SEVENTH EDITION VOLUME ONE

Sandra L. Hagen-Ansert

TEXTBOOK OF DIAGNOSTIC SONOGRAPHY

ELSEVIER

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with 3,463 illustrations

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To my daughters,
Becca, Aly,** and **Kati,
who are changing the world one day at a time

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INTRODUCING THE SEVENTH EDITION

The seventh edition of *Textbook of Diagnostic Sonography* continues the tradition of excellence that began when the first edition published in 1978. Like other medical imaging fields, diagnostic sonography has seen dramatic changes and innovations since its first experimental days. Phenomenal strides in transducer design, instrumentation, color-flow Doppler, tissue harmonics, contrast agents, and 3D imaging continue to improve image resolution and the diagnostic value of sonography. The seventh edition has kept abreast of advancements in the field by having each chapter reviewed by numerous sonographers currently working in different areas of medical sonography throughout the country. Their critiques and suggestions have helped ensure that this edition includes the most complete and up-to-date information needed to meet the requirements of the modern student of sonography.

Distinctive Approach

This textbook can serve as an in-depth resource both for students of sonography and for practitioners in any number of clinical settings, including hospitals, clinics, and private practices. Care has been taken to cultivate readers' understanding of the patient's total clinical picture even as they study sonographic examination protocol and technique. To this end, each chapter covers the following:

- Normal anatomy (including cross-sectional anatomy)
- Normal physiology
- Laboratory data and values
- Pathology
- Sonographic evaluation of an organ
- Sonographic findings
- Pitfalls in sonography
- Clinical findings
- Differential considerations

The full-color art program is of great value to the student of anatomy and pathology for sonography. Detailed line drawings illustrate the anatomic information a sonographer must know to successfully perform specific sonographic examinations. Color photographs of gross pathology help the reader visualize some of the pathology presented, and color Doppler illustrations are included where relevant.

To make important information easy to find, key points are pulled out into numerous boxes; tables throughout the chapters summarize the pathology under discussion and break the information down into Clinical Findings, Sonographic Findings, and Differential Considerations.

Sonographic findings for particular pathologic conditions are always preceded in the text by the following special heading:

Sonographic Findings. This icon makes it very easy for students and practicing sonographers to locate this clinical information quickly.

Study and review are also essential to gaining a solid grasp of the concepts and information presented in this textbook. Learning objectives, chapter outlines, comprehensive glossaries of key terms, full references for cited material, and a list of common medical abbreviations printed on the back inside cover all help students learn the material in an organized and thorough manner.

Scope and Organization of Topics

The *Textbook of Diagnostic Sonography* is divided into eight parts:

Part I introduces the reader to the foundations of sonography and patient care and includes the following:
- Basic principles of ultrasound physics and medical sonography
- Terminology frequently encountered by the sonographer
- Overview of physical findings, physiology, and laboratory data
- Patient care for the sonographer
- Ergonomics and musculoskeletal issues for practitioners
- Basics of other imaging modalities
- Image artifacts

Part II presents the abdomen in depth. The following topics are discussed:
- Anatomic relationships and physiology
- Abdominal scanning techniques and protocols
- Abdominal applications of ultrasound contrast agents
- Ultrasound-guided interventional techniques
- Emergent abdominal ultrasound procedures
- Separate chapters for the vascular system, the liver, gallbladder and biliary system, pancreas, gastrointestinal tract, urinary system, spleen, retroperitoneum, and peritoneal cavity and abdominal wall

Part III focuses on the superficial structures in the body including the breast, thyroid and parathyroid glands, scrotum, and musculoskeletal system.

Part IV explores sonographic examination of the neonate and pediatric patient.

Part V focuses on the thoracic cavity and includes:

- Anatomic and physiologic relationships within the thoracic cavity
- Echocardiographic evaluation and techniques
- Fetal echocardiography

Part VI comprises four chapters on extracranial and intracranial cerebrovascular imaging and peripheral arterial and venous sonographic evaluation.

Part VII is devoted to gynecology and includes the following topics:

- Normal anatomy and physiology of the female pelvis
- Sonographic and Doppler evaluation of the female pelvis
- Separate chapters on the pathologic conditions of the uterus, ovaries, and adnexa
- Updated chapter on the role of sonography in evaluating female infertility

Part VIII takes a thorough look at obstetric sonography. The following topics are discussed:

- The role of sonography in obstetrics
- Clinical ethics for obstetric sonography
- Normal first trimester and first-trimester complications
- Sonography of the second and third trimesters
- Obstetric measurements and gestational age
- Fetal growth assessment
- Prenatal diagnosis of congenital anomalies, with a separate chapter on 3D and 4D evaluation of fetal anomalies
- Chapters devoted to the placenta, umbilical cord, and amniotic fluid, as well as to the fetal face and neck, neural axis, thorax, anterior abdominal wall, abdomen, urogenital system, and skeleton

New to This Edition

Ten new contributors joined the seventh edition to update and expand existing content, bringing with them a fresh perspective and an impressive knowledge base. They also helped contribute the more than 1000 images new to this edition, including color Doppler, 3D, and contrast-enhanced images. More than 30 new line drawings complement the new chapters found in the seventh edition.

Essentials of Patient Care for the Sonographer (Chapter 3) covers all aspects of patient care the sonographer may encounter, including taking and understanding vital signs, handling patients on strict bed rest, patients with tubes and oxygen, patient transfer techniques, infection control, isolation techniques, emergency medical situations, assisting patients with special needs, and patient rights.

Ergonomics and Musculoskeletal Issues in Sonography (Chapter 4) outlines the importance of proper technique and positioning throughout the sonographic examination as a way to avoid long-term disability problems that may be acquired with repetitive scanning.

Understanding Other Imaging Modalities (Chapter 5) is a comparative overview of the multiple imaging modalities frequently encountered by the sonographer: computerized tomography, magnetic resonance, positron emission tomography (PET), nuclear medicine, and radiography.

Artifacts in Scanning (Chapter 6) is an outstanding review of all the artifacts commonly encountered by sonographers. There are numerous examples of the various artifacts and detailed explanations of how these artifacts are produced and how to avoid them.

3D and 4D Evaluation of Fetal Anomalies (Chapter 54) has a three-fold focus: (1) to introduce the sonographer to the technical concepts of 3D ultrasound; (2) to acquaint the sonographer with the 3D tools currently available; and (3) to provide clinical examples of the integration of 3D ultrasound into conventional sonographic examinations. Although a chapter with this title appeared in the last edition, this chapter has been entirely rewritten and includes all new illustrations.

Student Resources

Workbook. Available for separate purchase, *Workbook for Textbook of Diagnostic Sonography* has also been completely updated and expanded. This resource gives the learner ample opportunity to practice and apply the information presented in the textbook.

- Each workbook chapter covers all the material presented in the textbook.
- Each chapter includes exercises on image identification, anatomy identification, key term definitions, and sonographic technique.
- A set of 30 case studies using images from the textbook invites students to test their skills at identifying key anatomy and pathology and describing and interpreting sonographic findings.
- Students can also test their knowledge with the hundreds of multiple choice questions found in the four exams covering different content areas: General Sonography, Pediatric, Cardiovascular Anatomy, and Obstetrics and Gynecology.

Evolve. On the *Evolve* site, students will find a printable list of the key terms and definitions for each chapter; a printable selected bibliography for each chapter, and Weblinks.

Instructor Resources

Resources for instructors are also provided on the *Evolve* site to assist in the preparation of classroom lectures and activities.

- PowerPoint lectures for each chapter that include illustrations
- Test bank of 1500 multiple-choice questions in Examview and Word
- Electronic image collection that includes all the images from the textbook both in PowerPoint and in jpeg format

Evolve Online Course Management. *Evolve* is an interactive learning environment designed to work in coordination with *Textbook of Diagnostic Sonography.* Instructors may use *Evolve* to include an Internet-based course component that reinforces and expands upon the concepts delivered in class. *Evolve* may be used to:

- Publish the class syllabus, outlines, and lecture notes
- Set up virtual office hours and email communication
- Share important dates and information on the online class calendar
- Encourage student participation with chat rooms and discussion boards
- Post exams and manage grade books

For more information, visit http://www.evolve.elsevier.com/HagenAnsert/diagnostic/ or contact an Elsevier sales representative.

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My good fortune in learning about and understanding the *total patient* must be attributed to a very dedicated cardiologist, James Glenn, with whom I had the pleasure of working while I was at MUSC in Charleston, South Carolina. It was through his compassion and knowledge that I grew to appreciate the total patient beyond the transducer, and for this I am grateful.

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The continual push towards excellence has been encouraged on a daily basis by our Scripps Clinic Cardiologists and David Rubenson, Medical Director of the Echo Lab at Scripps Clinic.

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I would like to thank the very supportive and capable staff at Elsevier who have guided me though yet another edition of this textbook. Jeanne Olson and her excellent staff are to be commended on their perseverance to make this an outstanding textbook. Linda Woodard was a constant reminder to me to stay on task and was there to offer assistance when needed. Jennifer Moorhead has been the mainstay of this project from the beginning and has done an excellent job with the manuscript. She is to be commended on her eye for detail.

I would like to thank my family, Art, Becca, Aly, and Kati, for their patience and understanding, as I thought this edition would never come to an end.

I think that you will find the 7th Edition of the *Textbook of Diagnostic Sonography* reflects the contribution of so many individuals with attention to detail and a dedication to excellence. I hope you will find this educational experience in sonography as rewarding as I have.

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PART VIII Obstetrics

PART I

Foundations of Sonography

CHAPTER

1

Foundations of Sonography

Sandra L. Hagen-Ansert

OBJECTIVES

On completion of this chapter, you should be able to:

- Describe a career in sonography
- Detail a timeline for pioneers in the advancement of medical diagnostic ultrasound
- Demonstrate an understanding of the basic principles and terminology of ultrasound
- Discuss three-dimensional and Doppler ultrasound
- Identify ultrasound instruments and discuss their uses

OUTLINE

The words *diagnostic medical ultrasound*, *ultrasound*, and *ultrasonography* have all been used to describe the instrumentation utilized in ultrasound. *Sonography* is the term used to describe a specialized imaging technique used to visualize soft tissue structures of the body. The term *echocardiography*, or simply *echo*, refers to an ultrasound examination of the cardiac structures. A sonographer is an allied health professional who has received specialized education in ultrasound and has successfully completed the national boards given by the American Registry of Diagnostic Medical Sonography. Sonologists are physicians who have received specialized training in ultrasound and have successfully completed the national boards given by their respective specialty.

The field of diagnostic ultrasound has grown to become a well-respected and important part of diagnostic imaging, providing pertinent clinical information to the physician and to the patient. The applications of diagnostic ultrasound are extensive. They include but are not limited to the following:

1. Abdominal, renal, and retroperitoneal ultrasound
2. Interventional and therapeutic guided ultrasound
3. Thoracic ultrasound
4. Ultrasound of superficial structures (breast, thyroid, scrotum)
5. Cardiovascular and endoluminal ultrasound
6. Obstetric and gynecologic ultrasound
7. Intraoperative ultrasound
8. Neonatal and pediatric ultrasound
9. Musculoskeletal ultrasound
10. Ophthalmologic ultrasound

Extensive research has verified the safety of ultrasound as a diagnostic procedure. No harmful effects of ultrasound have been demonstrated at power levels used for diagnostic studies when performed by qualified and nationally certified sonographers under the direction of a qualified and board certified physician, using appropriate equipment and techniques.

Diagnostic ultrasound has come to be such a valuable diagnostic imaging technique for so many different body structures for many reasons, but two are especially significant. First is the lack of ionizing radiation for ultrasound as compared with the other imaging modalities of magnetic resonance imaging (MRI), computed tomography (CT), or nuclear medicine. The second reason is the portability of the ultrasound equipment. The ultrasound system can easily be moved into the intensive care unit (ICU), surgical suite, or small doctor's office, or packed into small planes for distant clinical sites. Ultrasound is unique in other ways as well. It allows an image to be