Preface

Bone densitometry is an extraordinary clinical and research tool. Most of us think of densitometry as a relatively recent technological development, but in fact, its history began over 100 years ago. In the field of dentistry, crude devices by today's standards were developed in the late nineteenth century to evaluate the density of the bone in the mandible. The advances in technology continued, albeit slowly for the first half of the twentieth century, gaining some speed in the 1960s and 1970s. The introduction of dual-energy X-ray absorptiometry in the late 1980s truly opened the door to clinician's offices for bone densitometry. In the last 20 years, the advances in technology and the introduction of new machines of various types have occurred with almost blinding speed compared to the pace of development during most of the twentieth century.

As densitometry has matured as a field, the number of disease states in which bone density is known to be affected has increased. With this knowledge, physicians in many different fields of medicine now recognize the need to measure the bone density as part of the management of their patient. More studies are being requested now than ever before. This demand for densitometry has also led to an increased need for qualified technologists to operate these machines.

Densitometry is one of the many quantitative techniques in use in clinical medicine today. That is, the technology is used to measure a quantity, the bone density, just as the measurement of blood pressure or cholesterol is also a quantitative measurement technique. But of all the quantitative techniques in use in clinical medicine today, there is none that has the potential to be more accurate or precise than bone densitometry. The technology is highly sophisticated. All of the devices in use today employ computer technology. Even with all this mechanical sophistication, however, the technology will only be as good as the technologist.

The densitometry technologist must have knowledge of skeletal anatomy, densitometry techniques, radiation safety, basic statistics, quality control procedures, and various disease processes like osteoporosis. The technologist must often make decisions about the conduct of testing without immediate input from the physician. The circumstances in which densitometry is usually performed create the opportunity for extended technologist–patient interaction and discussion. For technologists accustomed to performing radiological procedures, this degree of interaction is unprecedented. Today's densitometry technologist must be prepared for these encounters.

There is no substitute for the thoughtful training provided by the manufacturers of the various types of densitometry equipment when the devices are installed. There is also no substitute for careful study of the operator's manuals that are supplied with these machines. The exact operation of each machine is different. Ultimately, to be proficient on any densitometry device, the technologist must be trained on that specific device. There is a broad knowledge base however that all technologists should possess. This text is intended to help provide that base.

This book is overwhelmingly focused on the bone density technology known as dual-energy X-ray absorptiometry or DXA. While other technologies are discussed, clinical practice guidelines from national and international organizations that have evolved in recent years call for the use of DXA studies of the spine and proximal femur in the diagnosis and management of osteoporosis. Consequently, other technologies, although not without merit, currently have lesser roles in clinical practice.

It is always difficult to know where to begin. Like so many other fields of medicine, densitometry has its own language and conventions that must be explained so that in-depth discussions of densitometry are understood. Chapter 1 is an introduction to the terminology and conventions used in bone densitometry. In Chap. 2, a review of the various techniques and technologies used in quantifying the bone mass is presented. This review provides some of the historical development of the field as well as discussing the attributes of the various technologies and the differences between them. In Chap. 3, the skeletal anatomy of commonly measured densitometry sites is discussed with an emphasis on those attributes of anatomy that are either unique to densitometry or which would have an effect on the measurement of bone density at that site. This is logically followed by Chap. 4, in which the performance of DXA lumbar spine, proximal femur, and forearm studies is discussed. This chapter is new to the third edition of this book. While each manufacturer will provide specific instruction on positioning and analysis of studies performed on their machines, there are aspects of scan performance that are common to all. Chapter 5 is a discussion of radiation safety in general and in bone densitometry specifically. Most, but not all, densitometers are X-ray devices. Radiation safety then must be a concern. Fortunately, both patient and technologist exposures from X-ray densitometry are incredibly small. Nevertheless, the concept of *ALARA* (as low as reasonably achievable) demands that the patient, the public, and the technologist be protected from unnecessary exposure to ionizing radiation. In Chap. 5, radiation safety concepts are discussed with recommendations made for radiation safety procedures at densitometry facilities.

All densitometers, as sophisticated as they are, are ultimately mechanical devices. Things can and do go wrong. It is imperative that machine malfunctions be recognized as soon as possible. Otherwise, the data from the machine that are provided by the technologist to the physician will be flawed. This means that a good quality control program must be in place. This is normally the responsibility of the technologist, not only to create but also to monitor. Therefore, an understanding of quality control procedures, quality control phantoms, and the development of a quality control program is absolutely necessary, although it is recognized that these are not particularly popular subjects. Quality control issues are discussed in Chap. 6.

It is equally important that the technologist understand the concept of precision and how to measure and apply it. This is presented in Chap. 7. Without careful attention to precision, those factors that affect it and knowing how to calculate it, the physician to whom the results are given will not be able to interpret follow-up bone density studies to determine if the bone density has changed.

Also new to this edition is Chap. 8. One of the major applications of bone densitometry data is the prediction of fracture risk. The manner in which this determination is made has changed in only the last few years. Older expressions of risk such as relative risk are no longer considered appropriate. Instead, there are several absolute fracture risk prediction tools that are achieving widespread use. Because some of these are being incorporated into densitometry software and because the technologist may be asked to access and employ others to calculate fracture risk, a discussion of these new fracture risk prediction tools is included in this edition.

Two chapters of this book may seem unusual in a book for technologists. Chapter 9 is a review of the disease for which densitometry is most commonly used, osteoporosis. Chapter 10 is a review of how the data that comes from these machines is actually interpreted to diagnose osteoporosis and predict fracture risk. These chapters might at first seem more appropriate in a book written for physicians. The densitometry technologist, however, normally spends a significant amount of time with the patient. There is ample opportunity for the patient to ask questions of the technologist about osteoporosis and about the test that he or she is about to undergo. The knowledgeable technologist can be a vital link in the education of the patient. He or she can allay unnecessary fears and encourage appropriate medical follow-up. The technologist is not usurping the role of the physician by doing so if the technologist understands the issues involved. Indeed, the complete medical care of the patient must involve a partnership between the technologist and the physician. The final diagnosis and treatment recommendations for any patient must be left to the physician, but within those bounds, there is much the technologist can do that will actually strengthen the patient's trust in the quality of their care and improve compliance with the medical recommendations. The technologist who understands as much as possible about what the physician will consider as he or she looks at the densitometry report will only be better able to aid that physician in the performance of their profession. Since the publication of the last edition of Bone Densitometry for Technologists, new drugs have been approved for the prevention and/or treatment of osteoporosis. This information has been added to Chap. 9 in this edition.

Chapter 11 is also new to this edition. In this chapter, a series of DXA images in which artifacts or structural changes can be seen are reproduced. Often in densitometry in illustrating the utility of the technology, scan images of perfect spines, free of artifacts, are shown. In clinical practice, the spines of our patients are often not as perfect. While some of these less than perfect scan images are self-explanatory, others are not. Realizing that there is no substitute for having seen it before, these images are provided in the hope of aiding the technologist in recognizing these artifacts and changes in their patients. It is imperative that the technologist do so, because many of these artifacts and structural changes will affect the measured BMD. Their recognition is critical to the appropriate interpretation of the study.

In the last few years, densitometry has found increasing applications in pediatrics. The technical considerations are different from adult densitometry, and the interpretation of densitometry data is even more complex than its adult counterpart. The 2002, 2004, and 2007 ISCD guidelines that apply to pediatric densitometry are reviewed here. This is an area that is expected to grow however, and so many of the confounding issues in pediatric densitometry are addressed in Chap. 12.

Chapters 13 and 14 deal with some of the newer applications for DXA. In Chap. 13, there is a review of vertebral fracture assessment (VFA) imaging. VFA imaging with fan-array DXA devices is now being utilized to perform vertebral fracture diagnosis and aortic calcification assessment. Proximal femur morphometry and hip structural analysis can be performed using proximal femor studies. Body composition analysis with DXA, which is discussed in Chap. 14, is probably the least utilized application of DXA, but its advantages become obvious when compared with other body composition methods. Its potential utility, particularly in the context of growing concerns about the metabolic syndrome, is enormous.

The 12 appendices have been updated wherever necessary to reflect the most current information available. Contact information for organizations of interest can be found in Appendix A. Every attempt was made to verify the accuracy of this information at the time this book went to press. The World Health Organization criteria for the diagnosis of osteoporosis are summarized in Appendix B, and the conversion of the criteria to T-scores is illustrated. Guidelines for bone density testing from ISCD and other organizations are found in Appendices C and E, and the new ISCD-IOF position on the use of FRAX® is found in Appendix D. Appendices F–K summarize the Medicare Bone Mass Measurement Act of 1997, DXA PA lumbar spine labeling guidelines, frequently used conversion formulas, short-term precision study procedures, and the calculation of the LSC and quality control Shewhart rules.

Finally, in Appendix L, the contents of the accompanying CD-ROM are reviewed. On this CD, you will find the Precision Calculator Companion that was first included with the second edition of Bone Densitometry in Clinical Practice. With this calculator, you will be able to calculate the short-term precision and least significant change values for your facility as well as the statistical confidence level for any measured change in BMD. These concepts are discussed thoroughly in Chap. 7. There is also a densitometry patient questionnaire that may be customized for your facility. This questionnaire was designed to ensure the capture of necessary responses in a form suitable for use with FRAX®. A continuing education review is also found on the CD, which, if successfully completed, will result in the awarding of 16 hours of Category A credit acceptable to the American Society of Radiologic Technologists. (*Those readers who do not have access to the CD can download the material at* http://mixmastermedia.com/BDT3.)

As a technology, bone densitometry is really quite extraordinary. The ability to quantify the density of the bones at a variety of skeletal sites has truly revolutionized the approach to a number of diseases, the most important of which is osteoporosis. Using the information from the machines, physicians can recommend and prescribe interventions that will slow bone loss and reduce the risk of disabling fractures. The remarkable advances in skeletal imaging with densitometry devices have made possible quantitative and diagnostic assessments of skeletal structure. But it is in fact the skill and concern of the technologist that enable all of this to happen. It is our hope that this book assists you in your pursuit of excellence in your profession.

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