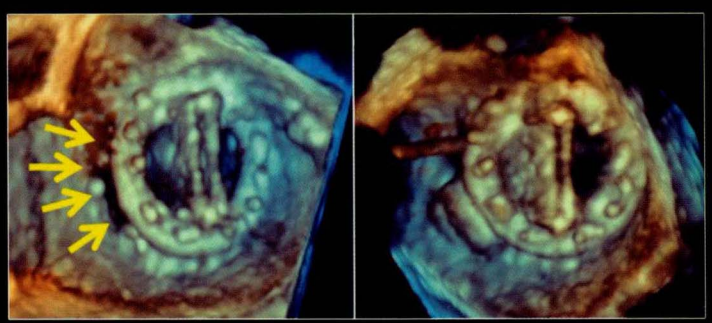
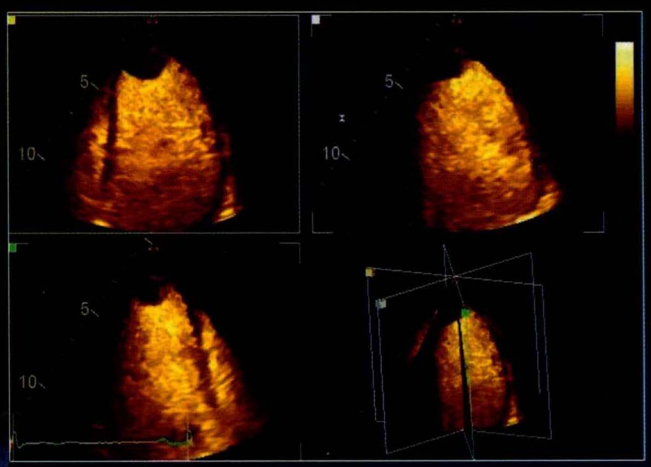
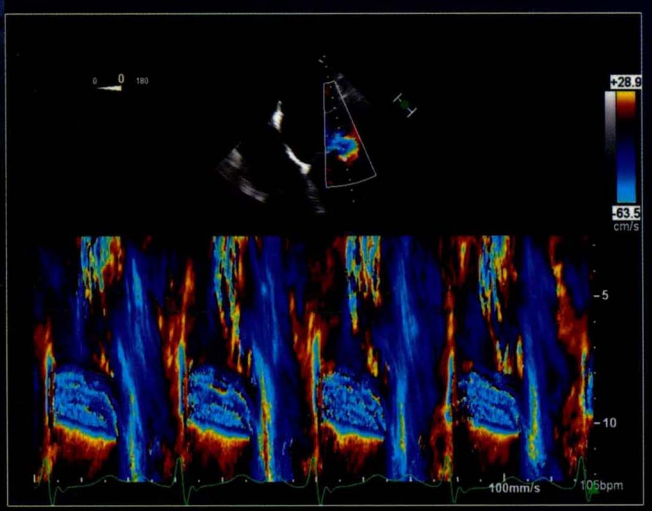
Clinical Echocardiography Review

SECOND EDITION

A Self-Assessment Tool







Allan L. Klein ▪ Craig R. Asher

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FOREWORD

For years students at all levels of medical education have stood at Attending Rounds or at the operating table while they were questioned about cases by their teachers or leaders. This time-honored Socratic method of transmitting information was often challenging, sometimes uncomfortable, but was always effective. It exploited the fact that students remembered well those concepts and facts that they could accurately restate, and even better those that they could not. In fact, many individuals preferred to be asked questions that they could not answer, since they would thereby learn new information. This volume by Klein and colleagues employs the Socratic method in a most effective manner.

The field of echocardiography has been expanding in an almost logarithmic fashion. Technology has advanced in a progressive and almost continuous fashion from M-mode recordings, to two- and three-dimensional imaging, to Doppler measures of flow and hemodynamics, to contrast enhancement of anatomy and perfusion, to handheld pocket instruments that complement the physical examination. The number and type of physicians using cardiac ultrasound has also expanded enormously. Anesthesiologists, emergency physicians, and even hospitalists are increasingly incorporating echocardiography into their clinical activities. Echo has assumed an important role in guiding a variety of interventional percutaneous procedures such as for structural heart disease and others. Echocardiography has matured into a noninvasive modality that has an established role in the standard care of patients with heart disease. Accordingly, there has been a proportional and pressing need for education in cardiac ultrasound.

The *Clinical Echocardiography Review* by Klein and colleagues employs the classic Socratic method in addressing this need for critical and applicable education in echocardiography. The book is comprehensive in the coverage of topics. The material deals with the basic tenets of physics and instrumentation fundamental to understanding the clinical use of echo. At the same time it emphasizes those clinical applications that are part and parcel of the everyday use of echo that has currently evolved. When readers can correctly answer a question, it will serve to indicate the importance of the information and to reinforce its place in their memory bank. When readers cannot answer the question, reviewing the correct response will insure a secure place in their store of knowledge. In either event, it will provide a self-evaluation of the strengths and limitations of an individual's knowledge bank, and guide future study.

The first volume of *Clinical Echocardiography Review* was an enormous success, and was well received by readers at every level of expertise. As is always the case, the Editor and authors profited from their experience with the initial book to enhance the second edition. The result is not only an extended coverage of echocardiography, but also a refinement of questions and answers. It is almost impossible to avoid writing a question that cannot be misinterpreted by some individuals. However, in providing the answers the intent of the question is clearly delineated.

Klein and his colleagues have used the Socratic method to address the growing need for education in the burgeoning field of echocardiography. The readers will benefit by the challenge of testing their knowledge in the setting of immediate feedback of the correct answer. Best of all, in contrast to Attending Rounds or the surgical suite, the reader can do this in the privacy of whatever setting they choose.

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FOREWORD

Echocardiography is one of the few technologic advances in the field of cardiovascular medicine that have truly transformed our specialty, not just once, but again and again. From its humble beginnings as M-mode echocardiography in the 1960s, this imaging modality has continued to deliver new and transformative insights into heart disease. Just when we think echocardiography has reached a stable state of maturity or even senescence, something new reawakens our excitement. Over six decades, we have witnessed the evolution of two-dimensional echo, Doppler color flow, transesophageal imaging, contrast ultrasound, tissue Doppler, three-dimensional echo and strain imaging. Innovation in cardiac ultrasound imaging has not paused and the increasing utility of echocardiography never plateaued. Along the way a new subspecialty of cardiovascular medicine emerged, cardiovascular imaging. Although cardiovascular imaging now includes many other modalities such as computed tomography, magnetic resonance imaging, and positron emission tomography, echocardiography remains the single most valuable and commonly performed imaging technology.

There are now many textbooks that teach the science and practice of echocardiography. Many focus on all of the field's technologic developments, including the physics and mathematics underlying advanced techniques such as strain imaging. While such knowledge is important, students learning echocardiography must understand practical applications in caring for real patients. The physical principles are useful, but echocardiography remains a discipline that will always be part of the fundamental core of the art of medicine, a skill that is difficult to teach. Dr. Klein and coauthors make it much easier. The *Clinical Echocardiography Review* emphasizes the practical knowledge required to use echocardiography in the care of patients. Using case examples, questions and answers, the authors engage the learner in the process of self-education. Many experts in the science of learning advocate this kind of case-based education because it provides more durable and usable knowledge. This book is particularly good for those studying for board examinations. Dr. Klein and coauthors have made reviewing for the boards efficient and importantly, great fun. The question and answer format facilitates self-assessment and helps focus the learner on what he or she knows and doesn't know. Whether you are an expert or novice, there's something in this book for everyone.

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PREFACE

We are delighted with this 2nd edition of this interactive and contemporary text book entitled *Clinical Echocardiography Review: A Self-Assessment Tool.* In 2017, echocardiography is seeing a major renaissance in interest and growth. We are now in the modern era of miniaturization, 3D and interventional echocardiography, strain imaging, real-time TEE, and molecular imaging with contrast. At the same time, reimbursement for imaging is decreasing and there is competing technology. The busy clinician and fellow have to keep up with the latest in the changing clinical practice of echocardiography. This book focuses on the time tested way of "the Socratic method" to teach the key concepts to busy clinical cardiologists, fellows, anesthesiologists, intensivists and sonographers using a multiple-choice question and answer format. The book will emphasize diagnostic interpretation rather than clinical management.

This book is comprehensive with 31 state-of-the-art chapters ranging from fundamentals to new technologies. The format of each chapter is standardized with three types of questions. At the beginning, there are simple questions followed by an answer. Then, questions associated with a still frame graphic (M-mode, 2D, or a 3D) come next and are followed by an answer. Finally, questions are presented involving case studies associated with several questions based on movies and still frames. The reader will need to go to the website to work with these questions in either study mode or test mode.

We have chosen leading national and international experts as well as educators in the field of echocardiography. We will cover the basics from physics and artifacts to more clinically oriented topics including atrial fibrillation, prosthetic valves, cardiomyopathies, and pericardial disease and then new technologies such as dyssynchrony assessment, strain, and 3D. New chapters include interventional echocardiography, focused ultrasound and LV assist devices. We have emphasized key take home points after each of the cases. This book uses the question and answer method which is similar to how we teach our fellows to read echocardiograms. Also, it will be useful for the clinical cardiologist who wants to hone their echocardiographic skills in day-to-day practice.

Clinical Echocardiography Review: A Self-Assessment Tool may be the largest echocardiography review book out there with over 1100 questions and answers as well as key references for each chapter. There are ample graphs, tables and figures, and detailed explanations to answer the questions.

We hope that you enjoy the basics as well as the "latest and greatest" of echocardiography in the 21st century.

Allan L. Klein and Craig R. Asher

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CONTENTS

CHAPTER 1

Physics: Fundamentals of Ultrasound Imaging and Instrumentation

Victor Mor-Avi, Rajesh Jaganath, Lynn Weinert, and Jim D. Thomas

1. Sound waves cannot travel through one of the following:
A. Water.
B. Air.
C. Metal.
D. Vacuum.

2. Ultrasound is a pressure wave with a frequency above the range of human hearing, which is:
A. 200 Hz.
B. 2 kHz.
C. 20,000 Hz.
D. 200 kHz.

3. The frequency of a sound wave is measured in hertz as the:
A. Inverse of the wavelength.
B. Maximal amplitude of particle vibration.
C. Number of times particles vibrate each second in the direction perpendicular to wave propagation.
D. Number of times particles vibrate each second in the direction of wave propagation.

4. Ultrasound imaging is usually performed using frequencies in the range of:
A. 1–30 kHz.
B. Below 5 MHz.
C. Above 0.5 MHz.
D. 1–30 MHz.

5. Assuming that sound velocity in muscle tissue is 1,600 m/s, the wavelength of a sound wave with the frequency of 1.6 MHz is:
A. 1 mm.
B. 1 cm.
C. 1 m.
D. 0.1 mm.

6. As an ultrasound wave travels through the human body, the type of tissue that results in the fastest loss of its strength is:
A. Fat.
B. Bone.
C. Lung.
D. Blood.

7. The main goal of the gel used during ultrasound imaging is to:
A. Disinfect the transducer.
B. Cool the transducer.
C. To numb the skin and thus reduce patient's discomfort caused by pressure.
D. To improve the contact between transducer surface and the skin.

8. Materials that respond to acoustic waves by generating electric signals and vice versa are known as:
A. Doppler crystals.
B. Acoustic coupling gels.
C. Piezoelectric crystals.
D. Chronotropic agents.

9. Doppler effect refers to:
- A. Change in strength of a sound wave reflected by a moving target.
- B. Change in frequency of a sound wave reflected by a moving target.
- C. Change in shape of a sound wave reflected by a moving target.
- D. Loss of ultrasound energy as a result of wave dissipation by flow.

10. Doppler angle is the angle between:
- A. The flow and the long axis of the left ventricle.
- B. The ultrasound beam and the long axis of the left ventricle.
- C. The flow and the transmitted ultrasound beam.
- D. The flow and the central axis of the transducer.

11. A positive Doppler shift indicates that the reflector is moving:
- A. Faster than the sound wave propagates.
- B. Directly toward the transducer.
- C. Directly away from the transducer.
- D. So that the angle between the direction of the beam and the direction of motion is >90 degrees.

12. A Doppler shift of zero indicates that the reflector is stationary or:
- A. Moving in a direction perpendicular to the beam.
- B. Moving in a direction parallel to the beam.
- C. Moving in a direction perpendicular to the central axis of the transducer.
- D. Moving too fast to register.

13. Time gain compensation is part of the ultrasound image formation aimed at correcting intensity for variations in the extent to which different media result in ultrasound ____.
- A. scattering
- B. absorption
- C. reflection
- D. attenuation

14. The strength of the transmitted ultrasound wave is controlled by adjusting the:
- A. Time gain compensation controls.
- B. Compression control.
- C. Power control.
- D. Overall gain control.

15. The spatial resolution of an ultrasound image is defined as the:
- A. Smallest distance between two objects that allows distinction between them.
- B. Size of the smallest object that can be clearly visualized in its entirety.
- C. Smallest cluster of pixels that can define a single object.
- D. Smallest difference in the size of an object that can be visually detected.

16. The spatial resolution of an ultrasound image is equal to the:
- A. Gap between two adjacent pixels.
- B. Twice the wavelength.
- C. Size of a pixel in the relevant direction.
- D. One-half of the wavelength.

17. The temporal resolution of a sequence of ultrasound images is defined by the:
- A. Shortest duration of an event that can be detected with confidence.
- B. Shortest time in which image information can change completely.
- C. Shortest time between two events that allows distinction between them.
- D. Shortest time in which pixel values can change.

18. The following phrase is meaningless:
- A. Spatial resolution.
- B. Temporal resolution.
- C. Frequency resolution.
- D. Contrast resolution.

19. The temporal resolution of a sequence of ultrasound images is equal to the:
- A. Inverse of transducer frequency.
- B. Inverse of frame rate.
- C. One cycle of the ultrasound wave.
- D. Inverse of the number of frames in the sequence.