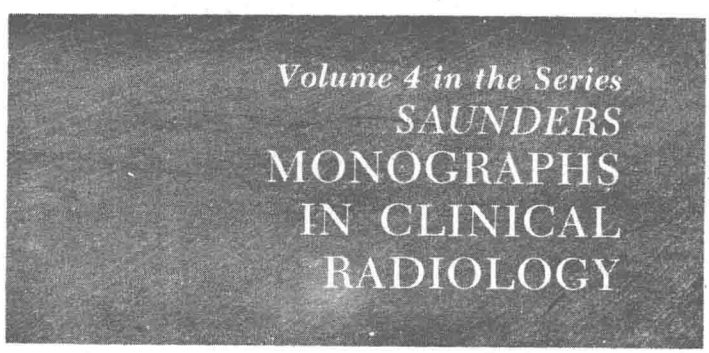

CONTRIBUTORS

JOSEPH J. BOOKSTEIN, M.D.

Professor of Radiology, Chief of Cardiovascular Radiology, University of Michigan Medical Center, Ann Arbor, Michigan

DEAN S. LOUIS, M.D.

Assistant Professor of Surgery—Orthopedics, Chief of Orthopedic Hand Clinic, University of Michigan Medical Center, Ann Arbor, Michigan; Chief of Orthopedics, Wayne County General Hospital, Eloise, Michigan

ANDREW K. POZNANSKI, M.D.

Professor of Radiology, Co-Director of Pediatric Radiology, C. S. Mott Children's Hospital, University of Michigan, Ann Arbor, Michigan; Research Scientist, Center for Human Growth and Development, University of Michigan, Ann Arbor, Michigan

TOM W. STAPLE, M.D.

Professor of Radiology, Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Missouri

EDITOR'S FOREWORD

> If the hand be held between the discharge-tube and the [fluorescent] screen, the darker shadow of the bones is seen within the slightly dark shadow-image of the hand itself. . . . For brevity's sake I shall use the expression "rays" and to distinguish them from others of this name, I shall call them "x-rays."
>
> WILHELM CONRAD ROENTGEN, 1895

This historic incident was no accident, but rather presaged the hand as a model for radiographic studies of bones and soft tissue. Early studies devoted much of their attention to the diagnosis of infectious diseases and trauma. These studies were followed by the recognition that the hand x-rays provided important diagnostic information on systemic disease processes ranging from abnormal body growth to metabolic diseases of bone. More recently, there has been renewed emphasis on the use of the hand x-ray to classify genetic abnormalities. The remarkable recent growth of medical genetics as a discipline is largely related to a combination of a better understanding of molecular genetics and a greater precision in clinical classification. The ability to discern more subtle differences between people has been nowhere more apparent than in the improved classification made possible by recognizing many of these abnormalities on the hand x-ray.

Some years ago I was taken by an excellent review article written by Dr. McAfee and Dr. Donner entitled The Differential Diagnosis of Radiographic Changes of the Hand, in which is stated, "Like the funduscope examination of the eyes, the bones of the hand frequently serve as 'mirrors' of systemic disease." The recognition of this precept has led to the wider application of the hand x-ray in the diagnosis of disease. However, their admonition "that routine radiographs of the hand deserve a wider role in the diagnosis of systemic disease" still holds true. This monograph was therefore invoked in an effort to enhance an appreciation for the use of the hand x-ray in the management of patients with infectious, metabolic, occupational and congenital diseases. It is envisioned that a more comprehensive understanding of the subtle differences seen in hand x-rays may lead to a renewed interest in this important diagnostic modality, based on a sound appreciation of the current state of the art.

We are indeed fortunate that Dr. Poznanski has accepted this challenge and has produced a scholarly monograph in a lucid and erudite style that clearly portrays the radiology of the hand and all its implications. Dr. Poznanski, a native of Poland and a graduate of McGill University, studied radiology at the Henry Ford Hospital. For the past six years, he has been on the faculty of the University of Michigan Medical Center and is currently the Co-

Director of Pediatric Radiology at the C. F. Mott Children's Hospital. Although his interests have ranged widely through the technical and clinical aspects of pediatric radiology, he personally has been involved in clarifying our understanding of the skeletal manifestations of congenital disease. While many radiologists have come to appreciate his work on the thumb and carpals in congenital malformation syndromes, most are unaware of his contribution to the field of physical anthropology, best exemplified in a paper entitled Disharmonic Maturation of the Hand in Congenital Malformation Syndromes.

As the recognized authority on the hand x-ray, Dr. Poznanski has complemented his publication of some 80 research articles with an extensive interest in teaching radiology. His contribution not only to the development of new knowledge but to its dissemination is amply documented in this monograph. Dr. Poznanski's characteristic aura of excellence has resulted in a work that is a fitting sequel to the previous monographs in this series.

E. JAMES POTCHEN, M.D.

PREFACE

For centuries the hand has been known as a mirror of disease. Similarly, the hand radiograph reflects a wide range of disease states. Although the hand responds to various disorders as does the remainder of the skeleton, many of the hand manifestations are unique, particularly in the congenital malformation syndromes. The goal in writing this book was to gather data about the various diseases as they affect the hand, so that the information would be readily available for reference.

After the discovery of the roentgen ray, the hand was the first portion of the body to be studied radiologically in a systematic fashion. This was partly because the hand is an accessible portion of the skeleton and has relatively little overlying soft tissue. Today the hand is still a diagnostically useful region. Because of the hand's thinness, films can be obtained without screens, allowing excellent visualization of fine trabecular structure. The hand is also remote enough from the body to be radiographed freely without significant bone marrow or gonadal dose.

There are four main sections of this book. The first (Chapters 1 through 5) deals with the normal hand, its development, skeletal maturation and measurement, and various special radiologic techniques.

The second section (Chapters 6 through 10) describes the normal variants and congenital anomalies of the hand. Although many of the congenital anomalies alone have no clinical significance, when they are associated with other congenital anomalies they may be diagnostic of certain congenital malformation syndromes. The aim of this section is to help the reader differentiate between the normal and the abnormal, and to determine whether a certain radiologic finding is isolated or whether it is related to a malformation syndrome. To attain this goal, tables are presented, listing other findings that are associated with the variants or anomalies discussed in the text. By referring to these tables, the physician should be able to identify the conditions in which a certain finding may occur.

The third section (Chapters 11 through 13) deals with congenital malformation syndromes. Chapter 13 is an alphabetical listing of a number of syndromes which have some roentgen manifestations in the hand. Each discussion includes a brief clinical description as well as a brief summary of other radiologic findings that may be helpful in diagnosis. The references have been kept to a minimum and should be used to obtain further information about these conditions.

The fourth section (Chapters 14 through 21) deals with the hand manifestations of acquired disorders. Sometimes the distinction between the acquired and the congenital is not clear. For example, several of the hematologic disorders are due to a congenital defect, as is the case for sickle cell anemia. They have nevertheless been included in the section on acquired

disorders because the radiologic manifestations are mainly secondary to the hematologic disorder.

A large portion of this book is devoted to the study of normal variants and congenital disorders of the hand, in particular the child's hand. This partially reflects my own personal bias as a pediatric radiologist, and also the facts that more variations are possible in the child's hand and that the spectrum of abnormalities on the basis of congenital disorders is probably wider than that due to acquired conditions. Normal variations are also much more common in the pediatric patient. Differentiation between the various congenital malformation syndromes is often possible by means of the radiograph of the child's hand, whereas when maturation has taken place, such identification may be impossible.

ANDREW K. POZNANSKI, M.D.

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Many individuals have been of considerable help to me in the preparation of this book, and their efforts are deeply appreciated.

Four chapters were prepared for me by three friends and colleagues. They deal with subjects in which they have much expertise, and their efforts are greatly appreciated. Dr. Joseph Bookstein, Professor of Radiology at the University of Michigan, wrote the section on angiography of the hand. Dr. Dean Louis, Assistant Professor of Surgery at the University of Michigan, prepared the section on trauma to the hand. Dr. Tom Staple, Professor of Radiology at Washington University in St. Louis, Missouri, wrote the chapter on the arthritides.

Dr. John Holt, Professor of Radiology at the University of Michigan, has helped and encouraged me in the preparation of this book. He has had a great interest in the hand; in fact, in 1944 at the joint meeting of the American Roentgen Ray Society and Radiological Society of North America, he presented an exhibit entitled "The Bones of Hands as an Index of Local and Systemic Disease." Dr. Holt has over many years collected many excellent radiographs which he made freely available to me. He also made many helpful comments as the text was being written.

Dr. Stanley M. Garn, a Fellow of the Center of Human Growth and Development and Professor of Nutrition in the School of Public Health at the University of Michigan, has been a source of stimulation and information. Over the past five years we have collaborated in numerous research projects dealing with the hand. He has freely supplied me with radiographs showing normal variants, as well as much normative data which he has derived. Some of his published, and previously unpublished, data are included in this book. He also assisted greatly by critically reviewing the chapters on measurement and maturation.

A number of other physicians have been extremely helpful in reviewing the manuscript. Dr. Lawrence Kuhns, a new colleague in the Division of Pediatric Radiology, carefully read most of the chapters and made many useful comments. He also provided some translations from the German literature. A number of pediatricians lent their expertise in reviewing the chapters in their special areas of interest. Dr. Roy Schmickel reviewed the chapters on the chromosomal abnormalities and on the malformation syndromes; Dr. Joseph Baublis, the chapter on infectious disease; Dr. George Bacon, the discussion of endocrine disease; and Dr. Al Burdi, from the Anatomy Department of the University of Michigan, reviewed the section on embryology.

Dr. Aaron Stern, Dr. John Gall and Dr. Roy Schmickel, as well as many of the other staff and residents in pediatrics, radiology and orthopedics at the University of Michigan have been very helpful in finding me interesting and unusual cases.

Most of the illustrations used in this book came from the files of the University of Michigan, but a significant number of cases were from my alma mater, the Henry Ford Hospital in Detroit. Drs. William Reynolds and Max Clark from the Henry Ford Hospital, and Dr. William McAlistair from Washington University, St. Louis, Missouri, were particularly cooperative in sending me many interesting films which added significantly to the scope of this book. Many other individuals have been kind enough to send me tabular and illustrative material. They include Drs. L. Ackerman, F. P. Agha, R. J. Allen, D. P. Babbitt, J. W. Barber, G. Baylin, M. H. Becker, W. E. Berdon, D. E. Boblitt, S. P. Bohrer, S. H. Boswell, J. W. Bowerman, C. Bream, W. R. Breg, H. H. Brueckner, A. Burdi, C. J. Campbell, M. P. Capp, J. Carr, W. P. Cockshott, D. P. Corbett, W. A. Crabbe, G. Currarino, M. K. Dalinka, J. E. Desautels, H. Dick, J. P. Dorst, D. Elzinga, C. D. Enna, W. Eyler, G. Fine, R. J. Fosmoe, B. Frame, K. Gefferth, A. Giedion, B. Gompels, R. J. Gorlin, J. L. Gwinn, R. Hall, R. C. Hildreth, E. Hooper, C. S. Houston, E. S. Huckins, B. S. Jones, R. C. Juberg, I. Krieger, K. Krufky, J. P. Kuhn, T. R. Lawrie, F. A. Lee, D. S. Louis, R. I. Macpherson, S. Markel, P. Maroteaux, W. Martel, V. McKusick, H. E. Meema, D. C. Moses, M. E. Mottram, R. J. Neviaser, M. B. Ozonoff, B. L. Pear, J. A. Pitcock, H. J. Pollock, R. V. Pozderac, R. Rapp, S. Reuter, W. Riggs, A. S. Romer, H. D. Rosenbaum, R. R. Schreiber, G. Shackelford, L. Shapiro, R. S. Sherman, F. N. Silverman, T. W. Staple, G. I. Sugarman, Y. Sugiura, D. Swindler, L. E. Swischuk, S. P. S. Teotia, M. Ting, D. Tinkle, J. M. Tishler, W. Walker, A. Weinstein, R. Weiss, W. J. Weston, A. A. White, III, D. Wilner, R. Carroll, R. D'Alonzo, and W. Glat.

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A. K. P.

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Part I

THE NORMAL HAND AND TECHNIQUES OF ITS EVALUATION

Chapter 1

HISTORY, RADIOGRAPHIC ANATOMY, EMBRYOLOGY AND COMPARATIVE ANATOMY

The hand is one of the features that distinguish man from other animals. Man is the only animal which effectively uses the hand. As stated by Alpenfels,[1] "Man alone has a hand. He uses it as a tool, as a symbol, and as a weapon. A whole literature of legend, folklore, superstition and myth has been built around the human hand. As an organ of performance, it serves as eyes for the blind; the mute talk with it; and it has become a symbol of salutation, supplication and condemnation. The hand has played a part in the creative life of every known society and has come to be symbolic or representative of the whole person in art, in drama, and in dance." The right-handedness of most men has been given varying significance in different societies. For example, in some cultures the right hand is used for cooking and eating, while the left is used for bathing, elimination and activities associated with sex.[1] The right and left hands have become symbolic of good and evil. The hand has been used to express feeling in various forms of art, ranging from the primitive to the present.[1,5] Durer (1471–1528) devoted much of his life to the study of the hand, as evidenced in his paintings, and Rodin (1840–1917) used the expressiveness of the hand in many of his sculptures.

The derivation of the word "hand" has been used for many words of action,[1] including manipulate, mandate and dexterous (having two right hands). The term "right" or "true" arises from right-handedness, as does the French word *droit,* meaning right or law. Similarly, the word "left" symbolizes "evil" and the Latin term *sinister,* meaning left, also has negative meanings.

The hand has been used for counting.

Units of measurement, including the inch, were derived from the hand. In the past, various tools were constructed using measurements in terms of numbers of hands.[1] The hand has been used for identification; fingerprints have been used for identification since ancient times. In China fingerprints were used to sign paintings,[1] while a present-day security system uses the hand configuration as a means of identification.* The hand has also had much symbolic and metaphysical significance. The art of palmistry or chiromancy was practiced in ancient times, but it was a physician named Hartlieb[4] who wrote one of the notable books on the subject in 1448. The hand is used as a mode of expression, particularly in certain national groups, although most individuals use their hands when talking. A formalized hand language has been developed for the deaf, and the tactile sensation of the hand has been used by the blind in interpreting braille.

Figure 1–1. This is one of the first radiographs of a portion of the human body. December 22, 1895. (Courtesy Deutsches Museum, Munich.)

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RADIOLOGY OF THE HAND

Historical Facets

On November 15, 1895, the first radiograph of a human being was produced, and was that of a hand. An early hand radiograph obtained on December 22, 1895, is illustrated in Figure 1–1. In 1896 over a thousand articles appeared in the world literature on the use of radiography;[1] most of these dealt with the hand. Partially because of the relatively low output of the x-ray machines in those days, the hand was the only part of the body thin enough to be easily radiographed.

Grigg[1] lists some of the firsts in radiology of the hand. These include the following: In January 1896 Jastrowitz published a description of a radiograph of a glass splinter within the hand. Also in January 1896 Haschek and Lindenthal outlined the arteries of a severed hand of a cadaver by injecting radiopaque material, thus producing the first angiogram. The use of a radiograph for aiding in the extraction of a bullet from the hand was reported in January of 1896 by Mosetig-Moorhof. In February 1896 Zenger described destruction of phalanges, probably from osteomyelitis. Wertheim-Salomonson, in February 1896, described a spina ventosa, hypertrophic pulmonary osteoarthropathy, and gave the first description of the appearance of a hand of a young child. He de-

*Identimation, Northvale, New Jersey 07647.