UNDERSTANDING RADIOGRAPHY

Fourth Edition

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By

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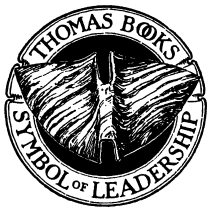

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To my wife Patricia
and my daughters Kimberly and Laura

PREFACE TO FOURTH EDITION

Since the first image of human anatomy was made in the late 1800s, medical diagnostic imaging has contributed significantly to the advancement of healthcare in a most extraordinary and unique manner. Indeed, the developments of new imaging devices throughout the history of diagnostic imaging has made a profound contribution in helping to define how medicine is practiced today by a wide range of physicians. From the first fluoroscopic machine, to the development of nuclear medicine, ultrasound, and more recently CT, MRI, and PET scanners, we have significantly expanded our ability to "see" diseases and make diagnoses at their earliest stages. In many ways this capability has saved lives, and stimulated research among physicians, scientists, and pharmaceutical companies to develop treatments and medications to correct or bring a wide range of serious diseases under control that would have otherwise resulted in increased morbidity and mortality.

This truly unique contribution provides many of us who are intimately involved with radiology services with a strong sense of pride. These advances come from a lineage of gifted, inspired, and demanding physicians, technologists, and physicists who worked together to look beyond the present and sought what only they could imagine. It has been a continuous infusion of creativity, vision, and tough mindedness among these professionals that brought new diagnostic capabilities to everyday clinical use, and further revolutionized healthcare treatments to improve the lives of countless numbers of patients.

In the early 1970s, we experienced a rush of excitement as scientists, technologists, and physicians worked together to integrate computer technology with x-ray producing equipment, and built the first CT scanners. This marvel of mechanical and electrical engineering, medical science, and computer technology opened a new and exciting world of disease imaging capabilities that could not have been imagined only a few years before. Today, the startling images we see with MRI scanners, along with newly developed and complex interventional techniques have allowed radiology services to

actually take the place of routine exploratory and complex corrective surgery–and advanced PET scanning. Techniques are likely to expand our knowledge and understanding of complex brain functions, and will no doubt lead us to other effective treatments that are not currently available.

Today, we are seeing diagnostic imaging technology pass through another threshold that offers additional capabilities and potential. At a time when there is ample justification for excitement about faster and faster MRI and CT that can produce even more diagnostic information–and new images from PET, we are also seeing the implementation of PACS technology. PACS will revolutionize how general diagnostic images are produced, archived, and distributed throughout the healthcare community. Technologists who work with general radiographic equipment are now learning how to use computerized and direct digital technology, and they are seeing how PACS will impact patient care and their everyday professional lives.

The fourth edition of Understanding Radiography not only contains updated and refreshed material on familiar imaging technology, it also provides thorough explanations with many original illustrations of high speed CT imaging, PACS networks, and computerized radiography. Further, it contains new insights that will help prepare students as well as experienced technologists on how these technologies can be used to provide the highest level of imaging services possible.

I recently heard someone say that people tend to think of "technology" as something that had been discovered only during their more recent life experience. Indeed, technology seems to be perception rather than reality because we often discount or take for granted what has [always] been available before our time as common and fundamental. Someday, MRI and PET scanners, along with a host of other developments, may also seem to be common and fundamental. For today, [our] new medical imaging technology adds to an already vast arsenal of imaging equipment which places technologists in a unique and commanding position. Despite the excitement of a new piece of equipment, we should always keep in mind that these devices have little merit on their own. The merit in these devices is realized when they are placed in the hands of skilled technologists who have a strong sense of professionalism and an ability to exhibit compassion toward their patients' best interests.

S. S. H.

PREFACE TO THIRD EDITION

New information is presented to cover tabular drain film and high frequency generators. Updated and new information is also presented on the subject of radiation protection and x-ray tubes.

A new chapter has been prepared on computerized tomography. This new chapter contains basic information, yet it is sufficiently comprehensive to make it a very worthwhile addition to the text that will orient the student soundly to this very interesting imaging modality. The discussions covering the history, major components, its value to medical diagnostic services, as well as methods of image reconstruction are explained in a fashion that is informative and easy to understand.

Additional updated information is also presented in the chapter covering digital imaging that will keep the student current with essential information on this fast developing technology.

S. S. H.

PREFACE TO SECOND EDITION

The First Edition of this work provided a firm base of information of radiographic imaging.

Four new chapters have been added which expand considerably the scope of this text.

It has been endeavored to provide, in a very practical format, a devotion to detail as this relates to the day-to-day clinical experience of the technologist. In this expanded edition, each of the four new chapters at the back of the book provides coverage of full and sufficient depth so that accurate insight may be obtained by the reader.

There has now been included a comprehensive chapter on radiation protection, covering complete and necessary details.

There is a complete chapter on radiographic tubes, x-ray production, and the nature and characteristics of x-radiation.

A chapter on the x-ray circuit utilizes a very clear and practical approach to this potentially confusing subject.

It has seemed important to include, in simple and concise terms, a chapter on T.V. cameras, image intensification, and digital fluoro subtraction.

S. S. H.

PREFACE TO FIRST EDITION

During the early planning stages of this text, a few important prerequisites were self-imposed in the firm belief that their absence would yield a publication so similar to those presently available that another text simply would not be justified. The information presented within the following pages is in some instances new ground for even the experienced technologist while, in other instances, old familiar concepts have been reassessed and aligned more closely with current data.

An important goal which had been set is that strict attention and ample time would be given to the many aspects of radiography which have, in the past, been treated perhaps too simplistically. Although complex physical formulae are not contained in this volume, an attempt has been made to not merely present these concepts of modern radiography for purposes of identification, but also to discuss and analyze each issue at hand from more than one perspective. Without this more rounded approach, much of the meaning is often lost, and as a result misconceptions and frustrations take the place of enlightenment.

It has been my intention from the outset that the information within these pages be presented in such a way that it can be readily understood, and that each concept discussed is covered thoroughly enough and with sufficient depth that an accurate insight can be gained to bridge the gap students often feel is present between classroom theory and its practical application.

In the end, it is often the concept of an idea that is most important to remember, because from it one can learn to answer many of his own questions.

The primary intention of this text is to provide those concepts and insights from which the technologist can grow into a competent professional.

S. S. H.

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Sincere thanks must be given to Mr. Jonathan Law and Carmine Pierno for their interest and effort.

There are moments in one's career when a single choice must be made

regarding the direction of one's career. Mr. Frank Horvath will never be forgotten for the opportunity he afforded by introducing me to radiography and for his unselfish guidance, good will, and trust.

Mr. Jack Cullinan's help and treasured advice have given me a wealth of knowledge and insight into radiography. His thoughtfulness, knowledge, and good will cannot be properly expressed in words, only felt within.

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For the opportunity to work with a publisher who expresses sincere interest in the author's well-being without sacrificing quality, I wish to thank Mr. Payne Thomas. His attitude throughout this project was one of support, trust, and the provider of valued guidance. To Mr. Thomas and his staff at Charles C Thomas, Publisher, I wish to express my sincere appreciation for their help and effort.

Mrs. Patricia Donnon deserves a great deal of thanks for laboring through my first set of handwritten notes and putting them into the first typing. Untold hours must have been spent deciphering those scribblings.

In the long run, good will and trust often determine the success of an undertaking. For those gifts, unselfishly provided me throughout my early years, I wish to thank my parents, Nicholas and Sophia.

In the preparation of the third edition, I was fortunate indeed to receive the help of Mr. Robert Murphy, and Mr. Bud Leonard of E. I. DuPont without whom the discussion covering tabular grain film could not have been written.

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The companion publication, *Lab Book & Study Guide,* has been reformatted and expanded to include: Chapter Learning Objectives, Experiments, and an Overview. These changes are the direct result of a collaboration with Mr. Gary Woogenrich, Program Director, North Hampton Community College. His extensive experience, insight, creativity, and council have resulted in a very useful study of the main text.

The information and council freely provided by Mr. Douglas Pfeiffer, M.S., Radiation Physicist, Hospital of the University of Pennsylvania, also deserves considerable recognition. His work in reviewing and updating Chapter Thirteen is very much appreciated.

CONTENTS

UNDERSTANDING RADIOGRAPHY

Chapter One

CHARACTERISTICS OF THE RADIOGRAPHIC IMAGE

Objectives

- Understand how basic terminology is used to describe the components of a high quality radiographic image
- Appreciate the difference between the image characteristics of visibility of detail and definition of detail.
- Understand the reasons why a high quality image must possess an optimal balance between visibility of detail and definition of detail.
- Understand the fundamental dependence between body tissue, the x-ray beam, processing, and film-screen combinations in producing a high quality radiographic image.
- Appreciate how x-ray photon-tissue absorption affects the remnant beam and in turn, how the remnant beam affects the final radiographic image.
- Understand what sensitometry is, and how this technique is used to evaluate key radiographic image characteristics, as well as properties of film-screen systems.
- Develop an expectation of how a high quality radiographic image should appear to the viewer.

THE TERM RADIOGRAPH is most commonly used to identify a permanent image produced by x-rays; however, over the years, terms such as *roentgenogram* or *plate* have been used to identify the permanent image. *Roentgen,* of course, is taken from Wilhelm Roentgen's discovery of x-rays, and *plates* was used because the first permanent images were on pieces of plate glass that had been coated with a silver bromide emulsion.

RADIOGRAPHIC BALANCE

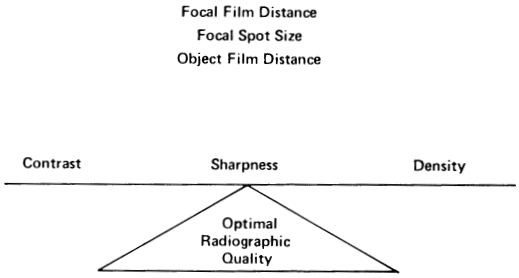

Figure 1. Contrast and density must compliment each other in order to produce optimal radiographic results. Too much or too little contrast for a given density or vice versa will destroy radiographic quality.

The radiographic image must meet certain requirements to be of any medical value, and although the standards are considerably higher today than they were at some point earlier in time, the specific characteristics desired have not changed. Considering all the desirable properties an image should possess (see Fig. 1), technical balance is perhaps the most important. In a radiographic sense, balance is the relationship between contrast, density, and sharpness. It would be incorrect, however, to associate a specific contrast with a specific density, or sharpness. A balanced radiograph can have short or long scale contrast and can be light or dark. This is an important concept for the technologist to realize because if he can learn to identify a technically imbalanced image he will more easily know when to make technical adjustments or corrections. Figure 2 shows the diagnostic value of a well-balanced radiographic image as compared to one that is not. An imbalanced image may also be too flat or too light, and detail that one ordinarily expects to be present will be absent. It is important that such characteristics as these be identified as separate entities by the technologist so that he will have a basis from which corrections can be made. The author's feeling is that a technologist who cannot appreciate the quality or lack of it in a radiographic image will not be able to affect the appropriate adjustments necessary to correct the problem.

In summary, one can state that overall technical quality of a radiographic image is strongly dependent upon the compatibility that exists between contrast, density, and sharpness, and, if one is not dominant over the other, a certain technical balance has been successfully achieved. Later in the text, much discussion and evidence will be presented as to how such a balance can be obtained by using the various tools the technologist has at his disposal.

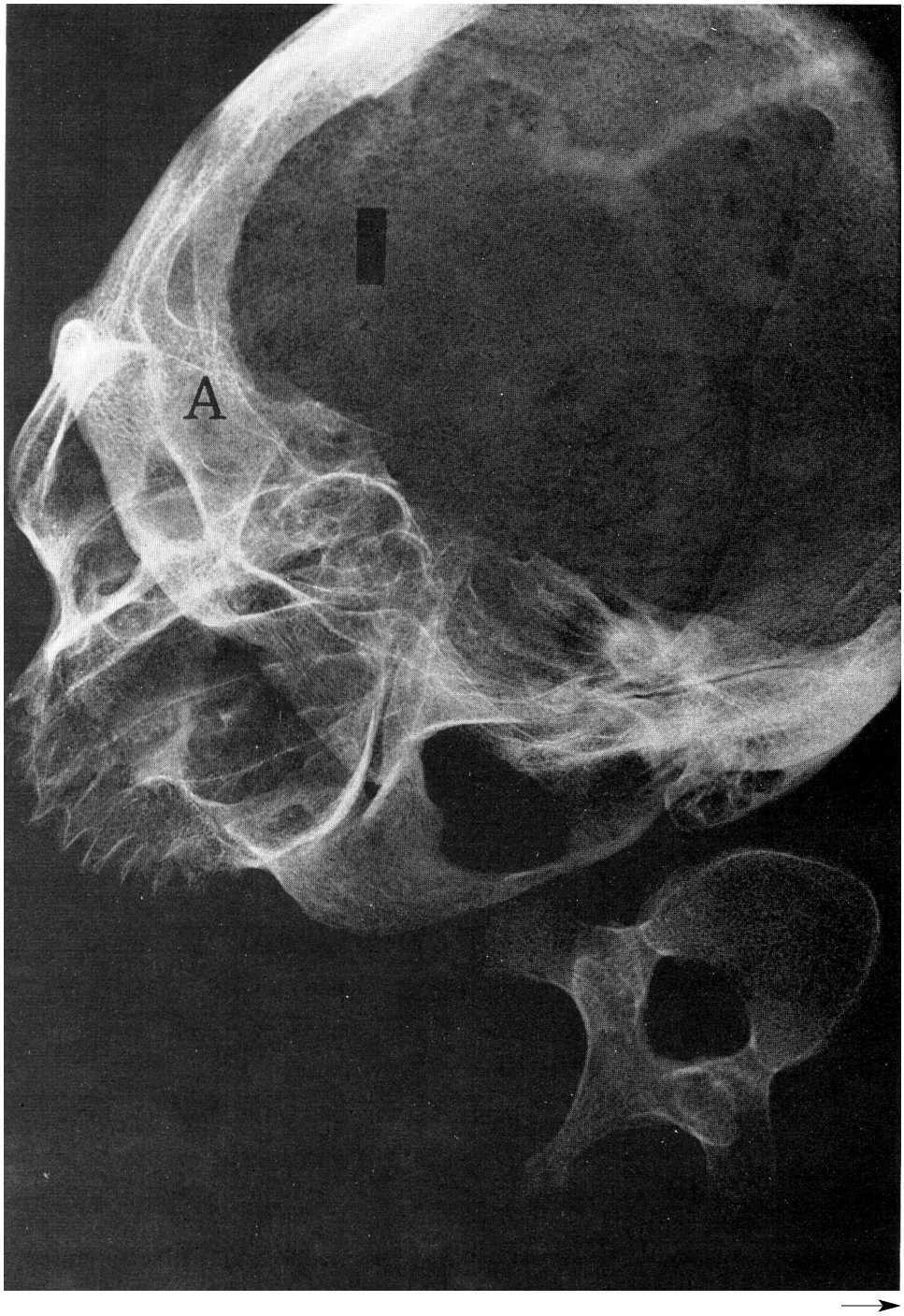

Figure 2A. Visibility of detail is much improved from *A* to *B* as a result of improved density.

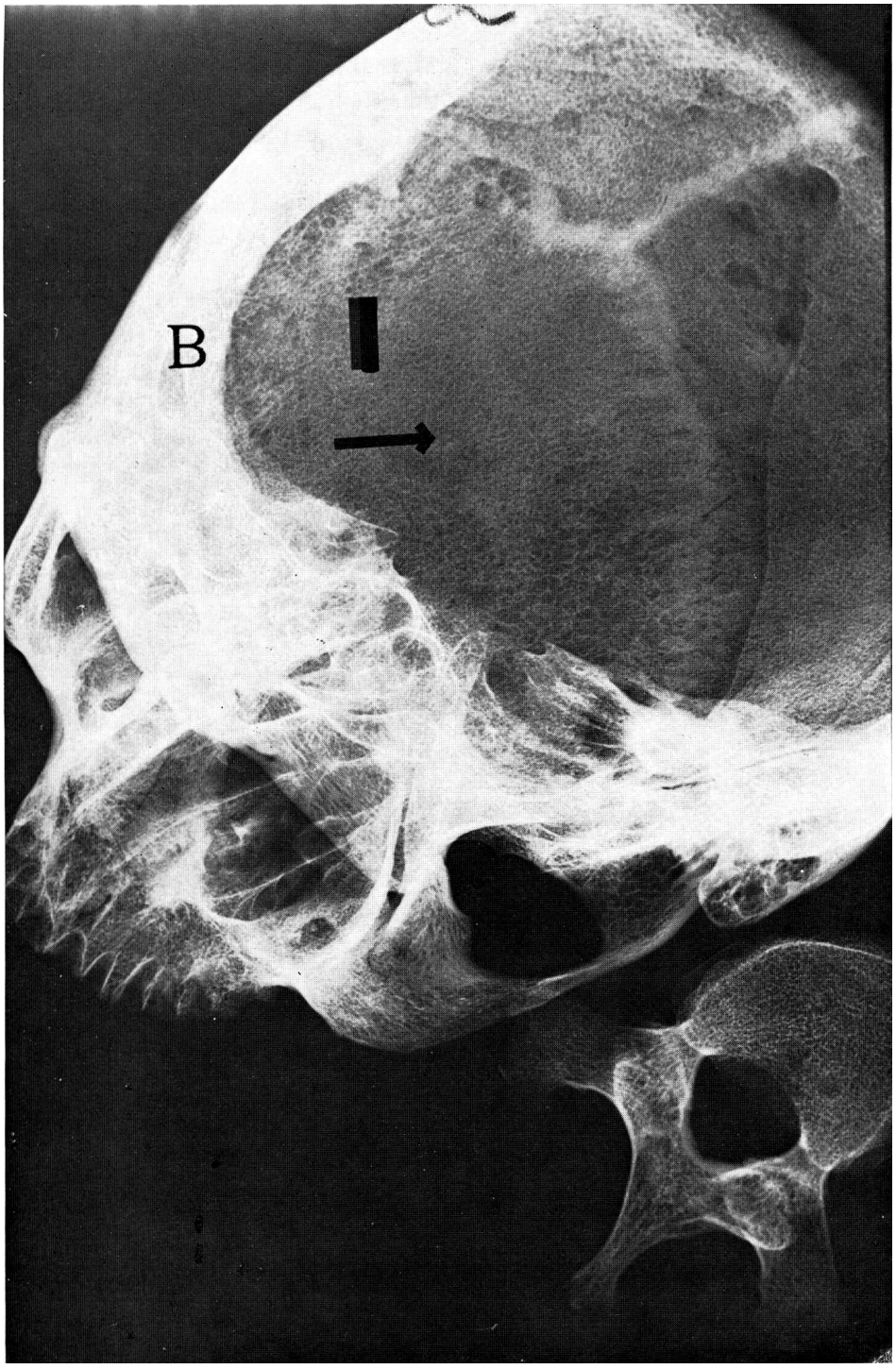

Figure 2B.